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FINAL REPORT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

VIENNA, AUSTRIA.

BASE-LINE SURVEY CUM DIAGNOSTIC STUDY OF FIROZABAD GLASS INDUSTRY

FEBRUARY 1995

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THE NATIONAL INDUSTRIAL DEVELOPMENT CORPORATION LTD.
CHANAKYA BHAWAN, AFRICA AVENUE
NEW DELHI, INDIA

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LIST OF ABBREVIATIONS

CCS	-	Cold Crushing Strength
CGCRI	-	Central Glass & Ceramic Research Institute
CIGI	-	Centre for Improvement of Glass Industry
CPCB	-	Central Pollution Control Board
CU	-	Composite unit
DG	-	Diesel Generator
DIC	-	District Industries Centre
GT	-	Glass Tank
HPMV	-	High Pressure Mercury Vapour
LPG	-	Liquified Petroleum Gas
OSHA	-	Occupational Safety & Health Association
PCE	-	Pyrometric Cone Equivalent
RUL	-	Refractoriness Under Load
SPM	-	Suspended Particulate Matter
UNIDO	-	United Nations Industrial Development Organization
UNDP	-	United Nations Development Programme

EXECUTIVE SUMMARY

0.1 Introduction

Firozabad glass industry today has multitude problems which include use of obsolete level of technology, primitive glass melting techniques, inferior quality of finished products, lack of management skills, in-human working conditions etc. So far no appreciable effort has been made by the industry to improve these conditions. The objectives of this Study are development and adoption of new glass melting and forming technologies; improvement of product quality;design and introduction of new types of glass other than soda lime; environment protection, and energy conservation. The Study is aimed to analyse and identify the critical problems relevant to the glass industry in Firozabad and suggest necessary recommendations thereof.

0.2 Status

Firozabad glass industry which is about 300 years old accounts for more than 70 per cent of all the glass items produced in the un-organised sector. At present, there are about 350 units engaged in the production of soda lime glass and glassware items with a value of around Rs.450 million and have given an employment to about 1,30,000 personnel. The products manufactured in Firozabad include Autolight covers, Tumblers, Tableware articles, Laboratory and Scientific glassware, Bangles, Beads, Block glass, Light shades & Chandeliers, Vacuum glass refill etc. In addition, there are about 800 to 1000 units in the cottage industries sector engaged in finishing and decoration of glass and glassware items and decoration of bangles.

The produce from Firozabad is supplied directly and indirectly to various segments of the industry which include Automobile industry, Hotel industry, Lighting industry, Glass industry, Medical institutions, Educational institutes, Household, Perfumery etc. However, the quality of the products mostly sold in he domestic market is quite poor. The exports from the Firozabad are mostly indirect. Lately, a couple of large units have made a modest beginning and have directly exported to West Germany, United States of America, Middle East countries etc.

The Firozabad glass industry could be classified broadly by the type of furnace used - pot (4 tpd capacity) and tank (10/20 tpd capacity). However, the technology used is quite traditional and has not undergone much changes. Coal is mostly used as the main fuel in the furnaces and this is the major source of pollution in the town.

0.3 Identified Glass Manufacturing Units

In order to study the problems of Firozabad glass industry in detail, following eight units were identified in consultation with the Centre for Improvement of Glass Industry (CIGI):

i) Manohar Glass Works
ii) Shiv China Glass Manufacturing Company
iii) Pooja Glass Works
iv) Adarsh Glass Works
v) West Glass Works
vi) Baby Glass Works
vii) Om Glass Works
viii) Electronic Glass Industry

The areas of detailed study for the glass units included Technology assessment and furnace performance; Energy measurement and audit; Pollution monitoring; Marketing of products and financial aspects.

0.4 Recommendations

The modern trends in small scale sector have been kept in view while formulating the recommendations, wherever possible.

The summary of problems/deficiencies and recommendations suggested thereof under each head is given in the ensuing paragraphs.

0.4.1 Product

The soda lime glass products produced in Firozabad are mostly of poor quality having high alkalinity, low chemical resistance, high co-efficient of expansion and prone to rapid weathering.

The new products recommended for commercial production are :

a) Coloured glass lenses for Railways, Airport runway and Traffic Signals.

b) Semi crystal glassware such as Bowl, Tableware, Vases, Lampshades, Tumblers etc.

c) Crystal glass items like Chandeliers, Globets etc.

d) Borosilicate (plain and opal) glass for Kitchenware items, Airport runway glass, HPMV lamp evelopes, Laboratoryware items etc.

e) Block glass for beads manufacture.

Special glass and high value added soda lime glass finds a good export market in countries like Europe, South Africa, Germany, Egypt, Middle East countries etc. Therefore, direct export potential of Firozabad glass industry should be exploited.

0.4.2 Raw Material

It has been observed that quality of raw materials used by most of the units is not upto the mark. Washing, sieving and magnetic separation is generally not carried out, which affects the quality of glass.

It is recommended that glass manufacturers should insist upon the suppliers to supply the various raw materials as per Indian/International standards and should supply the test reports or certificate from main producer along with the materials.

In the absence of raw material certificate of testing, it is suggested that raw materials should be got tested from CIGI, who have all the requisite testing facilities.

It is recommended that silica sand should be properly washed, sieved and passed through magnetic separator before use. A sand washing unit of 3 T/hr is recommended for installation in the glass units.

0.4.3 Batching

It has been observed during study that most of the glass manufacturers are not aware of the required particle size of various batch ingredients. Weighing is done roughly by volume rather than by weight and mixing is performed manually.

As grain sizes of various ingredients play a critical role in the melting process, both undersized and oversized particles are harmful. It is recommended that the batch particle size may be considered between 20 mesh to 80 mesh B.S. CIGI should advise the manufacturers to specify the grain size while placing the order and to maintain the grain size of the batch by proper sieving.

It is recommended that proper weighing of proper raw materials should be done in accurate balances (load cell type) and homogeneous mixing of the batch should be done in batch mixers.

It is recommended that wet batching should be practiced, which calls for addition of 2-4% moisture. This would not only minimise the incidence of dusting but also reduce the chances of batch segregation and result in fuel savings.

0.4.4 Cullet Handling & Recycling

It has been observed during study that processing of the cullets either generated in-house or purchased is not done properly. Sizing of the cullets especially those generated during forming operations is also not performed.

It is recommended that cullets should be processed before use in cullet processing unit. Installation of 2 T/hr cullet processing unit is recommended in the glass units.

0.4.5 Melting Furnace

Pot Furnace

The design of the coal fired down draft pot furnace is very old and the maximum flame temeprature achieved is around 1350°C. During the detailed study of the units, it has been found that the furnaces have heat utilisation between 9 to 13% and the campaign life is less than a year. The refractories used are low grade without any insulation and the radiation loss is between 20-40%. In most of the furnaces, there is no provision of essential instrumentation and 50-60% heat losses take place through the flue gases.

It is recommended that glass units should opt for oil fired pot furnaces having forced draft, with metallic recuperator and equipped with essential instrumentation.

For improving the efficiency of the existing coal fired pot furnaces, the following measures are suggested:

i) The walls of the furnace should be constructed with high alumina sillimanite or mullite bricks and the crown of the furnace should be constructed with high duty silica bricks and the insulation should be done with silica insulating bricks and layer of cerawool. This would reduce radiation losses and in turn would reduce coal consumption.

ii) It is recommended to instal one temperature indicator-cum-recorder in the middle of the crown and one temperature indicator in the flue path for monitoring of the furnace so that firing rate could be regulated.

iii) The waste heat of flue gases can be used for preheating the pots and thereby reducing the stack temperature and utilising outgoing heat.

0.4.6 Pots

The quality of the pots used in the pot furnace is not good and the average life of pot is between 15-25 days. The consultants during their visits in some of the pot making units in Firozabad have observed that pot is made from very coarse grog, and the alumina content is very low in the mix. This causes leaks in the bottom or side walls.

Pots with longer service life pots (with average life upto 10 weeks) which can withstand higher temperature and corrosion, are presently in use at Goldstar Glass Works, NOIDA, in the oil fired pot furnace. It is suggested that Firozabad glass manufacturers should adopt similar technology for manufacturing pots.

CGCRI is also presently working on low moisture cement castables to be used in the manufacture of pots for glass melting. If they succeed in the development of pots with longer service life, the same can also be used at Firozabad.

In view of the poor quality of pots, it is recommended that the activity of manufacturing pots for the whole of Firozabad region should be taken up in centralised units under the supervision of CIGI, so that the material specifications and manufacturing procedures can be kept under control and pots of better quality and reasonable life period can be made available to the glass units of Firozabad.

0.4.7 Tank Furnace

Most of the tank furnaces in Firozabad are coal gas fired and there are a few units having oil fired tank furnaces. The problems/deficiencies in the tank furnaces such as improper design, use of low grade refractories and inadequate instrumentation result in lower heat utilisation and higher heat losses through radiation and flue gases. Some of the units have converted coal gas fired furnaces to oil fired furnaces but without any substantial improvement in operating conditions. The regenertors are mostly of single pass type.

It is recommended that coal gas fired tank furnaces should be converted to oil/gas fired tank furnaces in phases.

For improving the efficiency of the existing coal gas fired tank furnaces, emphasis should be given on the design parameters such as length to breadth ratio of the melting zone, drawing zone area in relation to melting zone, combustion volume, breast wall height, refractories to be used, insulation and instrumentation etc. so as to get the maximum efficiency for that particular fuel. The details of the recommendations are given in Chapter-5.

It is recommended that the arrangement of converting coal gas to high calorific value producer gas should be made in the coal gas fired tank furnace by providing steam injection in the hearth bed. The arrangement would be similar to stationary producer gas plant of yester years.

In the coal gas fired tank furnace the design of the burner ports and the tongue arch should be properly calculated so that the burning of gas starts right at the port mouth. In that case, superior quality Zircon or Electrocast refractories should be used in the construction of the ports.

In an oil fired furnace, the burners recommended should be of medium/high air pressure type, and the atomising air in the range of 2 to 4 bars.

0.4.8 Subsidiary Furnaces

At present, less importance is given to the subsidiary furnaces such as Pot pre-heating furnace, Reheating furnace (Sikai Bhatti), Bangle spiralling furnace (Belan Bhatti). The furnaces are coal/coke/wood fired and have crude design and are poorly constructed.

The subsidiary furnaces should be properly designed ano fabricated by the reputed manufacturers of the furnaces. The fuel should be changed to oil which would not only save energy consumption but improve the woiking conditions also.

0.4.9 Energy Conservation

The glass industry is highly energy intensive and percentage of energy cost related to manufacturing cost is between 20-40%. Glass melting roughly accounts for 90-95% of the total energy input in the glass unit. During detailed study of the units, it has been found that more than 80% of the heat is dissipated through stack losses and radiation losses.

The recommendations made in the Report pertaining to improvement in the furnace design and manufacturing processes would no doubt save considerable energy.

It is recommended that increased use of properly processed cullet in the batch would result in reduction in the energy consumption. The glass manufacturers should take the help of CIGI in working out the maximum batch to cullet ratio, without impairing the quality of the resultant glass.

Feasibility of using melting additives should be worked out to reduce the melting temperature. In this regard the glass unit owners should take the advice of CIGI.

Reduction in energy consumption can be achieved if the reject rate is minimised by deploying proper moulds/dies and glass products (like containers) are manufactured in lighter weights.

0.4.10 Pollution

It has been observed during the detailed study that in the units deploying coal fired melting and subsidiary furnaces, stack emission levels are quite high and ambient air concentration of suspended particulate matter (SPM), Sulphur Dioxide, Carbon Monoxide and amb: ıt air temperature near the wc'k places are also on the higher side.

The recommendations suggested pertaining to improvement of furnace design, refractories, insulation and providing essential instrumentation would improve the working conditions.

Stack should incorporate measures for arresting dust as well as alkaline scrubbing to reduce the concentration of sulphur dioxide and NO_x, which in turn would also reduce the flue gas temperature.

It is recommended to provide proper sampling point and sampling platform for the stack gases, as per Central Pollution Control Board (CPCB) regulations.

It is recommended that glass manufacturers should get the pollution levels of their units checked by CIGI from time to time.

0.4.11 Fuel

Erratic supply and inconsistant quality of coal from Coal India are the major problems faced by the glass units, as coal is the major fuel used by the industry. It is recommended that Directorate of Industries, Coal India Ltd. and Indian Railways should ensure the supply of selected coal of 'B' Grade quality in time to industrial units.

In view of the suggestions to convert coal fired furnaces to oil/gas fired in phases, the requirement of oil would increase. It is recommended that Indian Oil Company should timely release quota of furnace oil of requisite quality to the glass units.

The use of natural gas will help the units to affect substantial savings in fuel and enhance their capacity to compete. It is strongly recommended that natural gas pipeline be extended to Firozabad area at the earliest.

0.4.12 Testing, Inspection and Quality Control

During the visits by Consultants, the procedures being used for inspection and quality control were studied at varios units. It has been observed that testing facilities and quality control are missing in almost all the units. Emphasis was being given on quantity rather than quality. Only a few units have facility for conducting annealing test on glass products.

In addition to the raw materials testing as mentioned earlier, it is recommended that inspection should be carried out after every stage of production, so as to minimise wastage of materials and manpower.

It is recommended that glass units should develop an inspection record system. The data so collected would be useful for management decisions and would help in carrying out reject analysis and improve the quality of the products in the subsequent batches.

0.4.13 Plant Layout/House-Keeping/Working Conditions

It has been observed that the layouts are generally cramped and haphazard and not according to any rational basis in most of the units. House-keeping in almost all the units is non-existant. Materials and scrap are cluttered inside the working areas, which are quite smoky.

The characteristics of a model layout have been given for the guidance of the entrepreneurs to develop suitable layouts to suit their manufacturing activities.

Simple measures such as good house-keeping will be advantageous not only for proper and unhindered material flow but also from the view-point of creating a safer and healthy working environment.

The working areas should be clean and free from smoke and dust. Proper ventilation, man-coolers, toilets, first-aid, comfort cooling etc. should be provided.

0.4.14 Manufacturing Systems

Modern management systems such as production planning and control, quality control etc. are practically non-existant. There is no doubt that it would be beyond the capacity of small units to employ specialists in all the above areas. However, they can make use of assistance available from governmental/private agencies in such areas. Practice of modern management techniques is essential to improve productivity.

0.4.15 Training

Due to small size of the units and financial limitations, the in-house training facilities are non-existant in these units. Education and training of technical personnel at various levels in the areas of batching, glass blowing, efficient furnace oper ion etc. is necessary. These programmes may be sponsored by Firozabad Glass Manufacturers Association.

Seminars/Symposia are recommended for the entrepreneurs and managers. Such meetings would not only provide opportunities to discuss some of the common problems faced by them in different fields but would also impart knowledge of the latest technologies and management techniques adopted elsewhere.

0.4.16 Model Unit

There are different product group combinations being followed by the small scale sector units. For reasons mentioned in Chapter on "Model Unit", two model units - one with Pot Furnace having a capacity of 4 tpd and the other with oil fired Tank Furnace having a capacity of 10 tpd have been planned. The technical and economic parameters have been worked out and given in Chapter-6. These model units can be used as a guide by the small scale entrepreneurs for designing their units.

I. INTRODUCTION

1.1 The origin of the glass industry in India can be traced to many centuries ago when the industry comprised of cottage units manufacturing glass products in centres such as Firozabad. The informal glass industry Sector of India can be classified in two distinct categories - cottage and small scale. The glass making of small scale units produce from 4 to 20 tonnes/day of finished products using pot or tank furnaces. The production of this sector covers a wide range of items including jars, tumblers, lamp shades, laboratory-wares, thermo flask refills, bangles etc. The cottage scale units are engaged in finishing operation of glass and glassware items and decoration of bangles. These glass manufacturing units are located in Firozabad, Sassni, Naini, Shikohabad and Behjoi areas. However, the concentration of these units is in Firozabad and Shikohabad belt.

1.2 The small scale and cottage industries are faced with multitude of problems which is affecting the economic viability and adaptation to changing market situation. These units continue to work on the outdated technology which is seriously affecting the health of the workers and polluting the surrounding environment. The quality of the products is quite poor and no efforts have been made by the owners to use advanced technology. Some of the so called large manufacturing units have shown interest in adding new products and have made certain improvements in technology.

1.3 In the units engaged in finishing and decoration of glass products, mostly employing women, the working atmosphere is highly polluted with dust and kerosene vapour caused by grinding and sealing operations.

1.4 In Firozabad and adjoining areas, mostly coal is used as fuel for glass melting and other operations. As such improvement in energy conservation, pollution control and working conditions need due attention. Because of the poor and unhygenic working conditions in the units, the workers are exposed to health hazard.

1.5 No efforts have been made by the Firozabad industry to improve and upgrade the skills in product design, decoration and quality of the products. As such, there is shortage of skilled manpower in the glass manufacturing town.

1.6 The glass industry is globally known to be highly technology intensive. This could primarily be due to process of manufacture and modern plant and equipment used. The glass manufacturing units in Firozabad were set up way back in 1950's. These units have been showing little interest in technology upgradation.There exists wide technology gap in the modern and the age old units of Firozabad. Due to technology gap, the units of Firozabad continue to supply inferior quality of produce to the local market. Also, the productivity level is quite low and no efforts have been made by the owners to improve the skill of the workers or train them.

1.7 Arising out of this, The United Nations Industrial Development Organisation (UNIDO) in association with Development Commissioner for Small Scale Industries in the Ministry of Industry have commissioned the National Industrial Development Corporation Ltd. (NIDC) to undertake a Base Line Survey-cum-Diagnostic Study of the Glass Industry in Firozabad. The objective of the Study is the development,adoption of new glass melting, forming technologies; improvement of product quality, design and introduction of new type of glass other than soda lime; environment protection, and energy conservation. The report identifies problems and deficiencies in the following areas of operation:

- Furnace operation
- Energy conservation
- Raw material used
- Glass technology used
- Operational management
- House-keeping & working conditions
- Pollution measurement
- Product design and development

1.8 The methodology adopted for conducting the study has been :

- designing a suitable questionnaire for data collection;
- selection of a few representative units in consultation with CIGI for all types of glass & glassware products using pot/tank furnaces in Firozabad;
- collection of data from the units selected.

This was done for :

I) Raw materials & batch preparation.

ii) Technology assessment

iii) Product details

iv) Markets and marketing
v) Plant & equipment
vi) House-keeping & working environment
vii) Pollution level and energy conservation
viii) Manpower
ix) Finance

- collection of data from modern units with regard to raw materials, technology, product quality etc.

- analysis of data highlighting the deficiencies of Firozabad units and recommendations thereof.

1.9 The NIDC wishes to place on records its grateful thanks for the valuable guidance provided by the Officials of UNIDO, Experts of UNDP, National Project Director and DC -SSI, and other officials of CIGI, Firozabad in conducting the study. NIDC is also thankful to its associates,PHD Chamber of Commerce and Industry for conducting energy conservation studies, Shriram Institute for Industrial Research for study of pollution aspects, and State Bank of India Project Uptech in data collection as well as to the management of glass units for their cooperation and active support in making the Report a success.

II. PRESENT STATUS OF GLASS INDUSTRY IN FIROZABAD

2.1 General

2.1.1 Glass Industry

For the Rs.5000 to 6000 million glass industry covering large, small scale and cottage sectors, steady demand prospects are expected despite increasing competition from substitute materials. The organised sector accounts for around 70 per cent of the industry's aggregate value of production.

Firozabad district has the origin of glass making right from the Mughal period and accounts for more than 70 per cent of all glass items produced in the small scale sector. A peculiar feature of glass industry in Firozabad is that inspite of non-availability of raw materials and coal which is the main fuel, majority of the industry's produce is from this district. The industry is pre-dominant by use of traditional skills, marked by craftsmanship handed over from generation to generation.

2.1.2 History & Growth

Glass industry is one of the oldest in the world. In India, it is nearly 300 years old and is generally non- mechanised, traditionally small scale and household industry. In Firozabad, majority of the population is engaged in the glass industry and making a variety of glass and glassware items.

The growth of glass industry in Firozabad has been quite substantial which is evident from the following table :

Table : 2.1
Growth of Glass Industry in Firozabad

Year	No. of Units	Employment
1950	30	7,500
1960	144	11,000
1970	170	40,000
1980	273	65,000
1990	342	127,000

Source: District Industries Centre, Firozabad

A list of the various glass units in Firozabad is given as Appendix 2.1.

2.2 Products

2.2.1 Types of Products

Glass industry in Firozabad and adjoining areas consists of about 350 registered units manufacturing a variety of glass and glassware products. List of about 300 units in Firozabad registered with DIC is appended at Appendix A.2.1. Mostly soda lime silica glass products are manufactured in Firozabad. However, for some of the glass and glassware products, lead glass and borosilicate products are also manufactured for decorative items and laboratory glassware respectively. The products manufactured in Firozabad are given below:

- Autolight covers
- Tumblers
- Tableware articles e.g. paper weight, decorative pieces etc.
- Light shades & chandeliers
- Laboratory & scientific glassware including beakers, bell jars, flasks, desiccators, funnels, gasjars, measuring cylinder, reagent bottles, specimen jars, winches for bottles etc.
- Bangles
- Beads - hollow & solid
- Block glass
- Glass bulb shells
- Signal glass
- Vacuum glass refills etc.

The products are manufactured in various sizes and shapes depending on the specifications and requirements.

2.2.2. Capacity

The status of glass industry in Firozabad giving number of units, installed capacity and production is given in the following table :

Table : 2.2
Status of Glass Industry in Firozabad

S.No.	Industry	No. of Units	Installed Capacity	Production (1991-92) Quantity	Production (1991-92) Value (Rs.mill.)
1.	Glass-holloware & pressedware	43	70,000 tonnes	36,000 tonnes	125.00
2.	Composite ware	-	-	-	6.00
3.	Glass bulb shells	20 CU	4,000 Pcs.	800 lakh Pcs.	20.00
4.	Chandelier & electric shade	35	-	-	6.00
5.	Bangles	177	100,000 tonnes	50,000 tonnes	260.00
6.	Block glass	40	39,000 tonnes	9,000 tonnes	30.00
7.	Hollow and solid glass beads	19	306	126	1.50
8.	Signal glass	3 CU	-	300 tonnes	1.50
	Total	342			450.00

Source: District Industries Centre, Firozabad
CU: Composite Unit

It may be seen from the above table, that the bulk of the production is of glass & glassware items which include hollow-ware and pressed items. The high value added items in this category are head- ghts for automobiles, wine glasses, glass shells etc. There are about 177 units manufacturing bangles which is one of the major products of Firozabad.

In addition to the above mentioned manufacturing units there are about 800 to 1000 units engaged in finishing and decoration of glass. Mostly, these units are in cottage industries and are engaged in finishing operation of glass and glassware items and decoration of bangles.

2.2.3 Market & Marketing

The produce from Firozabad is supplied directly and indirectly to various segments of the industry. The customer segments include Automobile industry, Hotel industry, Lighting industry, Glass industry, Perfumery, Medical Institutions, Educational Institutes, Research & Development Institutes, Household etc. The manufacturers sell their products to the dealers and their agents. The prices of the products vary from manufacturer to manufacturer. In order to boost the sale, the manufacturers are selling their products even below the cost price. As such underselling is quite predominant in the industry. The dealers are enjoying maximum benefit and do not pass the benefit of low prices from the manufacturer's to the customers.

The products from the main producers are available in the semi-finished stage and the finishing operations which include grinding, engraving, decoration etc. are done by the secondary producers. The quality of the produce from the Firozabad is mostly of two grades and the availability of inferior quality is quite predominant in the local market. The price difference between two qualities of products available in the market is around 25 per cent.

2.2.4 Exports

The exports of glass and glassware items from India during 1990-91 were around Rs. 550 million. Vacuum flask refills are the single largest product accounting for one third of total exports. The other items for export are glass bottles and vials, bangles, scientific glassware, glass & glassware items etc.

Mostly indirect exports are carried out from Firozabad. However, recently few units (large) have directly exported to West Germany, U.S., Middle East countries etc. The items exported from Firozabad are Tumblers, Chimneys, Tableware items. It is anticipated that the exports from Firozabad would grow in the near future as there is good potential provided the quality of the products is improved.

2.3 Manufacturing Technology

The Firozabad glass industry can be classified broadly in two categories depending on the furnace used, which may be either Pot Furnace or Tank Furnace. Generally both types of furnaces are coal-fired. However, the technology which has been quite traditional has not undergone much changes.

2.3.1 Technology Used

The following technologies are used in Firozabad for glass forming operation :

a) Mouth Blowing
The required quantity of molten glass is gathered at one end of an iron tube, placed in a mould and blown by mouth to take the required shape of the mould.

b) Semi-automatic Machine
The required quantity of the molten glass is taken on an iron rod and moved to pneumatically controlled hydraulic press to take the desired shape as per the mould.

c) Pressing
In this technique, the molten glass is collected on iron rods and the desired shape is achieved by placing into the moulds of the press.

2.3.2 Process of Manufacture (Clear Glass)

The process of manufacture, particularly in forming depends upon the product and the composition of glass. However, the general steps involved in the process of manufacture are briefly described in the following paragraphs.

2.3.2.1 Proportioning & Mixing

The major raw materials like silica and soda ash are mixed manually or mechanically in pre-determined quantities depending upon the type of products to be manufactured. Batch preparation comprises of three stages i.e. preparation of raw materials, weighing and mixing uniformly. Preparation of raw materials is done in order to sieve out oversize particles of silica quartz powder as other items are too fine to be sieved. Magnetic separation is done for removal of metallic iron in sand. Weighing of raw materials is done on two-pan type physical balance. The general practice is to confine the weighing to fine chemicals only. The other items like sand are measured on volume basis for which wooden boxes with handles are used. Mixing of the raw materials is done either manually or in rotary mixers.

Batch raw materials also include hazardous materials like Arsenic trioxide & Selenium which are harmful to the health of the workers employed in this section.

Cullets aid in melting of batch raw materials and hence these are mixed with the batch. In Firozabad, about 40 to 50 per cent of the batch constitutes of cullets. Some of the units in this town purchase cullets from the open market in addition to the own cullets which are recycled in the process.

Dry mixing of the batch ensures free movement of the grains of raw materials thereby aiding dispersion of these in the mix. However, dry batch produces lot of dust in the batch preparation section. Wet mixing which includes adding moisture in the batch is not being practised in Firozabad.

Batch preparation is similar in case of glass & glassware and bangles. However, the composition of the batch is different and differs from unit to unit.

2.3.2.2 Melting

A. Glass & Glassware

The batch mixture is charged into the melting furnace and melted at temperature ranging from 1200°C to 1500°C. Two types of furnaces are being employed in the Firozabad glass industry - Pot furnace (closed type) having a capacity upto 4 tonnes/day with melting temperature in the range of 1250°C to 1450°C and tank furnace having capacity upto 20 tonnes per day with melting temperature in the range of 1400-1500°C. These furnaces are utilised to produce a variety of items including tumblers, thermo-flask refills, lamp shades, automobile covers, laboratoryware, jars etc.

First, the fluxes e.g. soda ash and cullets present in the mixture are melted. The soda ash forms low melting alkali silicates with sand.

These silicates react with the high melting constituents to form the glass melt. The carbon-dioxide of the carbonates is expelled during the melting process.

For obtaining the desired colours of the glass, required quantities of metallic oxides e.g. Iron oxide, Cobalt oxide, Copper oxide, Charcoal, Manganese dioxide etc. are added to the mixture.

In the case of coal fired pot furnace, the molten glass is drawn during the day shift. After the pot has been emptied, charging of the fresh batch and cullets is carried out and the pot is closed and sealed.The melting is then allowed to take place for the following two shifts, in a period of 16-18 hours. In the case of continuous tank furnaces which are either coal or fuel oil fired, the charging is done after every 20-30 minutes through the "dog house" located at the feed end of the furnace. Melting takes place in the melting chamber of the furnace. The molten glass flows into the drawing chamber from where it is drawn out for forming operation.

B. <u>Bangles</u>

Melting of the batch raw materials is usually carried out in open pot furnace having a capacity of 4 to 5 tonnes/day and with temperature in the range of 1200-1250°C. These furnaces are coal fired, where the fuel is fired underneath the pots and the flue gases are passed to the chimney. Openings are provided to draw the molten glass out.

C. <u>Block Glass</u>

Block and vitreous glass, which is a soda lime glass, is manufactured in open type pot furnace coal fired). The furnace has 7 to 12 pots each having a capacity of 200-400 Kgs. each. The temperature in this type of furnace is in the range of 1150-1250°C. The glass is melted under extreme reducing conditions. About 16 to 18 hours are required for charging and melting and six to eight hours for drawing.

D. <u>Beads</u>

Beads manufacturing units employ open type coal fired pot furnaces which are comparatively smaller than those in bangles and glassware units. Raw materials - usually cullets are melted in a pot furnace containing six to eight closed pots each having a capacity of 10 to 12 Kgs. of glass.

2.3.2.3 Forming

The molten glass drawn from either pot or tank furnace is formed into required shape of product by the following techniques :

- Blowing & moulding
- Drawing
- Pressing
- Spiralling

a) Blowing & Moulding

Mouth blowing in conjunction with moulding is adopted for producing items such as bulb shell, lamp shades, chimneys, beakers, tumblers, thermo-refills etc. A small quantity of glass is collected at the end of an iron pipe and mouth blown into a small bubble. Depending upon the product to be made, it is blown to fill up the cast iron mould. Keeping the bubble in the mould, the pipe carrying it is revolved between the palms of hand and blown from time to time. In this way the required shape of the product is attained. These operations depend upon the skill of the worker for obtaining uniformity of shape and wall thickness of the product. For beads manufacture, forming process involves drawing the desired quantity of melted glass by mean of tubes and elongating with tongs and mouth blowing the same in the brass moulds.

b) Drawing

Tubes & rods are made by drawing operation. A large lump of glass is collected at the end of the blow pipe and is taken to a punty. The blower continues to blow and a tube is drawn of the required size and thickness, when the glass stiffens due to cooling, the tube is laid down and the punty and the blow pipe is detached by water. The tube is then cut into suitable length. Forming of glass rod is also done in a similar manner, without blowing.

For manufacture of block glass, the molten glass is drawn by means of laddles. After solidification, the glass is broken into blocks.

c) Pressing

Product such as autohead light covers, electric light covers, railway signal light covers, ash tray, candle stand, paper weight etc. are manufactured on either hand presses or semi-automatic presses. Tumblers are also manufactured on semi-automatic presses.

d) Spiralling

This operation is carried out for bangles only. A large parison of molten glass is gathered at the end of an iron rod and worked into a conical shape. A glass thread is pulled out and spiral is wound on an iron mandrel called 'belan' which is rotated in a small furnace called 'Belan Bhatti'. When multi- colour bangles are to be made, colour designs are imparted by means of block glass. For this, parisons of different colours are joined together and re-heated in an auxiliary furnace called 'Sikai Bhatti' where the colour gets fixed and the glass cone is softened. The softened glass cone is transferred to 'Belan Bhatti' where spirals are drawn manually. The spirals are then given a longitudinal cut and the bangle loops are bundled together by means of a string. Further operations such as joining of the ends of the individual bangle loops, application of cut-work designs are done in cottage industries.

2.3.2.4 Annealing

The purpose of annealing the formed glassware products is to relieve the internal stresses developed in the glass as a result of cooling and solidification during the forming operations.

For annealing the soda lime glass and glassware products, the schedule requires raising the temperature to about 550° C followed by slow cooling to about 450° C and then to 250° C. Thereafter the temperature is brought down to ambient.

Annealing is carried out in annealing chambers or lehrs. A lehr operates coninuously and there are three ways in which it differs from a chamber.

- Conveyance : Usually the glass products move on a belt drive
- Temperature : Maximum temperature is 550° C
- Entrance Temp. : A lehr is hot at the entrance and gradually cools through its length

2.3.2.5 Finishing

Finishing operations include grinding of edges, cutting, melting (fire-polishing), sand blasting etc. This operation differs from product to product.

2.3.2.6 Sorting

The glass articles are sorted manually and defective and broken articles are rejected for recycling to the process.

During the process, the articles are also visually examined for any defects such as bubbles, straie, cracks etc.

2.3.2.7 Testing

None of the units have testing facilities either for the raw materials or in-process or finished products. However, the testing facilities are available recently at CIGI for raw materials and finished products. The existing units are mostly not taking advantage of the testing facilities available at CIGI.

2.3.2.8 Packing

The finished products are finally packed suitably in cardboard boxes and dispatched.

2.3.3 Process of Manufacture (Decoration)

Clear glass products are brought from the manufacturing unit and decoration work is done by manual operations such as :

a) Colouring
Colouring is done after cleaning the clear glass, by spraying ceramic colour solution.

b) Milking
This is also done by spraying milk white ceramic solution.

c) Luster Lining
This is done by applying luster solution by means of a brush.

d) Application of Transfers
Transfer patterns, procured locally in the form of stickers are applied manually to the surface of the glassware.

e) Frosting
Frosting is carried out to give a dull appearance to the glass surface. This is done by a chemical process, by dipping the glassware in a solution of hydrfluoric acid or by mechanical

operation of sand- blasting.

f) Annealing

After carrying out the above decorating operations except the frosting, the glassware products are annealed so as to fix the colours/transfers etc. and make the decoration permanent.

Annealing of the ware is done at a temperature of 550° C.

Decoration of glass items is restricted to mostly lamp-shades and sometimes to tumblers depending upon the order received by these units.

g) Cutting and Polishing

Cutting and polishing is done mostly on glass tumblers by means of abrasive wheels and buffing wheels. For this purpose, a suitable profile is first cut on the periphery of the abrasive wheel by means of hand-held dressing tool. Cut-work design on the glass tumblers is then made by the individual skilled worker, who holds the tumbler against the dressed abrasive wheel face and simultaneously rotates the tumbler according to the cuts to be given. The process is labour-intensive and time consuming. The depth of the cut and shape depends upon the individual skill of the worker. Polishing of the cut-work design is carried out on the buffing wheel to give the articles the required reflecting edge and brilliance.

2.3.4 Finishing & Decoration of Bangles

In the bangle finishing & decoration process, the bangle ends are levelled and joined over kerosene or acetylene flame. This process is known as 'Jhalai or Jurai' in the Firozabad industry. Finally, the bangles are sent for designing. The plain bangles are grooved on mechanised wheel and filled with golden, silver or other colours. These are sent for heating on asbestos sheets in ovens to make the bangles ready for packaging.

2.3.5 Process flow sheets for glass and glassware products, bangles, block glass, beads etc. are appended as Sketch No. 2.01 to 2.09.

2.4 Production Plant & Equipment

The major plant and equipment being used by the Firozabad Glass Industry are described in the ensuing paragraphs :

2.4.1 Melting and Subsidiary Furnaces

The furnaces being used in the glass units are the glass melting furnaces and the subsidiary furnaces required for heating of glass/spiralling and pot pre- heating operations.

The melting furnaces being used in Firozabad area are of the following two types and the drawing capacity of most of these furnaces are 3-4 tonnes/day and 20-22 tonnes per day respectively :

* Pot Furnace
* Tank furnace

2.4.1.1 Pot Furnace

All the pot furnaces used in the Firozabad are coal fired operating on natural draft. There are two types of pot used for melting the glass :

* Open Pot
* Closed Pot (Japanese type)

Open Pot Furnaces are direct type furnaces, in which coal is fired in the centre of the furnace and the flue gases are reflected back from the roof and pass in and around each pot and are finally exhausted through an underground common duct to chimney. The floor on which pots are placed has openings through which flue gas passes into the circular flue channel below the floor and then to chimney. In this design multi-pots are arranged inside a circular furnace structure and openings are provided to draw the molten glass out. The furnace is made of 230 mm thick wall of refractory bricks and the temperature of the furnace is between 1200-1250°C.

In units, which make bangles, glass is melted in open type pot furnaces accommodating 7 to 12 pots,each having a capacity of 450 Kg. of glass.

Block glass and vitrite glass are melted also in open type pot furnaces accommodating 6-8 pots, each having a capacity of 350 Kg.. The glass for beads is also melted in pot furnace accommodating 4-6 pots, each having a capacity of 10 to 12 Kgs.

Closed Pot Furnaces are indirect type in which the flue gases do not come in contact with the glass and hence the product quality is better but the fuel efficiency and production rates suffer. The pots are special type called Japanese type and are cylindrical in shape with a rounded top and a narrow opening tilted towards one side. In this design, multi-pots are placed on the periphery of a circular furnace structure. Underneath the pots, coal is fired and hot gases are made to circulate around the pots. Underground ductings are provided through which the flue gases escape to the chimney. There is another channel below the flue gas channel, separated from the upper flue gas channel, to collect any molten glass spillages from the broken pots. The furnaces are generally made up of refractory bricks , 230 mm thick and the temperature obtained is between 1250-1350°C. The schematic of the pot furnaces is given in the Sketch No. 2.10.

Pots

In Firozabad both open pots and closed pots are being made by hand moulding methods. There are around a dozen green pot making units which are supplying pots to the glass units having pot furnaces. Three capacities of pots i.e. 250 Kg., 350 Kg. and 450 Kg. are normally used for manufacture of bangles and glasswares.

Some glass units have captive open type pots making facility also. The pot clay mix is made by dry mixing of broken fire clay (ground to granular size) and clay (Ash-1). This dry clay mix is soaked in water in a brick masonary tank to form a stiff paste for some days. This clay paste is then transferred to another pit, where it is tampered by bare feet several times. The clay is allowed to mature till it becomes paste and easy for moulding of pots. The pots are then hand moulded and the pot maker uses a few simple hand tools, wooden hammers and gouges to produce pots. These pots are then dried in the air under natural conditions.

The average life of these pots is around 20 days as there is no control of iron content in the clay and grog size.

Refractories

As the entrepreneurs of Firozabad are unaware of the quality of refractories, the pot furnaces are built of low grade sillimanite for the construction of the structure and low purity silica for the construction of the crown. As a result, the surface temperature of the furnace is very high resulting not only in high radiation losses but also unbearable working condition for operators. The silica brick quality presently used is not permitting to use any insulation in the crown of the furnace.

2.4.1.2 Tank Furnace

Most of the Firozabad industry uses symmetrical design of tank

furnaces for making variety of glasswares and these are either :
- Regenerative type or
- Recuperative type

Regenerative Type
Most of the tank furnaces are regenerative type furnaces with holding and drawing capacities of 70 tonnes and 20 tonnes per day respectively.

A tank furnace is divided into two parts viz. the melting area and the refining area,separated by a bridge wall. Molten glass flows from one chamber to the other through an inter-connecting channel known as the throat. Any melted batch or scum flowing on the melt surface is held back in the melting chamber by the bridge wall. The area of refining chamber is 25 to 40% of the melting chamber. Approximately 1.2 to 1.5 Sq.m of melting area is required to produce one tonne of colourless container glass per day.

The following 2 types of regenerative furnaces most widely used are :

* Side Port Regenerative Furnace
* End Port Regenerative Furnace

Side Port Regenerative Furnace
In the side port furnaces the two regenerative chambers are located one on either side of the melting chamber and contain a series of ports on either side, to convey hot gases and air inside the melting chamber, as shown in Sketch No. 2.11. The batch is fed into the furnace from the rear side.

These are coal fired type in which coal is gasified in gasification hearths almost similar to stationery gas producer except that there is no steam injection to reclaim sensible heat going out with ash and clinkers. Such gasification pits are top feed type. For a 20 tonne per day draw of glass, normally 4 to 5 static producers are used. Feeding of the coal is done normally in basket full of coal, each basket containing 9 to 10 Kg. of coal. Rate of feeding is governed by the quality of coal and batch feeding i.e. glass draw of the furnace. There is no check on the unburnt carbon, which passes out with the ash. Analysis of coal gas is not done in any of the unit. Theoretically about 3 m^3 of gas should be generated by 1 kg. coal of selected 'B' grade, so that calorific value should be 1500 K Cal/m^3. The flow of coal gas and air can be seen in the Sketch No. 2.12.

Coal gas generated is collected in a common underground duct, which goes to reversal valve, which is multi- chamber metallic drum in which there is water seal for separating the coal gas from the exhaust gases of the furnace going to chimney. The coal gas can be diverted through the chamber either to left side regenerator or to the right side regenerator. Coal gas enters the base of regenerators through tunnel and goes to the top of the regenerator into the burner port, where the combustion air from the other regenerator mixes with the coal gas to start its combustion. Flames from the port sweep across the width of the furnace. The flue gases enter the other regenerator, heating the checker work as these pass to the reversal valve on way to chimney. After half an hour the system is reversed by turning the coal gas and air valves. There are no temperature indicators in the regenerators to monitor the pre-heated air/gas temperature.

<u>End Port Regenerative Tank Furnace</u>

The regenerative tank furnaces, oil fired, are of End port design. The essential difference from the side port furnace, described above, is that in this case, there are two ports on the rear walls of the melting chamber instead of 4 to 5 ports in the side wall. There are two burners on the rear wall of the melting chamber and the regenerators are situated behind the ports. The flame travels along a horse shoe like path from rear to the front. Every 30 minutes the path of the flame is reversed i.e. combustion air comes up through a checker or packing of the refractory bricks which has been heated up by the hot gases during previous 30 minutes. A typical sketch is shown in the Sketch No.2.13. The other features are similar to the above, and the furnace is equipped with oil firing system.

<u>Single Pass/Multi-Pass Regenerative Furnace</u>

In single pass, the heat recovery is less as the furnace is constructed with single pass flow i.e. the flue gas escapes to the stack by passing through the regenerator once. In Firozabad almost all the units are single pass type and the temperature of pre-heated combustion air is comparatively low. In multi-pass regenerator, substantial amount of heat is recovered from the gas by passing them two or more times in the regenerator. Multi-pass regnerators have been installed in very few units. This reduces the stack temperature and increases the pre-heated combustion air temperature.

<u>Refractories</u>

Almost all the furnaces in Firozabad are constructed with low grade siliminite, silica, electrocast and fire bricks which are available locally.

Inferior quality permits heavy losses through the radiation depending upon the type of furnace. The heat loss through the walls and crown is as high as 20-40% of the total energy input. The heat loss through the walls and crown would be considerably lower in case of properly insulated furnaces compared to the existing ones.

Refractories used in tank furnaces can be broadly categorised as :
- Refractories in contact with molten glass
- Refractories for upper structure
- Refractories for Regenerators

In most of the furnaces Siliminite blocks of 300 mm thickness are used where molten glass is in contact with refractories. Glass Tank Quality Fire clay based refractories (GT blocks) of 300 mm thickness are used in the walls above the melting zone. The roof of the furnace is generally made of 88% silica bricks of 230 mm thickness, while other parts like regenerators are made of fire clay based refractories as per Indian Standards (IS:8 or IS:6) fire bricks. The silica bricks quality presently used may not permit any insulation.

Combustion System

In almost all the furnaces, there is no scientific means of adjusting the firing rate. Inadequate air will lead to partial combustion resulting in valuable unburnt carbon particles leaving the stack or remaining in the bottom refuse.They are following an age old system of adjustment of fuel feeding by visual experience.

The heart of any oil fired furnace is the burner which controls the air fuel ratio. The Firozabad Glass Industry is not conscious of the latest developments in the burner and are using locally fabricated burners. Mostly low air pressure atomising burners (LAP) were commonly in use in glass industry. In LAP, a very large proportion of the air, about 10% of the total requirement, is utilised at low pressures (1.1 to 1.2 Kg./cm^2) resulting in higher than minimum excess air requirement. This excess air leads to cooling effect of the flame and therefore lower combustion efficiency. Moreover, there is improper sealing at the burners leading to ingress of cold air into the furnaces.

Instrumentation

Most of the furnaces are working without any aid of instrumentation for monitoring and control of combustion conditions and they are following an age old system of adjustment by visual experience. Some of the glass units have started installing temperature indicators at the crown of the furnace. These are analog types with no feed back and control.

Recuperative Tank Furnace
Recuperators are similar to heat exchanger with heat transmission from hot flue gases to air. In Firozabad, recuperators have not gained much acceptance. Only in some of the smaller capacity tank furnaces refractory recuperators are being acknowledged.
The furnace comprises of melting chamber with batch charging hole, drawing chamber with ports for drawing molten glass and Recuperative chamber on the adjacent side of the melting chamber for pre-heating the secondary air by hot flue gases from the tank furnace. The recuperator chamber comprises of a refractory structure in which there are vertical ceramic fire bricks of square cross-section. The secondary air enters from the bottom of the tube and rises up inside the tubes. It gets heated up in its upward passage and this heated air is conveyed to the oil burner. The space outside the tubes is divided into three compartments by means of horizontal baffles, such that the hot flue gases entering horizontally into the top compartment flows across the tubes successively in the three compartments before being conveyed to the chimney.

Only one oil burner is provided in the tank furnace and the burner flame is directed longitudinally from the batch feeding end of the furnace.

Campaign Life
The campaign life of glass melting furnace is the term used to indicate the number of years of its useful life. The type, quality and specifications of refractory bricks used for the construction of furnaces has a direct bearing on campaign life.
The average campaign life of the furnace in Firozabad sector is around 10-12 months whereas units abroad are achieving campaign life to the extent of 5-6 years and above. The reasons for deviation in campaign life of the Firozabad furnaces are attributable to the quality of refractories used in the furnaces.

2.4.1.3 Subsidiary Furnaces

No care is taken in the construction of subsidiary furnaces such as Sikai Bhatti, Belan Bhatti and pot pre-heating ovens. The condition of these furnaces could said to be very bad in almost all the units. The flame was just leaping out through the furnace structure in the working areas and these are not provided with any chimneys. The fumes create dis- comfort to the operators and lot of energy is lost in heating the ambient unnecessarily.

Reheating Furnace (Sikai Bhatti)
The Sikai Bhatti is circular in shape with dome structure. It has several openings in the circular wall for reheating glass. It is constructed of single brick wall of 230 mm thick. No care is taken in the selection of furnace bricks and in most of the units, just ordinary construction bricks are used. These are fired with coal and the temperature is around 1000°C.

Bangle Making Furnace (Belan Bhatti)
This is also an open fire furnace, known as bangle making furnace used for converting the glass slab into bangles. In this type, coal is burnt in a heap in the middle of the furnace. The belan bhattis have suitable openings in each of the four walls. The temperture is around 700°C.

Pot Pre-heating Ovens
The pot pre-heating ovens being used are usually having a capacity to accommodate 1-2 pots and fired with coal. The approximate dimensions are 2.4 m x 1.8 m and the temperature is around 650°C of the pot arch furnaces without a chimney. The furnace is made of very low grade refractory bricks and the heat distribution is not uniform.

2.4.2 Annealing Furnaces

The annealing of glass products is carried out in a chamber/lehr with coal or oil/electricity heated furnaces. Almost all the units have annealing furnaces except the units manufacturing exclusively bangles.

2.4.2.1 Chamber Type Annealing Furnaces

These are locally fabricated coal fired furnaces having chamber to accommodate around 1 to 1.5 tonnes of glasswares. In most of the units chimneys have not been provided and smoke can be seen emanating from those ovens into the surrounding working areas from the openings provided near the top arch. Temperature indicators have not been provided and the annealing operation is carried out based on the experience of the workers. These are of very crude design and no insulation has been provided.

2.4.2.2 Annealing Lehrs

Annealing lehr consists essentially of a long tunnel fitted with endless conveyor belt. These are mostly oil fired type. In some of the units, the lehrs have also provision for electrical heating. These are also locally fabricated and the typical dimensions are 1.5 m width, 300-450 mm height and 20-30 m length. Belt speed of the lehrs are in the range of 270 mm/min. to 700 mm/min. The capacity ranges between 300 to 1000 pieces of average productsize per hour.The temperature maintained in the hot zone is between 450-550°C.

2.4.3 Forming Equipment

Major tools and equipment being used in the forming operations are as under :

- Manually operated presses
- Semi-automatic presses
- Mouth blowing hand tools

2.4.3.1 Hand Presses

Pressing is done by placing the mould with gob of soft glass in it under fixed position below plunger. Plunger is pressed down into mould with the help of hand operated lever. After pressing, the lever is released to lift the plunger. Formed article is manually retrieved by inverting the mould and tapping. Plungers, moulds and dies of the press are of cast-iron hard chrome plated. Pre-heating of the mould before start of the shift is necessary otherwise the articles crack and develop hazy appearance. Mould heating at Firozabad is done with hot glass and depending upon the size of the articles to be pressed, as much as 5 to 10 Kg. of molten glass is used for this purpose. If the article is of heavy weight, plunger is cooled by circulating water in its interior, otherwise external cooling of both the mould and plunger is done with compressed air.

2.4.3.2 Semi-Automatic Presses

Semi-automatic pressing system is used for production of pressed tumblers etc. This is similar to hand press except that the table in which the moulds are mounted rotates at fixed intervals. Moulds and plungers are air cooled externally, whereas plunger is also internally cooled by water circulation. Oil is sprinkled into mould cavities to facilitate release of the articles and also to provide graphite based lubricant in the moulds.

Moulds are made with fine grained cast iron or chill castings but the surface of the cavity should be well polished and machined.

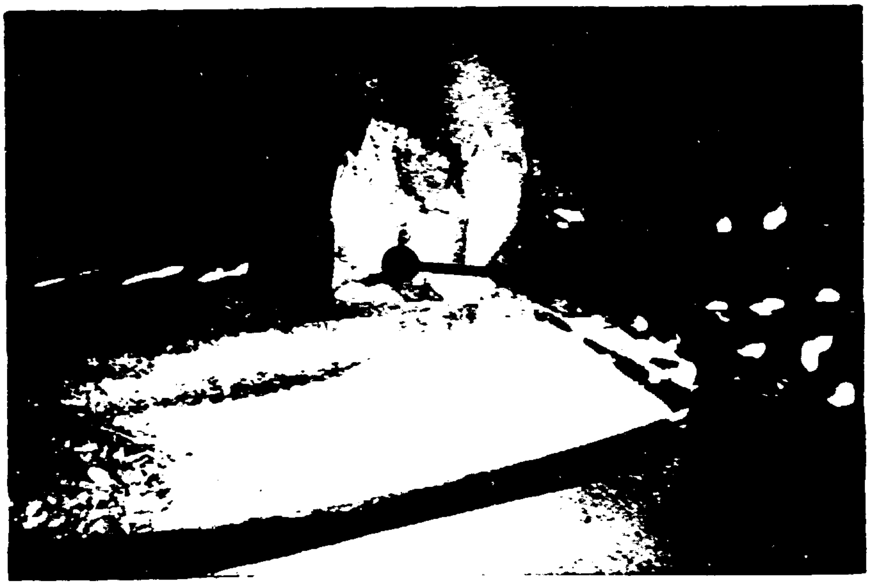
2.4.3.3 <u>Mouth Blowing Hand Tools & Moulds</u>

Mouth blowing hand tools such as iron pipes, rods, fixtures and moulds are used. Mould is a cast iron body where external contours match the contours of the article to be produced with it. Mould is made up of two halves, which are hinged at one end. Mould is operated manually and blown article is taken out by opening the mould.

2.4.3.4 Photographs showing the various operations and type of equipment in use at Firozabad are shown in the following pages.

2.4.3.5 Lists of the reputed manufacturers / suppliers of machinery & equipment and moulds and spares for glass manufacture are given as Appendices 2.2 and 2.3 respectively.

Also, a list of the manufacturers/suppliers of refractories for glass manufacturing units is given as Appendix 2.4.

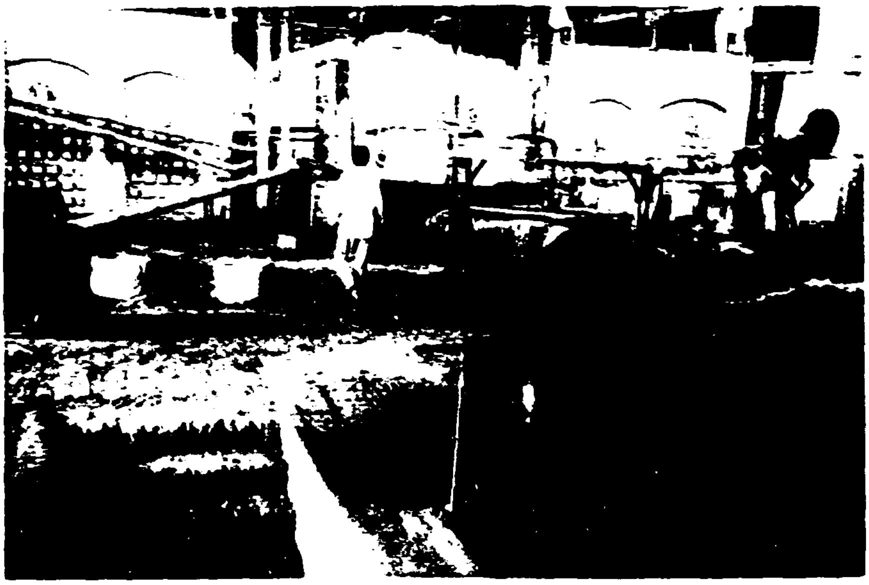


MANUAL BATCH PREPARATION

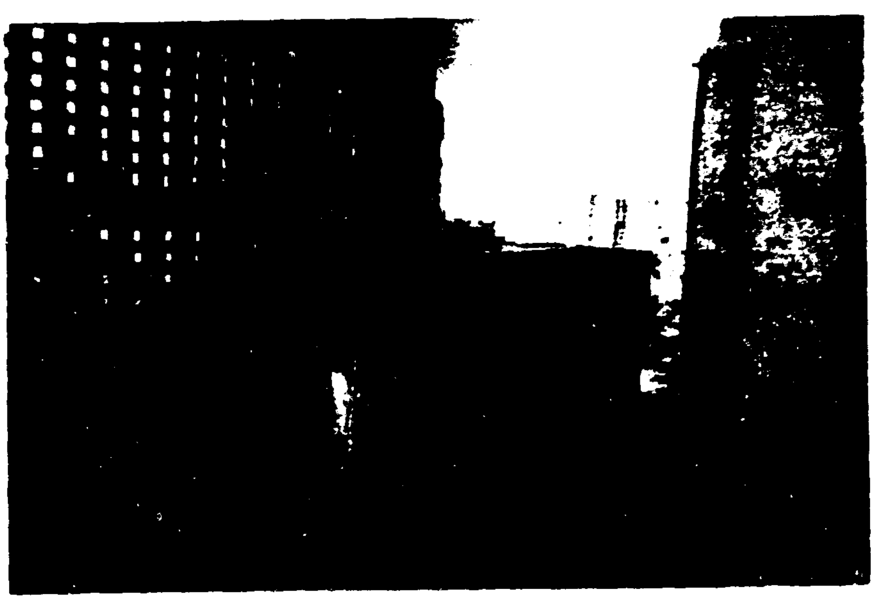
BATCH PREPARATION USING MIXER

POT FURNACE - OPEN TYPE

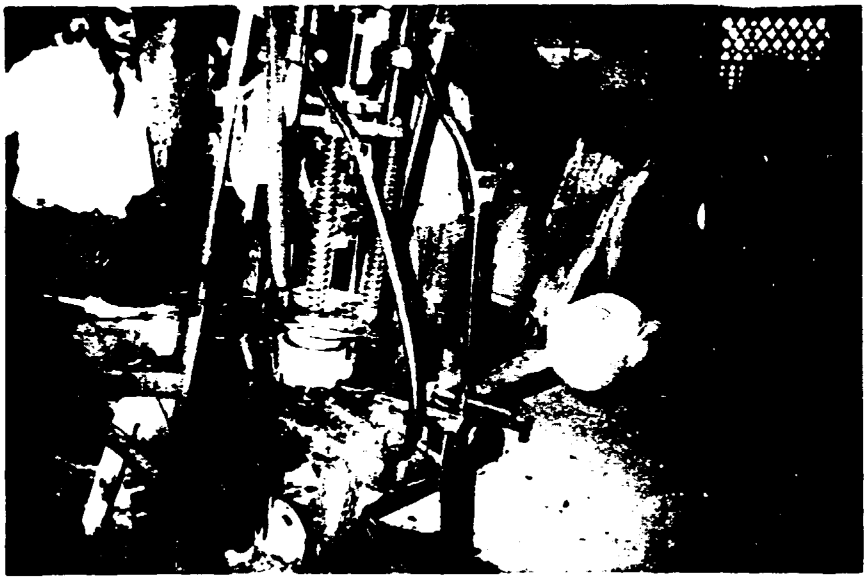
POT FURNACE - CLOSED TYPE



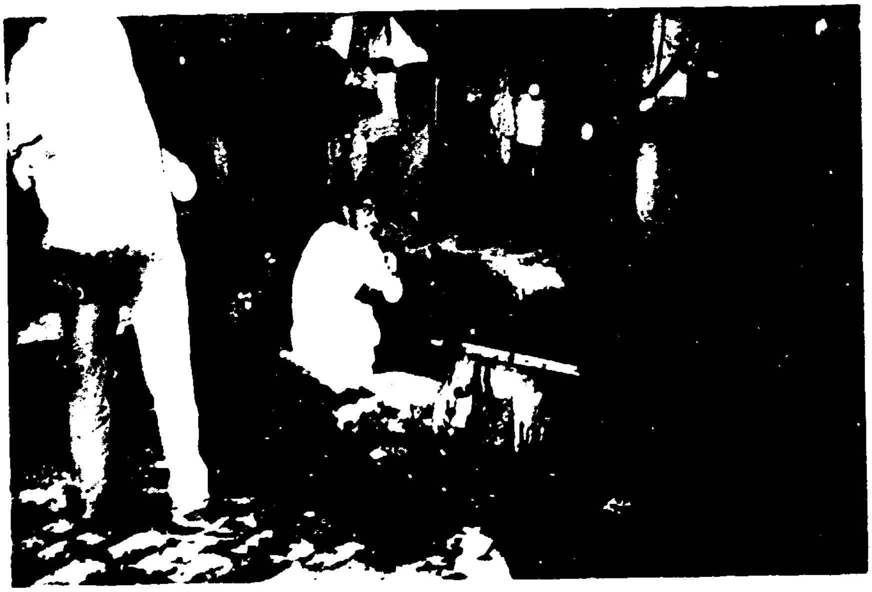
COAL FIRED REGENERATIVE TANK FURNACE - SIDE PORT



COAL FIRED POT PREHEATING FURNACE

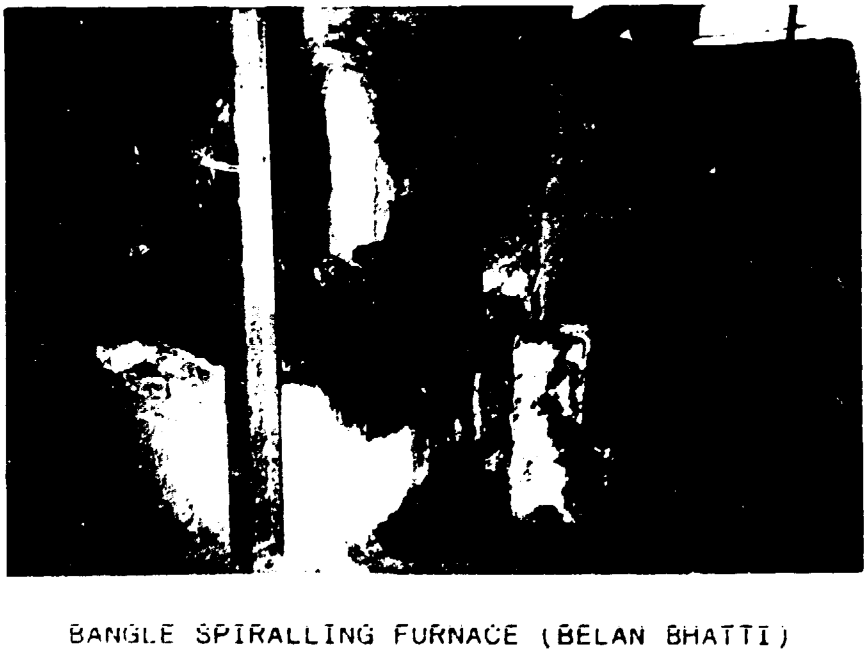


FORMING ON HAND LEVER PRESS



FORMING BY MOUTH BLOWING

REHEATING FURNACE (SIKAI BHATTI)



BANGLE SPIRALLING FURNACE (BELAN BHATTI)

ANNEALING LEHR

COAL FIRED ANNEALING CHAMBERS

2.5 Manpower

2.5.1 At present, there are about 350 registered glass manu- facturing units in Firozabad and around 1,50,000 personnel are engaged in these enterprises. Apart from these small scale units, there are about 50,000 to 75,000 workers engaged in the cottage industries who are employed mostly in bangle industry and other decoration work for the glass and glassware industry.

2.5.2 The Firozabad industry is mostly managed by the owners themselves as there are hardly any professional managers. In case of any break-down in the production line, the unit is shut down for quite sometime. The situation is heightened by the fact that there are very few qualified technologists in the small town. The glass industry is globally known to be highly technology-intensive. However, no efforts have been made by the factory owners to update their technological data base and they depend mostly on their long experience in the industry.

2.5.3 The Firozabad glass industry mostly relies on casual labour. Skilled labour - even marginally skilled is relatively scarce in Firozabad. The workers are generally exploiting the employers. The workers themselves do not want to be on muster roll, as that would mean sacrificing their bargaining strength.

2.5.4 The need of the industrialists for workers is apparently so desperate that the latter often demands advances as a pre-condition for joining the duty. There is no guarantee that the worker would continue until the advance is adjusted. This results in huge losses to the factory owners.

2.5.5 Indirect workers constitute about 15 to 20 per cent of the total work force. These are mostly casual workers and are engaged in workshop, maintenance work, sorting, packing and miscellaneous jobs.

2.5.6 In the units engaged in finishing and decoration of glass products,which employ mainly women,the atmosphere is highly polluted with dust and kerosene vapour caused by grinding and sealing operations. Against this background, it is estimated that the average life span of a worker in Firozabad is about 40 years.

2.6 Raw Materials

2.6.1 In Firozabad, mostly soda lime silica glass is manufactured. The raw materials used for manufacture for soda lime silica glass are :

- Quartz
- Soda Ash
- Limestone & Dolomite
- Calcite
- Potassium & Sodium Nitrate, Arsenic & Antimony Oxide
- Borax
- Colourant & special additives
- Decolourisers

2.6.1.1 Quartz/Silica Sand

The glass former is silica or silicon dioxide. The ideal raw material is very pure (99%). Silica sand plays a significant role in melting, finishing and colouring of the glass. Quartz or silica sand is the largest constituent of batch and has a high melting point of 1710°C. The chemical composition of glass making sand (Grade-I) as per IS:488-1980 is given below :

	Percentage
i) Silica (SiO_2)	: 98.5
ii) Iron Oxide (Fe_2O_3)	: 0.04
iii) Titanium Dioxide (TiO_2)	: 0.10
iv) Aluminium Oxide (Al_2O_3)	: 1.50
v) Loss on Ignition	: 0.50

The compositions vary from source to source and the units generally procure from Rajasthan or U.P. Because of the price difference between quartz and silica sand, the units in Firozabad mostly use silica sand.

2.6.1.2 Soda Ash

Both light and medium dense to dense soda ash from various manufacturers in Gujarat is used as flux to manufacture glass. As the material is industrial grade, the chemical composition and bulk density of various grade source-wise is nearly constant. Being the second largest constituent of batch and highly corrosive item which affects the furnace life, particle size of soda ash is important. However, this consideration is not taken seriously by the units in Firozabad. Cost of soda ash which is significant for different grades and availability with local dealers in the industrial town vary the economies of the individual units.

2.6.1.3 Limestone & Dolomite

Limestone is a stabilizer and is added to make the glass insoluble in water which results in soda lime glass. Limestone is received in the powder form from U.P. and Rajasthan. Iron content in the mineral is in the oxide form as well as in metal form acquired from handling tools & pulverising machinery. Particle size of powder is finer than 60-80 mesh BS which restricts magnetic separation of metallic iron.

Dolomite is also used as flux in the batch by very few units. Requirement of limestone and dolomite for glass industry as per IS:997-1975 is given below :

		Per cent (on Dry Basis)
i) Silica (SiO_2)	:	2.50
ii) Iron (Fe_2O_3) in		
- Calcite	:	0.05
- Limestone	:	0.10
- Dolomitic limestone & dolomite	:	0.15
iii) Lime (CaO)	:	53.00
iv) Total lime (CaO & MgO)	:	54.5

2.6.1.4 Calcite

Calcite is also used by some glass units as stablizer for producing better quality stuff particularly in colour. Particle size plays a significant role in rate of melting and quality of refining in glass.

2.6.1.5 Potassium & Sodium Nitrate, Arsenic Trioxide & Antimony Oxide

Refining agents are used in the batch for removal of air inclusions called bubbles and seeds from the molten glass. Use of refining agents is compulsory in the glass batch. Mostly Arsenic Trioxide along with nitrates of soda & potash make the standard refining mix. However, in certain cases Antimony Oxide can also be used with nitrates. These work on the principle of chemical changes, As_2O_3 & Sb_2O_3 taking the oxygen released from Nitrates at lower temperature in the furnaces forming pentoxide and releasing extra oxygen at high temperature to revert to trioxide stage.

Chemical composition of Sodium & potassium nitrate as per IS:9157-1979 is given below :

		Sodium Nitrate (%)	Potassium Nitrate (%)
i)	Moisture & volatile matter	1.00	1 00
ii)	Matter insoluble in water, percentage by mass	0.25	0.25
iii)	Chlorides (Cl)	0.50	0.50
iv)	Sulphates (SO_4)	0.20	0.20
v)	Iron (Fe)	0.05	0.05
vi)	Potassium Compound (K)	1.00	-
vii)	Sodium Nitrate	98.00	-
viii)	Potassium Nitrate	-	98.00

2.6.1.6 Borax

B_2O_3 is introduced in the batch through borax or boric acid. However, prohibitive cost restricts the use of B_2O_3 in glass unless specified e.g. borosilicate, medicinal & special coloured glass.

2.6.1.7 Colourants & Special Additives

A number of inorganic chemicals and metals are introduced in glass for specific purposes such as producing colours, optical characteristics etc.

Use of red lead to introduce Pb_2O_3 in the glass is done to make low temperature softening glass with high dielectric value. Lead glass cullet available from electric lamp factories is widely used in Firozabad for introducing Pb_2O_3 in glass for above purpose. Due to very high corrosive nature of Pb_2O_3, its use is limited to pot furnace only.

Opal glass termed as Block or China Glass in Firozabad is made by introducing either singly or in combination phosphorous oxide, flourine etc.

2.6.1.8 Decolourisers

Presence of greenish blue to greenish straw colour in glass is obnoxious and renders the glass unpleasant. This colouring effect comes from oxide of iron present in glass. Upto some extent, the greenish colour from iron oxide can be camouflaged by introduction of complementary colours of the spectrum in the glass. This is done with red and blue colours, introduced through selenium and cobalt oxide. Almost all tableware quality glass producing units in Firozabad use this chemical. Composition of Selenium as per IS:9425-1980 is given below :

		Percentage (Gr.I)
i)	Selenium (Se)	99.00
ii)	Lead (Pb)	0.70
iii)	Ash content	0.80
iv)	Iron (Fe)	0.04
v)	Sulphur (S)	0.10

2.6.1.9 A list of Indian Standards on glass is given in Appendix 2.5.

2.6.2 The percentage weight of natural raw materials for the soda lime silica glass being adopted by the units in Firozabad is given as follows :

Headlights, Tumblers, Shells, etc. (%)		Bangles (%)	
SiO_2	70-73	SiO_2	75-76
CaO	4-8	Na_2O	20
Na_2O	16-20	CaO	4
Al_2O_3	1-2	Others	0.5
K_2O	1-2		
As_2O_3	1-1.5		

The above mentioned percentage weights vary from unit to unit with slight modification depending upon the products being manufactured.

2.6.3 Among the various raw materials being used for glass manufacture in Firozabad, only a few such as sand, dolomite, limestone are covered by Indian Standards. The materials being used are as per raw material manufacturers' own standards. None of the glass manu- facturers in Firozabad has any raw material testing facility, and therefore the quality of raw materials is not being checked by them.

2.6.4 Cullet is the synthetic material used to make glass. It is the waste glass, rejects and recycled glass products. Cullet speeds melting, since it has been previously melted. Present practice in majority of the units in Firozabad is to use own produce together with market cullet without any regard to size of the lumps or quantity being fed. Batch is shovelled over cullet heap and the mix is fed into furnace. Only in case of melting in pots, the cullet is in small sizes and mixed with batch. The ratio of cullet to the raw materials in the existing units is around 40:60. However, the range of cullet used is 40 to 50 per cent of the batch.

2.7 Fuels

Fuels used in Firozabad glass units are Coal, Furnace oil, Kerosene & LPG and to a very small extent Fire- wood. Details of the fuels used are discussed in the ensuing paragraphs.

2.7.1 Coal

Most of the factories use coal as main fuel in the furnace. The coal used by the units is supplied by Coal India Ltd. under the allocation made by DIC. Source of coal is from the deposits in Eastern Bihar, Jharia, Dhanbad & Karampura belt. Quality of coal as received in the units is very inconsistant to the extent that same consignment may contain upto 15% shales. Larger portion of the coal consumed in Firozabad is brought by road from Varanasi Depot, and only a part comes direct in Railway wagons. The total consumption of coal in Firozabad is of the order of 4,00,000 tonnes per annum. Steam coal of 'B' Grade is sanctioned for glass factor- ies but actual receipt of the material is different. The analysis of 'B' grade of coal is as follows :

	Percentage (%)
Carbon	48.92
Hydrogen	3.79
Sulphur	0.51
Nitrogen	1.00
Oxygen	5.36
Moisture	6.04
Ash	34.38

The quality of coal received in the units is poor as such the heat in the furnace is not attained. Coal is received in large lumps and the same is broken to about 75 mm or smaller size and the fines are left behind for sale latter on to miscellaneous buyers.

Feeding of coal in furnace is normally done in basketful of fuel, each containing about 9 to 10 Kg. Feeding is after 7 to 10 minutes so that total 450 to 600 Kg. coal is fed for gasification per hour. Rate of feeding is governed by the quality of coal and batch feeding rate of the furnace.

Fuel (coal) to glass ratio is from 0.75 to 1.4:1 depending upon pot or tank furnace. This is primarily due to improper furnace design. Unburnt carbon (soft coal cake) which passes out with the ash from the direct fired furnace is collected and sold to small buyers.

2.7.2 Furnace Oil

A few units in Firozabad are using Furnace oil. Residual Furnace Oil (RFO) available from nearby refinery at Mathura is also being used by a couple of units. The advantages of furnace oil over the coal are good heat recovery, less pollution, better housekeeping etc.

In using RFO, the storage tank and pipelines are heat traced with electricity. In the case of oil fired furnace, the power heat units have ring main piping. The advantages of RFO over the furnace oil are low cost and high calorific value.

Furnace oil in Firozabad is used by only a few manufacturers who have tank furnaces with regeneration or recuperative system of heat recovery. The quality of products using furnace oil and fuel is superior than those using coal.

Besides use of furnace oil in melting, it is also used in annealing-lehrs.

2.7.3 LPG

LPG is used as fuel in finishing operation of glassware and to small extent in decoration. It is also used in the vacuum flask manufacture for hole making mouth heating and tube joining operations.

2.7.4 Kerosene

Kerosene use as fuel is similar to LPG except the manufacture of vacuum flask. It is mostly used on Dyna machines employed for finishing operation.

2.7.5 Fire Wood

Fire wood and stalks of some agricultural crops are used in "bhattis" in bangle and beads manufacturing units.However, this use is restricted to few units only.

2.8 Finance

2.8.1In order to study the periodic review of a manufacturing unit, the financial statements i.e. Profit & Loss Account and Balance Sheets have to be studied. However, these financial statements prepared at the end of each year do not convey the operating results and financial health of a unit. Such financial statements at the most present various facts; managerial performance of a particular company. Also, no satisfactory diagnosis could be achieved on the information available from the statements.

2.8.2 Apart from the analysis of financial statements, an attempt has been made by the Consultants to study the existing per tonne cost of glass and glassware items for both pot and tank furnaces based on the data collected from the units. Following rationale has been adopted in working out the existing per tonne cost of glass and glassware products:

a) Raw materials batch based on the average composition being adopted in Firozabad.
b) Prices of raw materials based on latest FOR Cost in Firozabad and transportation cost.
c) Production capacity is based on the type of furnace normally being used in Firozabad , 4-5 tpd for pot furnace and 10/20 tpd for tank furnace.
d) Average salary for the workers has been assumed at Rs.40 per day as per the prevailing rate in the district.

e) The fixed investment for any unit is based on cost as given in balance sheet (written down value of plant & equipment and buildings)

f) The cost of the fuel i.e. coal has been based on the actual prevailing price as procured from Varanasi coal depot.

g) The product-mix of the existing units depends on the order received and vary from time to time. The product-mix assumed is based on the tentative capacity of the eight existing units under study.

h) Depreciation charges have been taken on the basis :

Civil works	:	3 per cent
Plant & Equipment	:	10 per cent

i) Maintenance costs have been taken on the basis :

Civil works	:	1 per cent
Plant & equipment	:	2-1/2 per cent

j) Interest charges on short term borrowings have been reckoned at 18 per cent per annum

2.8.3 Comparative cost of production for different type of furnaces for glass & glass products, based on the existing units in Firozabad have been worked out in Chapter III. This cost per tonne has been considered as the basis of calculation for working out the main area of diagnosis in furnace design, pollution control, energy conservation and its cost thereof.

2.9 ENERGY CONSUMPTION

2.9.1 The Glass Industry is highly energy intensive and the percentage of energy cost as related to manufacturing cost comes to about 30%. The primary forms of energy used in Firozabad glass industry are coal and oil. Roughly, melting accounts for 90-95% of the total energy input in most of the units while rest 5-10% is consumed by ancillary equipment like pre-heating of pots or annealing chambers. The energy balance of the furnaces indicate approximately 80% of the heat is dissipated in the following two areas :

* Radiation losses from the walls, crown, bottom and ports
* Stack losses from the melting furnace.

2.9.2 International Standards

As per the standing report of European countries on glass industry, the total energy consumption of a glass furnace ranges from 100 to 200 gms. of oil per kg. of glass as compared to 300-550 gm of oil equivalent per kg. in Firozabad glass industry. The main parameters affecting energy consumption in glass industry are listed below :

a) The Type of Wares Produced
A wide variety of specific goods are to be formed within each glass sector. Each type requires energy consumption specific to it, depending upon its composition.

b) The Capacity of the Furnaces
The specific energy consumption is related to the size of the furnace and is the highest with the lower size of the furnace. The highest production capacity in the Firozabad area is nearly 20 tonnes per day.

c) Use of Furnace Production Capacity
Every furnace is designed to yield its minimum specific consumption for its normal production. If, for economic reasons, production capacity is under utilised, the specific energy consumption goes up.

d) The Age of the Furnace
The working life of the furnace (time period between two repairs justifying the shut down of the furnace) extends over 10 months to 12 months. At the end of the working life, an increase in energy consumption is noted due to higher losses through walls resulting from wear and tear of the refractories.

2.10 POLLUTION

A study was carried out to assess the present status of pollution levels prevailing in the Firozabad town as well as within the premises of various glass units, as a result of the effluents being discharged by these units. The general status observed is discussed in the following paras.

2.10.1 Micro-Meteorology

During the Study period, it was observed that 79.3% of the total wind conditions were under calm category, indicating that the local population will be most affected, since the deposition of pollutants takes place in and around the plant areas only.

Wind conditions and wind direction were observed from East-South East (13.7%) and out of the rest NE (6.8%). Maximum and minimum tempertures were 30°C and 22°C during the Study period. Maximum and minimum humidity was found to be RH 75% and RH 36% during the Study period.

The wind rose diagram is shown in Sketch No. 2.14.

2.10.2 Firozabad Town Ambient Air Quality

Six ambient air quality stations were chosen taking into account different types of areas, covering the complete cross section of the city. The categorisation of the monitoring stations was done as follows :

Name of Station	Area Specifications
Police Chowki, Station Road	Industrial Area
Roof of Hospital	Sensitive Area
CIGI	Mixed Area
Suhag Nagar	Residential Colony
Ravi Nagar	Mixed Area
C.B. Guest House	Mixed Area

Sketch No. 2.15 shows the locations of the Town Ambient Air Quality Stations chosen.

Eight-hourly monitoring was conducted in 3 shifts for 24 hours sampling for the parameters :

SPM (Suspended Particulate Matter)
SO_2 (Suphur Dioxide)
NO_x (Nitrogen Oxides)
CO (Carbon Monoxide)
F (Fluoride)

The results of measurements of the above parameters are shown in the following table:

FIROZABAD TOWN AMBIENT AIR QUALITY

Monitoring Stations	Shift	Observed Values (ug m^{3})				
		SPM	SO_2	NO_x	CO	F
Police Chowki Station Road	A	971	7	15	565	
	B	678	4	7	328	
	C	719	10	19	492	
Hospital Roof	A	670	14	12	[illegible]52	
	B	769	8	7	212	
	C	732	7	9	346	
CIGI	A	630	8	17	892	
	B	640	7	8	655	
	C	325	8	13	590	
Suhag Nagar	A	604	7	13	424	
	B	320	2	9	400	
	C	480	4	11	435	
Ravi Nagar	A	713	12	11	285	
	B	417	4	4	270	
	C	310	7	5	340	
C.B. Guest House	A	767	7	7	925	
	B	424	3	4	628	
	C	524	7	7	792	

Shift A : 14.00 - 22.00 Hrs.
Shift B : 22.00 - 06.00 Hrs.
Shift C : 06.00 - 14.00 Hrs.

Sketch Nos. 2.16 to 2.19 show the Firozabad Town Ambient Air Quality with respect to the above data in the form of a bar chart.

<u>Police Chowki, Station Road</u>

SPM values are observed to range from 678-971 ug/m^3, with an arithmetic mean of 789 ug/m^3. These values are above the limit of 500 ug/m^3 prescribed by CPCB (Central Pollution Control Board).

Other parameters were found to be within the limits. Fluoride was not detected during the monitoring period.

Roof of Hospital
The hospital selected was district hospital, which can be considered to be a sensitive area. According to CPCB the prescribed norms are :

SPM	-	100 ug m^3
SO_2	-	30 ug m^3
NO_x	-	30 ug m^3
CO	-	1000 ug m^3

It is seen from the observed data, that the SPM values are higher than the prescribed norms. The observed SPM values lie above 650 ug/m^3, which is even higher than the limit prescribed for the industrial area. The arithmetic average of the observed SPM values is 724 ug/m^3. Since not much variation was observed for all the three readings round the clock, it can be presumed that the concentration can be of the same order, and as such it is a potent hazard. All other parameters were found to be within the limits.

Other Stations
All other four stations (CIGI, Suhag Nagar, Ravi Nagar, C.B. Guest House) come under mixed and residential categories, for which the ambient air quality standards, as per CPCB are :

SPM	-	200 ug m^3
SO_2	-	80 ug m^3
NO_x	-	80 ug m^3
CO	-	2000 ug m^3

The observed values obtained show higher level of SPM values compared to the above prescribed norms. Other parameters were found to be within the limits.

2.10.3 Stack Emission Quality

Based on the pollution data collected at the identified glass units, the prevailing range of the various stack emission parameters of the glass industries of Firozabad have been compared with the prescribed norms and are shown in the following table.

Parameter	Prevailing Range	Prescribed Norm
Stack height, m	25 - 43	30
Temperature, °C	90 - 500	-
Velocity, m/s	4 - 12	-
Quantity of emissions, Nm^3/hr	4000 to 20000*	-
SPM, mg/Nm^3	80 -1700	1200 / 150**
SO_2, mg/Nm^3	55 - 230	- / 50
NO_x, mg/Nm^3	25 - 110	-
CO, mg/Nm^3	60 - 280	-

* Will vary depending on stack diameter

** Norms of CPCB / Ministry of Environment & Forests

As seen from the above table, the prevailing SPM values and SO_2 values exceed the prescribed norms. The CO values are indicative of incomplete combustion in the furnaces.

2.10.4 Ambient Air Quality At Glass Units

Based on the measurements carried out at the identified glass units, the prevailing range of polluting parameters for the Firozabad glass industries can be considered to be as shown in the following table.

Parameter	Range in ug/m^3		
	Within Premises	Work Places	Prescribed Norm for Industrial Area
SPM	550 -2500	625 - 5500	500
SO_2	5 - 225	9 - 150	120
NO_x	5 - 55	10 - 75	120
CO	550 -3300	950 - 5500	5000
F	10 - 45	10 - 65	-

As seen from the above table, the observed SPM values are indicative of a dusty atmosphere, which is not conducive for the health of the workers. The conditions at the work places are worse than those within the factory premises.

The SO_2 and NO_x values are within the prescribed limits.

Regarding the CO, the mean value may fall within the limits, but the individual CO values of some of the units exceed the prescribed limits. The high CO values are mainly due to the unscientific design of the furnaces and the system of coal feeding.

Fluoride, which is found to be present in the ambient air, is a potent pollutant , and as per Occupational Safety & Health Association (OSHA) standards of USA, needs to be taken care of.

2.10.5 Water Pollution

Analysis of the waste water of some units indicated that water is only slightly polluted, and can be controlled by adequate measures. If the waste water is discharged into the public sewers, only proper drainage system is required.

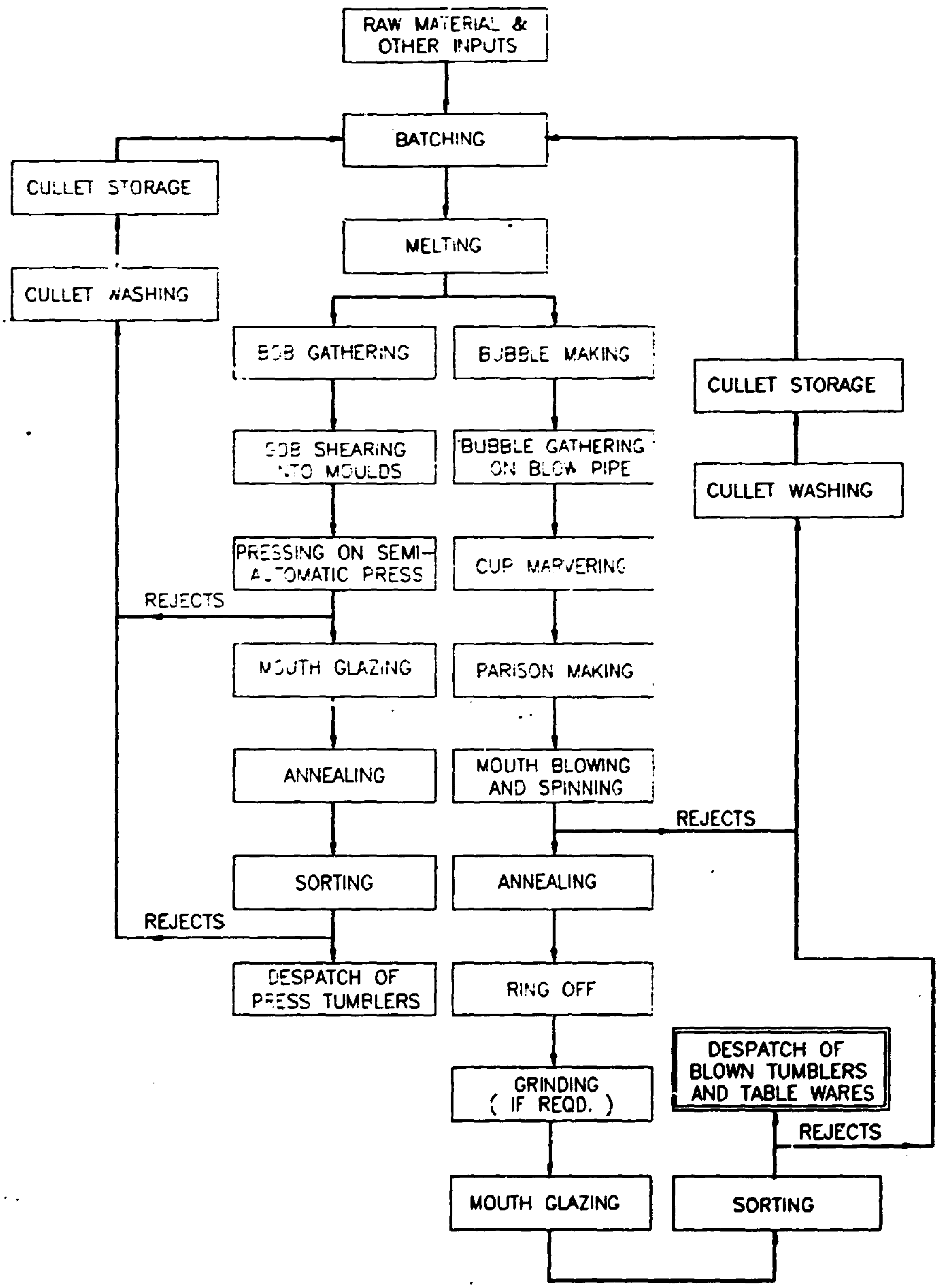
2.10.6 Solid Waste

Based on the analysis of coal ash samples from some of the units, it was found that in a few cases, high percentage of volatile matter was present, indicating incomplete combustion . Also high percentages of Aluminium and Silica were found to be present.

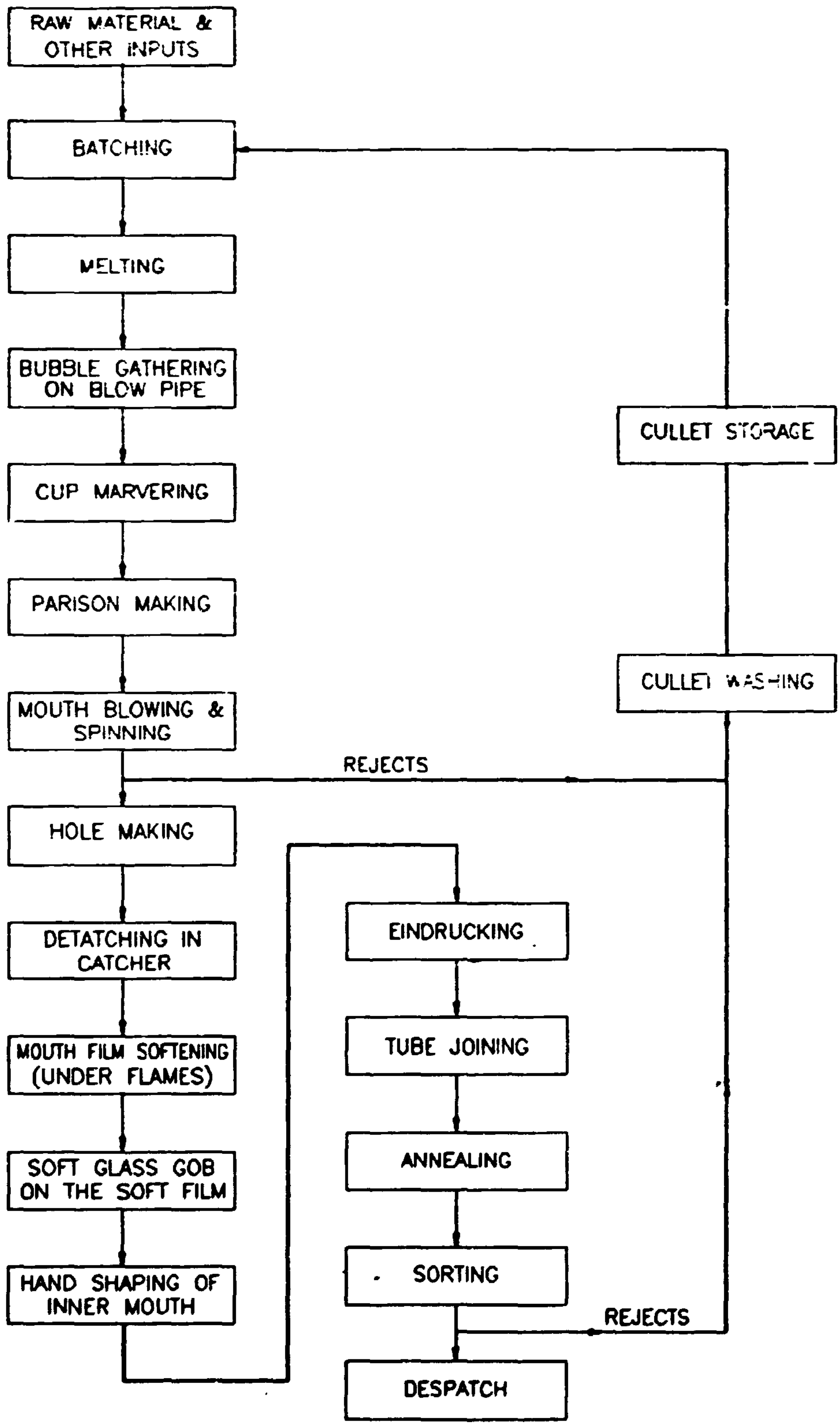
The usual practice of disposal of the solid waste in the glass units is to periodically dispose off the same through a contractor who regularly takes away the solid waste from different parties.

Most of the units of Firozabad do not have any specific areas marked in their layouts for dumping of solid waste, which is a poor house-keeping practice.

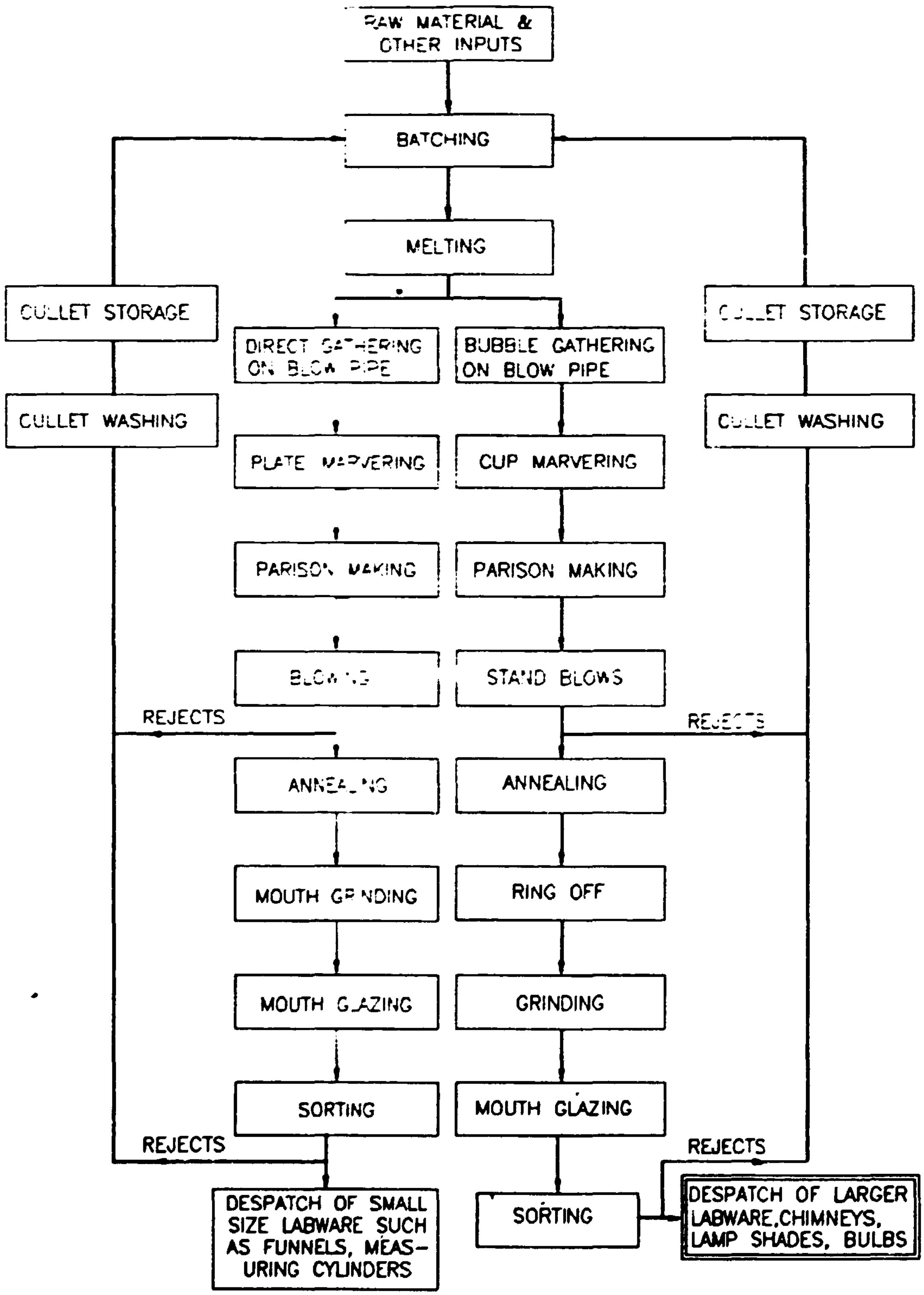
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF TUMBLERS, TABLE WARES



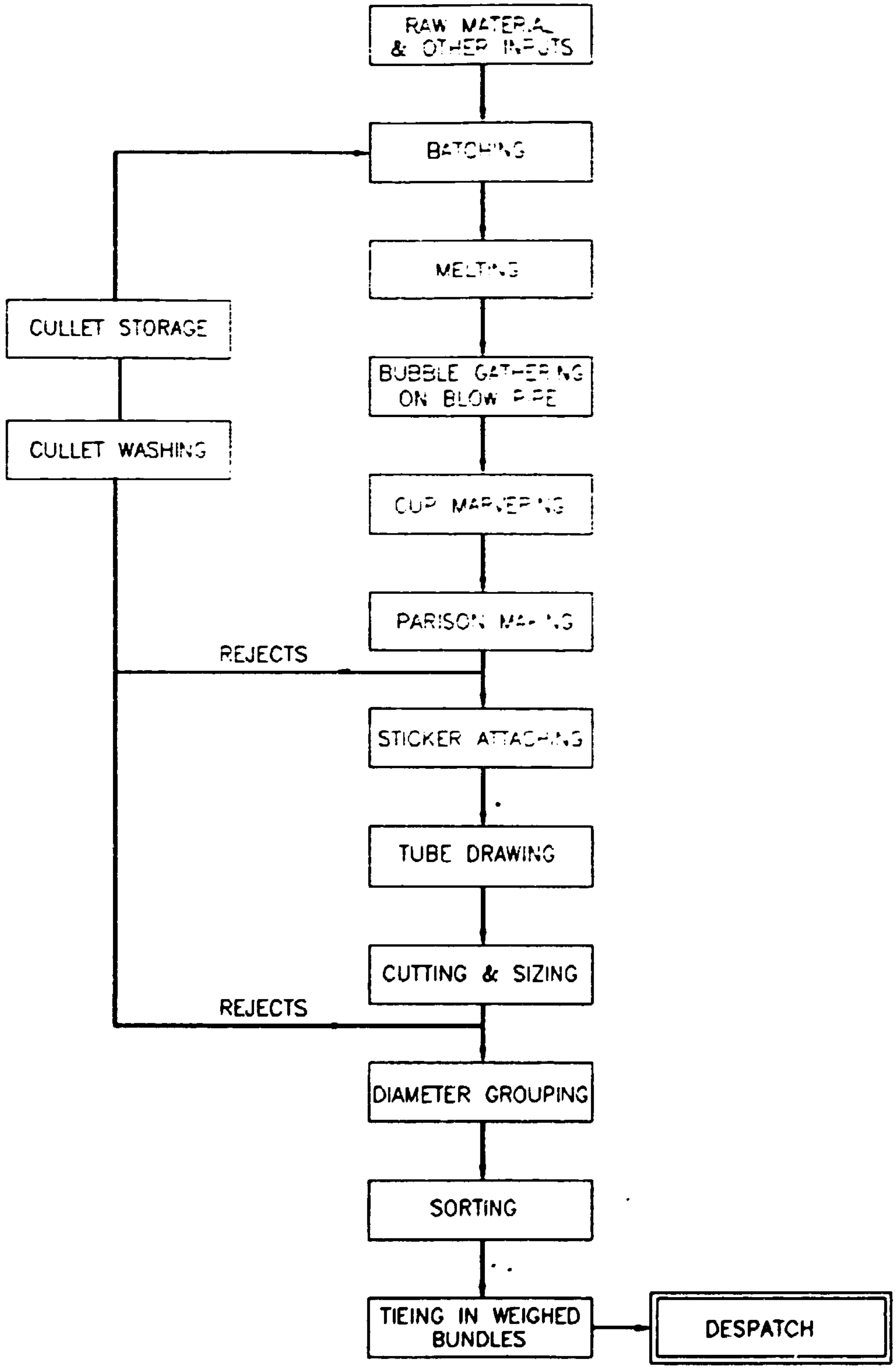
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF REFILLS AND DOUBLE WALL VACUUM FLASKS



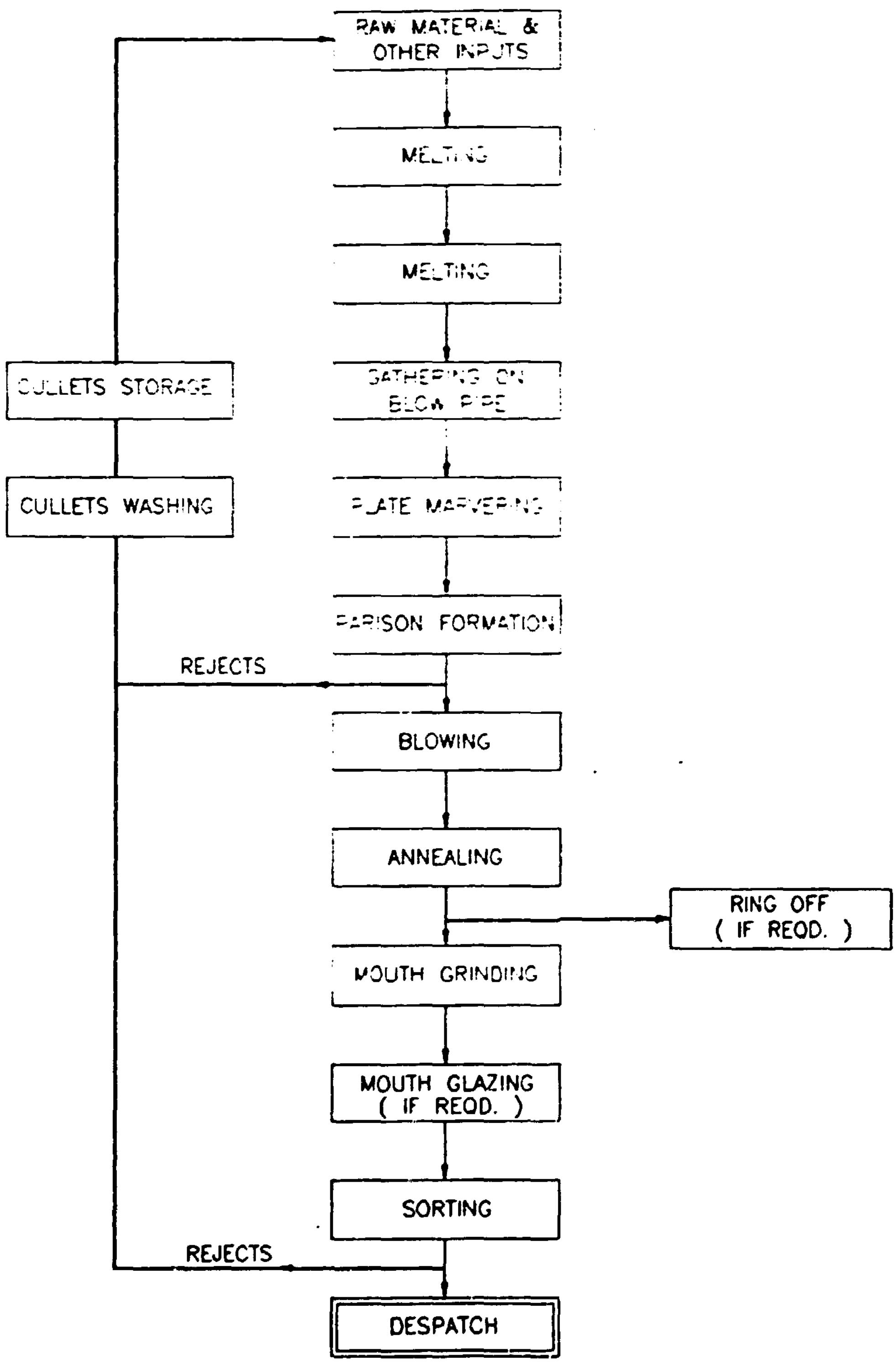
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF LABWARE, CHIMNEYS, LAMP SHADES, BULBS



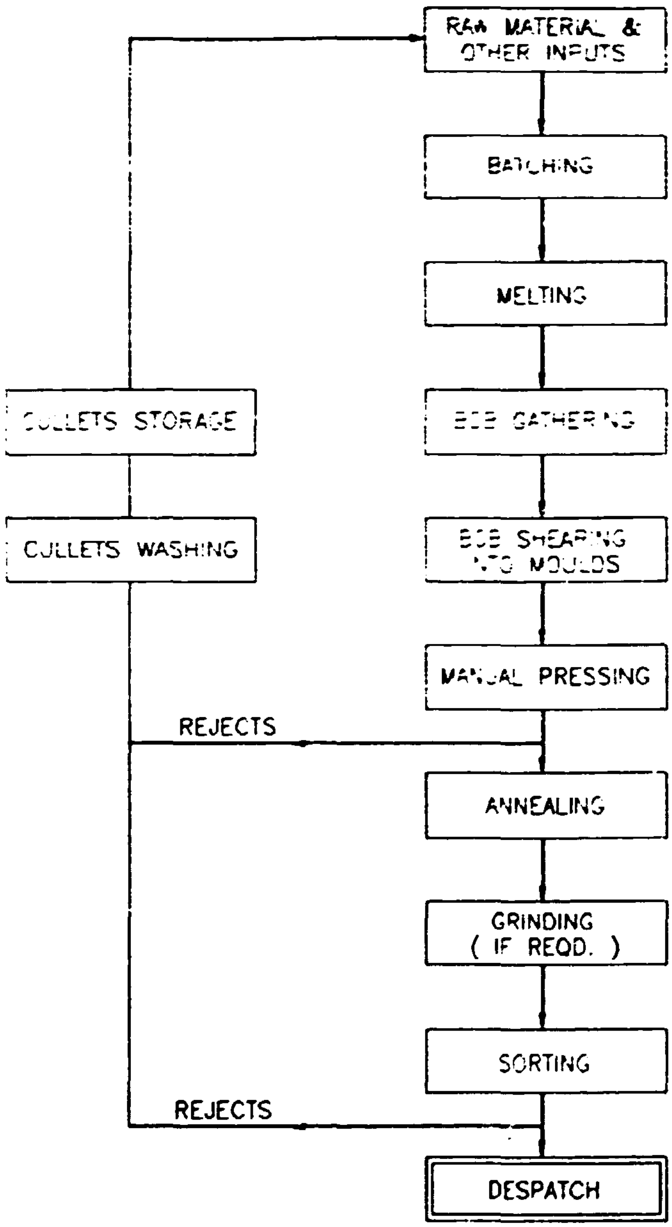
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF THERMOMETER CAPILLARY, NARRPWDIA PIPES FOR BULBS & LABWARE AND PODS FOR BEADS



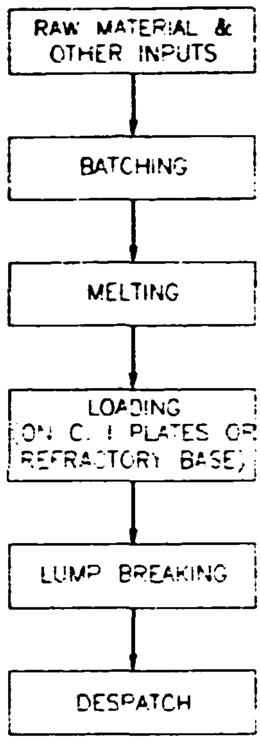
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF BULB SHELLS AND PETRI DISHES



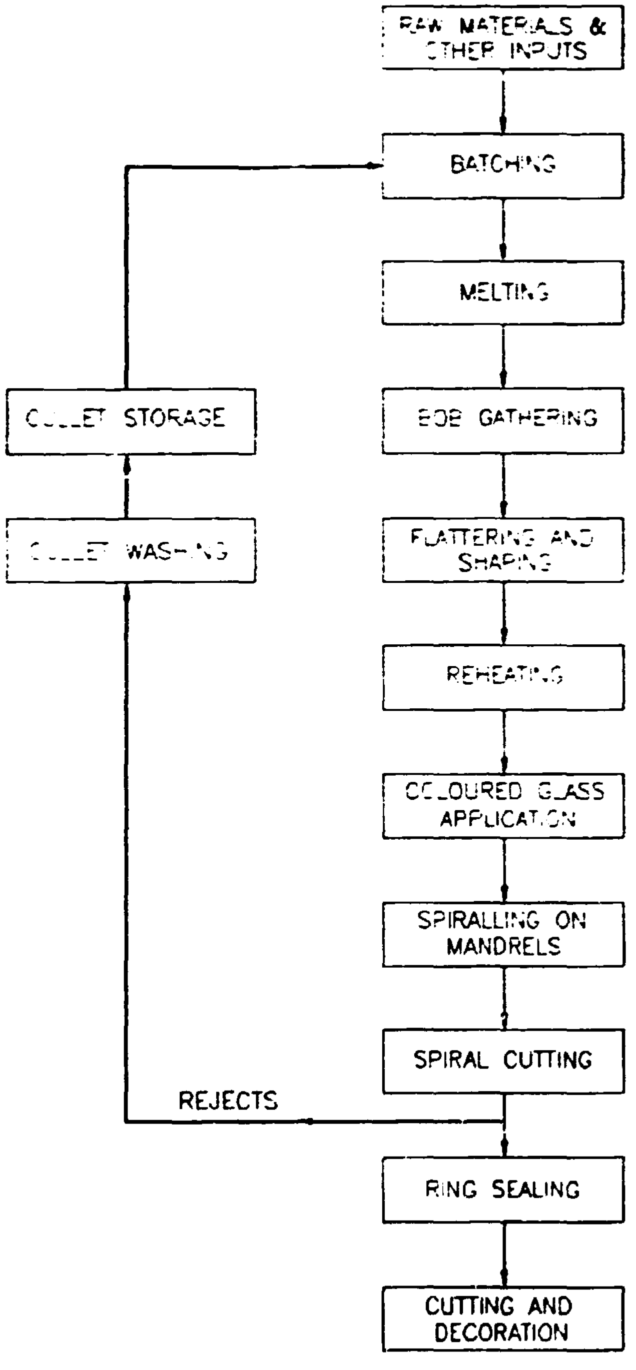
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF HEAD LIGHTS, ASH TRAYS AND OTHER MISCELLANEOUS PRESS ITEMS



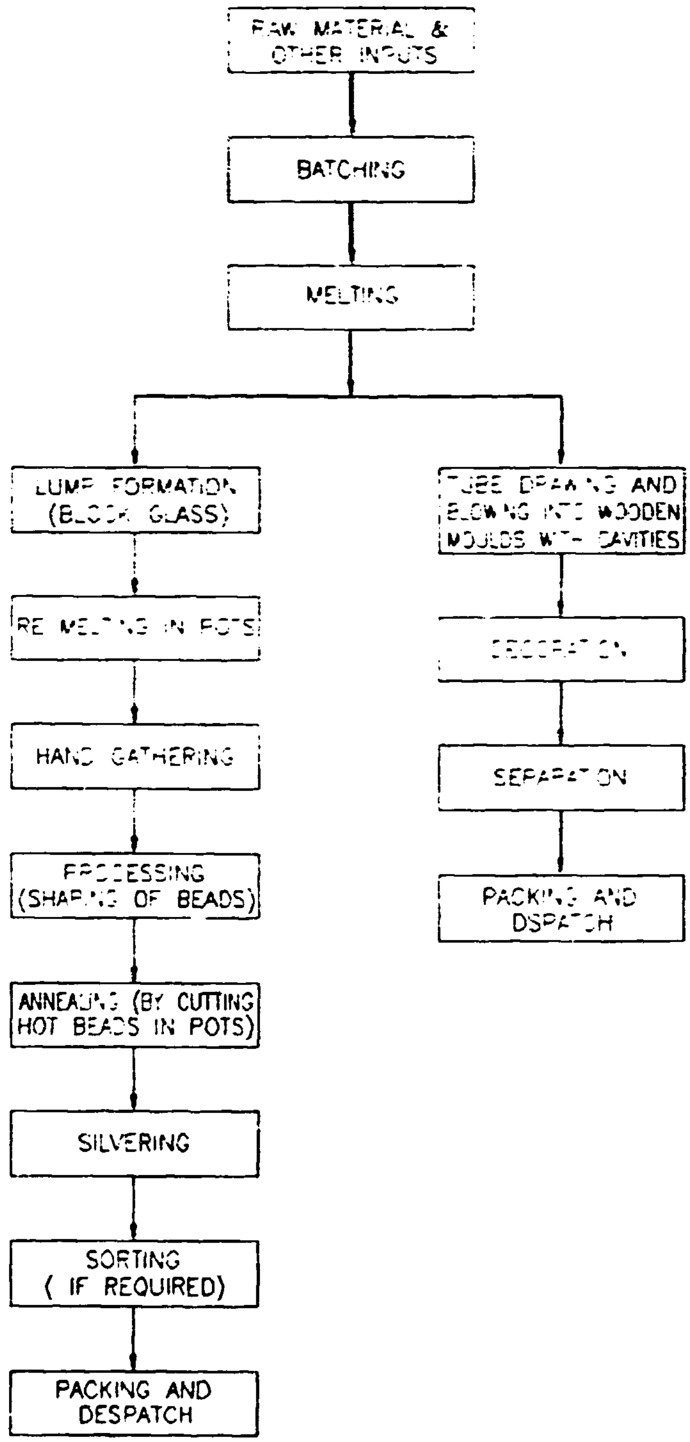
PROCESS FLOW DIAGRAM FOR MANUFACTURE OF VITRITE, BLOCK GLASS AND COLOURED GLASS



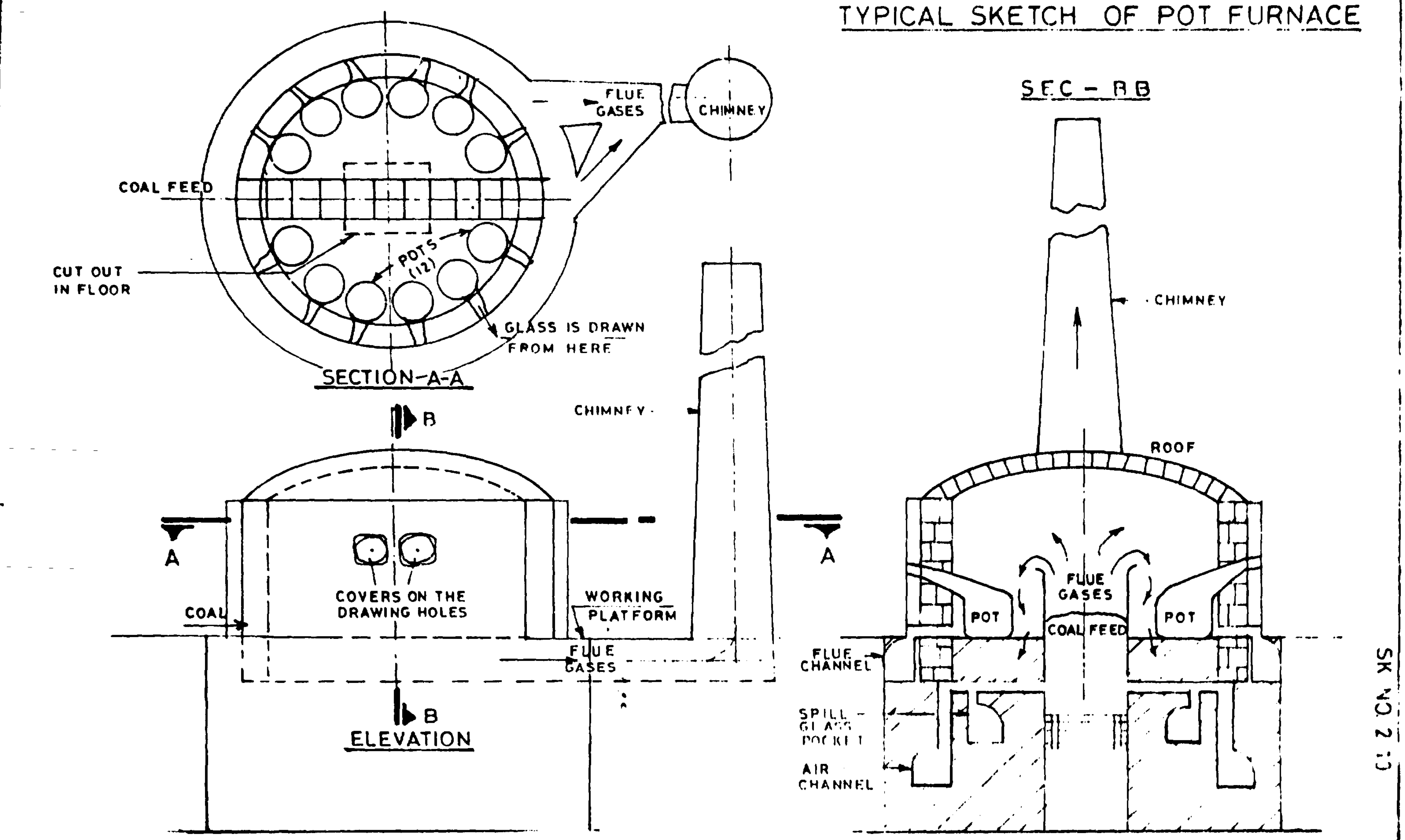
PROCESS FLOW DIAGRAM OF BANGLES MANUFACTURE

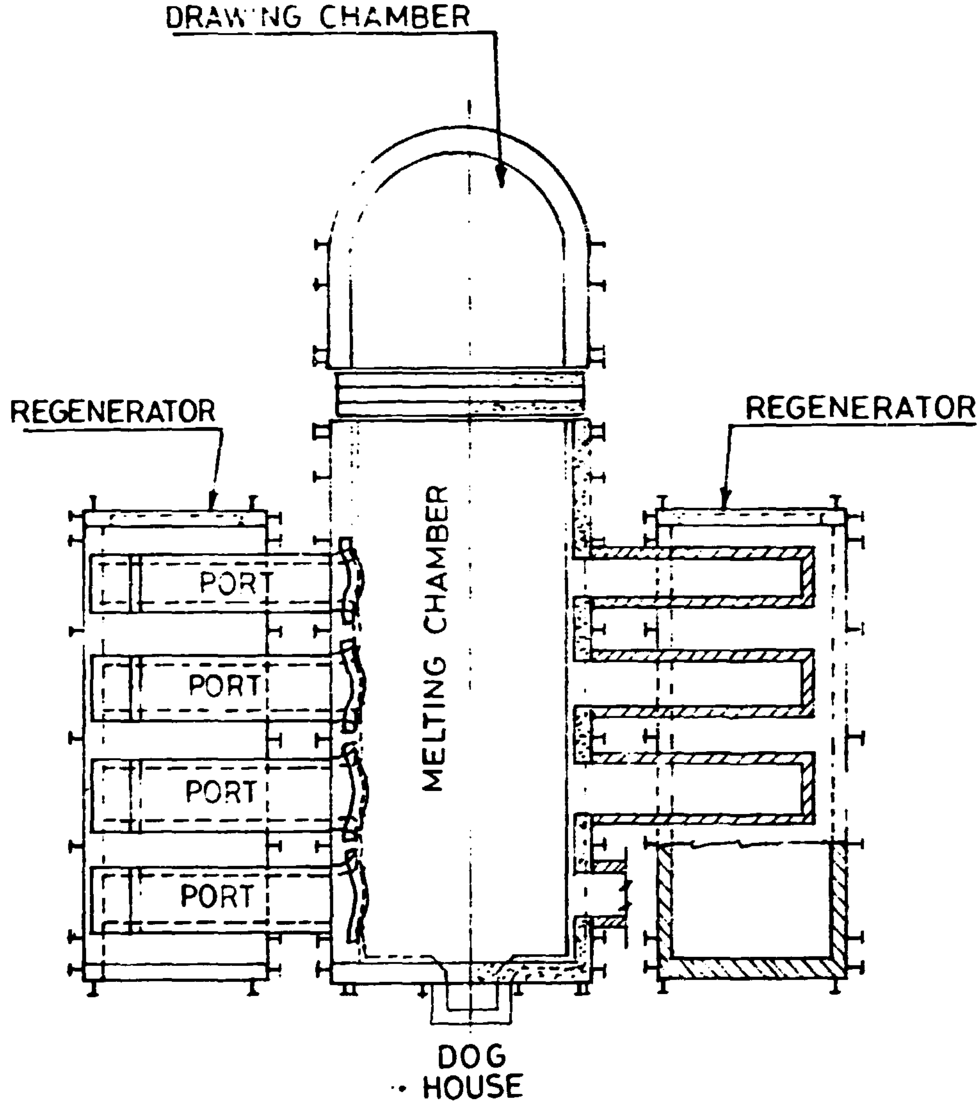


PROCESS FLOW DIAGRAM FOR MANUFACTURE OF BEADS

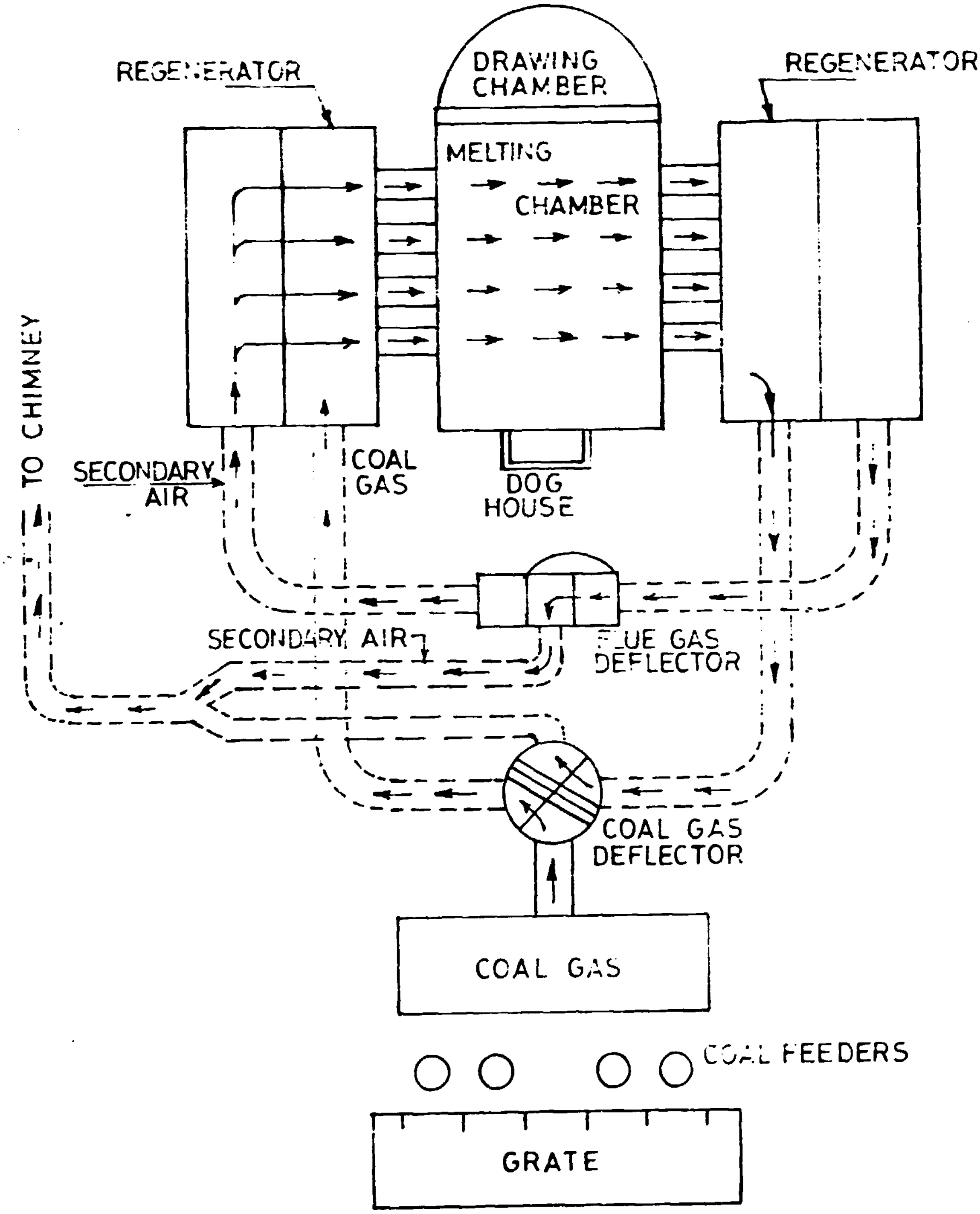


TYPICAL SKETCH OF POT FURNACE

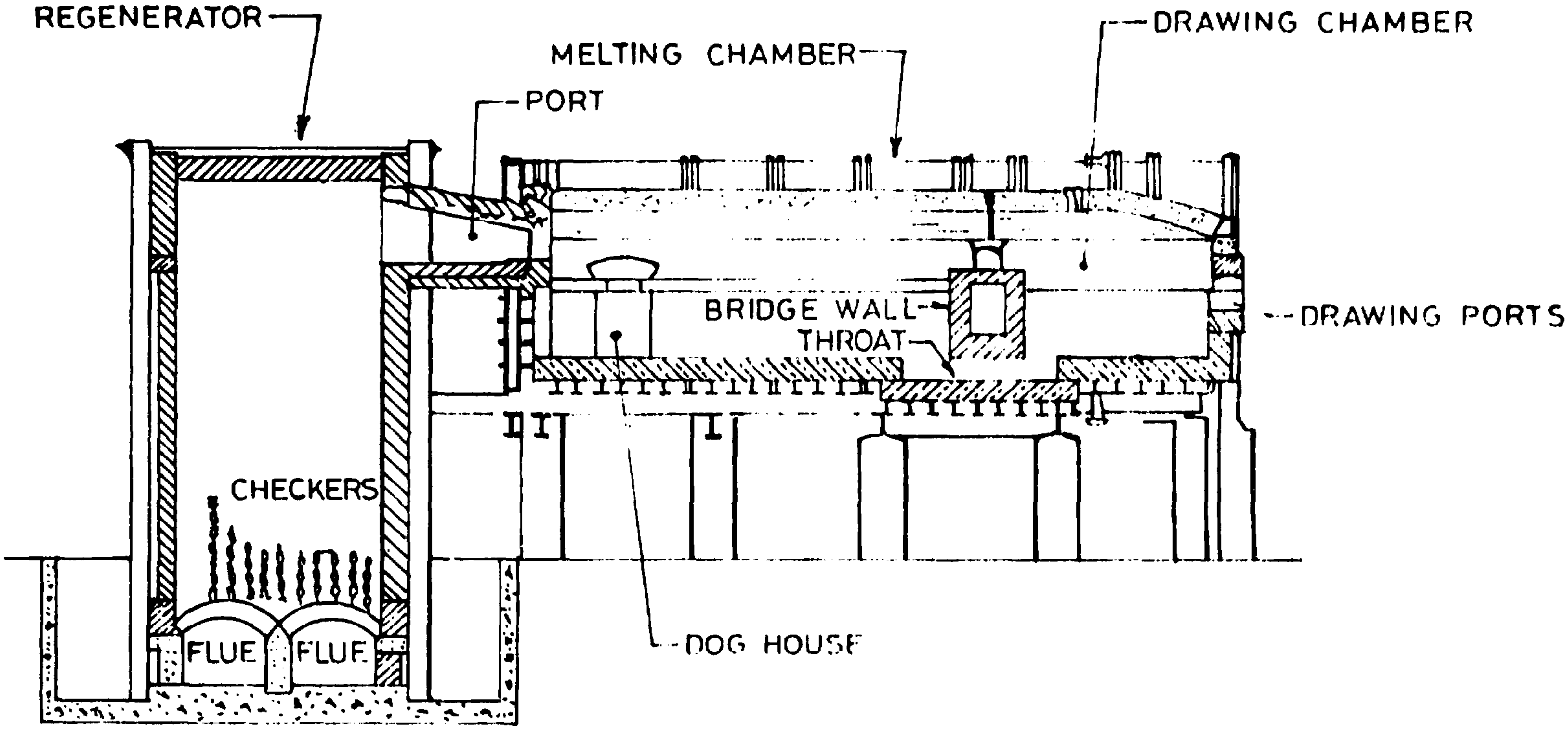




TYPICAL SKETCH OF
SIDE PORT REGENERATIVE FURNACE



SIDE PORT REGENERATIVE FURNACE
FLOW OF COAL GAS AND AIR

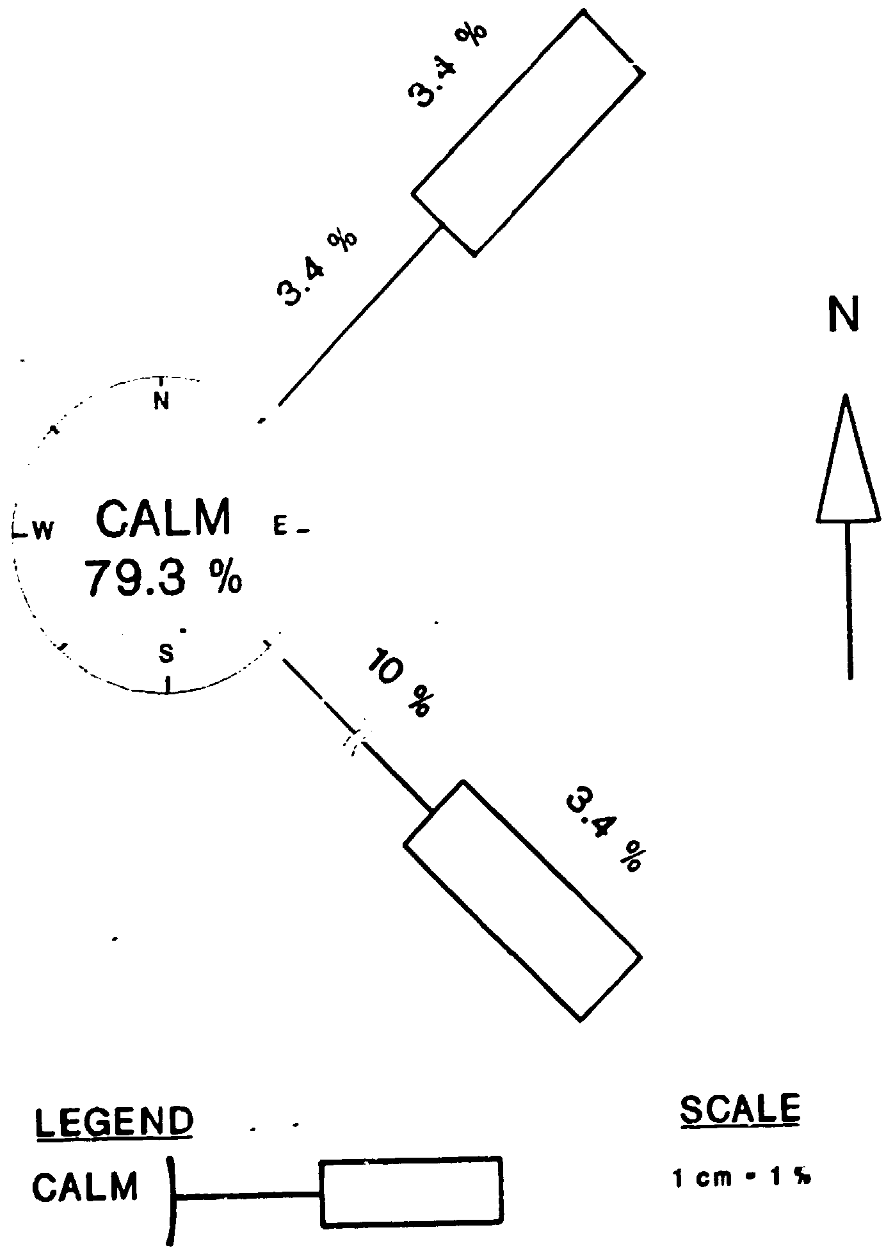


TYPICAL SKETCH OF END PORT REGENERATIVE FURNACE

SK. NO. 2. 13

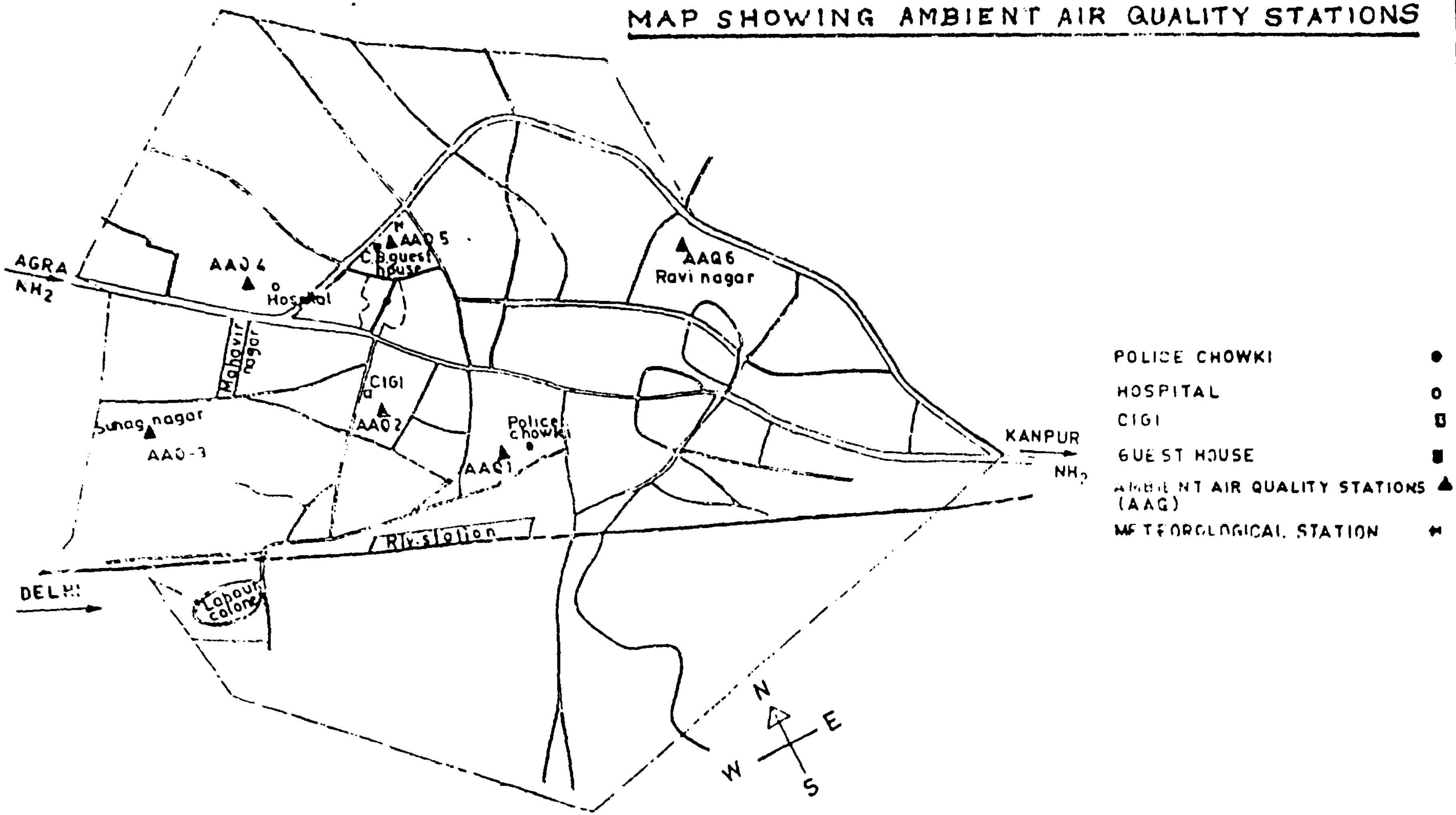
Sketch No. 2.14

WIND ROSE DIAGRAM (FROM) DURING STUDY PERIOD



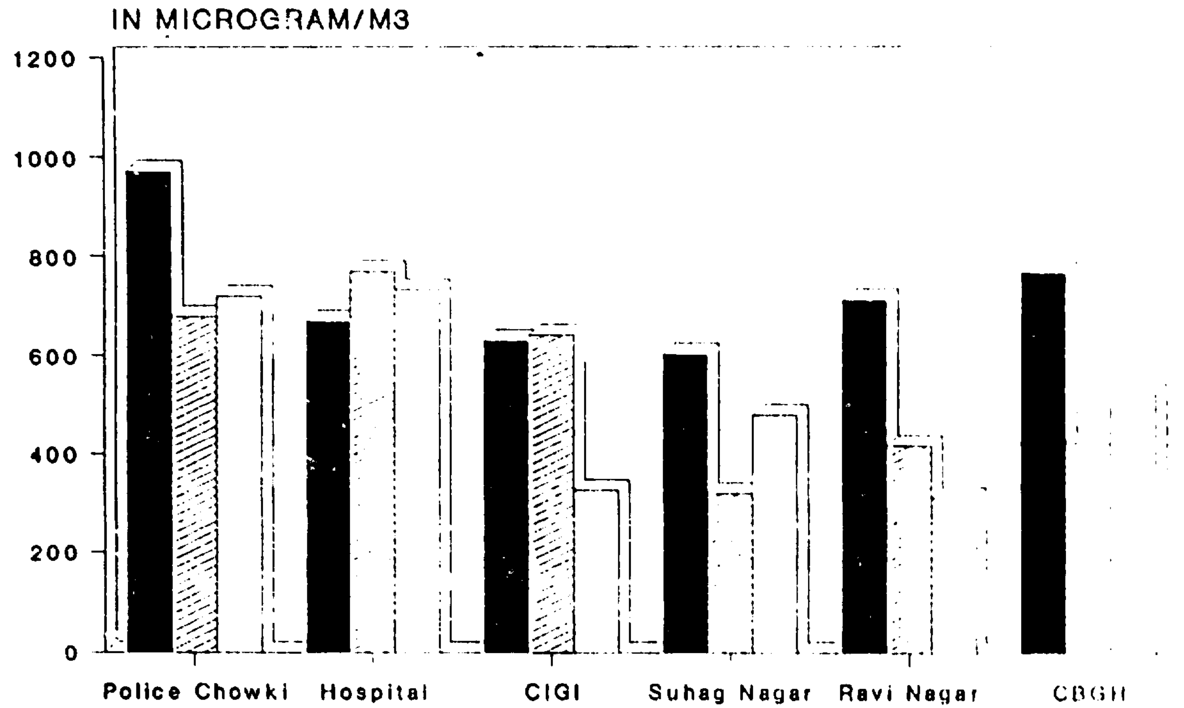
Sketch No. 2.15

MAP SHOWING AMBIENT AIR QUALITY STATIONS



Sketch No. 2.16

FIROZABAD TOWN AMBIENT AIR QUALITY
SPM CONCENTRATION

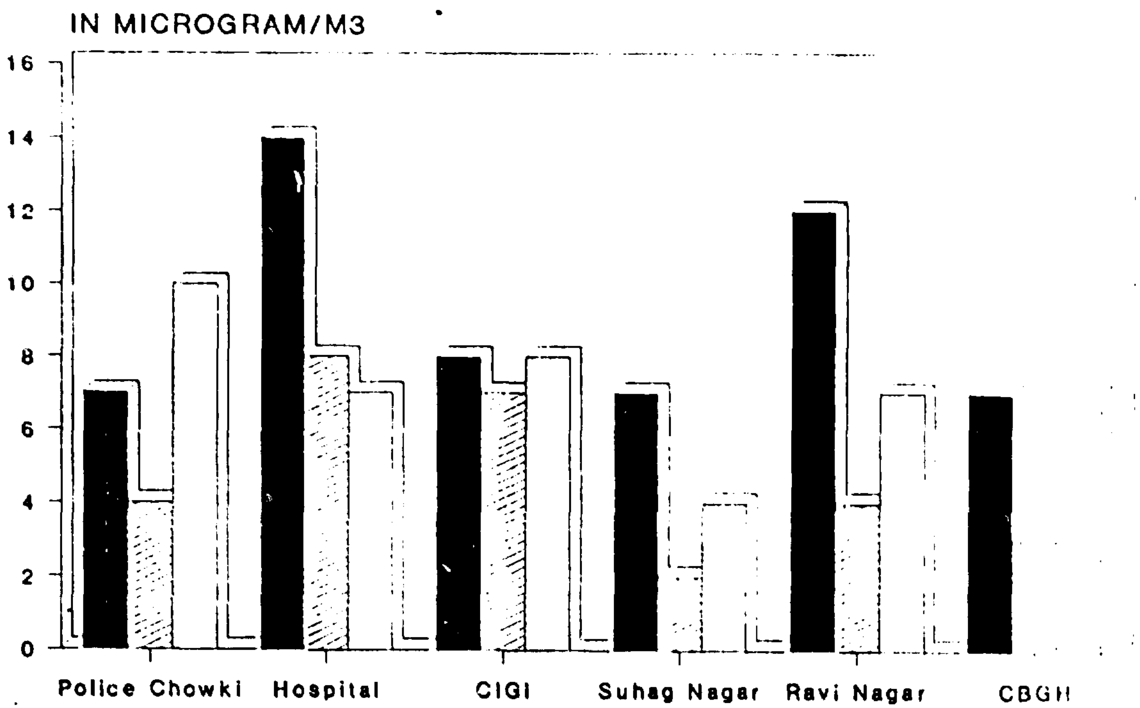


	Police Chowki	Hospital	CIGI	Suhag Nagar	Ravi Nagar	CBGH
SHIFT A	971	670	630	604	713	767
SHIFT B	678	769	640	320	417	424
SHIFT C	719	732	325	480	310	524

<u>NOTE</u> : *SHIFT-A 14·00 - 22·00 HRS*
SHIFT-B 22·00 - 06·00 HRS
SHIFT-C 06·00 - 14·00 HRS

Sketch No. 2.17

FIROZABAD TOWN AMBIENT AIR QUALITY
SO2 CONCENTRATION

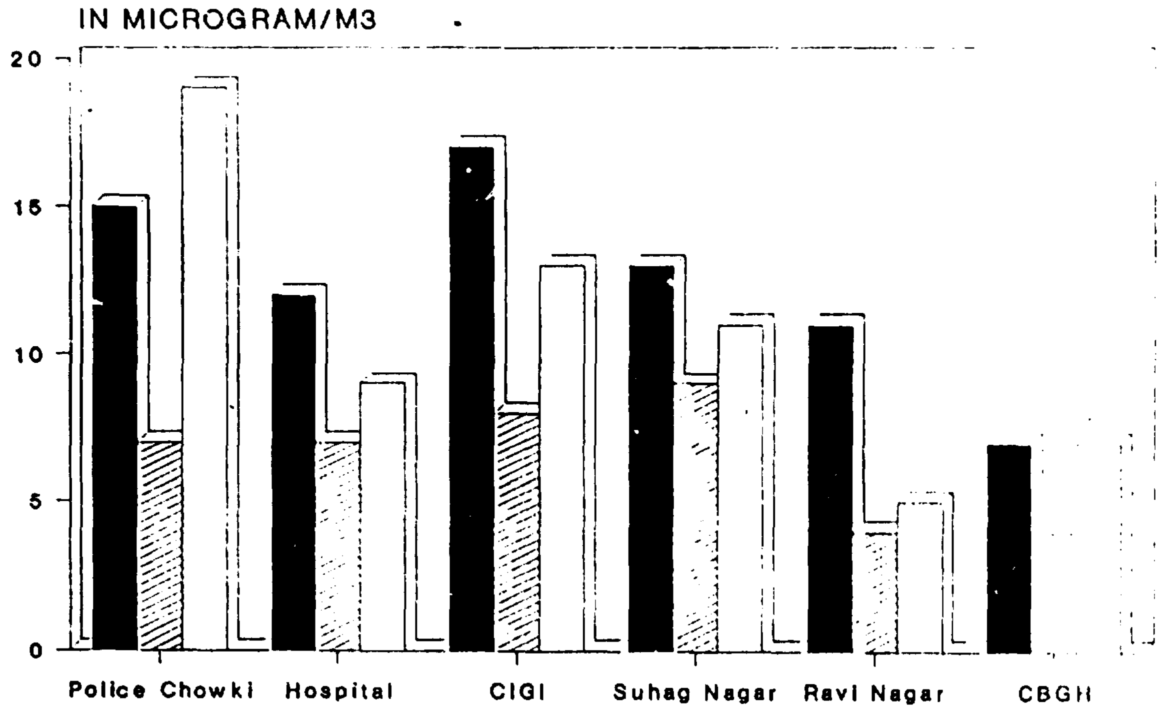


	Police Chowki	Hospital	CIGI	Suhag Nagar	Ravi Nagar	CBGH
SHIFT A	7	14	8	7	12	7
SHIFT B	4	8	7	2	4	3
SHIFT C	10	7	8	4	7	7

NOTE : SHIFT-A 14:00 - 22:00 HRS
SHIFT-B 22:00 - 06:00 HRS.
SHIFT-C 06:00 - 14:00 HRS.

Sketch No. 2.18

FIROZABAD TOWN AMBIENT AIR QUALITY
NOX CONCENTRATION

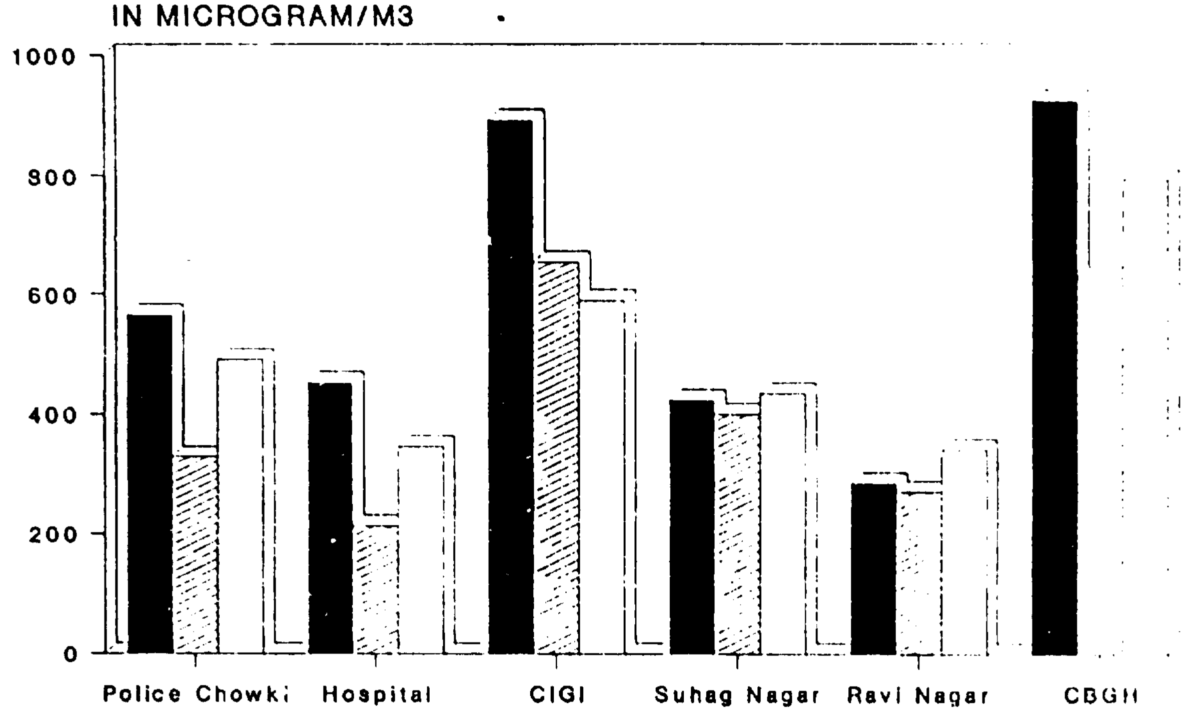


	Police Chowki	Hospital	CIGI	Suhag Nagar	Ravi Nagar	CBGH
SHIFT A	15	12	17	13	11	7
SHIFT B	7	7	8	9	4	4
SHIFT C	19	9	13	11	5	7

NOTE : SHIFT-A 14:00 - 22:00 HRS.
SHIFT-B 22:00 - 06:00 HRS.
SHIFT-C 06:00 - 14:00 HRS.

Sketch No. 2.19

FIROZABAD TOWN AMBIENT AIR QUALITY
CO CONCENTRATION



	Police Chowki	Hospital	CIGI	Suhag Nagar	Ravi Nagar	CBGH
SHIFT A	565	452	892	424	285	925
SHIFT B	328	212	655	400	270	628
SHIFT C	492	346	590	435	340	792

NOTE : SHIFT-A 14:00 - 22:00 HRS
SHIFT-B 22:00 - 06:00 HRS
SHIFT-C 06:00 - 14:00 HRS

III. STUDY OF THE IDENTIFIED GLASS MANUFACTURING UNITS OF FIROZABAD

3.0 INTRODUCTION

3.0.1 The glass manufacturing units, which were to be extensively surveyed, were identified in consultation with CIGI, local Glass Manufacturers Associations, and individual owners, engaged in the manufacture of clear glass products, their decorations and bangles, and are listed below.

i) Manohar Glass Works
ii) Shiv China Glass Manufacturing Co.
iii) Meera Glass Industries
iv) Pooja Glass Works
v) Adarsh Glass Works
vi) Shivali Glass Industries
vii) West Glass Works
viii) Baby Glass Works
ix) Om Glass Works
x) Electronic Glass Industry

3.0.2 Out of the above mentioned ten identified units, the following eight glass units were finally taken up for detailed study in consultation with CIGI, as these were found functioning and their owners also agreed to extend cooperation in such a study.

* Manohar Glass Works
* Shiv China Glass Manufacturing Co.
* Pooja Glass Works
* Adarsh Glass Works
* West Glass Works
* Baby Glass Works
* Om Glass Works
* Electronic Glass Industry

3.0.3 In order to carry out the detailed study of the glass units, the following four subgroups were formed, who visited these units during the study period.

* Technology Assessment & Furnace Performance
* Energy Measurement and Audit
* Pollution Monitoring
* Marketing of Products & Financial Aspects

This Chapter deals with the detailed study of the selected glass manufacturing units covering glass manufacture and technologies, energy conservation, pollution, and marketing aspects of each of the units and also presents a summary of the study of the identified units.

3.0.4 The facts found by the consultants are based on the information collected during visit to these units personal interviews /discussions with key personnel and the Questionnaire forwarded to each of the units for collections of plant data

3.1 SUMMARY OF FINDINGS

This section summarises the findings of the Consultants and high-lights some of the key issues that have emerged during the detailed study of the identified glass units.

3.1.1 SITE

All the units are located at sites which are well suited to their needs and there is no constraint for movement of materials in and out of these units.

The units located on Station Road have adequate areas for present scale of operation but it would not be possible to extend the boundaries for further expansion as these are surrounded by other industrial units, while the units located in the industrial area of Agra Road have adequate space available within their premises for future expansion.

3.1.2 PRODUCTS

All the identified units manufacture soda-lime glass, which is generally of poor aesthetic quality, having high alkalinity, low chemical resistance, and high coefficient of expansion and prone to rapid weathering. Some of the manufacturers add small amounts of lead (4 to 5 %) to bring lustre in their products. The products being manufactured include table wares, laboratory wares, auto headlight covers, bulb shells, bangles, and miscellaneous items like ash trays, paper weights, candle stands, etc.

There is, however, no lack of demand, and the units are able to market their products not only in the domestic markets, but in some foreign countries also. But during the last few years, there is a demand for better quality of glass products such as oven wares of boro-silicate glass, and table ware of opal glass, crystal glass, etc from the urban markets. Production of such glasses requires a melting temperature in the higher range,and corrosion resistant refractories which are not being used presently.

3.1.3 PRODUCTION

3.1.3.1 Installed Capacity

The installed capacity of the units having pot furnaces is in the range of 3 - 4 tonnes per day with 10 - 12 pots , either open or closed type, and the installed capacities of the units having tank furnaces are in the range of 20 -25 tpd.

The Technology used in the production of soda-lime glass products is traditional, and labour-intensive. Most of the units are still operating coal-fired melters and using out-dated production equipment, resulting in lower output and poor quality.

3.1.3.2 Manufacturing Operations

The methods used in the manufacturing operations are conventional, which include melting, forming, annealing, and finishing, and the key issues are high-lighted in each as under.

3.1.3.2.1 Raw Materials & Batching

The percentage range of composition of major constituents in the batch being used by the various identified glass units is indicated as follows.

S.No.	Constituent	Percentage Range
1.	Formers (Sand, Borax)	61 - 70
2.	Fluxes (Soda ash, Potassium carbonate, Lead oxide, Felspar)	23 - 35
3.	Stabilizers (Calcite, Dolomite, Barium carbonate)	2 - 10
4.	Refiners (Sodium nitrate,Arsenic trioxide, Sodium silico fluoride, Potassium nitrate)	1 - 3

The quality of raw materials used by most of the units is not upto the mark, as no test reports of the raw materials are obtained from the suppliers,nor any tests are carried out in the units. Moreover, the glass manufacturers are not aware of the required particle size of sand to be used . Washing of the sand is not being practiced by any of the units, while magnetic separation is done by some of the units. Mixing of the batch ingredients and washing of the cullets & segregation is done mostly manually. Only one unit is using mixing machine and cullet washing machine. Crushing of the cullets to proper size is not being practiced. Feeding of the batch and cullets is carried out manually by all units. There is ample scope for improvement in the sizing, weighing and preparation of proper batch.

3.1.3.2.2 Melting

Melting of glass is carried out either in pot furnace or tank furnace. Coal is being used by all the units having pot furnaces. The melting temperature in pot furnace is in the range of 1250 to 1450 deg. C. Since high temperature is not achieveable due to the use of inferior quality of coal, some units resort to increasing the proportion of soda ash in the batch composition in order to lower the melting temperature of the batch.

The quality of pot used for melting is not good. Quality of refractory mass (clay and grog) employed in the preparation of the pots is of low PCE (pyrometric cone equivalent). Moulded pots suffer from high porosity. These factors result in very fast corrosion of the pots due to which the pots develop leakage and have to be immediately discarded. Loss of leaked out glass and down time till the replaced pot comes in service are serious draw backs in pot melting of glass as practiced at Firozabad.

The pot is made from very coarse grog size and alumina content in the body is very low, which causes leaks in the bottom or side walls, and the average life of the pot is highly uncertain, around 15 to 25 days.

In the tank furnace, coal is mostly being used. The coal is gassified using insufficient air and the gas containing CO and CO_2 and some hydrocarbons has a low calorific value and the maximum flame temperature achieved is 1400 - 1500 deg. C. Lately, some of the units have started using oil-fired tank furnaces, but without substantial improvement in operating conditions.

3.1.3.2.3 Forming

The forming operations currently practiced for manufacture of glass ware are blowing & moulding, drawing and pressing, while for manufacture of bangles, spiralling operation is used. All the forming operations are highly labour intensive except in some units, where semi-automatic presses are being used.

3.1.3.2.4 Annealing

Most of the units are not conscious of the annealing cycle for soda-lime glass ware. Annealing is done in locally fabricated Chambers or Lehrs. In units where annealing chambers are used, there is no provision for measuring the inside temperature of the chamber.

3.1.3.3 Layout/Material Flow/House-keeping

In most of the units, the overall layout is not according to any rational basis . Only in one or two units, the layout appears to be according to production flow. In units which were established over 30 years back, the additions of equipment have taken place haphazardly over the period of time. Floor areas in almost all the units are paved with brick rubble and there is no hard flooring.In a few units, there is difference in the levels of working areas, and transporting the preheated pots to the pot furnaces becomes very risky.

House-keeping in almost all the units is non-existent. Materials and scrap are cluttered inside the working areas, which are quite smoky. This hinders the movement of materials and disrupts the flow of production. There is a lack of ventilation and exhaust fans in most of the units. Ambient temperature is quite high, particularly near the molten glass drawing/forming area, dog house and feed area of annealing lehrs. Simple measures such as good house-keeping will be significant , not only from a practical standpoint through improved material flow, but also in terms of producing a safer and healthier working environment, more conducive to higher productivity.

3.1.4 RESOURCES

3.1.4.1 Manpower

Most of the workers employed in all the units are contract labourers. It is observed that women and child labourers are also employed by the contractor. The child labourers are generally engaged in activities of drawing molten glass from the furnace for further processing and women are employed in cullet washing, segregation of cullets, and other activities in the bangle units.

Workers employed in glass units are exposed to dust, pollution, and high temperature, without any preventive safety measures like gloves, masks, eye-goggles, boots, etc. , leading to respiratory diseases. Medical check-up of batch house workers, which is statutary, is not being done. The workers mix raw materials and other chemicals manually and inhale toxic substances without knowing their effect. Lack of basic infrastructural facilities in the units, such as man-coolers, exhaust fans, toilets, first aid etc. were either absent or scantly provided.

The skill base is generally eroded and there is no training activity. In most of the units, quantity of the production is given emphasis over the quality.

3.1.4.2 Production Equipment

Almost all the glass units have a symmetrical design and capacity of furnaces irrespective of the glass composition. The furnaces are constructed with low grade refractory bricks without any insulation which permits heavy radiation losses (20 to 40 %) and the campaign life is between 8 to 12 months.

Pot furnaces are not equipped with any heat recovery system and about 50 - 60 % heat losses take place through the flue gasses. In some of the pot furnaces, there is no provision of essential instruments like temperature indicator and the temperature is monitored through workers experience. In the furnace design, there is great scope for better control of combustion, higher heat recovery and reduced radiation losses. All the melting furnaces are equipped with chimney of at least 30 m height except in Baby Glass where the chimney height is 20 m. The furnaces operate on natural draft and the suction created for flow of flue gases is quite adequate.

The Regenerators of the coal-fired tank furnaces are mostly of single pass type and there is inadequate provision of monitoring and controlling the inflow of secondary air for adjusting the ratio of excess air. It has been observed that the heat loss through flue gas is between 30 to 40 % and excess air ranges 50 % and above.

The heat losses in the oil-fired regenerative tank furnaces are not different from the coal-fired tank furnaces, as these are also constructed from low grade refractory bricks. In addition to this, the burners are locally designed and fabricated , causing imperfect atomisation of oil . Adequate instrumentation for measuring the oil-firing parameters, such as air /oil pressure, temperature, and oil flow rate are not provided. There are no scientific means of adjusting the firing rate. Lack of control on secondary air leads to high fuel consumption. Subsidiary furnaces, such as Pot Pre-heating Furnace, Reheating Furnace (Sikai Bhatti) and Bangle Making Furnace (Belan Bhatti), have crude design and are poorly constructed, and in almost all the units, the flames and smoke are seen escaping out into the working areas. There is no provision of chimneys, and no care seems to have been taken in selecting the refractory bricks, and in most of the units ordinary red bricks have been used, and there is total absence of provision of insulation which affects the ambient temperature.

Annealing chambers are poorly designed and constructed. These are locally fabricated without any insulation. These are coal-fired but not equipped with any chimneys in most of the units. Heat distribution inside the chambers is not uniform. No check on the quality of annealing is excercised.

Most of the annealing lehrs in use are oil-fired, but there is no provision for proper air circulation, which causes nonuniform heat distribution along the width and length of the lehr and consequent non-uniform annealing. Their condition is better than that of the annealing chambers.

The finishing equipment include grinding machine for edge-grinding, electrical cutting devices, buff polishing machine, and melting machines for fire-polishing. All these equipment are individual work-stations for manual operations. The fire-polishing machine is fired with LPG and Oxygen in one unit and with kerosene oil in other units.

3.1.4.3 Facilities/Utilities/Services.

Quality control and testing facilities are missing in all the units. Only one unit has facility for conducting annealing test on glass products. Occassionally, some tests on glass compositions are got done from CIGI, but guidance to the units regarding the correct batch composition does not appear to be available.

Workshop facility for maintenance of moulds/dies and other locally fabricated equipment is available with most of the units. These facilities have some old centre lathes and drilling, shaping, and welding machines.

Material handling within the plant is entirely manual. Even wheel-barrows and trolleys for transporting material from one work-station to another are not provided. Most of the units have platform type trolley for transporting heated pots to the furnace.

Proper Storage Areas for raw materials, chemicals, moulds/dies, packing material, finished goods, have not been provided . In some units, separate sheds are there for storing raw materials and finished goods, but in other units, the materials are scattered on the working areas.

None of the units has satisfactory Fuel Oil storage, handling, and distribution system. There is no provision for filtration of oil, proper pumping system and required instrumentation.

There is also no provision of Fire-fighting facilities and other safety devices for workers.

3.1.5 FUEL AND ENERGY UTILISATION

The useful heat utilisation and the various heat losses have been worked out from the data collected and measurements taken at each of the identified units and these are tabulated as under.

Name of Unit	Type of Furnace	Useful heat (%)	Flue gas losses (%)	Radiation losses(%)	Openings losses (%)	Unaccounted losses (%)
Baby	Open pot	13.0	33.4	27.8	11.5	12.6
Manohar	Closed pot	8.8	51.5	20.0	11.5	8.2
Shiv	Closed pot	8.8	30.6	13.2	11.5	35.9
Pooja	Closed pot	8.8	59.8	20.8	9.2	1.4
	Closed pot	8.8	59.8	11.4	11.5	8.5
West	Tank	15.7	44.2	34.4	3.0	10.6
Om	Tank	17.3	39.3	34.0	3.0	6.4
Electronic	Tank	23.5	26.4	42.5	4.6	3.0
Adarsh	Tank	10.4	31.3	22.3	9.6	23.4

In general, it can be said that the efficiency of the pot furnaces varies from 8.8 to 13.0 % and that of the tank furnaces, from 10 to 24 %.

Although the smaller size of units is partially responsible for higher specific energy consumption, a large scope exists for major improvements in reducing flue gas losses and radiation losses, as the energy input constitutes 20 to 40 % of the cost of production.

3.1.6 MANUFACTURING SYSTEMS

There are no formal systems for planning and controlling of production, and no ways of ensuring that maximum use is made of the resources. Designs of the products to be manufactured are provided by the customers and no effort is made to develop own product designs for the market, as there is no R & D activity even in the bigger units.

There are no proper systems for materials management and there is no control at the shop level. At a few units , the inventory levels of finished goods and coal are quite excessive.

Only break-down maintenance is carried out and no schedule for preventive maintenance is followed. No history cards are maintained even for furnaces.

The product quality is generally poor in all the units. Accepted quality products form less than 10 % of the production . The rejects analysis has not been done by any of the units, even though the rejects percentage is between 30 to 35 % at different stages. It would be worthwhile to look into the possibility of modifying tools and dies and changing over to semi-mechanical operations to minimise the rejection rates.

3.1.7 POLLUTION

Problems/Deficiencies

Based on the study of pollution levels in the identified glass industries as well the city ambient air, the findings regarding pollution problems are as follows:

Ambient Air Inside Factory

- Suspended particulate matter concentration was found to be very high
- In some cases Sulphur Dioxide concentration was above the stipulated norm of 120 ug/m^3
- There was appreciable concentration of Fluoride

Ambient Air At Work Places

- High ambient temperature (50 - 55 °C)
- Suspended particulate was found to be of the highest order
- High concentration of Sulphur Dioxide
- Appreciable amount of Carbon Monoxide and Fluoride inside the work place

City Ambient Air Quality

Main problem in the city is due to suspended particulate matter only

Stack Emissions

- Very high stack gas temperature
- High concentration of SPM
- Moderately high concentration of Sulphur Dioxide
- Appreciable concentration of NO_x and CO

Water Pollution

Water pollution problems are found to be negligible or nil except the presence of suspended solids and Fluoride in high concentration than the permissible limits.

Solid Waste

In one case, the volatile matter in the ash was found to be very high due to unburnt carbon.

Concentration of aluminium and Silica are also found to be high. Though concentration of Silica is justifiable, aluminium concentration gives some serious concern.

Improper house-keeping is prevailing in all the industrial units monitored.

The Stack Emission quality and the ambient air quality in the identified glass units is shown in Sketches No. 3.09 to 3.14.

3.1.8 PERFORMANCE

3.1.8.1 Raw Material Consumption

The raw material consumption is generally expressed in terms of the quantity of raw material consumed per tonne of the molten glass drawn.

Based on the data and information collected from the management of the identified glass units, the quantity of Sand, Soda ash, and cullets used per tonne of the molten glass drawn, and the percentage of rejects and the percentage of cullets in the charge are estimated to be in the following range:

Sand	:	0.31 - 0.53 t/t draw
Soda ash	:	0.11 - 0.17 t/t draw
Cullets	:	0.30 - 0.50 t/t draw
Rejects	:	30 - 50 %
Cullets in charge	:	26.38- 45.87 %

3.1.8.2 Energy Consumption

The specific energy consumption of a glass unit is the sum total energy consumed divided by the quantity of molten glass drawn. The specific energy consumption in the identified units works out to be in the range of 11.39 to 23.40 Million kJ / t draw, against the international norm of 8.36 Million kJ/t draw in case of small furnaces and in large furnaces it is about 4.5 million kJ / t draw.

3.1.8.3 Rejection Rate

The rejection rate is expressed as the percentage of the difference between the quantity of glass drawn and quantity of glass products packed, on the quantity of glass drawn, and serves as an indicator of the quality of the products being produced.

Based on the data and information collected, the rejection rate in the identified glass units ranges from 30 % to 50 %.

3.1.8.4 Pollution

The pollution status of the identified glass units is as follows.

Stack Emission Parameters:
- SPM values of most of the units exceed the prescribed limits
- SO2 values of almost all the units exceed the prescribed limit
- CO values are not satisfactory, indicating incomplete burning of fuel

Ambient Air Quality Parameters:
- SPM values of all the units exceed the prescribed limits
- SO2 values of many of the identified units exceed the prescribed limits
- NOX values are within the prescribed limits

- Fluoride is found to be present in the ambient air

3.1.9 Finance

3.1.9.1 As discussed in Chapter II of the Report, Balance Sheet and Profit & Loss Account of the various identified units have been studied in detail. However, these documents do not give clear performance of a unit because of various reasons like excise duty, corporate tax, sales tax etc. Also there is wide difference in performance of these units because of varied product mix and the year in which these plants were set up.

3.1.9.2 In view of the above, an attempt has been made by the Consultants to study the performance of the identified units by the type of furnace being used. Cost of production per tonne of glass produced has been worked out for the Pot Furnaces (closed and open) and Tank Furnaces. The capacity of the furnace has been selected keeping in view the existing capacity of the identified units, i.e., 4 tpd for pot furnace and 20 tpd for tank furnace.

Investment for the purpose of working out the fixed cost, i.e.,depreciation, maintenance, interest charges etc has been taken from the balance sheet of the units. Sales realization for the type of furnace has been based on the average product mix for the existing units.

3.1.9.3 The prices of the raw materials, other inputs and the finished products have been based on the prevailing cost structure of the existing units. Similarly, average wage structure of the existing units has been adopted for working out the cost of production.

3.1.9.4 The cost of production per tonne of soda-lime glass produced for the pot and tank furnaces is summarized below:

	Rs/tonne
Pot furnace (4 tpd, closed)	10,205
Pot furnace (4 tpd, open)	11,392
Tank furnace (20 tpd, regenerative type)	8,677

3.2 MANOHAR GLASS WORKS

3.2.1 DESCRIPTION OF THE SITE

3.2.1.1 Size and Location

The works is located on Station Road at a distance of about one km southward from the Firozabad Railway Station. The unit is located within the Firozabad municipality area. The enterance gate of the works is on the main road. The works occupies a total area of about 2000 Sq.m, of which around 1000 Sq.m is the covered area.

3.2.1.2 Principal Features

Manohar Glass Works is quite old and the manufacturing operations started around 1945. The works is well connected by road along the railway line (Station Road).

3.2.1.3 Constraints/Suitability

There are no constraints including transportation to and fro from the works. The factory has sufficient room for the present scale of operations, but it would not be possible to extend the boundaries of the site, as it is sarrounded by other units.

3.2.2 PRODUCTS

3.2.2.1 Product Features

The unit is involved in the manufacture of the following soda-lime glass products.

* Glass bulbs,tubes, and rods
* Glass ware items such as shades, tumblers, head lights, railway lenses, signal glasses and vials.
* Laboratory wares.

The export of the above items is done mostly indirectly. Only occasionally, some of these items are exported directly to Nepal, Bangladesh and SriLanka. For domestic use, generally the party approaches the unit for marketing.

3.2.2.2 Production Volume

The production volumes for the last 3 years as reported by the unit are shown hereunder.

Year	Production (Tonnes)	Production (Tonnes/month)
1990-91 (3 months)	479.592	159.8
1991-92 (10 months)	630.960	63.1
1992-93 (7 months)	408.890	58.4
June 1993	-	61.4

From the above figures , it can be seen that the highest production was around 160 tonnes/month and the average over the last three years was around 60 tonnes / month.

3.2.3 PRODUCTION

In general, the manufacture of glass products is labour intensive requiring a range of craft skills for batching, forming and finishing.

3.2.3.1 Features of Production Areas

The mixing of various ingredients with cullets is undertaken in the batch preparation section. Melting of the batch is done in 12-pot coal fired furnace and tank furnace (presently not working). Forming of the molten glass to the desired shape is done near the furnaces.

There are areas for preheating the pots, annealing the glass products, and finishing to required shape.

Separate areas are provided for coal storage and raw-material storage.

3.2.3.2 Layout/Material Flow

The original layout of the works was planned over 40 years ago and some of the equipment have been added since then, in a somewhat haphazard way. Annealing Lehr (used when tank furnace is in operation) is installed 60 metres away from the tank furnace, which signifies that there is back track of production flow.

Coal is stored near the main gate, which is not only a safety hazard but inhibits the flow of materials also.

House-keeping around the pot furnace is satisfactory, but overall it is not good. The working conditions in the factory area are very poor.

3.2.3.3 Key Methods/Technology

For raw material preparation, washing and sieving of the sand is not practiced. There is one magnetic separator available for sand.

For batch preparation, weighing of the ingredients is done manually in pan balances. One horizontal rotary type mixing machine is available for mixing, but the same is not in operation. The mixing of the batch ingredients is thus carried out manually in shallow trays using shovels.

Washing and segregation of cullets is done manually but sizing of the cullets is not being practiced.

Typical batch composition being used by the unit for production of clear soda glass in pot furnace is as follows.

Constituent	Weight(kg)	Weight %
Sand	80.00	63.29
Soda ash	34.00	26.90
Felspar	3.00	2.40
Dolomite	2.00	1.60
Arsenic trioxide	1.00	0.80
Sodium silico fluoride	0.50	0.40
Potassium permanganate	0.20	0.16
Tanka (Cobalt/selenium/borax)	0.20	0.16
Borax	3.00	2.40
Sodium nitrate	2.50	1.98
	126.40	100.00
Cullet(approx.)	100.00	
	226.40	

The technologies used for glass forming are basically traditional which are well established practices followed in Firozabad. The methods followed in forming the molten glass into the required shapes are drawing, blowing, moulding or pressing . The processes are carried out manually by using moulds and blow pipes.

Annealing is done in Annealing Chambers or in Annealing Lehr (presently not working).

3.2.4 RESOURCES

3.2.4.1 Manpower

The total manpower strength at Manohar Glass Works as on June 1993 was 123 nos. The break-up is as follows:

On rolls	:	48 no.
Contract labour	:	75 no.
		123 no.

There are a few persons at the top, who are either partners or their relatives, who manage the business. It is noted that none of the managerial/supervisory staff is technically qualified. Some of their on-rolls employees also supervise the different production areas and keep a watch on the contract labour, to extract maximum amount of work from them. Contract labour have to work in a very poor working environment i.e. constant exposure to fumes and coal dust, working near the furnace at a temperature of 300-400 deg. C, handling the molten glass on iron rods without wearing any gloves etc., which affects their health adversely.

It is observed that narrow based single skilling is predominant throughout the production areas.

3.2.4.2 Production Equipment

The equipment and machinery installed in the production areas is generally adequate for current production volumes. The locally fabricated coal fired 12-pot furnace has a capacity of 3-4 tonnes / day (pot capacity 360 kg).

Fire clay refractories with poor insulation are used in the furnace. Pot type furnace is made of about 225 mm thick refractory bricks. The approx. dia and height of melting zone is 3.6 m and 1.5 m respectively. Twelve pots are placed along the periphery of the furnace. There are 12 openings provided to draw the molten glass out of the pots. Underneath the pots, coal is fired and hot gases are made to circulate around the pots. Underground ductings are provided through which the flue gases are conveyed to the chimney.The hearth temperature is between 1350-1450 deg.C. Only one temperature indicator is installed to monitor the hearth temperature. The furnace design is not satisfactory resulting in high coal consumption and heat losses. The pot life is uncertain and it is reported that the average life of the pot is around 15-20 days. It seems that the pot is made from poor quality of clay.

The condition of other equipment like Annealing Chambers, Pot-preheating furnace, Melting Bhatti (Fire Polishing Machine)and cutting machine (all are locally fabricated) is not satisfactory.

A list of the equipment provided is placed in Annexure 3.2.1.

3.2.4.3 Facilities/Utilities/Services

The works has no laboratory for testing and inspection of either raw materials or products at intermediate or final stages. Material handling facilities are inadequate . Only one trolley based lifter (locally fabricated) for transporting pots from pre-heating chambers to the furnaces is provided.

3.2.5 ENERGY AUDIT

3.2.5.1 Working Parameters

The working parameters of the furnace such as coal consumption were taken from the management. The other parameters, such as furnace temperature, molten batch temperature, average side and crown temperatures alongwith stack temperatures , the flue gas flow rate and carbondioxide percentage in the flue gas were measured to find out heat utilisation and heat losses. Similarly measurements and data were taken pertaining to pot preheaters and annealing chambers. Details of working parameters are shown in Annexure 3.2.2.

3.2.5.2 Heat Balance

From the measurements and fuel consumption figures of the pot furnace, the heat utilisation and the various losses had been worked out and the same are presented in the pie-chart,Sketch No. 3.01.

3.2.5.3 Analysis

The reasons for various heat losses in the furnace and annealing chamber are tabulated as under.

Heat Losses		Reasons
Pot Furnace		
Flue gas loss	i)	High stack temperature
	ii)	Presence of large amount of excess air.
Radiation loss	i)	Ageing of the furnace
	ii)	Poor quality of refractories
	iii)	No insulation
Annealing Chamber		
		Volume of annealing chamber is very large compared to the volume of the material to be annealed.

Electric power is supplied by the state authorities and the service is inadequate due to unscheduled power cuts and erratic supply. A captive 62.5 kvA DG set is used when annealing lehr is in operation.

3.2.6 MANUFACTURING SYSTEMS

3.2.6.1 Production Planning & Control

On receipt of order from the party (which directly contacts them), plan to manufacture the same is drawn up, based on quantities and scheduled time. There are no systems or procedures for detailed planning.

Raw materials, fuels, moulds/dies and contract labour is arranged depending upon the order. The key indicator against which production is monitored is the daily production of glass products.

3.2.6.2 Material Planning & Control

Partner/key personnel is responsible for material planning & control. Materials requirements are roughly estimated and purchased from the local market (even the imported raw material Arsenic trioxide is available locally on rupee payment from local suppliers).

It was pointed out by one of the partners that coal received from Coal India is of very poor quality. Many times Coal India supplied grade C or D coal instead of grade A or B coal. The supply is also erratic and sometimes the delay of alloted coal supply is up to 2 years . So they have to purchase good quality coal from local suppliers at higher rates.

There is no shop floor control of the materials. The rejection, which is recycled, is of the order of 25 to 50 % depending on the design of the glass product.

Inventory levels of raw materials is 15 days. For coal it is 6 to 7 days and for finished goods, it is also 6 to 7 days as reported.

3.2.6.3 Maintenance

There is only reactive maintenance in these types of works, as owners give less importance to preventive maintenance. There are no log books maintained by the owner.

There is a small maintenance shop where locally fabricated cutting machines, grinders, moulds/dies are repaired.

3.2.6.4 Quality Control

There is no method of controlling the quality of glass products. As the methods of forming are mostly manual, thickness and weight of each piece is not uniform and sometimes bubbles appear in the product. The quality is inferior than the quality standards. Only visual checks are done.

3.2.7 POLLUTION

The main source of pollution is usually the emission from the stack of the furnace , which affects the ambient air quality. Measurements have been taken to check the quality of stack emissions, ambient air, waste water and solid waste, and these are discussed in the following paras.

3.2.7.1 Stack Emission Quality

Monitoring of the stack gases has been carried out by simultaneously sampling for SPM (suspended particulate matter) and gaseous pollutants such as Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), and Carbon Monoxide (CO). The stack emission quality for Manohar Glass Works was found to be as follows.

Stack height	29 m
Velocity	8.8 m/s
Stack temperature	450° C
Quantity of emissions	10250 Nm^3/hr
SPM	883 mg/Nm^3
SO_2	134 mg/Nm^3
NO_x	63 mg/Nm^3
CO	275 mg/Nm^3

As seen from the above values, the SPM value of 883 mg/Nm^3 is below the limit of 1200 mg/Nm^3 prescribed by the CPCB (Central Pollution Control Board), but exceeds the ammended value prescribed by the Ministry of Environment & Forests (150 mg/Nm^3).

SO_2 level is 134 mg/Nm^3 . Even though no limit has been prescribed so far by the CPCB, a new limit of 50 mg/Nm^3 prescribed by the Ministry of Environment and Forests will be applicable from 1994 onwards. Hence control measures have to be taken to bring down the SO_2 value below 50 mg/Nm^3.

Regarding NO_x value, there is no limit presently prescribed by CPCB. Measures to be adopted by the unit for reducing the SO_2 value will also improve the NO_x values.

CO level in the stack emission, at 275 mg/Nm^3 is high and indicates improper combustion of fuel. For optimum combustion efficiency, the flue gas should be maintained with above 12% CO_2 or with 4% O_2, which will in turn reduce the CO concentration appreciably.

3.2.7.2 Ambient Air Quality

Ambient air quality measurements with respects to the various pollutants were carried out inside the factory premises at two locations and the results are shown below.

Parameter	Value in ug/m^3	
	Near Office	Near Furnace
SPM	2446	2096
SO_2	212	61
NO_x	51	22
CO	3250	3430
F	42	18

As seen from the above table, the SPM level exceeds with respect to CPCB norms prescribed for industrial area (500 ug/m^3)

The value of SO_2 near the office is found to be higher than the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

The NO_x value is well below the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

The CO value is well below the limit of 5000 ug/m^3 prescribed by CPCB for industrial area.

Regarding the Fluoride concentration, there is no standard so far prescribed by CPCB. However, the limits prescribed by OSHA show that:

The origin of Fluoride is mainly from furnace gases where fluoride is also a constituent in the raw material in the form of CaF_2 . Studies in fluoride show that it is a very potent gaseous pollutant and adequate measures are to be taken to contain the hazard.

3.2.7.3 Water Pollution

Water is mainly used for cooling purposes and for human consumption. The water pollution problem is not accute.

3.2.7.4 Solid Waste

Solid waste is mainly generated from coal which is being used as a fuel. In general , the analysis of solid waste of some of the glass units indicates that the parameters are more or less as expected, except aluminium which is present in high percentage.

No specific area in t' e plant is marked for dumping the solid waste.

3.2.8 PERFORMANCE

3.2.8.1 Raw Material Consumption

Based on the information collected from the management, the consumption of major raw materials and cullet per tonne of the molten glass works out to be as follows.

Sand	0.37 t/t draw
Soda ash	0.16 t/t draw
Cullets	0.50 t/t draw

3.2.8.2 Energy Consumption

The unit consumes 4 tonne of coal for a draw of 3 tonne of glass. The specific energy consumption thus works out to be 22.3 million kJ/t draw, which is unduly high.

3.2.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 50 %.

3.2.8.4 Pollution

The observed parameter values of stack emission and ambient air, when compared with the latest limits prescribed by the Central Pollution Control Board/Ministry of Environment & Forests indicate the following.

Stack Emissions :

- SPM values exceed the limits
- SO_2 values exceed the limit
- CO value is high

Ambient Air:

- SPM values exceed the limit
- SO_2 value exceeds the limit
- NO_x value within the limit
- CO value within the limit
- Fluoride is present

Annexure 3.2.1

PLANT & MACHINERY

S.No.	Section	Type of Plant & Machinery
1.	Batching	Mixing machine, horizontal rotary type, with fixed blade capacity 150 kg, cycle time 5 min., 10 HP, (Not in operation) Iron separator Weighing balance, 1 quintal capacity
2.	Melting	Closed Pot Furnace (Japanese), with 12 pots, with capacity 340 kg each. Drawing capacity 3-4 tpd. Tank furnace, capacity 15 tpd, presently not working.
3.	Pot Pre-heating	Pot preheating furnace, coal fired, having capacity to preheat 2 pots.
4.	Forming	Mouth blowing pipes, rods, cups for making shells, glass ware, shades etc. Hand drawing rods for tubing. Pressing dies, moulds and presses.
5.	Annealing	Annealing chambers, coal fired, cycle time 3 days;Dimensions 2.4 m x 3 m x 2.4 m. Annealing Lehr, electrical/kerosene fired,size 1.2 m belt width x 300 mm ht x 27 m length (not working presently)
6.	Finishing	Melting Bhatti (Fire Polishing Machine) for smoothening of edges. Cutting machines Grinding machines

Annexure 3.2.2

WORKING PARAMETERS

Melting Furnace

1. Furnace t.:mperature,deg.C	1530
2. Molten h·· h temp. ,deg.C	1420
3. Avg. sid. wall temp.,deg.C	265
4. Avg. crown temp., deg.C	300
5. Stack temp. deg.C	560
6. Carbondioxide in flue gas (%)	7
7. Oxygen in flue gas (%)	13
8. Excess air (%)	150

Annealing Lehr/Chamber

10. Chamber temperature, deg.C	475
11. Avg. surface temp., deg.C	100

Pot Heating Furnace

12. Inside temp., deg.C	580
13. Avg. surface temp., deg.C	120

3.3 SHIV CHINA GLASS MANUFACTURING CO.

3.3.1 DESCRIPTION OF SITE

3.3.1.1 Size and Location

The works is located on Station Road, within one km northwards from the Firozabad Railway Station, and falls on the eastern side of the road. The factory is located on the main road itself.

The works occupy an area of around 5600 Sq.m, with a covered area of around 2500 Sq.m.

3.3.1.2 Principal Features

The works is well connected by road along the railway line (Station Road). The railway station is at a distance of about 3 km by road from Agra Road (National Highway No.2).

There are other glass units in the area nearby, such as Ashok Glass Works, Adarsh Glass Works, Shri Durga Glass etc. Also some cottage scale establishments for mechanical maintenance, die making etc are located in this area.

3.3.1.3 Constraints/Suitability

The factory site being well connected by road and near to the railway station, there is no constraint regarding transportation of materials in and out of the works.

The factory has sufficient space for the present scale of operations, but it would not be possible to extend the boundaries of the site, as it is surrounded by other units.

3.3.2 PRODUCTS

3.3.2.1 Product Features

The works is involved in the manufacture of the following products.

- Bulb shells
- Lead glass tubes
- Glass ware items such as shades, tumblers, chandelier parts and vials.
- Glass rods for beads

* Laboratory glass ware including dropper tubes, flasks, beakers, etc.
* Auto headlights

The export of some of the above producs (about 25 %) is done indirectly through dealers in Delhi, Bombay, Calcutta, Kanpur, Mathura, and Muradabad. For domestic use, gererally the party approaches them directly for marketing.

3.3.2.2 Production Volume and Value

The production volume for the year 1992-93, during which closed pot furnace (Japanese type) was in operation, amounted to 531 tonnes for 166 operational days.

The value of the above production has been reported by the unit as Rs 11.95 million, on the basis of average value of Rs 22,500/tonne.

3.3.3 PRODUCTION

3.3.3.1 Features of Production Areas

Melting of the batch is done in 12 pot closed furnace, housed in industrial shed. The furnace is provided with a 43 m high chimney constructed with brick work.

There is a coal fired Direct Tank furnace, which is presently not working.

Mixing of various ingredients with culiets is undertaken near the pot furnace area. Forming of the molten glass to the desired shape is done near the furnace.

Facilities for pre-heating of the pots, annealing the glass products and finishing to the required shape are located in separate areas.

Separate areas are provided for raw-material storage and coal storage.

3.3.3.2 Layout/Material Flow

The layout is not as per the process flow. For example the raw-material storage is far away from the batch feeding point for closed pot furnace and similarly, pot preheaters are installed by the side of the tank furnace. far away from the pot furnace.

The finishing area is not clearly demarked. Annealing chambers are far away from the packing area.

Housekeeping is not satisfactory in the production area. The working conditions in the factory are very poor.

3.3.3.3 Key Methods/Technology

The methods followed for manufacturing glass products are as under.

i) For preparation of the raw materials, sand washing and iron removal from sand are not practiced. Sieving of the sand is also not being practiced.

   Segregation of cullets is done manually, but sizing of cullets is not being practiced.

   For preparation of the batch, weighing of ingredients is done using weighing balance. Mixing is done manually in batch trays with shovels which is not satisfactory.

   Typical batch composition used by the unit for production of crystal glass in Pot Furnace is given as follows.

Constituent	Weight(kg)	Weight %
Sand	100.00	59.40
Soda ash	40.00	23.70
Borax	3.00	1.80
Sodium nitrate	2.50	1.50
Arsenic trioxide	1.25	0.70
Potassium carbonate	6.00	3.60
Lead oxide	5.00	3.00
Barium carbonate	0.50	0.30
Dolomite	5.00	3.00
Calcite	2.50	1.50
Felspar	2.50	1.50
	168.25	100.00
Cullet (approx.)	60.00	
	228.25	

ii) The technologies used for glass forming are basically traditional and according to the well established practices followed in Firozabad.The forming operations are mouth blowing and pressing using pipes, shaping cups, moulds and hand presses.

iii) The finishing operations of cutting, grinding, buffing, smoothening of edges are performed on individual work-stations using locally fabricated machines.

iv) Annealing of products is done in chamber type, coal fired annealing chambers, of crude design. The cycle time of annealing is about 72 hrs. The owner / key personnel is not conscious of the annealing cycle for glass.

3.3.4 RESOURCES

3.3.4.1 Manpower

The total manpower strength at Shiv China during full production from pot furnace, as reported by the unit , is between 90-100, out of which 16 workers are on rolls.The break-up is as follows:

On rolls : 16 Nos.
Contract labour : 75-85 Nos.

In this unit also, none of the managerial/supervisory staff is technically qualified.

Out of the 16 regular payroll employees, there are 11 firemen (1 fireman + 2 helpers per s[illegible] plus two replacemants),for pot furnace. Some of their on-rolls employees also supervise the different production areas and keep a watch on contract labour.

Contract labour, which include women , have to work in a very poor working atmosphere i.e., constant exposure to coal fumes, dust, working near furnace at a temperature of 300-350 deg.C, handling the molten glass on iron rods without having any safety devices.

3.3.4.2 Production Equipment

The plant and equipment installed in the production areas is generally adequate for current production volumes.

The mixing of ingredients for making the batch is done manually in shallow rectangular trays with the help of shovels.

The locally fabricated closed pot furnace (12 pots), coal fired, has a capacity of 3 to 4 tpd. (Pot capacity 360 kg). Fire brick is used for the furnace arch with no insulation. The pot type furnace is made up of refractory bricks of 225 mm thick wall. The melting zone has a circular cross section of approx. 3 m and 900 mm height. The hearth temperature is between 1250 - 1350 deg. C, but there is no temperature indicator to monitor the hearth temperature .

The pot life is uncertain and it is reported that the average life of a pot is around 30 days.

The condition of other equipment like Annealing Chambers, Pot pre-heating furnace, Rocsa Bhatti (Annealing Furnace for large pieces), and some of the hand presses is very poor.

A list of the equipment is placed at Annexure 3.3.1.

3.3.4.3 Facilities/Utilities/Services

There is no provision in the unit for carrying out any quality tests. Only by visual inspection, it is observed whether the quality of the products is up to the desired standards or not.

Material handling facilities are inadequate. Only one trolley based lifter (locally fabricated) is usedfor transporting heated pots from pre-heating chambers to the furnace and transporting hot cracked pots from the furnace.

Requirement of power is only of the order of 25 kW and requirement of water is also not significant.

3.3.5 ENERGY AUDIT

3.3.5.1 Working Parameters

The working parameters of the pot furnace such as draw rate and coal consumption were taken from the management. The other parameters such as furnace temperature, molten bath temperature, average side and crown temperature alongwith stack temperature, flue gas flow rate and carbondioxide percentage in the flue gas were measured to find out heat utilisation and heat losses. Similarly , data measurements pertaining to pot pre-heaters, annealing chambers were taken. A list of the working parameters is shown in Annexure 3.3.2.

3.3.5.2 Heat Balance

From the measurements and fuel consumption figures of pot furnace, the heat utilisation and various heat losses have been worked out and the same are presented in the pie-chart, Sketch No. 3.02.

3.3.5.3 Analysis

The useful heat of the furnace is just 8.80 % of the total heat input. The unaccounted losses are 35.90 %, which is obviously on a very high side and should not normally exceed 10 %. The useful heat is dependent on draw rate and fuel consumption and,it seems that the fuel consumption figures provided by the management are not correct and are on much higher side.

Moreover, the furnace efficiency could not be so low as the furnace was commissioned recently and is authenticated by the low radiation loss when compared with other units. As radiation loss depends upon the quality and ageing of the furnace, it is clear that the actual useful heat would be much higher at the initial stages. The flue gas loss is characterised by the high stack temperature of the furnace operating without any heat recovery device. Excess air is found to be well within the control.

3.3.6 MANUFACTURING SYSTEMS

3.3.6.1 Production Planning Control

On receipt of order from the party, which directly contacts them, planning is carried out to manufacture the lot, based upon the quantity and time. Orders for procurement of moulds dies, if not available in the stock, are given (sometimes, the party brings their own moulds in case of special design).There are no systems or procedures adopted. For management of the production, good workers are employed and the only indicater of production control, is the daily output of glass products.

3.3.6.2 Material Planning & Control

The owner is responsible for material planning . The requirements of materials are estimated and purchased from the local market (even the imported raw materials such as Arsenic trioxide are available locally on rupee payment from the local supplier).

The owner is not at all satisfied with the quality of coal from Coal India, which is either of Grade B or C and was also complaining about its erratic suply. The consumption of coal for production of 531 tonnes of glass was 1112 tonnes. There is no shop floor control of the materials. It is reported that the rejection , which is recycled , is of the order of 30-40 % .

Inventory levels of raw materials is kept for 30 days. For coal, it is for 7 days, and for finished goods, sometimes it is between 10-15 days.

3.3.6.3 Maintenance

No preventive maintenance is done in the works. The only maintenance they do is the break-down maintenance. There are no records or history cards of the equipment . It is reported that when a pot cracks/leaks in the furnace and for replacing a new pot it requires 100 kg of fireclay bricks and 120 No. of ordinary bricks and labour. There is no provision for any maintenance of moulds/dies or presses.

3.3.6.4 Quality Control

There is no method of controlling the quality of the products. The emphasis is given on the quantity rather than quality . Everything is left on the workers, who also give importance to the production. Only visual checks are made before packing the finished goods.

3.3.7 POLLUTION

The unit uses coal as fuel. Therefore the main source of pollution will be from the stack emissions which affect the quality of the surrounding ambient air. The unit has a well built chimney of 43 m height. As reported by the management, the pollution control agency at Agra had tested the stack gases sometimes in the past, and the result of the flue gas analysis indicated the SPM and SO_2 values to be within the prescribed limits.

3.3.8 PERFORMANCE

3.3.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of major raw materials and cullets works out to be as follows.

Sand	0.49 t/t draw
Soda ash	0.20 t/t draw
Cullets	0.30 t/t draw

3.3.8.2 Energy Consumption

Based on the data collected from the management on the consumption of coal and the corresponding draw of molten glass, the specific consumption of energy works out to be 22.3 million kJ/t draw.

3.3.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced . The rejection rate for the unit works out to be 30 %.

Annexure 3.3.1

PLANT & MACHINERY

S.No.	Section	Type of Plant & Machinery
1.	Batching	Weighing balance, cap. 100 kg, steel mixing trays with shovels , charging shovels. Batch handling boxes of 40 kg capacity.
2.	Melting	Closed Pot (12 pots) Japanese type furnace, coal fired, Pot capacity 360 kg. Direct Tank Furnace, coal fired of capacity 24 tpd (not working)
3.	Forming	Forming tools such as pipes, rods, cups, cutter, tongs, hand presses, etc.
4.	Annealing	Annealing Chambers (Coolie man), brick work construction, coal fired crude design, locally fabricated,temperature 600 deg.C.
5.	Pot Preheating	Pot preheating chambers to preheat 2 pots, brick work construction with no chimney.
6.	Finishing	Finishing equipment & tools such as cutter with heating element, Grinding machine, Buff polishing machine, Melting machine, kerosene oil fired.

Annexure 3.3.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temp., deg.C	1441
2.	Molten bath temp., deg.C	1270
3.	Avg. side wall temp., deg.C	200
4.	Avg. crown temp., deg.C	240
5.	Stack temp., deg.C	548
6.	Carbondioxide in flue gas, %	11.5
7.	Oxygen in flue gas, %	8
8.	Excess air, %	55

Annealing Lehr/Chamber

9.	Lehr Chamber temperature, deg.C	650
10.	Avg. surface temp., deg.C	80

Pot Heating Furnace

11.	Inside temperature, deg.C	540
12.	Avg. surface temp., deg.C	110

Sikai Bhatti

13.	Inside temp., deg.C	975
14.	Avg. surface temp., deg.C	100

Belan Bhatti

15.	Inside temp., deg.C	650
16.	Avg. surface temp., deg.C	85

3.4 POOJA GLASS WORKS

3.4.1 DESCRIPTION OF SITE

3.4.1.1 Size and Location

The works is located on Delhi-Agra Road (National Highway No.2) within 6 km from Firozabad. The enterance gate of the works is on the main road, Raja ka Tal - Agra Road . The site is about 7 km from Firozabad Railway Station.

The works occupies an area of around 7000 Sq.m. out of which about 2500 Sq.m is covered area.

3.4.1.2 Principal Features

Pooja Glass Works is in the industrial area and the site is adjacent to Om Glass Works. The works is quite new and the manufacturing operations started in 1990. Access by road is reasonable and there is rail head nearby.

3.4.1.3 Constraints/Suitability

There are no constraints including transportation of materials, bought-outs and finished goods, to and fro from the works. The site is well suited to manufacturing operations and has enough space for future expansion.

3.4.2 PRODUCTS

3.4.2.1 Product Features

The unit is involved in the manufacture of a wide variety of soda lime glasses and lead glass(lead content 4-5 %) as under.

- Glassware (Tumblers, cups, bowls, etc.)
- Auto headlight covers
- Lead tubes for bulbs
- Fine glass (lead content 4-5 %)
- Chimneys
- Jars
- Candle stands
- Ash trays
- Tubes & rods

The products are manufactured in colour shades such as red, green, blue, etc. Decorative work on clear glass items such as tumblers, flower vases, bowls, etc is also carried out in the unit.

The unit exports about 50 % of its items to developed countries such as U.S.A, Canada, U.K.,Germany, as reported by the management of the unit.

3.4.2.2 <u>Product Volume/Value</u>

The average production as reported is about 3 tpd when only closed pot furnace (Japanese type) is in operation. The value of the abov production has been reported as Rs 25,000/tonne.

3.4.3 PRODUCTION

3.4.3.1 Features of Production Areas

Melting of the batch is done in closed pot (12 pots), coal fired furnace, which is housed in industrial type shed and equipped with chimney of height 37 m. There are areas for Direct Tank Furnace, coal fired (presently not working) and oil fired Regenerative type Tank furnace (under modification) and another new design small tank furnace (under construction).

Mixing of the various ingredients and forming of the molten glass to the desired shape either by blowing or pressing is done near the furnace . There are areas for Annealing Lehr, Pot Preheaters, Roosa Bhatti (Annealing Furnace for large pieces) in the lean-to shed.

Separate areas are provided for packing of the products, finished goods store and coal storage.

3.4.3.2 Layout/Material Flow

The overall layout has not been based on any specific flow , but has simply evolved over a period of time. The owner has tried melting in direct tank furnace, closed pot furnace and oil fired Regenerative tank furnace (under modification). Lack of space obstructs movement of material between two closed pot furnaces when both are in operation.

The working condition in the factory is very poor. House keeping is not satisfactory in the production area.

3.4.3.3 Key Methods/Technology

The technology used for manufacture of glass products is traditional and manual as in other units of Firozabad. The main operations followed for manufacture are as under.

i) For preparation of the raw materials the unit procures washed silica sand, but magnetic separation is not being practiced. Sieving of the sand is also not being practiced.

For batch preparation, weighing of ingredients is done manually, using balances Mixing is done manually in batch trays with shovels and is not satisfactory.

Washing and segregation of cullets is done manually, but sizing of the cullets is not being practiced.

Typical batch composition being used by the unit for glass melting in the pot furnace is given as follows.

Constituent	Weight(kg)	Weight(%)
Silica sand	100.00	65.04
Soda ash	42.00	27.30
Borax	3.00	2.00
Arsenic trioxide	0.25	0.16
Dolomite	3.00	1.95
Calcite	3.00	1.95
Sodium nitrate	2.50	1.60
Selenium oxide	0.003	-
Cobalt oxide	0.005	-
	153.76	100.00

ii) Melting of the batch is done in closed pot furnace, coal fired, in which pots are loaded with the raw material batch and firing is started, which continues for 18 to 20 hours for the batch to be ready . The glass from each pot is drawn in single shift.

iii) The forming operations are mouth blowing and hand pressing.

iv) Annealing is done in oil fired Annealing Lehr and Annealing Chambers, coal fired, which is not satisfactory.

v) Fire polishing is performed on melting machine and edge grinding on grinding machine.

vi) Cut work designs on glass wares such as tumblers, flower vases, bowls, etc are carried out by means of grinding discs and the pieces are then subsequently buff polished.

3.4.4 RESOURCES

3.4.4.1 Manpower

The total manpower strength at Pooja Glass Works, as reported, is 200. The break-up is as under.

On rolls	:	50 Nos.
Contract labour	:	150 Nos.
		200 Nos.

The break-up of the on-rolls employees is as follows:

Manegerial	:	4 Nos.
Supervisory	:	7 Nos.
Staff	:	4 Nos.
Workers	;	35 Nos.
		50 Nos.

This includes firemen working in 3 shifts. Among the contract labour , many children and women workers were seen during the visit to the works. It was also noted that contract labour was far more in number than reported by the owner. Contract labour were working in a very poor working environment and are exposed to hazardous toxic fumes. Even the child labourers were working near the furnace, handling the molten glass on iron rods without any gloves etc.

3.4.4.2 Production Equipment

The production areas are generally equipped with the types of equipment which are adequate for the production techniques being followed in the works. The type of equipment being used are shown in Annexure 3.4.1.

There are two number coal fired closed pot furnaces, (pot capacity

270 kg) having a drawing capacity of 3 tpd. Refractory bricks of 230 mm thickness are used for construction, with no insulation. The melting zone has a cross-section of approx. 3.6 m diameter and 1.5 m height.

The temperature of flue gases is 1250 deg.C. which is indicated by the temperature indicator installed. The pot life is uncertain and it is reported that the average life of the pot is around 15 - 20 days. Coal consumption per tonne of glass is very high because of high heat losses.

There are other furnaces such as Direct Coal fired Tank furnace (under modification) and a small Tank furnace (new construction) which were not in operation.

The condition of other equipment such as coal fired Annealing Chambers, Pot - Preheaters, coal fired, and hand presses except Annealing Lehr is very poor.

3.4.4.3 Facilities/Utilities/Services

There is no provision in the unit for carrying out any quality tests either on raw materials or at intermediate stage or at final stage.

The works has a maintenance workshop for repair of moulds/dies and other equipment such as hand presses, grinding machine etc.

Material handling from one workstation to another is done manually.

Electric power is supplied by state authorities, but the service is inadequate due to power cuts and erratic supply. Two captive DG sets of 15 HP each are provided, for use during power breakdowns.

There are two compressors, one of 10 HP motor and other of 5 HP motor for generating compressed air required for Annealing Lehr and fire polishing machines. Water is taken out by tube well for catering to the needs in the factory premises.

3.4.5 ENERGY AUDIT

3.4.5.1 Working Parameters

The working parameters of the two pot furnaces, such as draw rates and coal consumption were taken from the management. The other parameters for the two furnaces such as furnace temperatures, molten bath temperature, average side and crown temperatures, flue gas flow rates and carbondioxide percentage in the flue gas were measured to find out the heat utilisation and heat losses of each pot furnace. Similarly measurements and data were taken pertaining to pot preheaters and annealing lehrs/ chambers. A list of working parameters is shown in Annexure A.3.4.2.

3.4.5.2 Heat Balance

From the measurements and fuel consumption figures of the pot furnaces, the heat utilisation and various heat losses had been worked out and are presented in the pie-chart, Sketch No. 3.03.

3.4.5.3 Analysis

Pooja Glass Works have dirct closed type pot furnaces with an efficiency of 8.8 %. Both the pot furnaces were found to have the same efficiency as per the calculations which are based on the information given by the management.

The flue gas loss is found to be the highest among the rest of the units as no control is excercised on the excess air level and stack temperature . Both the parameters were recorded to be high, resulting in high flue gas loss.

When analysing the causes for the difference in radiation loss between the two pot furnaces the reasons seem to be the factors such the time difference in the construction of the furnace, quality of construction if both furnaces are constructed of the same quality of refractories .

Regarding the annealing lehr, the furnace volume was twice that of the volume of the material to be annealed.

3.4.6 MANUFACTURING SYSTEMS

3.4.6.1 Production Planning and Control

The purchasing party approaches the factory owner manager and shows the drawing of the item to be purchased. A sample is got made in the unit and after getting approval of the sample from the party, plan to manufacture the same is made on receipt of the firm order from the party. Orders for the procurement of the moulds/dies, if not already present in the stock, are given. Raw materials planning is also done based upon the quantity of each product.

There are no systems or procedures adopted for any production planning or control.

The only indicator of production control is the daily output of the glass products.

3.4.6.2 Material Planning and Control

Owner is responsible for material planning. Material requirements are roughly estimated based on the order quantity and purchases are made from the local market.

The owner is satisfied with the quality of the raw materials received from the local market but he was complaining about coal quality and the undue late release of Government quota by Coal India.

There is no shop floor control of the materials. The rejection, which is recycled, is of the order of 40 to 50 % depending on the design of the glass product.

Inventory level of raw materials is 15 days. For coal it is 7 days and for finished goods, it is 15 days , as reported.

3.4.6.3 Maintenance

There is only break-down maintenance in these type of works, as the owners give preference to quantity of goods produced. Even the records of maintaining the furnace are not kept.

There is a small maintenance shop, where locally fabricated moulds/dies, fire-polishing machines or presses are repaired but the maintenance of the furnaces is contracted out.

3.4.6.4 Quality Control

There is no method of controlling the quality of the glass products. Mixing of the ingredients of the batch is done manually. Washing of the sand and removing of the suspended particles is not done within the plant. It was informed that sometimes they get the batch tested from the CIGI.

Quality is left totally on the workers, who also give importance to the quantity of the glass production. Only visual checks are made before packing the finished goods.

3.4.7 POLLUTION

The main source of pollution is usually the emissions from the stack of the furnace, which affect the ambient air quality. Measurements have been taken to check the quality of stack emissions, ambient air, waste water and solid waste, and the same are discussed in the following paras.

3.4.7.1 Stack Emissions Quality

Monitoring of the stack gases has been carried out by simultaneously sampling for SPM (suspended particulate matter) and gaseous pollutants such as Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), and Carbon Monoxide (CO). The stack emissions quality for Pooja Glass Works was found to be as follows.

Stack height	3.5 m
Velocity	3.4 m/s
Stack temperature	200 ° C
Quantity of emissions	4558 Nm^3/hr
SPM	1650 mg Nm^3
SO_2	144 mg/Nm^3
NO_x	26 mg/Nm^3
CO	114 mg/Nm^3

As seen from the above data, the SPM level for the unit is high at 1650 mg/Nm^3 against the norm of 1200 mg/Nm^3 prescribed by CPCB (Central Pollution Control Board). Further , the new norm of 150 mg/Nm^3 prescribed by the Ministry of Environment and Forests will be applicable from 1994 onwards, which will further aggravate the situation.

The SO_2 level for the unit is 144 mg/Nm^3. Even though no limit has been prescribed by CPCB, a new limit of 50 mg/Nm^3 prescribed by the Ministry of Environment & Forests shall be applicable from 1994 onwards . Hence the unit has to adopt control measures for reducing the SO_2 level in the stack emissions.

Regarding NO_x value , no limit has been presently prescribed by CPCB. Also, measures to be adopted by the unit for reducing the SO_2 levels will also bring down the NO_x level for the unit.

The CO level is 114 mg/Nm^3 as above, which indicates that fuel is not burning properly . The efficiency of fuel burning can be brought upto the mark by maintaining the flue gases with 12 % CO_2 or by 4 % O_2.

3.4.7.2 Ambient Air Quality

Ambient air quality measurements with respect to the various pollutants were carried out inside the factory premises at three locations and the results are shown below.

Parameter	Value in ug/m^3		
	Near Office	Near Furnace	Near Godown
SPM	648	2913	640
SO_2	26	125	9
NO_x	42	68	21
CO	942	5250	983
F	32	60	15

As seen from the above table, the SPM level exceeds the norm prescribed by CPCB (500 ug m^3) at all the three locations and is particularly high near the furnace.

The value of SO_2 level near the furnace is marginally above the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

The NO_x value is well below the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

The CO level is marginally above the limit of 5000 ug/m^3 prescribed by CPCB for industrial area.

Regarding the Fluoride concentration, there is no standard so far prescribed by CPCB. However, according to OSHA standards, this being a very potent gaseous pollutant, adequate measures are to be taken to contain the hazard.

3.4.7.3 Water Pollution

Water is mainly being used for human consumption. The water pollution is not an acute problem.

3.4.7.4 Solid Waste

The analysis of Coal Ash samples from Pooja Glass indicated the parameters to be normal, except aluminium, which was found to be present in high percentage.

There is no specific area in the plant that has been marked for dumping of solid waste.

3.4.8 PERFORMANCE

3.4.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of major raw materials and cullets works out to be as follows.

Sand	0.39 t/t draw
Soda ash	0.16 t/t draw
Cullet	0.50 t/t draw

3.4.8.2 Energy Consumption

The unit consumes 1.4 tonnes of coal per tonne of draw. The specific energy consumption thus works out to be 23.4 Million kJ/t draw.

3.4.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 50 %.

3.4.8.4 Pollution

The observed parameters of stack emission and ambient air quality when compared with the latest limits prescribed bv the CPCB/Ministry of Environment & Forests, indicates the following.

Stack Emissions:
- SPM value exceeds the limit
- SO_2 value exceeds the limit
- CO value is not satisfactory

Ambient Air:

- SPM value exceeds
- SO_2 value marginally exceeds
- NO_x value below the limit
- CO value marginally exceeds the limit
- Fluoride is present

Annexure 3.4.1

PLANT AND MACHINERY

S.No.	Section	Type of Equipment
1.	Batching	Weighing balance, Cap. 100 kg & 2 kg Trays and shovels
2.	Melting	Closed pot furnace (12 pots), Cap. of each pot 240 kg, coal fired. Direct coal fired Tank Furnace, cap. 8 tpd. Regenerative oil fired tank furnace, (under modification) New Tank Furnace, oil fired, Cap. 1 tpd (new construction)
3.	Forming	Mouth-blowing pipes, moulds, hand presses, lever operated.
4.	Annealing	Annealing Lehr, oil fired,size 600 mm x 300 mm x 18 m long; belt speed 18 m per 45 min., temperature 500 deg.C, cap. 300 kg / 45 min. Annealing chambers, coal fired, chamber size 2.4 m x 3 m x 2.4 m height.
5.	Finishing	Melting machine for fire polishing. Grinding machines. Grinding discs for cut-work design. Buff polishing machines.

Annexure 3.4.2

WORKING PARAMETERS

	Furnace-1	Furnace-2
Melting Furnace		
1. Furnace temp., deg.C	1450	1475
2. Molten bath temp., deg.C	1325	1303
3. Avg. side wall temp., deg.C	280	175
4 Avg. crown temp., deg.C	290	225
5. Stack temp., deg.C	690	690
6. Carbondioxide in flue gas, %	7.5	7.5
7. Oxygen in flue gas, %	12.2	12.5
8. Percentage excess air	135	135
Annealing Lehr/Chamber		
9. Lehr/Chamber temp., deg.C	447	
10. Avg. surface temp., deg.C	75	
Pot Heating Furnace		
11. Inside temp., deg.C	675	
12. Avg. surface temp., deg.C	125	

3.5 ADARSH GLASS WORKS

3.5.1 DESCRIPTION OF THE SITE

3.5.1.1 Size & Location

The Works is located on Station Road within one km from Firozabad Railway Station and lies in the Firozabad municipality area. The enterance gate of the works is on the main road.

The works occupies an area of about 3000 Sq.m, of which around 1200 Sq.m is covered area.

3.5.1.2 Principal Features

Adarsh Glass Works is quite old and the manufacturing operations started around 1961. The works is well connected by road along the railway line (Station Road). The Railway Station is at a distance of 3 km from Delhi-Agra road (National Highway No.2).

There are other glass units in the nearby area. Small cottage units for making dies/moulds, mechanical maintenance etc are also available in the area.

3.5.1.3 Constraints/Suitability

The works being well connected by road and with railway station nearby, there is no constraint regarding transportation of materials in and out of the works.

The factory has sufficient space for the present scale of operations, but it would not be possible to extend the boundaries of the site, as it is surrounded by other units.

3.5.2 PRODUCTS

3.5.2.1 Product Features

The unit is involved in the manufacture of the following soda lime glass products.

- Glass tubes
- Glass shells
- Tumblers

* Chandelier parts such as Nag, Badaam, etc.
* Auto headlight covers
* Lead glass (bulb shells and laboratory wares)

The unit is exporting only glass shells indirectly through M/s R D Exporters of Calcutta. For domestic use the unit is supplying to the traders who sell the products after decorating the same.

3.5.2.2 Product Volume

The average production volume when closed pot furnace was in operation, as reported , is 1.5 tonnes of finished goods per day.

3.5.3 PRODUCTION

3.5.3.1 Features of Production Areas

Melting area is equipped with two furnaces. One is closed pot furnace (12 pots), coal fired and the second is oil fired Tank furnace (Regenerative type). The furnace is equipped with mild steel constructed chimney of 30 m height.

Mixing of the batch with cullets is done near the furnace area.

There are areas for pre-heating of pots, annealing the glass products and finishing to the required shape.

Separate areas are provided for raw materials and consumables store, coal storage and workshop etc.

3.5.3.2 Layout/Material Flow

The layout of the works was planned over 30 yrs ago and over the years, the additional furnace and other equipment have been added in somewhat haphazard way.

Lot of unused materials and waste materials are seen lying in the area. Annealing chambers are far away from the forming area.

The working condition is very poor and housekeeping is not at all satisfactory.

3.5.3.3 Key Methods/Technology

The technology used for manufacture of soda lime glass products is traditional and manual as in other units of Firozabad.

i) For preparaton of the raw materials, washing of sand is not being practiced as washed silica sand is being procured for use. The sand is passed through magnetic separator, but no sieving is being done.

For batch preparation, weighing of various ingredients is done using weighing machines, mixing is done manually in batch trays with shovels, which is not satisfactory.

Washing and segregation of cullets is done manually, and sizing of cullets is not being practiced.

Typical batch compositions indicated by the owner of unit for production of soda lime glass and lead glass are given as follows.

Constituents	Soda lime glass		Lead glass	
	Weight (kg)	Weight (%)	Weight (kg)	Weight (%)
Silica sand	80.00	63.10	80.00	53.50
Soda ash	34.00	26.80	21.00	14.05
Borax	2.50	1.97	2.50	1.67
Calcite	4.00	3.15	-	-
Dolomite	2.00	1.58	-	-
Felspar	2.00	1.58	5.00	3.44
Arsenic trioxide	0.30	0.24	0.50	0.33
Potassium nitrate	2.00	1.58	2.50	1.67
Potassium carbonate	-	-	6.00	4.01
Red lead oxide	-	-	32.00	21.40
Total	126.80	100.00	149.50	100.07
Cullet(approx.)	70.00		80.00	
	196.80		229.50	

ii) The forming operations are performed either by blowing or by pressing by hand presses, manually.

iii) Annealing of glass products is done in chamber type, coal fired furnace of crude design. The cycle time is kept for 48 hrs and the temperature of the chamber is not monitored.

iv) The finishing operations like grinding, melting, etc are performed on individual workstations using locally fabricated crude design equipment.

3.5.4 RESOURCES

3.5.4.1 Manpower

The total manpower strength at Adarsh Glass Works, as reported is around 90, out of which 10 employees are on rolls. The break-up is as under.

On rolls	:	10 Nos.
Contract labour	:	80 Nos.
		90 Nos.

Out of the 10 on-rolls employees, four are managerial/supervisory and six are staff.

The number of employees indicated by the owner appears to be far less than those seen actually working. Moreover, the skills of the workers are not satisfactory.

3.5.4.2 Production Equipment

The production areas in different sections are generally equipped with the type of equipment suitable to the production techniques being followed in the works. The type of equipment are shown in Annexure 3.5.1.

There are two locally fabricated melting furnaces. One is closed pot furnace (12 pots), coal fired, with pot capacity 250 kg (presently not working), and the other is oil fired Regenerative Tank furnace of melting chamber size 2.4 m x 2.4 m and having a drawing capacity of 4 tpd. The production rate is 3 tpd of finished products.

The refractories used in the tank furnace are as under.

i)	Bottom and bridge of melting chamber	:	Sillimanite
ii)	Crown of furnace	:	Silica bricks
iii)	Regenerative chamber	:	IS 8 bricks

The furnace wall is made up of 300 mm x 450 mm blocks of sillimanite. Steel beams are provided for the rigidity of the furnace structure. The flue gas leaving the furnace heats the air entering in for combustion. By this waste heat is recovered partially.

Temperature indicated in the hearth of the furnace is around 1430 deg.C.

There are two burners (one as a stand-by) and the oil pressure of the burners used in the oil fired tank furnace is around 65 psig. Nearly 1600 litres of oil/day is consumed. The condition of both the furnaces is satisfactory.

Melting machine is used for fire polishing of tumblers. Kerosene oil is used for firing and the consumption is around 100 litres/day.

The condition of other equipment like coal fired pot furnace, coal fired annealing chambers, hand presses etc is very poor.

3.5.4.3 Facilities/Utilities/Services

The works has a maintenance workshop for repair of moulds/fixtures etc. It is equipped with old centre lathe, pedestal drill, hand drill and welding machine.

There is no provision in the unit for carrying out any quality tests either on raw materials, or at intermediate stage or after annealing to test the quality of products.

Electric power is supplied by state authoritries and two captive D.G. sets of 125 kVA each are provided for use during power failure.

There are 2 compressors of 25 HP motor for generating compressed air at 70 psig required for burners of tank furnace and fire polishing machines.

3.5.5 ENERGY AUDIT

3.5.5.1 Working Parameters

The working parameters of oil fired tank furnace, such as draw rate and oil consumption were taken from the management . The other parameters such as furnace temperatures, molten bath temperature, average side wall and crown temperature, stack temperature, carbondioxide and oxygen in flue gas , temperature of regenerators were taken to find out the heat utilisation and heat losses. A list of working parameters is shown in Annexure 3.5.2.

3.5.5.2 Heat Balance

From the measurements and fuel consumption figures of the tank furnace, the heat utilisation and various heat losses had been worked out and presented in the pie-chart, Sketch No. 3.04.

3.5.5.3 Analysis

Adarsh Glass have an oil fired end port tank furnace with an efficiency of 10.4 %. The unaccounted losses are high which leads to the conclusion that the information provided by the management is not correct.

Adarsh Glass have comparatively lower flue gas loss as fuel oil combustion requires lower percentage of excess air than solid fuels like coal.

The burners were seen to be locally fabricated .

The cracks and spots seen in the furnace are due to improper heat loading and uneven heat distribution. The cause of the above defects is improper alignment and location of burner as it is placed on one side end of the furnace.

3.5.6 MANUFACTURING SYSTEMS

3.5.6.1 Production Planning & Control

On receipt of order from the party, and getting the sample approved, schedule for manufacture of the same is drawn based on quantities and schedule time. There are no systems or procedures for either production planning or control.

The key indicator against which production is monitored is the daily production of glass products, and the management is totally dependent upon the workers.

3.5.6.2 Material Planning & Control

Raw materials are roughly estimated and purchased from the local market. All the raw materials and chemicals are readily available in the market.

It was pointed out that coal received from Coal India (which is a Government agency) is of poor quality and the coal supply is erratic, so they have to purchase coal from open market at higher rates.

The inventory of raw materials is kept between 15- 20 days and for coal it is 10-15 days.

There is no shop floor control of materials, and the rejection is between 20-40 %,and the rejection rate is even higher in summer.

3.5.6.3 Maintenance

There is only break-down maintenance, as owners of these types of units are not conscious of preventive maintenance. The records are not maintained and no log books are maintained even for furnaces.

It was pointed out by the key personnel that the maintenance is negligible. For break-down maintenance of the furnaces the overall contract is given to outside parties.

There is a small maintenance shop where other equipment and moulds/ fixtures are repaired.

3.5.6.4 Quality Control

There is no method of controlling the quality of glass products in the works. As the methods of forming are manual, thickness and weight of pieces is not uniform and sometimes, bubbles, and lines appear on the glass products. Reject analysis is never done by the owner even though in the accepted batch, the commercial grade may be as high as 70 %.

Only visual checks are done before packing the different products.

3.5.7 POLLUTION

The main source of pollution is usually the emissions from the stack of the furnace, which affects the ambient air quality. Measurements have been taken to check the quality of stack emissions, ambient air, waste water and solid waste, and the same are discussed in the following paras.

3.5.7.1 Stack Emissions Quality

Monitoring of the stack gases has been carried out by simultaneously sampling for SPM (suspended particulate matter) and gaseous pollutants such as Sulphur Dioxide (SO_2),Nitrogen Oxides (NO_x), and Carbon Monoxide (CO). The stack emissions quality for Adarsh Glass was found to be as follows.

Stack height	30 m
Velocity	11.6 m/s
Stack temperature	121° C
Quantity of emissions	17915 mg/Nm^3
SPM	147 mg/Nm^3
SO_2	58 mg/Nm^3
NO_x	48 mg/Nm^3
CO	230 mg/Nm^3

As seen from the above results, the SPM value is within the limit of 1200 mg/Nm^3 prescribed by CPCB (Central Pollution Control Board). An amendment of SPM value of 150 mg/Nm^3 by Ministry of Environment & Forests for glass industries will be applicable from 1994 onwards, which will not affect the status of the unit with respect to SPM of the stack emissions. The unit is using LDO as fuel instead of coal.

Regarding Sulphur Dioxide level, even though no limit has been prescribed at present, a new limit of 50 mg/Nm^3 prescribed by the Ministry of Environment and Forests will be applicable from 1994 onwards. In view of this , adequate measures have to be taken by Adarsh Glass to bring down the SO_2 level below 50 mg/Nm^3 in the stack emissions.

Regarding NO_x, no limit has been prescribed so far. Measures for reduction of SO_2 level will automatically take care of the NO_x value too.

CO level in the stack emission indicates that fuel is not burning properly at the unit. If the flue gases can be maintained with above 12 % CO_2 or by 4 % O_2, it can be presumed that efficiency of burning will be upto the mark. This will in turn reduce the CO concentration appreciably.

3.5.7.2 Ambient Air Quality

Ambient air quality measurements with respect to the various pollutants were carried out inside the factory premises at two locations and the results are indicated to be as follows.

Parameter	Value in ug/m^3	
	Near Office	Near Furnace
SPM	568	1919
SO_2	8	31
NO_x	7	10
CO	892	1083
F	15	10

The SPM values as above exceed with respect to CPCB norms prescribed for industrial area (500 ug/m^3). This is an indication of the dust pollution, particularly near the furnace, and lack of a conducive working atmosphere. Adequate measures are very much required to be taken to contain pollution in the area.

The SO_2 values as above are well below the limits as prescribed by CPCB (120 ug/m^3) for industrial area.

The NO_x values are also well below the prescribed limit of 120 ug/m^3.

The CO levels as above are well below the limits prescribed by CPCB (5000 ug/m^3).

Regarding the Fluoride levels observed, no standards have been so far prescribed by the CPCB. However, according to OSHA standards, the fluoride levels in the air constitute a potent pollutant and adequate measures are to be taken to contain the hazard.

3.5.7.3 Water Pollution

Water is being used mainly for cooling and for human consumption. The water pollution problem is not acute. Waste water characteristics were measured for grab samples collected from outlet drain of the factory . Analysis of the sample indicates that the waste water is only slightly polluted, and water pollution problem is not acute in comparison with air pollution. If these effluents are discharged into public sewers, only proper drainage system is required.

3.5.7.4 Solid Waste

Solid waste is being generated mainly from the coal being used as a fuel. In general the analysis of solid waste of some of the glass units indicates that the parameters are more or less as expected, except aluminium, which is present in high percentage.

No specific area in the plant is marked for dumping the solid waste.

3.5.8 PERFORMANCE

3.5.8.1 Raw Material Consumption

Sand	0.45 t/t draw
Soda ash	0.19 t/t draw
Cullets	0.40 t/t draw

3.5.8.2 Energy Consumption

The unit consumes 480 lit. of oil per tonne of the molten glass drawn. The specific energy consumption thus works out to be 19.06 Million kJ/t draw.

3.5.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced . The rejection rate for the unit works out to be 40 %.

3.5.8.4 Pollution

The observed parameter values of stack emissions and ambient air , when compared with the latest limits prescribed by CPCB/Ministry of Environment & Forests, indicate the following.

Stack Emissions:
- SPM value within the limit
- SO_2 value marginally exceeds the limit
- CO value not satisfactory

Ambient Air:
- SPM values exceed the limit
- SO_2 value within the limit
- NO_x value within the limit
- CO value within the limit
- Fluoride is present

Annexure 3.5.1

PLANT AND MACHINERY

S.No.	Section	Types of Equipment
1.	Batching	Weighing machine - 100 kg capacity Batch mixing trays and shovels.
2.	Melting	Closed pot furnace (12 pots) coal fired, having capacity of 250 kg per pot (presently not working). Oil fired Tank Furnace, Regenerative type, drawing capacity 4 tpd.
3.	Pot Preheating	Coal fired pre-heating chambers to accommodate 2 pots for pre-heating .
4.	Annealing Chambers	Coal fired Annealing Chamber having capacity to accommodate glass production of one day.
5.	Hand Presses	Locally fabricated, lever operated hand presses - 4 No.
6.	Melting Machine	For fire polishing of tumblers-1 No.
7.	Grinding Machine	Grinding plates for smoothening of edges - 2 No.

Annexure 3.5.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temp., deg.C	1490
2.	Molten batch temp., deg.C	1276
3.	Avg. side wall temp., deg.C	300
4.	Avg. crown temp., deg.C	300
5.	Stack temp., deg.C	435
6.	Carbondioxide in flue gas, %	7
7.	Oxygen in flue gas, %	13
8.	Excess air, %	150

Regenerative Chamber

9.	Inside temp., deg.C	-
10.	Furnace temp., deg.C	120

3.6 WEST GLASS WORKS

3.6.1 DESCRIPTION OF THE SITE

3.6.1.1 Size & Location

The Works is located in labour colony, which is about 2 kms from Firozabad Railway Station, and falls on the western side of the railway track. The works is about 3 kms from the Agra Road (National Highway No.2).

The works occupies an area of around 9000 Sq.m.

3.6.1.2 Principal Features

The works is well connected by road as it is located in the residential area of the labour colony. There are also some other units located around this works,such as Hariom Glass Industry, which makes pressed glass wares and Cozy International, which is a decorative unit.

3.6.1.3 Constraints/Suitability

There is no constraint on account of transportation of materials to and fro from the works. The factory has sufficient space for the present scale of operations. With rational relocation of areas within the unit, sufficient space can be created for future expansion, as this unit occupies a large area of 9000 Sq.metres.

3.6.2 PRODUCTS

3.6.2.1 Product Features

The unit is involved in the manufacture of the following glass products.

* Glass ware
* Laboratory ware
* Bangles
* Auto head-light covers
* Chimneys
* Paper weights
* Bulb shells

The items manufactured in the maximum quantities are glass ware and laboratory ware Exports formed 30 % of the sales value in 1992 and the items exported are chimneys and laboratory ware. For domestic use generally the parties approach the unit for marketing. For laboratory ware, there are agents, who book orders and collect payment.

3.6.2.2 Production Volume and Value

The production volumes and value for the last three years, as reported, are shown hereunder.

Year	Production(Tonnes)	Value(Rs Million)
1991	3211.5	22.854
1992	3532.5	27.056
1993(6 months)	1768.7	13.543

From the above figures,it can be seen that there is about 10 % increase in production in 1992 as compared to 1991.

3.6.3 PRODUCTION

3.6.3.1 Features of Production Areas

Melting of the batch is done in Regenerative type coal fired Tank Furnace, which is housed in industrial type shed. The furnace is equipped with chimney of height 38 m.

There are separate areas for Direct type tank furnace, coal fired (presently not working). Forming of the molten glass to the desired shape either by blowing or pressing is done near the furnace. There are areas for Bangles spiralling in Belan Bhatti (bangle making furnace) after heating in Sikai Bhatti (reheating furnace). There are separate areas for finishing operations after annealing in Annealing Lehr. Separate areas are also provided for coal storage, finished goods storage, and raw material storage.

3.6.3.2 Layout/Material Flow

The laouts of various production equipment for the manufacture of glass wares, laboratory wares, etc. are generally arranged according to the production flow. But in the bangle making area, the Sikai Bhatti and the Belan Bhattis are located at random.

Space-wise, the layout is not congested and there is adequate space available for carrying out various operations.

The working conditions are slightly better than Manohar & Shiv China Glass works.

House-keeping in the production area is generally satisfactory except in the bangles making area.

3.6.3.3 Key Methods Technology

The technology used for manufacture of glass wares, laboratory wares, and bangles is traditional and manual as in other units of Firozabad. The methods followed for manufacture of glass wares and bangles are as under.

i) In preparation of the raw materials, washed silica sand is procured, and therefore washing of sand is not done at the works. Magnetic separation of the silica sand is being practiced. Sieving of the sand is not being practiced.

For batch preparation, weighing of ingredients is done using weighing balance, mixing is done manually in batch trays with shovels.

Part of the cullets used are procured from outside. Washing and segregation of cullets is being done manually, but sizing of cullets is not being practiced.

Typical batch composition used for melting in the tank furnace is as follows.

Constituent	Weight(kg)	Weight %
Silica sand	120.00	64.90
Soda ash	45.00	24.37
Calcite	10.00	5.45
Felspar	5.00	2.70
Borax	2.00	1.00
Sodium silico fluoride	1.00	0.50
Sodium nitrate	0.50	0.25
Sodium sulphate	0.50	0.25
Selenium metal powder	0.005	-
Cobalt oxide	0.005	-
Barium carbonate	0.50	-

(as substitute for sodium nitrate
or sodium sulphate.

Salt petre	1.00	0.50
	185.00	100.00
Cullets(approx.)	70.00	
	255.00	

ii) For batch preparation, weighing of ingredients is done using weighing balance, mixing is done manually in batch trays with shovels.

iii) For making bangles, manual spiralling is done on belans (mandrels) using belan bhatti (bangle making furnace) after reheating in sikai bhatti (reheating furnace).

iv) For annealing the glass products, Annealing Chambers and Annealing Lehr are used. Annealing in the annealing chambers is not satisfactory.

v) For fire-polishing the glass products Dyana machines are used.

3.6.4 RESOURCES

3.6.4.1 Manpower

The total manpower strength at West Glass Works, as reported, is 250. The break up is as under.

On rolls	:	50 No.
Contract labour	:	200 No.
		250 No.

This manpower strength of 250 Nos. is for 3-shift working of furnace,forming, pressing and annealing of glass ware, laboratory ware and other products except bangles and 1-shift working of bangle making, finishing, fire polishing and packing operations. The break-up of on-roll employees is as follows.

Managerial : 1 No.

Supervisory	:	20 No.
Staff	:	29 No.
		50 No.

Out of 250 employees, 200 No. are direct workers and 50 No. are indirect workers.

Among the contract labour many women workers were seen during the consultants visit to the works. Some of the on-rolls employees supervise the different production areas and keep a watch on the contract labour. In this works, the contract labour was using handling aids for transfering products from one station to another.

It is observed that narrow based single skilling is predominant throughout all production areas.

3.6.4.2 Production Equipment

The production areas are generally equipped with the numbers and types of equipment which are adequate to production techniques being followed in the works.

The type of equipment used is given in Annexure 3.6.1.

There are two locally fabricated coal fired Tank furnaces. One is regenerative type having a drawing capacity of 20 tpd and the other is direct tank furnace of capacity 8 tpd (presently not working) and the owner is planning to convert this to oil fired furnace).

The refractories used in the Regenerative tank furnace are as under.

Top of crown	:	Silica bricks
Bottom and Bridge	:	Sillimanite bricks

The insulation used in the regenerative chamber is glass wool.

Three temperature indicators are installed on the regenerative tank furnace.

The melting zone is made of 300 mm thick sillimanite brick and GT blocks of 300 mm thickness are used above the melting zone. The roof is made from 225 mm thick bricks and the regenerators are made of IS: 8 or IS: 6 bricks.

The coal consumption is about 15 tpd for 20 tpd draw as reported.

There is one Annealing Lehr of 1.8 m belt width and 26 m long with belt speed of 26 m per 90 minutes.

This annealing lehr is either electrically heated or kerosene oil fired and the maximum temperature attainable is about 525 deg.C. The burners are locally fabricated . The Lehr is fitted with three temperature indicators and the condition is satisfactory.

There are two Dyna Machines for fire-polishing of export items and laboratory ware, which are LPG fired. Their condition is satisfactory. The condition of other equipment such as grinding machines, electrical cutting machines, etc is generally satisfactory.

The rotation of Belans (mandrels) by the skilled workers for spiralling of bangles is manual, through a reduction gear box, and the handling of products from one station to another station is also done by handling aids.

3.6.4.3 Facilities/Utilities/Services

The works has maintenance workshop for repair of moulds/dies. The workshop is equipped with centre lathes, shaping and drilling machines. There is no laboratory for testing and inspection of either raw materials or at intermediate stage or at final stage.

The works has a connected load of 400 HP, but the service is inadequate due to unscheduled power cuts and erratic supply.Two captive D.G. sets of 250 kvA each are there, for use during power break-downs.

There are 3 No. of compressors for generating compressed air required for burners of Annealing Lehr and two fire-polishing machines.

Water is taken out from tube well and 2 No. of pumps of 7.5 HP are installed for supply in the premises.

3.6.5 ENERGY AUDIT

3.6.5.1 Working Parameters

The working parameters of coal fired Regenerative Tank furnace such as draw rate and coal consumption were taken from the management. The other parameters such as furnace temperature, molten bath temperature, average side wall and crown temperatures, inside and surface temperature of regenerator chamber, stack temperature, carbondioxide and oxygen percentage in the flue gas were taken . Similarly, measurement and data were taken pertaining to Annealing Lehr. A list of the working parameters is shown in Annexure 3.6.2.

3.6.5.2 Heat Balance

From the measurements and fuel consumption figures of the Tank furnace, the heat utilisation and various heat losses had been worked out and presented in the pie-chart, Sketch No. 3.05.

3.6.5.3 Analysis

West Glass Works has coal fired Regenerative side port tank furnace with efficiency or useful heat utilisation of 15.7 %. When compared with the tank furnaces in other units, it has the lowest efficiency.

The flue gas loss of 44.2 % is the maximum among the other tank type furnaces. The main causes of flue gas loss are higher stack temperature and high amount of excess air in the flue gas. The unit does not excercise any control on excess air and the reason for high stack temperature is the low heat storage capacity of the regenerators.

Radiation loss of 34.4 % is much affected by the surface temperature. Higher radiation loss indicates either the poor quality of the refractories or delagging of the refractory surfaces due to the ageing of the furnace.

3.6.6 MANUFACTURING SYSTEMS

3.6.6.1 Production Planning & Control

On receipt of order from the party, production planning is done, based upon the quantity and scheduled time. Information from the store-keeper regarding in-house availability of the particular type and size of the mould/die, is gathered. If new mould is required then order for the same is placed with the manufacturer of mould/die.

There are no systems or procedures adopted. Reports of the quantity of wares and types produced are received from the finished products section.

3.6.6.2 Material Planning & Control

On receipt of order, the raw materials store is directed to release the required raw materials. Records of incoming materials and outgoing materials is maintained, but in the batching section, no records are kept regarding the composition of the batches produced.

All the raw materials are readily available and there is no problem regarding the supply or quality of the raw materials. However, they are not satisfied with the quality and quantity of coal received from Coal India. Even in case of kerosene oil, it is pointed out that the government quota of 20 KL/yr has been reduced to only 8 KL/yr from the last 2-3 years, and kerosene is also not available in the open market.

Inventory levels of different raw materials, fuels and consumables are as under.

Material	Inventory Level
Silica sand	3 months
Soda ash	1 week
Other chemicals	1 week
Coal	1 week
H.S.Diesel/LDO	1 week
Finished goods	200 tonnes (contains max. quantity of laboratory ware)

3.6.6.3 Maintenance

No preventive maintenance is done in the works, the only maintenance being done is the reactive maintenance. There are no records of maintenance carried out earlier of the furnaces, though annual cost of one furnace repair is between Rs 300,000 to 400,000, out of which 50 % is the cost of refractories and rest for labour. It takes about 20 to 25 days with 20 to 30 workers for repairing the furnace once the production is stopped for furnace repairs. Overall maintenance of furnace is contracted out, as the unit does not have the necessary manpower for carrying out the maintenance.

There is a small maintenance shop for repair of locally fabricated moulds/dies and other equipment.

3.6.6.4 Quality Control

There is no method of controlling the quality of the glass products in the works. Their only emphasis is to buy good quality of raw materials, particularly washed silica sand free from iron particles, etc. It was informed that sometimes they got the batch tested from CIGI and there is strict supervision during preparation of the batch and during sorting before packing the products. Their product quality is slightly better than many glass manufacturers in Firozabad.

3.6.7 POLLUTION

The unit uses coal as fuel. The main source of pollution will therefore be the stack emissions , which affect the ambient air quality. The levels of pollution for the unit are are expected to fall in the viscinity of those obtained in other units using coal as fuel, due to the problems associated with use of coal.

3.6.8 PERFORMANCE

3.6.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of major raw materials and cullets works out to be as follows.

Sand	0.53 t/t draw
Soda ash	0.20 t/t draw
Cullets	0.30 t/t draw

3.6.8.2 Energy Consumption

The unit consumes 15 tonnes of coal for a draw of 20 tpd. The specific energy consumption thus works out to be 12.54 Million kJ/t draw.

3.6.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 30 %.

Annexure 3.6.1

PLANT AND MACHINERY

S.No.	Section	Type of Equipment
1.	Batching	Weighing balances of capacities 200 kg, 5 kg, 0.5 kg. Magnetic separator for silica sand. Batching trays & shovels. Charging buckets of capacity 30 kg.
2.	Melting	Coal fired Regenerative Tank furnace of drawing capacity 16 tpd. Coal fired Direct Tank furnace of drawing capacity 8 tpd (Presently not working).
3.	Forming/Pressing	Mouth blowing pipes, moulds, dies for eight working stations.
4.	Reheating/Spiralling	Sikai Bhatti, coal fired. Belan Bhatti, coal fired. Belans of different sizes (Mandrels) equipped with reduction gears.
5.	Annealing	Annealing Lehr, Electrical/kerosene oil fired, size 1.5 m wide x 450 mm ht. x 26 m long. Annealing Chambers for large items, Chamber size 3.6 m x 3.6 m x 2.4 m ht., capacity 1 to 1.5 tonnes or 300 dozen pieces, cycle time 24 hrs.
6.	Fire Polishing	Dyna Machines, LPG fired.
7.	Finishing	Electrical cutting stations for cutting the glass products. Grinding machines for edge grinding. Grinding stations for grinding of laboratory reagent bottle stoppers.

Annexure 3.6.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temperature, deg.C	1465
2.	Molten batch temp., deg.C	1247
3.	Avg. side wall temp., deg.C	300
4.	Avg. crown temp., deg.C	300
5.	Stack temp., deg.C	550
6.	Carbondioxide in flue gas, %	8
7.	Oxygen in flue gas, %	12
8.	Excess air , %	120

Regenerative Chamber

9.	Inside temp., deg.C	690
10.	Surface temp., deg.C	225

Annealing Lehr/Chamber

11.	Lehr temp., deg.C	506
12.	Avg. surface temp., deg.C	85

Sikai Bhatti

13.	Inside temp., deg.C	1050
14.	Avg. surface temp., deg.C	115

Belan Bhatti

15.	Inside temp., deg.C	700
16.	Avg. surface temp., deg.C	90

3.7 BABY GLASS WORKS

3.7.1 DESCRIPTION OF THE SITE

3.7.1.1 Size & Location

The works is located on Delhi-Agra Road (National Highway No.2) within 2 kms from Firozabad. The enterance gate is on the main road. The site is about 5 kms from Firozabad Railway Station.

The works occupies an area of around 4300 Sq.m, out of which about 1500 Sq.m is covered area.

3.7.1.2 Principal Features

Baby Glass Works is in the Industrial area and is surrounded by other factories. Pot manufacturing unit is also located in the adjoining area.

The unit is in operation since 1980 and access to to the factory by road is reasonable.

3.7.1.3 Constraints/Suitability

As the works is located on the main highway, there is no constraint in respect of transportation of materials to and from the unit.

The site is well suited to the manutacturing operations and has enough space for future expansion , as free space is available within the works.

3.7.2 PRODUCTS

3.7.2.1 Product Features

The unit is involved in tne manufacture of bangles in various colours and sizes.

3.7.2.2 Product Volume/Value

The average production, as reported is about 2.5 tpd of bangles, when only one open type pot furnace (10 pots) is in operation. The annual production for 300 days would be around 750 tonnes, which is equal to about 0.6 million 'Todas' (1 Toda = 312 No. of bangles). The value of the above production has been reported as Rs

12 million per year, on the basis of average value of Rs 20.00/Toda.

3.7.3 PRODUCTION

3.7.3.1 Features of Production Areas

Melting of the batch is done in coal fired open type pot furnace (10 pots), which is housed in industrial type shed and equipped with chimney of 18 m height.

There is another open type pot furnace (7pots) , coal fired (under repair) which is housed in another industrial type shed which is about 15 m from the other shed.

Sikai Bhatti (reheating furnace) and Belan Bhattis (bangle making furnaces)are provided in each shed.

There is an area for making batch composition near the furnaces.

There are areas for cutting and bundling of bangles, pot making and coal storage.

3.7.3.2 Layout/Material Flow

There does not appear to be any systematic planning in the layout. The equipment are installed in a haphazard way. Pot pre-heaters are far away from the pot furnace. There is no hard standing and the working area is paved with brick rubble.Moreover, there is a difference in levels , and transporting the heated pots from pot preheaters to the pot furnace becomes very risky.

The standard of housekeeping in the entire shop is unacceptable and there is large quantity of scrap & waste materials cluttering the shop.

3.7.3.3 Key Methods/Technology

The technology being used for manufacture of bangles is traditional, low-level and labour intensive.

The key methods followed are as under.

Sand washing and sieving is not being practiced. Magnetic separation of sand is also not carried out.

For batch preparation, weighing of the various ingredients is done in pan type weighing balances and the mixing is done manually in trays using shovels.

Washing and segregation of cullets is done manually. Cullet used is partly procured from outside.

Typical composition being used for making the batch is as follows:

Constituent	Weight (kg)	Weight %
Silica sand	37.00	66.91
Soda ash	18.00	32.55
Borax	0.25	0.45
Cobalt oxide	0.05	0.07
	55.30	100.00
Cullet (approx.,assuming no purchased cullet is used)	35.00	
	90.30	

Melting of the batch is done in coal fired open pot furnace (10 pots). The prepared batch along with the cullets is packed in pots and allowed to melt for 16 - 18 hours at a temperature of 1200 - 1250 deg.C.

Forming is done manually. The molten glass is collected from the pot and is reheated in Sikai Bhatti (reheating furnace), followed by drawing and spiralling of the glass thread on mandrels in Belan Bhatti (bangle making furnace).

The continuous spirals formed as above are given a cut manually to separate the bangles and the counted bunch is bundled using a string.

The bundles are sub-contracted to outside parties for joining the two ends of bangles. The joined bangles are then brought back and sold to the parties who carry out decoration and cut-work designs,and thereafter sell them.

3.7.4 RESOURCES

3.7.4.1 Manpower

The total manpower strength at Baby Glass Works, as reported is around 110 when the 10-pot furnace is in operation. The break-up is as under.

On rolls	:	15 No.
Contract labour	:	95 No.
		110 No.

Out of the 15 on-roll employees, 3 are supervisory and 12 are staff.

The wages of the contract labour vary from Rs 40 to Rs 100 per day depending upon the type of work.

Multi-skilling is not prevalent in Firozabad industry. There is no training centre in Firozabad. Unskilled workers learn the techniques in the works.

3.7.4.2 Production Equipment

There are two open type pot furnaces, coal fired, locally fabricated, one with 10 pots of 450 kg capacity each, and the other with 7 pots , which is under repair.

The 10-pot furnace is made up of 230 mm thick wall of refractory bricks. The approximate diameter and height of melting zone is 3.6 m and 1.5 m respectively. The 10 pots are placed around the periphery of the furnace . The size of each pot is 900 mm diameter and 750 mm height. Openings are provided to draw the molten glass out. Underneath the pots, coal is fired and combustion gases are made to circulate around the pots. Underground ductings are provided through which the flue gases escape to the chimney. The temperature attained in the furnace is between 1200 - 1250 deg.C and the coal consumption is around 4 tonnes/day. The reheating of drawn out molten glass before forming is carried on in Sikai Bhatti (reheating furnace) of approx. 2.4 m diameter and 1.2 m height and it consumes about 750 kg of coal per day. It is also constructed of single brick of 230 mm thickness. The condition of this furnace is very bad with almost all the refractories broken. The flame could be seen protruding out which not only results in increased heat loss but also poor working conditions and discomfort for the workers.

There are five Belan Bhattis (bangle making furnaces) for spiralling of bangles. These are also constructed of single brick of 230 mm thickness. Their condition is also very bad .

The pots are preheated to 400 - 450 deg. C in coal fired Pre-heating furnace before being placed in the furnace. This is also of very crude design and the consumption of coal is around 500 kg/day.

The type of equipment used are indicated in Annexure 3.7.1.

3.7.3.4 Facilities/Utilities/Services

The works have a pot making facility. The open pots of size 825 mm dia. and 675 mm height are made manually with the help of wooden moulds. Broken/crushed grog and fire clay are mixed with water for 10 days. The mixture is poured in wooden moulds and rammed to shape. This is allowed to dry before pre-heating the pots.

There is no laboratory for testing of any material or product.

The works has a connected load of 15 kw. One captive DG set of 6 kw is installed to cater to the requirements in case of power failure.

3.7.5 ENERGY AUDIT

3.7.5.1 Working Parameters

The working parameters of open type pot furnace such as draw rate and coal consumption were taken from the management . The other parameters such as furnace temperature, molten bath temperature, average side wall and crown temperatures, stack temperature, carbondioxide and oxygen percentage in the flue gas were measured.

Similarly, measurement and data were taken pertaining to subsidiary furnaces such as pot pre-heaters, Sikai Bhatti (reheating furnace) and Belan Bhatti (bangle making furnace). A list of the working parameters is shown in Annexure 3.7.2.

3.7.5.2 Heat Balance

From the measurements and fuel consumption figures of the pot furnace, the heat utilisation and various heat losses were worked out and presented in pie-chart, Sketch No. 3.06.

3.7.5.3 Analysis

Baby Glass has open pot furnace with an useful heat utilisation of 13 % which is the highest among the other pot furnaces. The reason for high efficiency is that the entire glass surface area is in contact with combustion gases and the heat transfer is much faster .

The flue gas loss which is 33.4 %, depends upon the stack temperature and excess air. Though the excess air percentage is 60 % corresponding to Carbondioxide content of 11 %, the stack temperature is on the higher side.

The radiation loss of 27.8 % is comparatively high in glass industry and the reasons would be the ageing of the furnace over a long period and no insulation .

3.7.6 MAUFACTURING SYSTEMS

3.7.6.1 Production Planning & Control

There are no systems and procedures followed either for production planning or for control of production. As in other factories, rough estimates for materials, consumables, fuels, etc are made. Depending upon the requirement of bangles in different colours, number of pots required for one colour are estimated and batch is prepared and charged in the pots.

Reports of daily production of bangles in different colours are received from the supervisors.

3.7.6.2 Material Planning and Control

The requirements of materials and fuels, their purchase from the market and inventory is managed by the plant incharge.

There is no control of materials and no records are kept . All operations such as preparation of batches, charging of the batch into the furnace,etc are carried out by the contract workers under the plant supervisors.

3.7.6.3 Maintenance

The equipment installed at Baby Glass Works are melting furnace, and other subsidiary furnaces such as Sikai Bhatti, Belan Bhatti, pot pre-heating furnaces etc. The maintenance required is only for the furnaces. Only break-down maintenance is carried out . Overall maintenance labour contract is given for carrying out the maintenance of the melting furnace and there is no inventory for any refractory bricks or other maintenance materials. There are also no records available for earlier maintenance of the furnaces.

3.7.6.4 Quality Control

There is no method of checking the quality of the glass bangles produced. The emphasis is given on the quantity of bangles produced rather than the quality. Only visual inspection is done during the manufacturing operations. Sorting is done at the bundling stage of bangles.

3.7.7 POLLUTION

The main source of pollution is usually the emissions from the stack of the furnace, which affects the ambient air quality. Measurements have been taken to check the quality of stack emissions, ambient air, waste water and solid waste, and the same are discussed in the following paras.

3.7.7.1 Stack Emissions Quality

The levels of pollution caused by the stack emissions are expected to be in the viscinity of those of other units using coal as fuel. The pollution effect can be expected to be even higher in case of this unit because of the open type pot furnaces being used, and lot of flames and gases escaping through the openings provided near the top of the pot furnaces.

3.7.7.2 Ambient Air Quality

Ambient air quality measurements with respect to the various pollutants were carried out inside the factory premises at three locations and the results are shown below.

Parameter	Value in ug/m^3		
	Near Gate	Near Furnace	Coal Yard
SPM	685	4246	1844
SO_2	55	143	25
NO_x	26	40	16
CO	1980	2350	983
F	18	42	10

The SPM values at all the three locations as above exceed the limit of 500 ug/m^3 prescribed by CPCB (Central Pollution Control Board). The values near the furnaces and Coal Yard are much higher than those near the Gate. The high SPM values observed indicate high dust pollution and lack of a conducive working atmosphere.

Regarding the SO_2 level, the highest level as observed above is 143 ug/m^3 near the furnace, which exceeds the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

Observations for the NO_x values as above are much below the limit of 120 ug/m^3 prescribed by CPCB.

The CO levels observed as above are found to be within the limit of 5000 ug/m^3 prescribed by CPCB.

Regarding the Fluoride content, so far the CPCB have not published any standards for ambient fluoride. But according to OSHA standards, fluoride is a potent gaseous pollutant and adequate measures are to be taken to contain the hazard.

3.7.7.3 Waste Water Pollution

Water is used for human consumption only, and therefore the water pollution problem is not acute.

3.7.7.4 Solid Waste

Analysis of Coal ash samples from Baby Glass indicated the parameters to be normal, except aluminium, which was present in very high percentage.

There is no specific area provided in the plant for dumping of solid waste.

3.7.8 PERFORMANCE

3.7.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of major raw materials and cullet works out to be as follows.

Sand	0.31 t/t draw
Soda ash	0.22 t/t draw
Cullets	0.44 t/t draw

3.7.8.2 Energy Consumption

Based on the information collected regarding coal consumtion and the glass melted, the energy consumption of the unit works out to be 14.7 million kJ/t draw.

3.7.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 44.50 %.

3.7.8.4 Pollution

The observed parameter values of ambient air, when compared with the limiting norms prescribed by the CPCB, indicate the following.

SPM value exceeds the limit
SO_2 value exceeds the limit
NO_x value much below the limit
CO value within the limit
Fluoride is present in the ambient air

Annexure 3.7.1

PLANT AND MACHINERY

S.No.	Section	Type of Equipment
1.	Batching	Weighing balances. Mixing trays and shovels.
2.	Melting	Open pot type furnace (10 pots), coal fired, capacity 450 kg per pot. Open pot type furnace (7 pots), coal fired (presently under repair)
3.	Reheating of glass	Sikai Bhatti (reheating furnace), Dimensions: 2.4 m dia. x 1.2 m height, temperature 450 - 600 deg.C, coal fired, without chimney.
4.	Spiralling of bangles	Belan Bhatti (bangle making furnace), constructed of single brick of 230 mm thickness, coal fired, without chimney.
5.	Pot Pre-heating	Pot pre-heating furnace of capacity 2 pots, coal fired.

Annexure 3.7.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temp., deg.C	1475
2.	Molten batch temp., deg.C	1305
3.	Avg. side wall temp., deg.C	340
4.	Avg. crown temp., deg.C	350
5.	Stack temp., deg.C	570
6.	Carbondioxide in flue gas, %	11
7.	Oxygen in flue gas, %	8.5
8.	Excess air, %	60

Pot Heating Furnace

9.	Inside temp., deg.C	600
10.	Avg. surface temp., deg.C	120

Sikai Bhatti

11.	Inside temp., deg.C	1010
12.	Avg. surface temp., deg.C	110

Belan Bhatti

13.	Inside temp., deg.C	720
14.	Avg. surface temp., deg.C	90

3.8 OM GLASS WORKS

3.8.1 DESCRIPTION OF THE SITE

3.8.1.1 Size and Location

The works is located on Delhi-Agra Road within 6 kms from Firozabad. The enterance gate is on the main road, Raja-ka-Tal, Agra Road. The site is about 7 kms from Firozabad Railway station.

The works occupies an area of around 7500 Sq.m, out of which about 3500 Sq.m is covered area.

3.8.1.2 Principal Features

Om Glass Works is in the industrial area and the site is adjacent to Pooja Glass Works. The manufacturing operations started in 1984. Access by road is reasonable and there is rail head nearby.

3.8.1.3 Constraints/Suitability

There are no constraints including transportation of materials, bought-outs and finished goods to and fro from the works. The site is well suited to manufacturing operations and has enough space for future expansion.

3.8.2 PRODUCTS

3.8.2.1 Product Features

The unit is involved in the manufacture of glass products of soda lime glass as under:

* Tumblers
* Thermo-flask Refills
* Auto headlight shells

The unit supplies thermo refills to Eagle Factory.

3.8.2.2 Product Volume/Value

The approximate production volume, as per latest figures available with the management of the unit, was informed to be as follows.

	tpa
Glass and Glassware	1500
Thermo Refills	1200
Auto Headlight shells	1500
	4,200

The approximate value of the above production , based on the sales value indicated by the management, works out to be as follows.

	Rs mill./Yr
Glass and Glassware	22.5
Themo Refills	54.0
Auto Headlight shells	22.5
	99.0

3.8.3 PRODUCTION

3.8.3.1 Features of Production Areas

Melting of the batch is done in coal fired Regenerative Tank furnace, which is housed in industrial type shed and equipped with mild steel fabricated chimney of height 37 m.

There are areas for oil fired Regenerative Tank furnace and oil fired Recuperative Tank furnace (under repair) that are housed in another industrial type shed.

Mixing of various ingredients in the mixer after sieving and separating iron particles from quartz is done in separate shed.

Forming of the molten glass to required shape either by blowing or by pressing, and annealing the glass products is performed near the furnace.

There are separate areas for finishing , raw material storage, fuel storage, finished goods storage, packing, die store, power house and maintenance shop.

3.8.3.2 Layout/Material Flow

The layout of various production equipment such as furnace, forming / pressing equipment and annealing lehrs are generally arranged according to the production flow. Batch mixing is done in separate shed, which is near to the coal fired regenerative Tank furnace but is slightly far away from oil fired Regenerative and Recuperative Tank furnaces.

Spacewise, the layout is not congested and there is adequate space available for carrying out operations around oil fired furnaces.

Working condition is slightly better because of absence of coal fired Annealing chambers, pot pre-heating furnaces, etc, but due to coal gasification, lot of fumes, dust is seen near the dog house of the furnace.

House-keeping in the production areas is generally satisfactory but lot of improvement can be made.

3.8.3.3 Key Methods/Technology

The technology used for manufacture of soda lime glass products is traditional and manual as in other units of Firozabad. The key methods followed are as under:

i) For raw material preparation the quartz sand (which is procured as washed) is sieved in the sieving machine to obtain -30 mesh size for use. The sieving machine is also equipped with magnetic separator.

   For batch preparation, weighing of ingredients is done using weighing balance, mixing is done in pan-type mixer of 250 kg capacity.

   Washing and segregation of cullets is done manually. Sizing of cullets is not being practiced.

   Typical batch composition being used for melting in the tank furnace is as follows:

Constituent	Weight(kg)	Weight(%)
Quartz sand	120.00	63.16
Soda ash	40.00	21.05
Calcite	20.00	10.53
Other chemicals	10.00	5.26
	190.00	100.00
Cullet(approx.)	65.00	
	255.00	

ii) Melting is done in coal fired regenerative type Tank furnace at a temperature of 1450 deg.C.

iii) Forming is performed either by mouth blowing or by pressing using hand operated presses.

iv) Annealing is done in continuous type Annealing Lehr. Temperature of annealing is maintained at 480 deg.C to 490 deg.C.

v) For fire-polishing the glass products, Dyna machines are used, where the edges are fire-polished after grinding.

In general the methods in use are appropriate to the nature of the product and scale of operation. Low levels of production and lack of skills preclude the optimum utilisation of technology available.

3.8.4 <u>RESOURCES</u>

3.8.4.1 Manpower

The total manpower at Om Glass Works , as reported is 1300 No. The break-up of on-rolls and contract labour is as under:

On rolls	:	400 No.
Contract labour	:	900 No.
		1300 No.

This manpower strength of 1300 employees is for 3-shift operation of furnace, forming, annealing and 1-shift operation for batching, finishing, packing & despatch. The break-up of the on-roll employees is as follows:

Managerial/supervisory and staff	:	60 No.
Workers	:	340 No.

It is observed that narrow based single skilling is predominant throughout all production areas.

3.8.4.2 **Production Equipment**

The production areas are generally equipped with the types of equipment which are adequate to the production techniques followed in the works. The types of equipment used are given in Annexure 3.8.1.

There are three types of melting furnaces:

* Coal fired Regenerative cross fired Tank furnace
* Oil fired Regenerative end fired Tank furnace
* Oil fired Recuperative Tank furnace

Only coal fired Regenerative cross port Tank furnace was operating during the visit of the study team. The drawing capacity of tank of the furnace is 22 tpd. The coal consumption is 15 tpd. The melting zone is made of Sillimanite bricks of 300 mm thickness and above melting zone, GT blocks of 300 mm thickness are used. The roof of the furnace is made of silica bricks of 230 mm thickness, while other parts like regenerators are made of IS 8 or IS 6 fire bricks. The approximate volume of melting zone and furnace zone are 70 Cu.m and 12 Cu.m respectively. The production of glass wares, as reported is 10 tpd. The regenerator has a three pass system and oil consumption is 4 000 litres/day.

There is another oil fired Recuperative Tank furnace (under repair) which has a drawing capacity of 8 tpd and a fuel oil consumption of 3000 litres/day.

The refractories used in the Tank furnaces are:

Bottom and bridge of tank	:	Sillimanite
Crown of the tank	:	Silica bricks
Side of the tank	:	IS 8
Regenerator chambers	:	IS 8 & IS 6.

It was informed that the quality of sillimanite bricks used was not good. Electrocast should have been used in drawing and melting chamber.

There are two sizes of Annealing Lehrs used. One is 1.5 m x 22 m x 450 mm ht. and another is 900 mm x 16 m x 450 mm ht. Both the annealing lehrs are oil fired and the consumption of oil per day is 500 litres and 350 litres respectively. All the annealing lehrs are equipped with control panels and their conditions are satisfactory.

Besides having hand presses and blowing workstations there are finishing operation machines such as cutting workstations, grinding machines and melting machine.

3.6.4.3 Facilities/Utilities/Services

The works have a maintenance shop for repair of moulds/fixtures and other equipment. The workshop is equipped with centre lathes , shaper, drill and welding machine.

There is no laboratory for testing of raw material and batch mix. Only apparatus for testing the annealing quality is there, and some pieces of the batch are tested to find the annnealing quality.

The works has a connected load of 235 kvA, but supply is inadequate due to unscheduled power cuts. Three captive DG sets of 180 kvA are there for use during power failure.

There are three compressors of 50 HP each for generating compressed air at 70 psig required for burners of melting machine, cooling during head light pressing and refill machines.

There is a provision for fuel oil handling system which is equipped with filters, pumps, heaters for supplying fuel oil for furnaces and Annealing Lehrs.

Water is taken out from the tube wells and 2 No. of 10 HP pumps are installed for supplying water in the premises.

3.8.5 ENERGY AUDIT

3.8.5.1 Working Parameters

The working parameters of coal fired tank furnace such as draw rate and coal consumption were taken from the management. The other parameters of the furnace such as furnace temperature, molten bath temperature, average side wall and crown temperature, inside temperatures of regenerative chambers, carbondioxide and oxygen percentage in the flue gas were measured.

Similiarly measurements and data pertaining to Annealing Lehr were taken. A list of the working parameters is shown in Annexure 3.8.2.

3.8.5.2 Heat Balance

Om Glass has a coal fired, side port regenerative tank furnace with an efficiency of 17.3 %, as shown in the heat distribution pie-chart,Sketch No. 3.07.

The flue gas loss of 39.3 % is also high because of low carbondioxide percentage indicating high amount of excess air by operating the dampers. Moreover, as the furnace is pressurised, carbon monoxide produced in the furnace escapes out through the coal feeding hoppers. This results not only in environmental and pollution problems but also in deficiency of combustion gas in the regenerators.

Radiation loss of 34 % is also comparatively high. The probable reason is the low quality of refractories used which looses its life within a short period of time.

3.8.6 MANUFACTURING SYSTEMS

3.8.6.1 Production Planning & Control

There are no systems or procedures followed either for production planning or for production control.

As in other factories, requirement of raw materials, fuel etc is roughly estimated. For their standard products, the works has its own moulds/dies. For any specific/new order, moulds/dies are ordered, if not given by the party concerned.

Reports of the quantity of wares and types produced are received from the packing section.

3.8.6.2 Raw Material Planning & Control

Inventory levels of different materials, as informed by the owners are:

Quartz	:	20 - 30 days
Soda ash	:	2 weeks
Other chemicals	:	2 weeks
Coal	:	1 week
H.S.Diesel/LDO	:	1 week
Finished goods	:	10 days

All the raw materials are easily available in the market. The problem of coal is the same as indicated by other manufacturers. There is no shop floor control of materials.

3.8.6.3 Maintenance

No preventive maintenance is done in the works. There are no records of previous maintenance of furnaces, though annual cost of maintenance and repairs is between Rs 300 to 400 thousand.

Overall maintenance labour contract is given for carrying out the maintenance under the supervision of works supervisor. There is no regular inventory control for maintenance materials and no advance provision is made for replacement or servicing stock. The in-house maintenance & repair facilities are poor and the level of support is inadequate.

3.8.6.4 Quality Control

The unit does not have any laid out quality control procedures. There is no inspection of incoming materials and the quality of the material or fuel depends upon the supplier.

Sometimes annealing tests are performed on some samples of the batch but that too is not a regular practice . The reject percentage is between 25 - 30 % and no reject analysis has been done so far. It was informed that good quality of the accepted batch is 70 % and the rest is commercial grade, which the unit has to sell at a lower price.

3.8.7 POLLUTION

The main source of pollution is usualy the emissions from the stack of the furnace, which affects the ambient air quality. Measurements have been taken to check the quality of stack emissions, ambient air, waste water and solid waste and these are discussed in the following paras.

3.8.7.1 Stack Emissions Quality

Monitoring of the stack gases has been carried out by simultaneously sampling for SPM (suspended particulate matter) and gaseous pollutants such as Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), and Carbon Monoxide (CO). the stack emissions quality for Om Glass Works was found to be as follows.

Stack height	37 m
Velocity	4.6 m/s
Stack temperature	95° C
Quantity of emissions	4951 Nm^3/hr
SPM	90 mg/Nm^3
SO_2	147 mg/Nm^3
NO_x	31 mg/Nm^3
CO	62 mg/Nm^3

As seen from the above, the SPM value for the unit is well below the limit of 1200 mg/Nm^3 prescribed by the CPCB (Central Pollution Control Board). The low value of 90 mg/NM^3 could be achieved by the unit is obviously due to the pollution control measures adopted by the unit. An ammendment of the SPM value of 150 mg/Nm^3 by the Ministry of Environment & Forests for glass industries will be applicable from 1994 onwards, which will not affect Om Glass.

Regarding SO_2, even though no limit has been prescribed at present, a limit of 50 mg/Nm^3 has been prescribed by the Ministry of Environment and Forests, which will be applicable from 1994 onwards. In view of this, Om Glass, with a present value of 147 mg/Nm^3 as above, will have to adopt further measures to bring down the value below the limit of 50 mg/Nm^3.

For NO_x value, no limit has been prescribed so far.

The value of NO_x level for the unit will also be further suppressed when measures for reducing the SO_2 level are adopted.

The CO level as above is 62 mg/m^3, which is perhaps the l- west in comparison with other unit:, and indicates a better combustion of fuel. For a desirable combustion efficiency, the flue gases should be maintained with above 12 % CO_2 of 4 % O_2.

3.8.7.2 Ambient Air Quality

Ambient air quality measurements with respect to the various pollutants were carried out inside the factory premises at two locations and the results are as follows.

Parameter	Value in ug/Nm^3	
	Near Gate	Near Furnace
SPM	1031	942
SO_2	12	70
NO_x	28	70
CO	568	1025
F	20	52

As seen from the above, the SPM level for the unit exceeds the norms of 500 ug/m^3 prescribed by the CPCB (Central Pollution Control Board). Measures for reducing the dust pollution are required to be taken.

The value of SO_2 is well below the limits prescribed by CPCB (120 ug/m^3) for industrial area.

The NO_x is also below the limit as prescribed by the CPCB (120 ug/m^3) for industrial area.

The CO value is found to be within the limits prescribed by CPCB (5000 ug/m^3) for industrial area.

The Fluoride value is 20-52 ug/m^3 . So far there are no Indian Standards prescribed for the Fluoride concentiation . However, the limits prescribed by OSHA show that :

The origin of Fluoride is mainly from the furnace gases where Fluoride is also present as CaF_2 in the raw material. Studies in Fluoride show that it is a very potent gaseous pollutant and adequate measures are to be taken to contain the hazard.

3.8.7.3 Water Pollution

Waste water characteristics were measured in the grab samples collected from the outlet drain of the factory. Analysis of the samples indicate that water is only slightly polluted, and the water pollution problem is not acute in comparison with the air pollution. If these effluents are discharged into public sewers, only proper drainage system is required.

3.8.7.4 Solid Waste

The analysis of Coal ash samples from Om Glass indicated the volatile carbon content to be very high, which shows incomplete combustion of fuel.

Other parameters are normal except alumium which shows a high percentage.

No specific area inside the plant has been earmarked for dumping of solid waste.

3.8.8 PERFORMANCE

3.8.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of major raw materials and cullet work out to be as follows.

Quartz	0.53 t/t draw
Soda ash	0.18 t/t draw
Cullets	0.30 t/t draw

3.8.8.2 Energy Consumption

Based on the information collected regarding consumption of fuel and the corresponding production of molten glass, the specific energy consumption of the unit works out to be 11.39 million kJ / t draw.

3.8.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 30 %.

3.8.8.4 Pollution

The polluting parameter value of stack emission and ambient air, when compared with the norms prescribed by CPCB, indicated the following.

Stack Emissions:

- SPM value well below the limit
- SO_2 value exceeds the limit
- CO value lowest compared to other units.

Ambient Air:

- SPM value exceeds the limit
- SO_2 value well below the limit
- NO_x value below the limit
- CO value within the limit
- Fluorine present in the air

Annexure 3.8.1

PLANT AND MACHINERY

S.No.	Section	Types of Equipment
1.	Batching	Sieving arrangement for quartz Magnetic separator Weighing balance Batch mixer, pan type, capacity 250 kg, cycle time 5 minutes.
2.	Melting	Coal fired regenerative tank furnace, drawing capacity 20 tpd. Oil fired regenerative tank furnace, drawing capacity 16 tpd. Oil fired recuperative tank furnace, capacity 8 tpd.
3.	Forming	Mouth blowing pipes, cups and blowing workstation Hand presses, lever operated, with moulds & dies.
4.	Annealing	Annealing Lehrs of size 1.5 m x 22 m x 450 mm, 3 No. Annealing Lehr of size 900 mm x 16 m x 450 mm, oil fired, one No.
5.	Finishing	Melting machines, 2 No. Grinding machines, 2 No. Cutting workstation fitted with electrical element.

Annexure 3.8.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temp., deg.C	1440
2.	Molten bath temp., deg.C	1240
3.	Avg. side wall temp., deg.C	341
4.	Avg. crown temp., deg.C	341
5.	Stack temp., deg.C	435
6.	Carbondioxide in flue gas, %	7
7.	Oxygen in flue gas, %	13
8.	Excess air, %	150

Regenerative Chamber

9.	Inside temp., deg.C	780
10.	Surface temp., deg.C	220

Annealing Lehr/Chamber

11.	Lehr temp., deg.C	490
12.	Avg. surface temp., deg.C	82

3.9 ELECTRONIC GLASS INDUSTRY

3.9.1 DESCRIPTION OF THE SITE

3.9.1.1 Size and Location

The works is located on Delhi-Agra Road within 3 km from Firozabad. The factory site is approachable by a side lane branching from the main road towards Raja - ka - Tal. The site is only 4 km from Firozabad Railway Station.

The works occupies an area of about 3600 Sq.m, out of which around 2200 Sq.m is covered area.

3.9.1.2 Principal Features

Electronic Glass Works is in the industrial area and is surrounded by other glass factories. The manufacturing operations started in November 1975. Access by road is reasonable and there is rail-head nearby.

3.9.1.3 Constraints/Suitability

There are no constraints including transportatior of materials , fuels, consumables and finished goods to and fro from the works. The site is well suited to the manufacturing operations and has enough space for future expansion.

3.9.2 PRODUCTS

3.9.2.1 Principal Features

The unit is involved in the manufacture of the following soda lime glass products and bangles.

* Glass and glass wares
* Table wares
* Auto headlight covers
* Bangles

The unit is exporting some of the above products indirectly. For domestic use, the unit is supplying to the traders who sell the products after decorating the same.

3.9.2.2 Product Volume

The average production of glass products and bangles is about 12 tpd. The annual production for 300 days would be around 3600 tonnes, out of which about 400 to 500 thousand Todas of bangles are produced (1 Tora = 312 No. of Bangles).

3.9.3 PRODUCTION

3.9.3.1 Features of Production Area

Melting of the batch is done in regenerative type coal fired tank furnace, which is housed in an industrial shed. The furnace is equipped with chimney of height 41 m.

There is separate area for mixing of various ingredients after weighing and passing silica sand through magnetic separator. Forming of the molten glass to the desired shape either by blowing or by hand pressing is done near the furnace.

There are areas for reheating the glass and spiralling in the Belan Bhatti (bangle making furnace). Separate areas are there for annealing in the Annealing Lehrs and Annealing Chambers.

Finishing operations such as grinding , melting etc are performed in separate shed.

There are areas for raw material storage, coal storage, finished goods store, and packing of finished goods.

3.9.3.2 Layout/Material Flow

The layout of various production equipment for manufacture of glass and glass ware is generally arranged according to the production flow but in the bangle making the Sikai Bhatti and Belan Bhatti are located at random in lean-to shed.

Spacewise the layout is not congested in other production areas, but in tne forming and pressing area near the furnace there is not adequate space for the 9 hand presses and 6 to 7 blowing workstations.

The working condition is slightly better than many other works as there are mancoolers and exhaust fans installed.

House-keeping in the production area is generally satisfactory except in the bangle making area.

3.9.3.3 Key Methods/Technology

The technology used for manufacture of glass ware and bangles is traditional and manual as followed in other units of Firozabad. The key methods being followed for manufacture of glass ware and bangles are as under:

i) For preparation of the batch, the Quartz sand which is procured as washed and received in size of 80 to 100 mesh, is passed through magnetic separator. No sieving is done and the sand is used in the size as received, i.e., 80 to 100 mesh.

For batch preparation, weighing of various ingredients is done using weighing balance, mixing is done manually in batch trays.

Cullet washing is being practiced in the Cullet washing machine. Segregation of cullets is done manually. Sizing of cullets is not being practiced.

Typical batch composition being used for melting in the tank furnace is as follows:

Constituents	Weight(kg)	Weight(%)
Quartz sand	120.00	67.54
Soda ash	34.00	19.18
Calcite	14.50	8.17
Felspar	4.00	2.25
Sodium/potassium nitrate	2.50	1.40
Barium carbonate	2.00	1.12
Arsenic trioxide	0.30	0.17
Fluorspar	0.30	0.17
Selenium/cobalt oxide	as reqd.	-
	178.00	100.00
Cullet	75.00	
	253.00	

ii) Melting is done in regenerative coal fired Tank furnace of capacity 20 tpd at a temperature of around 1450 deg.C. The charge including the batch and 30 % cullet is charged to the furnace regularly. In 24 hours, about 75 to 85 batches are charged manually to draw about 18 tonnes of molten glass.

iii) The forming operations used in the glass ware are mouth blowing and pressing using blow pipes, moulds/fixtures and hand presses.

iv) For making bangles, manual spiralling is done on mandrels (belans) using Belan Bhatti (bangle making furnace) after reheating the glass in Sikai Bhatti (reheating furnace).

v) For annealing the glass products, Annealing Lehrs and Chambers are used , and the temperature of annealing maintained is about 525 deg.C.

vi) For fire-polishing , Dyna machines are used

3.9.4 RESOURCES

3.9.4.1 Manpower

The total manpower strength at the Electronic Glass Works as reported is 700 No. for 3-shift operation of melting, forming, annealing, and bangle-making, and 1-shift operation of batch mixing, finishing, and packing. Out of the 700 employees, only 40 No. are on rolls and the rest are contract labour. The maximum paid workers are those who work on Belans for spiralling of bangles and most of the workers are paid minimum wages.

It is observed that narrow-based single skilling is predominant throughout all the production areas.

3.9.4.2 Production Equipment

The production areas are generally equipped with the number and type of equipment which are adequate for the production techniques being followed. The type of equipment being used are indicated in Annexure 3.9.1.

There is one regenerative type tank furnace (coal-fired) of 20 tpd capacity. The coal consumption is 10 tpd. The melting chamber size is 4 m x 300 mm diameter.

The refractories used in the tank furnace are:

Bottom of furnace and bridge	:	Sillimanite bricks (300 mm thick)
Side	:	GT Blocks (300 mm thick)
Roof	:	Silica (230 mm thick)
Regenerative chamber	:	IS-8 or IS-6

Only one temperature indicater is installed in the roof of the furnace for temperature monitoring.

Annealing Lehr is kerosene oil fired and the maximum temperature in the hot zone is 525 deg.C. The consumption of oil is 400 litre/24 hours, and the size of the Annealing Lehr is 1.5 m x 300 mm x 32 m. There are three temperature indicators installed at different places of the heating zone. The condition of the Annealing Lehr is satisfactory. In addition, there are three Annealing Chambers, coal fired, of size 3 m x 3 m x 1.8 m height for annealing bigger size of glass articles. There are two Dyna machines for fire-polishing, which are fired with kerosene oil. Their condition is also satisfactory.

The condition of the other equipment like the oil-fired Sikai Bhatti and coal-fired Belan Bhatti is very poor, and lot of fumes were seen spreading into the working area.

3.9.4.3 Facilities/Utilities/Services

There is no laboratory for testing and inspection of either raw materials or intermediate products.

The works has a maintenance workshop for repair of moulds/fixtures and other equipment such as Dyna machines, hand presses, grinding machines, blowing and other workstation equipment.

The works has a connected load of 96 HP but the electric supply is inadequate due to unscheduled power cuts. Captive DG sets, one of 125 kVA and 3 No. of 12.5 kVA are installed to cater to the needs of furnace (blowers are used for furnace wall and bridge cooling), Annealing Lehrs, etc.

One compressor of 2.83 m^3/min capacity for generating compressed air at 70 psig, required for melting machine, Annealing Lehr and Sikai Bhatti, and another standby compressor of 2.83 m^3/min, engine driven, are provided.

Two No. of 10 HP Pumps are installed for supply of water to the premises.

3.9.5 ENERGY AUDIT

3.9.5.1 Working Parameters

The working parameters of the regenerative coal-fired tank furnace, such as furnace temperature, molten bath temperature, average side wall and crown temperatures, inside surface temperature of the regenerative chamber, stack temperature, carbondioxide and oxygen percentages in the flue gas were measured. Similarly, measurement and data pertaining to Annealing Lehr and Belan Bhatti were taken. A list of the working parameters is shown in Annexure 3.9.2.

3.9.5.2 Heat Balance

From the measurement and fuel consumption of tank furnace, the heat utilisation and various losses were worked out and presented in the Pie-chart, Sketch No. 3.08.

3.9.5.3 Analysis

Electronic Glass Works has a coal-fired regenerative side port tank furnace operating at an efficiency of 23.5 %, which is the highest.

Though the percentage of the carbondioxide (excess air) is 50 %, the stack temperature is slightly high which leads to flue gas loss of appreciable level.

Radiation loss of 42.5 % is comparatively high because of ageing of the furnace. Due to inferior quality of bricks/refractories, the unit has resorted to forced cooling to enhance the life of refractories.

3.9.6 MANUFACTURING SYSTEMS

3.9.6.1 Production Planning and Control

On receipt of order from the party after approval of the sample, production planning is done. Instructions are given to the store-keeper for issue of the moulds / dies to the production section. Sometimes the parties bring their own moulds dies if special design is required. Similar instructions are given to the raw material store- keeper. There are no systems or procedures for either production planning or control. The only indicator of production control is the quality of production of different products.

3.9.6.2 Material Planning and Control

The partner/key person is responsible for the material planning. The requirements of the materials are met through purchase from the local market.

The inventory levels of different materials are indicated as under.

Raw materials	:	15 - 20 days
Fuels	:	2 - 3 days
Finished goods	:	1 week

There is no shop floor material control. Only a register is maintained in the raw material store.

3.9.6.3 Maintenance

Only break-down maintenance is carried out in the works. There are no records of maintenance of furnace or other equipment. Maintenance of the furnace is given on contract and the campaign life of the furnace is around 1 year. The maintenance cost after one year is around Rs 500 thousand.

There is a small work-shop to cater to the repairs needs of other equipment.

3.9.6.4 Quality Control

There is no method of controlling the quality of glass in the works. Emphasis is given on the quantity rather than quality. Every thing is left to the judgement of the workers . Only visual checks are made in sorting the glass products before packing. Rejects are usually between 20 - 35 % and in the accepted products the grading is usually 20 % good quality and the rest 80 % commercial quality , and it was informed that the commercial quality products have to be sold at 20 % lower price.

3.9.7 POLLUTION

The main source of pollution is usually the emissions from the stack of the furnace, which affects the ambient air quality. Measurements have been taken to check the quality of the stack emissions, the ambient air, waste water and solid waste, and the same are discussed in the following paras.

3.9.7.1 Stack Emissions Quality

Monitoring of the stack gases has been carried out by simultaniously sampling for SPM (suspended particulate matter), and gaseous pollutants such as Sulphur Dioxide(SO_2), Nitrogen Oxides (NO_x), and Carbon Monoxide (CO). The stack emissions quality of Electronic Glass were found to be as follows.

Stack height	41 m
Velocity	9.5 m/s
Stack temperature	360 °C
Quantity of emissions	4706 Nm^3/hr
SPM	1140 mg/Nm^3
SO_2	222 mg/Nm^3
NO_x	106 mg/Nm^3
CO	252 mg/Nm^3

As seen from the above data, the level of SPM at 1140 mg/Nm^3 is marginally within the limit of 1200 mg/Nm^3 prescribed by CPCB (Central Pollution Control Board). This will , however, be much above the new limit of 150 mg/Nm^3 of the Ministry of Environment and Forests which will be applicable from 1994 onwards Thus the unit has to take adequate measures for controlling the SPM level appropriately.

The SO_2 level of the unit is 222 mg/Nm^3 . Even though no limit of the CPCB exists presently, the new limit of 50 mg/Nm^3 of Ministry of Environment and Forests , coming into force from 1994 onwards will require the unit to take adequate measures to bring down the SO_2 value below 50 mg/Nm^3.

For NO_x value no limit is there so far. The value obtained for the unit is 106 mg/Nm^3. Measures to be taken by the unit for reducing the SO_2 value will bring down the NO_x value appreciably in the stack.

The CO value is 256 mg/Nm^3, which is quite high and indicates improper burning of fuel. For efficient burning of fuel, it is desirable to maintain the flue gases with above 12 % CO_2 or with 4 % O_2.

3.9.7.2 Ambient Air Quality

Ambient air quality measurements with respect to the various pollutants was carried out within the factory premises at three locations and the results are shown below.

Parameter	Value in ug/m^3		
	Main Gate	Near Furnace	Coal Yard
SPM	1413	5225	845
SO_2	31	20	43
NO_x	27	19	16
CO	2026	6000	5250
F	42	50	14

As seen from the above table, the SPM level exceeds the CPCB norm of 500 ug/m^3 at all the three locations. The high SPM values as above, are indicative of dust pollution and an atmosphere that is not conducive for the health of workers. Adequate measures are very much required to be taken to control the pollution in the area.

Regarding the SO_2 level, the values observed above are well below the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

For NO_x level, the observed values are far below the limit of 120 ug/m^3 prescribed by CPCB for industrial area.

Regarding CO level, the observed values as above, slightly exceed the limit of 5000 ug/m^3 prescribed by CPCB for industrial area, for two of the three test locations (near work area).

Regarding the Fluoride levels, so far no standards have been prescribed by the CPCB. According to OSHA standards, it is a potent gaseous pollutant and adequate measures should be taken to contain the hazard.

3.9.7.3 Water Pollution

Water is being used for cooling and human consumption. The water pollution is not acute.

3.9.7.4 Solid Waste

Solid waste is mainly being generated from Coal which is being used as fuel. In general, the analysis of solid waste of some of the glass units indicates that the parameters are more or less as expected, except aluminium which is found to be present in very high percentage.

No specific area in the plant is marked for dumping of solid waste.

3.9.8 PERFORMANCE

3.9.8.1 Raw Materials Consumption

Based on the information collected from the management, the consumption of the major raw materials and cullets works out to be as follows.

Quartz sand	0.52 t/t draw
Soda ash	0.15 t/t draw
Cullets	0.33 t/t draw

3.9.8.2 Energy Consumption

Based on the information collected regarding consumption of fuel and the corresponding production of molten glass, the specific energy of the unit works out to be 8.36 million kJ/t draw.

3.9.8.3 Rejection Rate

The rejection rate is an indicator of the quality of the products being produced. The rejection rate for the unit works out to be 33 %.

3.9.8.4 Pollution

The observed polluting parameter values of the stack emission and ambient air, when compared with the norms of CPCB/Ministry of

Environment & Forests , indicated the following:

Stack Emissions:
- SPM value exceeds the limits
- SO_2 value exceeds the limits
- CO value is high

Ambient Air:
- SPM value exceeds the limit
- SO_2 value well below the limit
- NO_x value far below the limit
- CO value slightly exceeds the limit
- Fluoride is present in the composition

Annexure 3.9.1

PLANT AND MACHINERY

S.No.	Section	Type of Equipment
1.	Batching	Weighing balances of capacity 500 kg, 5 kg, and 10 gms. Cullet washing machine Magnetic separator
2.	Melting	Regenerative Tank Furnace, coal-fired, capacity 20 tpd and having 15 ports for drawing glass.
3.	Forming	Mouth-blowing Work-stations with blow pipes cups , etc. Hand presses, 9 No.
4.	Annealing	Annealing Lehr, oil-fired, of size 1.5 m x 300 mm x 32 m long. Belt speed: 32 m in 45 minutes. Max.temp. 525 deg.c, equipped with control panel. Annealing Chambers, coal-fired, chamber size: 3 m x 3 m x 1.8 m.
5.	Reheating & Spiralling	Sikai Bhatti (reheating furnace), oil-fired, with oil consumption 300 litres/24 hrs. Belan Bhatti (bangle making furnace), coal-fired, 3 No.
6.	Finishing	Melting machine, oil-fired, 2 No., equipped with 0.5 HP motor. Grinding machines, with 2 HP motor.

Annexure 3.9.2

WORKING PARAMETERS

Melting Furnace

1.	Furnace temperature, deg.C	1530
2.	Molten bath temp., deg.C	1410
3.	Avg. side wall temp., deg.C	280
4.	Avg. crown temp., deg.C	280
5.	Stack temp., deg.C	495
6.	Carbondioxide in flue gas, %	12
7.	Oxygen in flue gas, %	7.5
8.	Excess air , %	50

Regenerative Chamber

9.	Inside temp., deg.C	700
10.	Surface temp., deg.C	225

Annealing Lehr/Chamber

11.	Lehr temp., deg.C	530
12.	Avg. surface temp., deg.C	70

Belan Bhatti

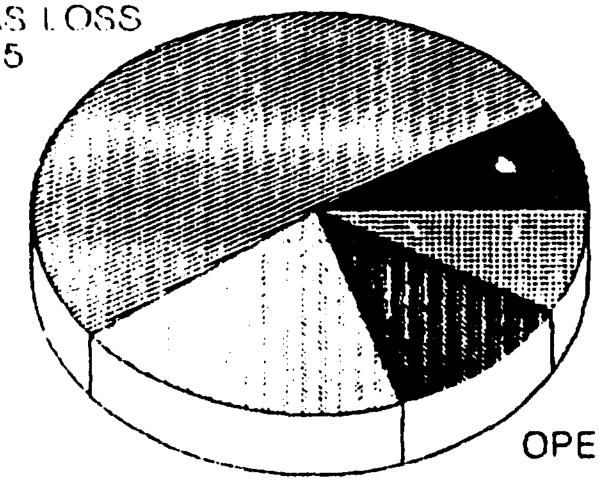
13.	Inside temp., deg.C	650
14.	Avg. surface temp., deg. C	90

3.10 Financial Aspect of Identified Glass Units

3.10.1 As discussed in para 3.1.9, the cost of production per tonne of soda lime glass has been estimated by consultants both in case of pot furnace (open and closed types) as well as for tank furnace, and the same are presented in Appendices 3.10.1 to 3.10.5.

Sketch No. 3.01

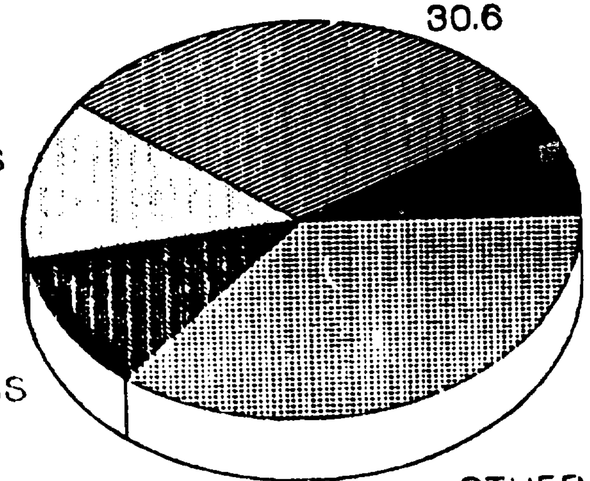
MANOHAR GLASS WORKS
% HEAT DISTRIBUTION



CLOSED POT FURNACE

Sketch No. 3.02

SHIVCHINA GLASS WORKS
% HEAT DISTRIBUTION

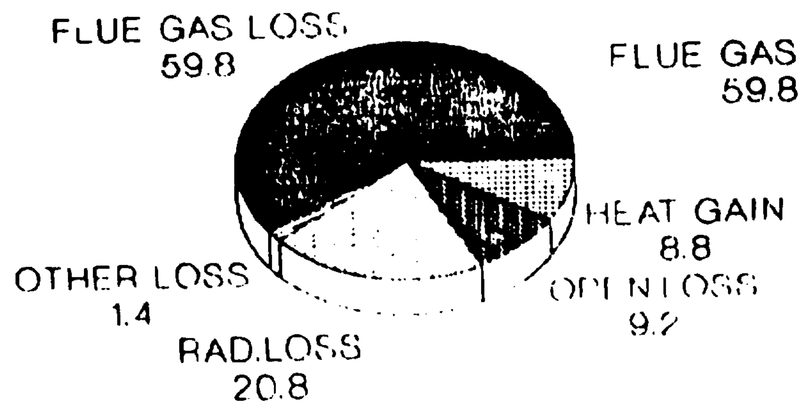


CLOSED POT FURNACE

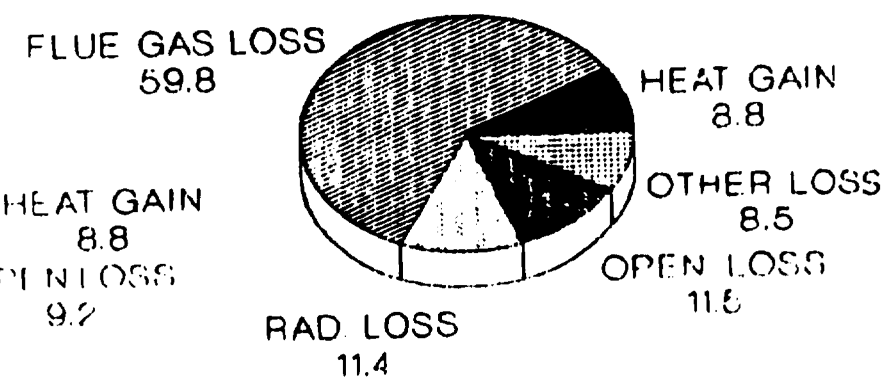
Sketch No. 3.03

POOJA GLASS INDUSTRY

% HEAT DISTRIBUTION



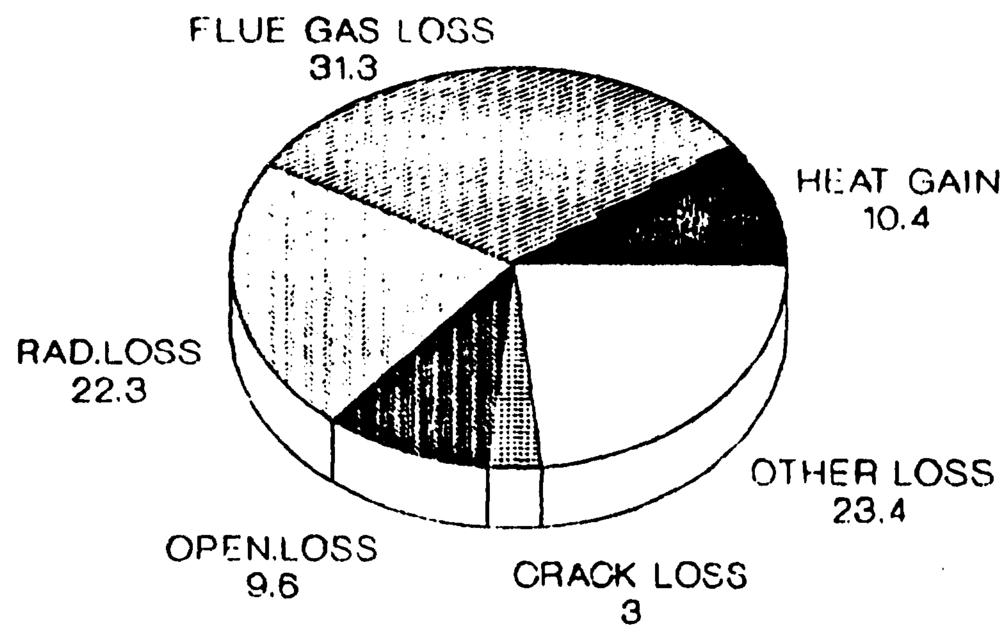
POT FURNACE 1



POT FURNACE 2

Sketch No. 3.04

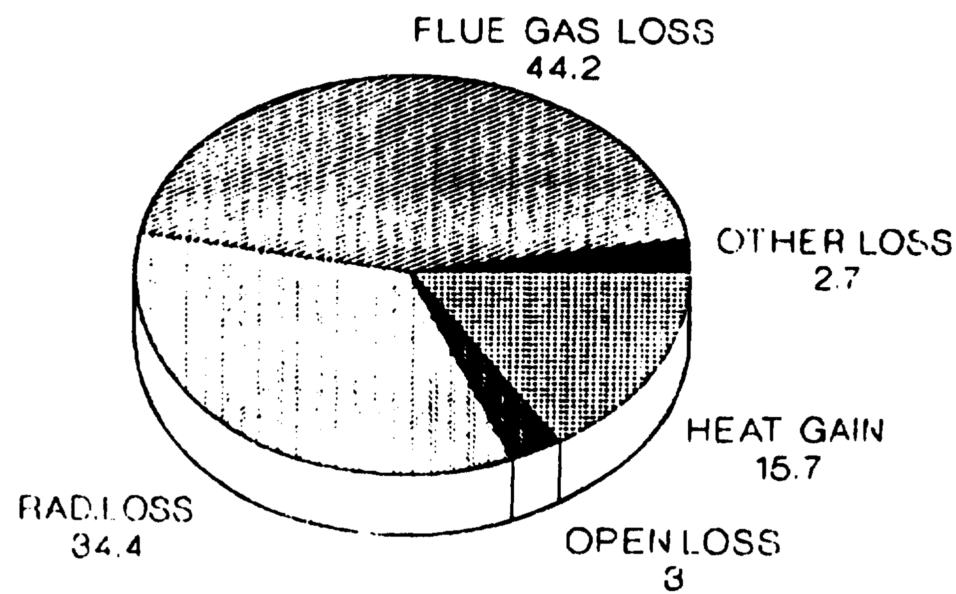
ADARSH GLASS INDUSTRY
% HEAT DISTRIBUTION



TANK FURNACE (OIL FIRED)

Sketch No. 3.05

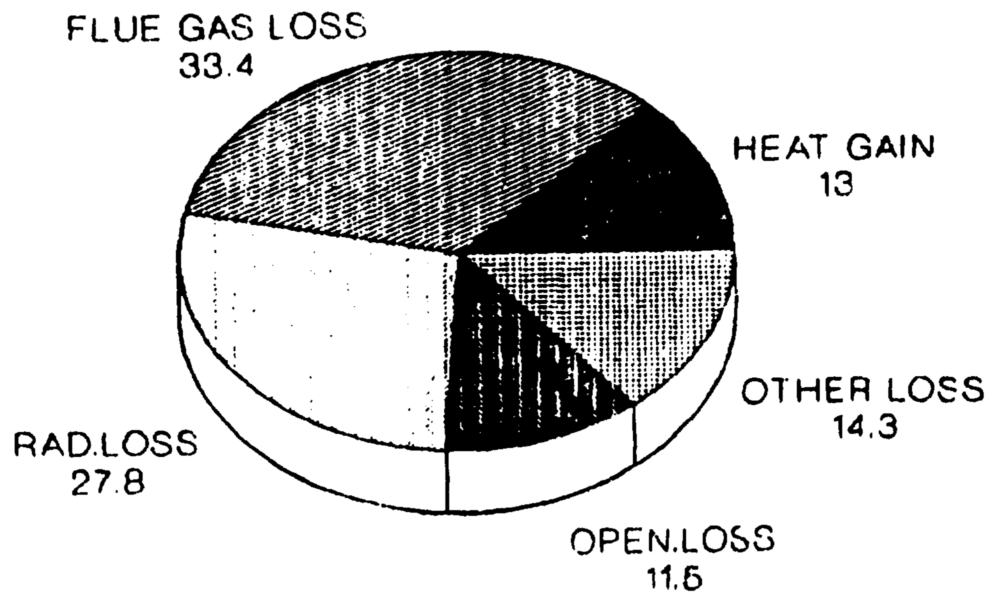
WEST GLASS WORKS
% HEAT DISTRIBUTION



TANK FURNACE

Sketch No. 3.06

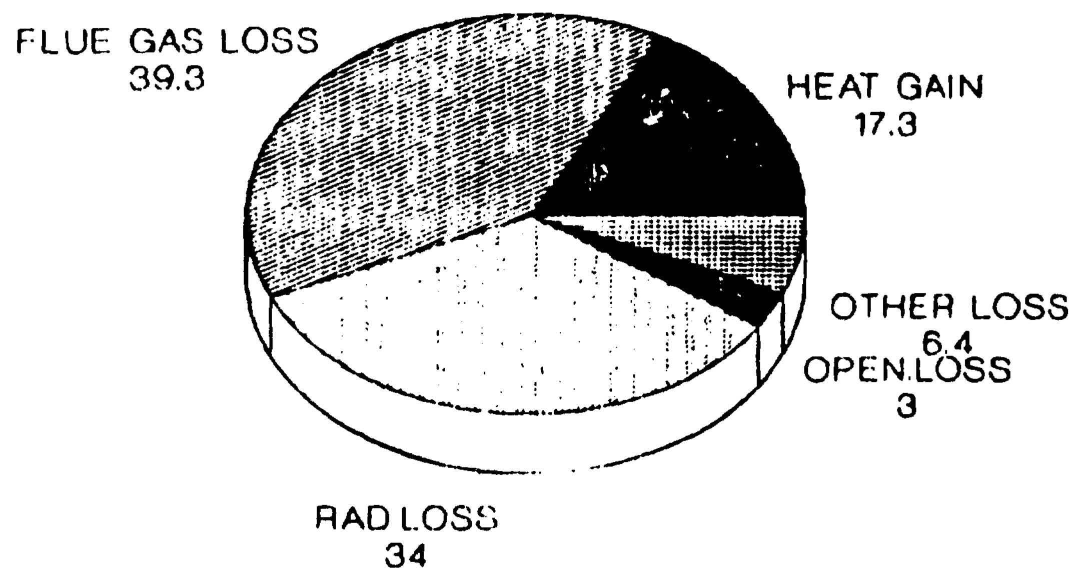
BABY GLASS WORKS
% HEAT DISTRIBUTION



OPEN POT FURNACE

Sketch No. 3.07

OM GLASS WORKS
% HEAT DISTRIBUTION

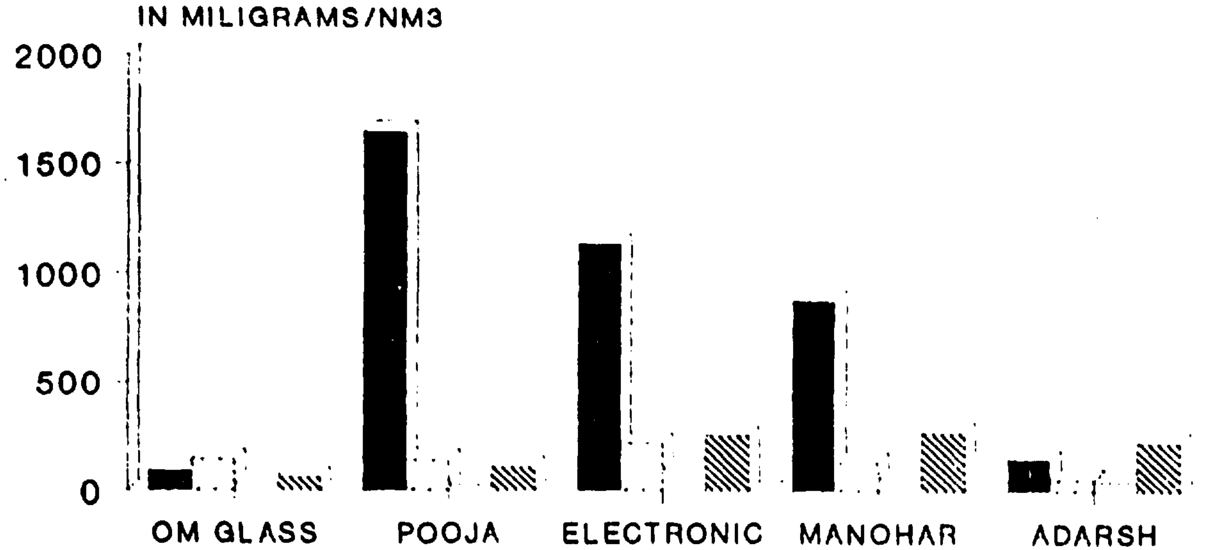


TANK FURNACE

Sketch No. 3.09

STACK EMISSIONS QUALITY

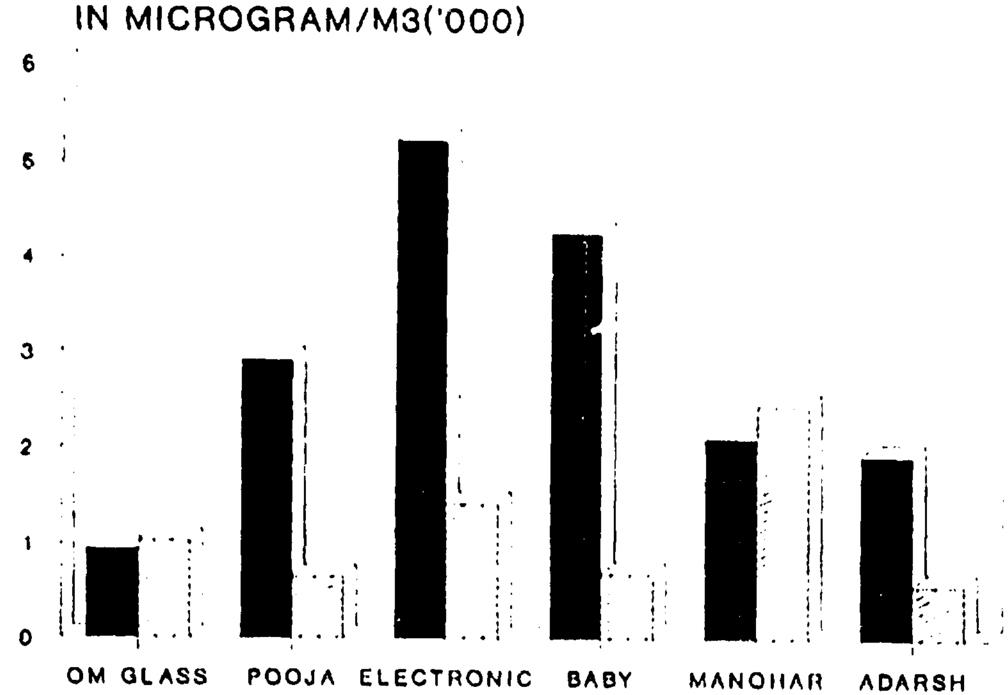
(SPM, SO2, NOX & CO)



	OM GLASS	POOJA	ELECTRONIC	MANOHAR	ADARSH
SPM	90	1650	1140	883	147
SO2	147	144	222	134	58
NOx	31	26	106	63	48
CO	62	114	256	275	230

Sketch No. 3.10

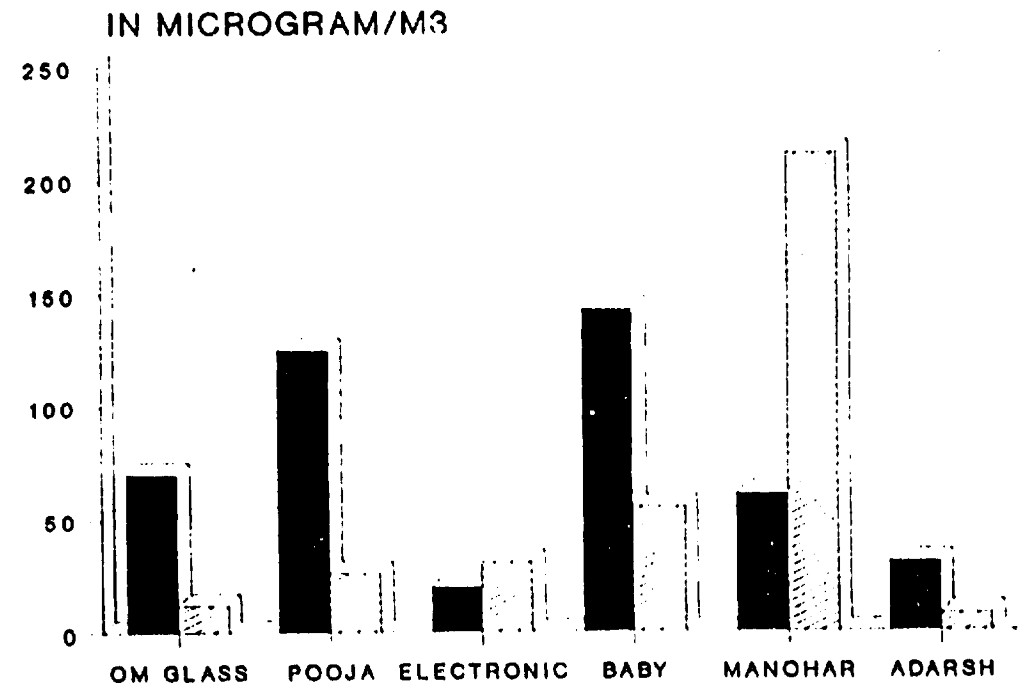
SPM CONCENTRATION
IN GLASS INDUSTRIES



	OM GLASS	POOJA	ELECTRONIC	BABY	MANOHAR	ADARSH
WORK PLACE	0.942	2.913	5.226	4.246	2.096	1.919
FACTORY PREMISES	1.031	0.648	1.413	0.685	2.446	0.568

Sketch No. 3.11

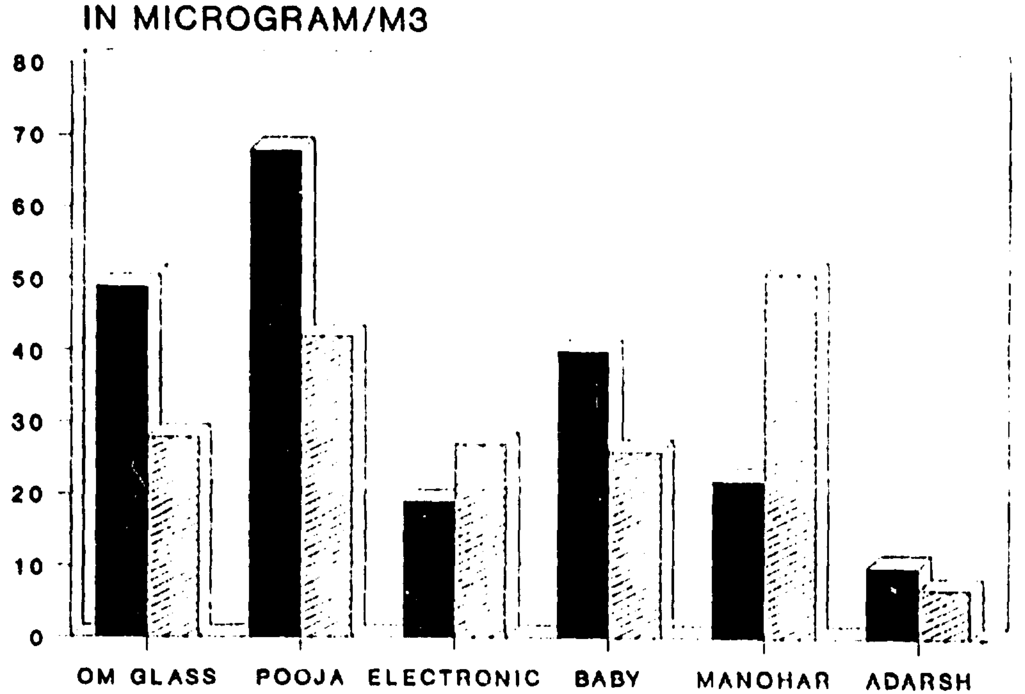
SO2 CONCENTRATION
IN GLASS INDUSTRIES



	OM GLASS	POOJA	ELECTRONIC	BABY	MANOHAR	ADARSH
WORK PLACE (solid)	70	125	20	143	61	31
FACTORY PREMISES (hatched)	12	26	31	55	212	8

Sketch No. 3.12

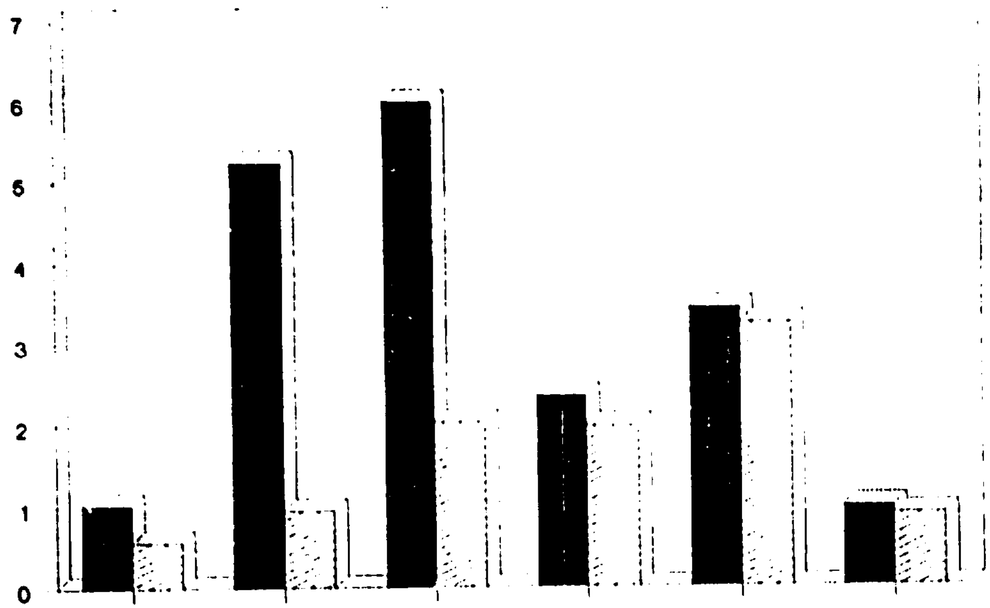
NOX CONCENTRATION
IN GLASS INDUSTRIES



	OM GLASS	POOJA	ELECTRONIC	BABY	MANOHAR	ADARSH
WORK PLACE	49	68	19	40	22	10
FACTORY PREMISES	28	42	27	26	51	7

Sketch No. 3.13

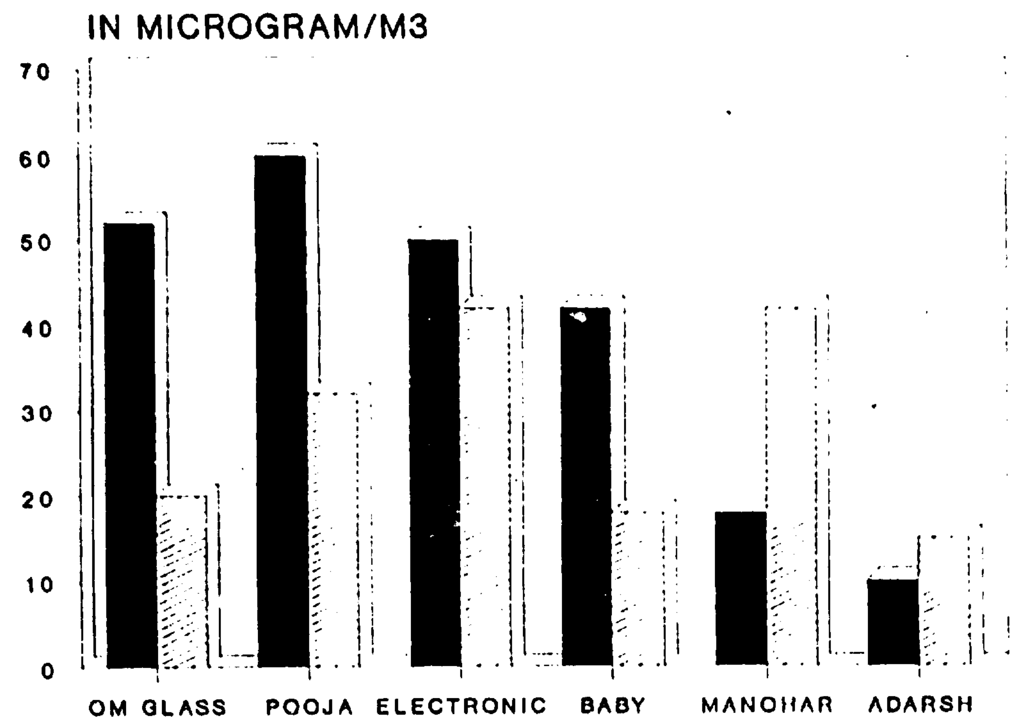
CO CONCENTRATION
IN GLASS INDUSTRIES



		OM GLASS	POOJA	ELECTRONIC	BABY	MANOHAR	ADARSH
WORK PLACE	■	1.025	5.25	6	2.35	3.43	0.983
FACTORY PREMISES	▨	0.568	0.942	2.026	1.98	3.25	0.892

Sketch No. 3.14

FLUORIDE CONCENTRATION
IN GLASS INDUSTRIES



	OM GLASS	POOJA	ELECTRONIC	BABY	MANOHAR	ADARSH
WORK PLACE	52	60	50	42	18	10
FACTORY PREMISES	20	32	42	18	42	15

IV. MODERN TECHNOLOGY TRENDS

4.1 Technological Aspects

The comparison of technology practised in Firozabad glass industry and the modern technology trends in small scale units, needs specific considerations of those aspects with which the quality can be improved, cost of production reduced and productivity increased. The technology in use at present in Firozabad, has certain areas of draw backs, which are detailed in Chapter 3. The modern trends with respect to raw materials and batching, furnace design and manufacturing techniques are summarised in the ensuing paragraphs.

4.2 Raw Materials and Batching

The modern trend in batch preparation, which is the first stage in the glass manufacture includes raw material processing, accurate weighing in balances and mixing of raw materials. The use of correct particle size of the various ingredients and quality of the raw materials also plays a critical role in making good quality glass.

4.2.1 Raw Materials

The major raw materials used for glass manufacture are sand, limestone and soda ash. Silica sand and limestone are used as prescribed in IS:488-1962 and IS:997-1987 respectively. To keep the iron oxide content less than 0.02%, washed sand or quartz is used. All the mineral type raw materials, which had to undergo crushing and pulverisation are subjected to magnetic separation before use.

Soda Ash

Dense variety of soda ash with about 80% grains of 80 mesh to 20 mesh and free from dust is used. This reduces segregation of the mixed batch, dusting inside the furnace and carry over to the regenerators.

Dolomite

Crushed dolomite is available to the industry and the preferred grain size is 20 mesh. For colourless glass relatively high purity dolomite is used.

Other Batch Materials

These include salt peter or nitre, borax, felspar and other ingredients like arsenic, selenium, cobalt oxide, etc.

It is generally preferred to use selenium in the form of selenium selenite which volatilizes to a lower extent, for decolourisation of glass. Also, Arsenic Trioxide is usually used in quantities less than 0.5 % in the glass composition, in view of its being poisonous.

Grain sizes of various glass ingredients are well selected and maintained by proper sieving, as this aspect plays a critical role in the melting process. Both the undersize and oversize particles are harmful and the best size of the batch particles may be considered between 20 to 80 mesh B.S. The oversized particles take longer time to fuse and melt and mostly float on the surface of the glass tank and form scum, which acts as a heat shield and lowers the thermal efficiency of the furnace. The fines on the other hand are carried away by the exhaust gases on their way out through flues, regenerators and chimney etc. The oversized particles are eliminated by sieving of the batch materials and the fines may be confined during mixing stage by adding 2-4% moisture.

Care is taken in storing of hygroscopic materials such as soda-ash, potash, nitrates and sodium sulphate. Lot-wise,day to day moisture estimation and requisite quantity corrections are carried out for such materials before use.

4.2.2 Batching

Weighing of the various ingredients is done with load cell type balances before mixing in desired proportions. Mixing is done in rotary drum or pan type mixers and water is added with the help of sprayers mounted on the mixing machine. Moisture to the extent of 3% prevents dusting inside the mixing chamber and also helps in melting and refining of glass. Mixing of fairly uniform type can constantly be achieved in this system. Handling of cullets depends upon the source i.e. whether generated in-house or bought from outside sources. Cullets generated internally, specially waste glass, during forming operations is very hot and on cooling down it turns into a hard mass. This requires size reduction to make it fit for recycling. Foreign cullet or purchased cullet require pre-processing before its use. The cullets are screened on conveyors for removal of unwanted inclusions like stones, coloured glass, ceramic and tramp particles.

The cullets either purchased or generated in plant are crushed to size less than 30 mm x 30 mm , well washed and subjected to magnetic separation before use. The modern methods of mixing and charging of cullets upto 50 tonnes per day draw are as under :

* Mixing of the cullet in the mixer along with other batch ingredients and then charging

* Mixing the cullet with mixed batch in the bunker above dog house

Feeding of the batch is done with electromagnetic vibrator on the reciprocating pan feeder or with screw feeder. Feeding is regulated with timer which can be set according to glass draw rate or automatic glass level controller. A schematic sketch of batch preparation system is shown in Sketch No. 4.01.

4.3 Glass Melting Furnaces

Basic considerations behind furnace design are :

* To ensure maximum yield per unit area of the melter of desired quality glass
* Ensure efficient use of fuel by proper combustion and heat recovery from flue gases
* Prevent air pollution to the maximum possible extent.

Modern trend for realising the above is aided with the availability of high heat and corrosion resistant electrocast refractories, insulation materials and efficient fuel firing equipment.

4.3.1 Pot Furnaces

Use of pot furnace in the modern trend is confined to units producing coloured glass, opal glass, lead crystal glass, optical glass and special type of glass requiring specific atmosphere during melting and processing.

In India, CGCRI is using oil fired pot furnaces for production of optical and special type of glasss such as Radiation Shields for atomic plants and development of special items like glass ceramics and glasses for super-conductivity trials. Pot melting is best suited for coloured glasses used in lenses of fog lights of automobiles, traffic railway signal glasses.

Furnace oil or gas is used as fuel which facilitates installation and use of Recuperative heat recovery system.

In case of furnace oil, the type of burners used in pot furnace is of total air, low pressure burners having oil pressure of 1.0 kg/cm^2 and air pressure is around 0.3 to 0.4 kg./cm^2, ensuring complete combustion within the space in furnace in a well designed and operated pot furnace. The oil consumption for 3 tonnes of glass melt/day is around 45 litres per hour and the fuel to glass ratio is 1:3.

Metallic Recuperator is of Radiation type, in which inner shell is of resistant material and the outer shell is of mild steel construction. The flue gas from the furnace passes through the inner shell of the Recuperator. The air volume to be pre-heated is passed in parallel flow arrangement through the annular space between inner and outer shell of the recuperator. The air is pre-heated to around 350°C and the pressure drop on air side is 50 mm of water gauge. The chimney in this case is working on forced draft instead of natural draft. The refractories used in the side walls of the pot furnaces are of high Alumina-Sillimanite or Mullite bricks and in the crown, high heat duty silica bricks are used. The insulation in the crown of the furnace is done with silica insulating bricks plus layer of cerawool.

Instrumentation

The furnaces have two indicator-cum-recorder type pyrometers installed in the crown, one thermocouple in the flue path at the entry of Recuperator and one at exit at chimney base for continuous monitoring of furnace and flue gas temperatures. In addition to this, one indicator type thermocouple is installed to maintain combustion air pre-heating temperature. There is also one oil-flow meter and on-line flue gas analyser to maintain oxygen level from 1.5 to 2.5%.

The energy requirement per kg. of glass drawn, in case of properly designed and operated pot furnace with oil/gas fired pot furnace equipped with heat recovery system is in the range of 3000 kilo calories.

Pot Technology

Quality of pot is most critical in melting of glass. New concepts are being advocated for improving the corrosion resistance and life of the pots, which include amongst others the following :

- Providing layer of monolithic ramming mass inside the pots

- Use of alternate high alumina containing clay and grog mixture instead of regular fire-clay grog only

In the context of Indian clays, matching of the size analysis of selected suitable clays with those of standard pot manufacturing clays should be carried out for achieving a proper body mix.

A vacuum press should be employed in order to diminish the porosity of the mass obtained.

Forming of the pots from the plastic mass offers a simple and quick method for making the pots.

For drying of pots, it is necessary to have a closed and strictly conditioned room with respect to air temperature and humidity, so that pot drying can be carried out at a controlled rate. This will shorten the unduly long drying periods required in natural drying of pots and also prevent unfavourable effects on the body structure which are caused by very high drying rates.

The cost of pots is another significant consideration hampering development of new alternative concept of pot manufacture.

At CGCRI, optical glass is made in pots. The pots used are made by slip casting method, in which grog containing burnt kyanite powder is added so that pots can withstand higher temperature and can have higher corrosion resistance. The pots are made in three layers. The drawback is that the pots in which optical glass is melted are broken for taking out the glass

The efficiency of a pot is the number of melts that can be obtained from it without impairing the quality of molten glass.

Development of longer service life pots which can withstand higher temperature and corrosion by glass was taken up at NOIDA, few years back and some success was achieved in the direction to enhance the average pot life from 2 weeks to around 4 weeks. Further development work was carried out at Bishenpura and Punchkula in the light of compositions used in other countries like

U.K., Korea and U.S.A. etc. Further success was achieved and the resultant pot life increased from 2 weeks to 10 weeks. Pot specifications and pot body composition was finalised as under :

Pot Specifications

PCE (Pyrometric cone equivalent)	= 34 min.
RUL (Refractoriness under load)	= 1550°C (Min.)
CCS (Cold crushing strength)	= 300 Kg/cm²
Alumina	= 45%
Silica	= 53%
Iron Oxide	= 1.5% max.

Body Composition

Kyanite	= 53
Kaolin	= 20
Pyrophallite	= 20
Ball clay	= 10
Talc	= 4
Grog	= 30

Much care was exercised in moulding and drying of the pots so that there was no stratification at the joints of the layers of pot walls and bottom. Drying of hand moulded pots was carried out in rooms having controlled humidity to ensure against development of hair cracks.

Pre-heating of Pots

To ensure longer service life of pots, pre-heating of the pots is done in an oil fired pot kiln in a scheduled manner. This is done with a view to achieve the following :

- To remove the water ofcrystallisation of the clay body
- To ensure complete vitrification and mullite formation so that pots can withstand corrosion and high heat involved during the service life.

The above two objectives are achieved by programmed heating to around 1350°C. The firing of the pots in this way not only expells free water, hygroscopic water, chemical or bonded water but also brings chemical changes in the body of the pots which reduces its porosity and completes vitrification.

4.3.2 Tank Furnace

The modern trend is to melt the glass in oil/gas fired End Port Recuperative Furnace, as good homogeneity is much more difficult to attain in pots without using mechanical stirring, than in the tanks. The design features of oil/gas fired end port Recuperative furnace are described as under :

Oil/Gas Fired End Port Regenerative Furnace

The design of tank furnace can be considered in two separate parts - melting area and the combustion area, with the only essential link between the two being the exchange of heat. Excess volume of the melting area leads to undesirable heat losses and shortage of space results in incomplete combustion within melting area. The ratio of length and breadth of the melting zone for good furnace design is very important and is between 1.4 to 1.6:1 for oil/gas fired end port Recuperative furnace for a 20 tonnes per day draw melting.

The depth of the melt should be kept taking into consideration the following:

- It should allow the required longitudinal circulation but also avoid the bottom refractories becoming too hot for easy corrosion.

- It should prevent the melt at the bottom to cool and thus too viscous to flow easily.

Depths between 1.0 metre to 1.3 metre are common and related to the type of glass with infrared absorption and the area of the melting zone.

The combustion space must match the length and width of the melting area but its dimensions must allow the insertion of ports for fuel and combustion air in sufficient quantity to supply the necessary energy and establish the desired temperature distribution. There is a minimum effective flame length for any particular system of fuel firing. Small tanks often have a horse-shoe or U-shaped flame or half horse-shoe flame. Glass draw from the small size tank furnace is generally between 20 to 30% of the glass holding capacity of the furnace. The working zone or refining zone is provided with 10-14 drawing holes in its outer periphery. The working zone is semi-circular in shape and radius of curvature is equal to width of the melting zone plus 300 mm.

Refractories

The refractories used in the melting area are Electrocast blocks Alumina-Zircon-Silica (AZS) type, which ensure long campaign life of the furnace. The top layer of the tank bottom in melting zone is made from electrocast paving tiles and layer under it is made from IS:8 refractory blocks. The third layer is then followed with fire clay tiles and the fourth layer is constructed with insulating materials. Considerable bottom thickness is very important to reduce heat iosses from glass melt. The details of refractories used in side walls, crown of the melting zone and working zone are shown in the Sketch No. 4.02.

Heat Recovery System

Both metallic and ceramic recuperators are used in modern melting systems. Only recently, advantages of metallic recuperators are being acknowledged and increasingly used in smaller units. Life of the recuperator varies from 4 to 10 years depending upon the type of furnace and operating tempe atures. Also repairs can be carried out quickly. The construction of the metallic recuperator is similar as described earlier. Ceramic recuperators are useful in the flue gas upto the temperture of 1500°C and can pre-heat air upto 800°C.

Combustion System

Furnace oil or gas is useo as fuel which facilitates installation and use of high conductivity recuperator heat recovery system. In case of furnace oil, the type of burners used in tank furnace is high/medium air pressure burners, atomising air being in the range of 2 to 4 bars. The oil consumption is generally between 0.2 - 0.25 tonnes/tonne soda lime glass and for borosilicate glass, the consumption of oil is between 0.4 to 0.5 tonnes/tonne of draw. Underport system is considered most efficient, as it provides most effective transmission of heat by radiation from sweeping flame to glass surface over a wide area. As the furnace is mostly under positive pressure, it eliminates cold air ingress and results in higher flame temperatures promoting significant fuel savings.

Instrumentation

Temperature measurements at various points of furnace and flue gas paths provides not only valuable clues regarding the condition of the furnaces, but also helps in proper furnace operation. In the tank furnace, the areas to be monitored are crown temperatures at soaking and hot spot, flue gas inlet and outlet temperatures and pre-heated secondary air temperature. Other important parameters to be monitored and controlled are quantities and rate of flow of oil for control of oil-air mixture, analysis of flue gas at exit point, chimney draft, furnace pressure and glass level.

It is also desirable to maintain constant furnace pressure as it keeps the furnace atmosphere stable. If the furnace pressure is lower than atmosphere, there is a valuable heat loss due to cold air in-leaks, which affects the temperature distribution and combustion. If the furnace pressure is higher than required, heat losses occur due to expulsion of hot gases, and the campaign life of refractories is also reduced. Quite often this also indicates choking in the exit path of the flue gases and chimney.

If the furnace is used for automatic production of glass items i.e. tumblers etc. then it is necessary to regulate the glass level with automatic indicating glass level meters.

Instrumentation, particularly for temperature monitoring and flue gas analysis, is regularly used. Process control and energy utilisation tools are meticulously used for obvious advantages.

4.4 FORMING

Glass may be shaped by either machine or hand moulding. With the development of faster and better machines the tedious hand moulding process is gradually giving way.

The manufacture of tablewares, tubes including thermometer capillary and bulb shells by manual process has been almost abandoned in modern plants. But bench worked art glassware, pressed ware and bangles are still being made by manual and semi-automatic presses.

Almost the entire range of tablewares is gradually shifting to automatic and semi-automatic systems except the manufacture of heavy items, special shaped items etc. For blownware items such as chimneys and some special labware, semi-automatic stand blows are in use presently. Mouth blowing is limited to only special quality glassware of expensive type, which does not demand very fast working. The modern trend in mouth blowing techniques for such items is same as being practiced at Firozabad. The only difference is the replacement of bubble making and bubble gathering of gobs, with use of nozzles at the blowing pipe gathering ends and introduction of foot-operated mould opening and closing device. By this method not only the use of manpower has been reduced but the defects like obliquity of the glassware arising from defective bubbles can also be avoided. The other advantage is that nozzle gathering facilitates marvering on flat plates instead of cup marvering, which helps in achieving the desired thickness in sides and bottoms of the glasswares. Moreover, the moulds mounting on stands with the facility of dipping in water after each Blow' produces rich lustre in the blown glassware, which otherwise cannot be achieved by using moist paper strips.

4.4.1 Bench Worked Art Glassware

Bench working for production of stemware is confined to expensive crystal glass and coloured glasses. Semi-automatic system is used in modern trends for common soda-lime glass. The stemwares are produced in two parts. Cup is made by machine blowing and the stem is produced by pressing process. The base of the stem in these cases is generally polygonal and thicker than bench worked art glasswares. The two are sealed together under flames by hand while still hot. To produce correct sealing, gadgets and fixtures are employed.

4.4.2 Pressed Wares

The production of pressed glassware involves the following three main activities :

- Gathering of glass from the furnace
- Cutting of gob into mould
- Pressing to form an article

In hand pressing process, all these functions are done manually, whereas in semi-automatic process, some of these functions are performed with the aid of hydraulic, pneumatic or mechanical systems.

Hand Pressing

Hand pressing is desirable in case where the product quantity is small and the quality specifications are lax. The most critical factors, other than those of the operators, are dependent on the material of the mould, mould and plunger temperature before use, hard chrome plating of the moulds and maintenance of the moulds.

Semi-Automatic Pressing

In semi-automatic pressing, some of the main functions listed above, have been switched over to automation. Glass gob gathering and feeding into the moulds is done by automatic feeders, which receive the molten glass direct from the furnace. A plunger from the feeder pushes the glass mass and lump of glass flows down through the refractory orifice. As the plunger moves upwards, it creates a narrow 'neck' of the glass mass, which is detached off with the help of mechanical shears. Gob of the detached glass flows down into the mould. Gob can be directed with the help of chutes into different locations on the forming machine, if so desired. Glass ware forming is done either by hydraulically or by pneumatically operated plungers. Weight variations in the pressed wares in this case are less. The quality and finish of the pressed items depends upon the mould and plunger material, their pre-heated temperatures before use and maintenance of the moulds and plungers.

The material of the moulds and plungers is special alloy steel instead of cast iron and also hard chrome plating on the inside of the mould is necessary to bring out quality and finish of the glasswares.

Mould heating is done in electric ovens rather than doing it with molten glass as practiced in Firozabad. The plunger is heated by gas before use.

4.4.3 Bangles

This industry has been, and continues to remain a highly labour-intensive industry in Firozabad at present. However, two units have put up automatic Bangle Manufacturing units, with molten glass drawn by gravity through a circular hole in the bottom of the feeder of the furnace. One Unit (B.K. Glass Works) is already in production. This unit has a semi-automatic spiralling machine, taking molten glass feed vertically down from the feeder of the Tank Furnace. However, in this system, the mechanism of reversal of the spiralling mandrel operates rather slowly. Another unit (Goverdhan Glass Works) has developed an automatic spiralling machine, in which the above draw back has been rectified. It was informed by the owner of the unit that the trial runs of this unit have been successful and commercial production shall be commencing shortly.

4.5 ANNEALING

Thickness of the glass articles is the main consideration for deciding the annealing temperature and time required for annealing of any composition of glass. For soda lime glass, generally the annealing cycle is as under :

Raise the temperature to about 550°C, then maintain this for 6 to 7 minutes, then lower the temperature to around 450°C within 4 to 5 minutes, then cool it and bring it to 200°C and then allow the articles to cool slowly in ambient temperature. The annealing cycle schedule is shown in Sketch No. 4.03.

For boro-silicate glass, the temperture would be 50°C to 100°C higher than soda lime glass.

The modern trend is to anneal the glasswares in a continuous lehr, which is oil fired/electrically heated in a muffle, where products of combustion do not come into contact with the glass.

Some of the lehrs are gas (LPG) heated lehrs instead of electrically heated lehrs. Air circulation is by fans to ensure even temperature distribution.

4.6 FINISHING

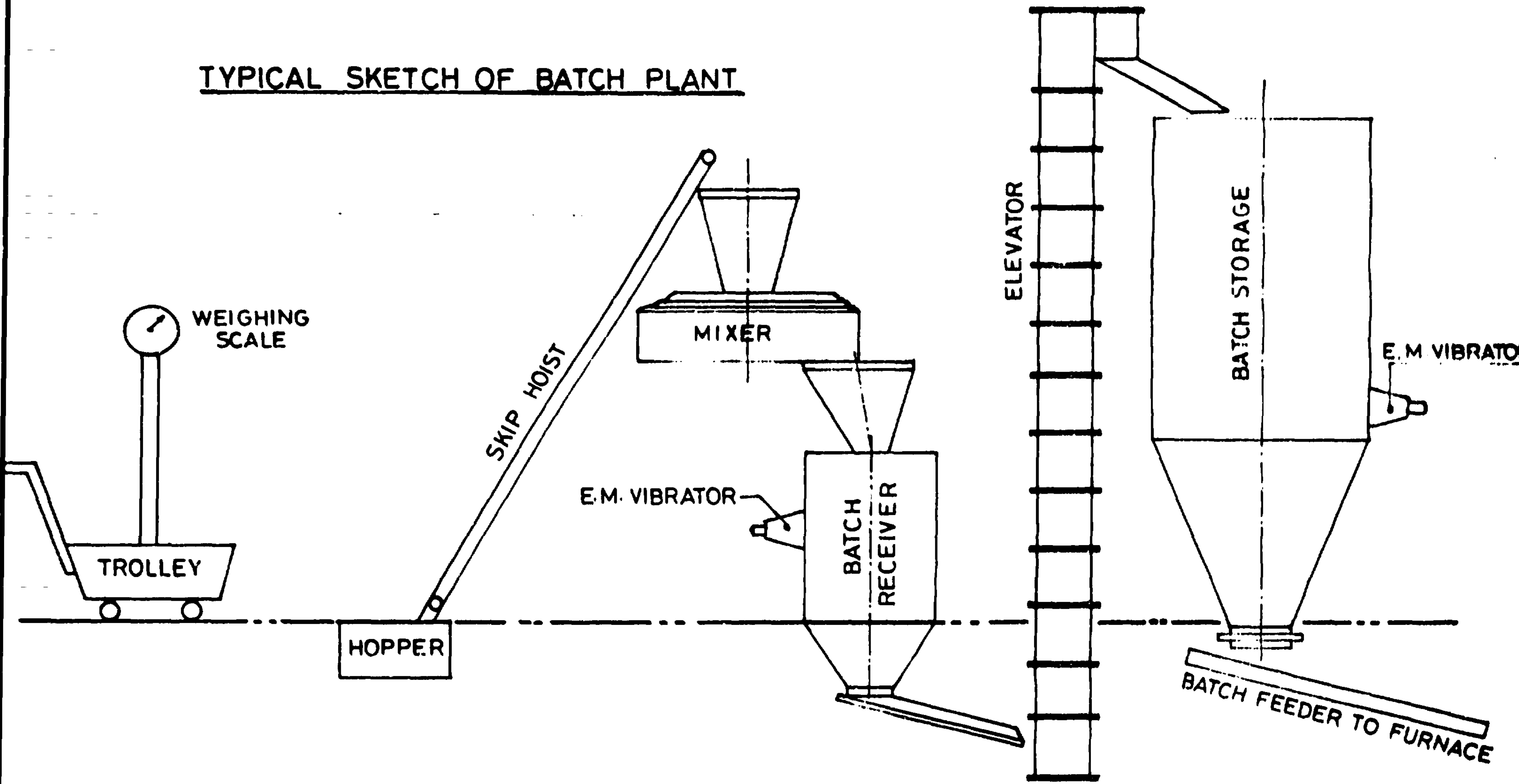
Ring-off and finishing operations used in Firozabad glass industry are out-dated, labour intensive, quality damaging and sometimes product damaging.

Ring-off is rarely used in modern trends.

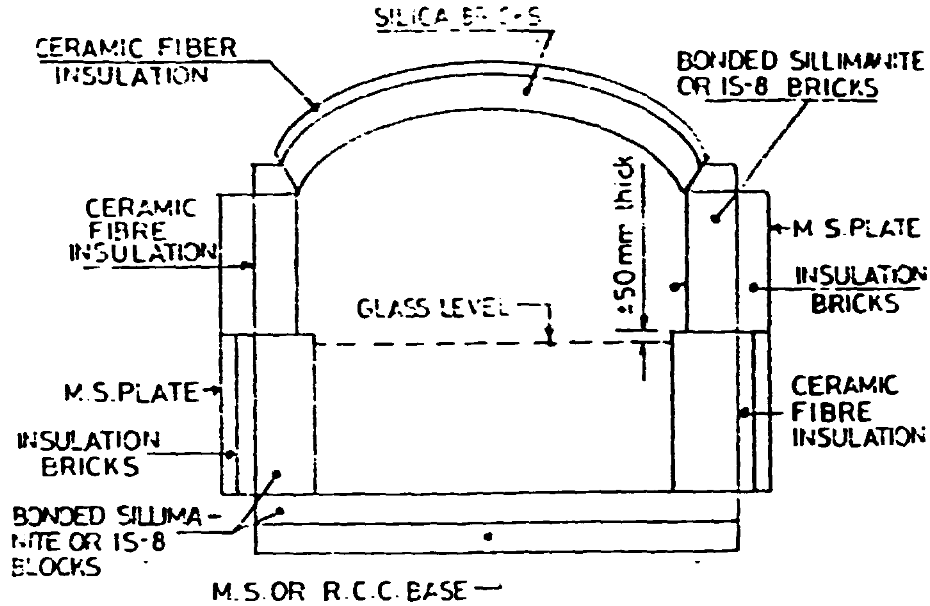
Grinding, if required is carried out with the help of endless abrasive belts, which perform the job with precision and fast.

Regular blown wares are cut-off with the help of Dyna type machines, which while melting away excess glass on the mouth of the wares, also form a fine 'ring' on the mouth of the wares, which have good aesthetic appeal.

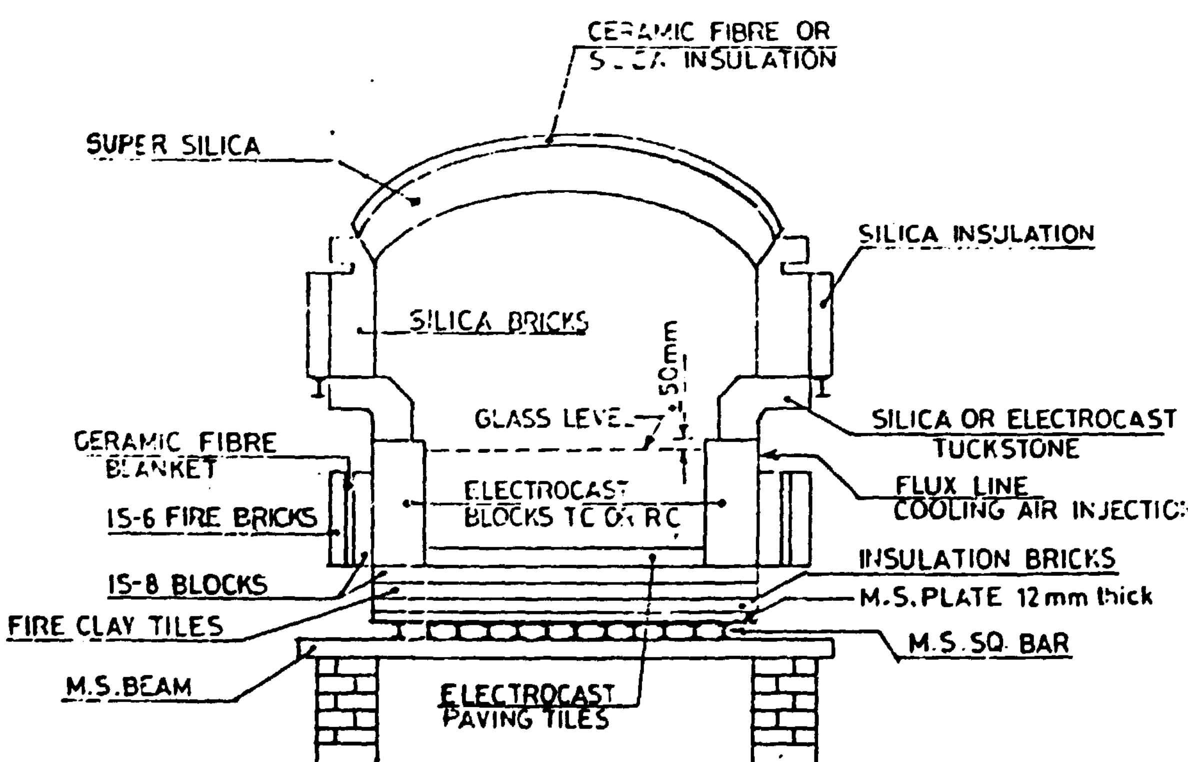
TYPICAL SKETCH OF BATCH PLANT



SK. NO. 4.02



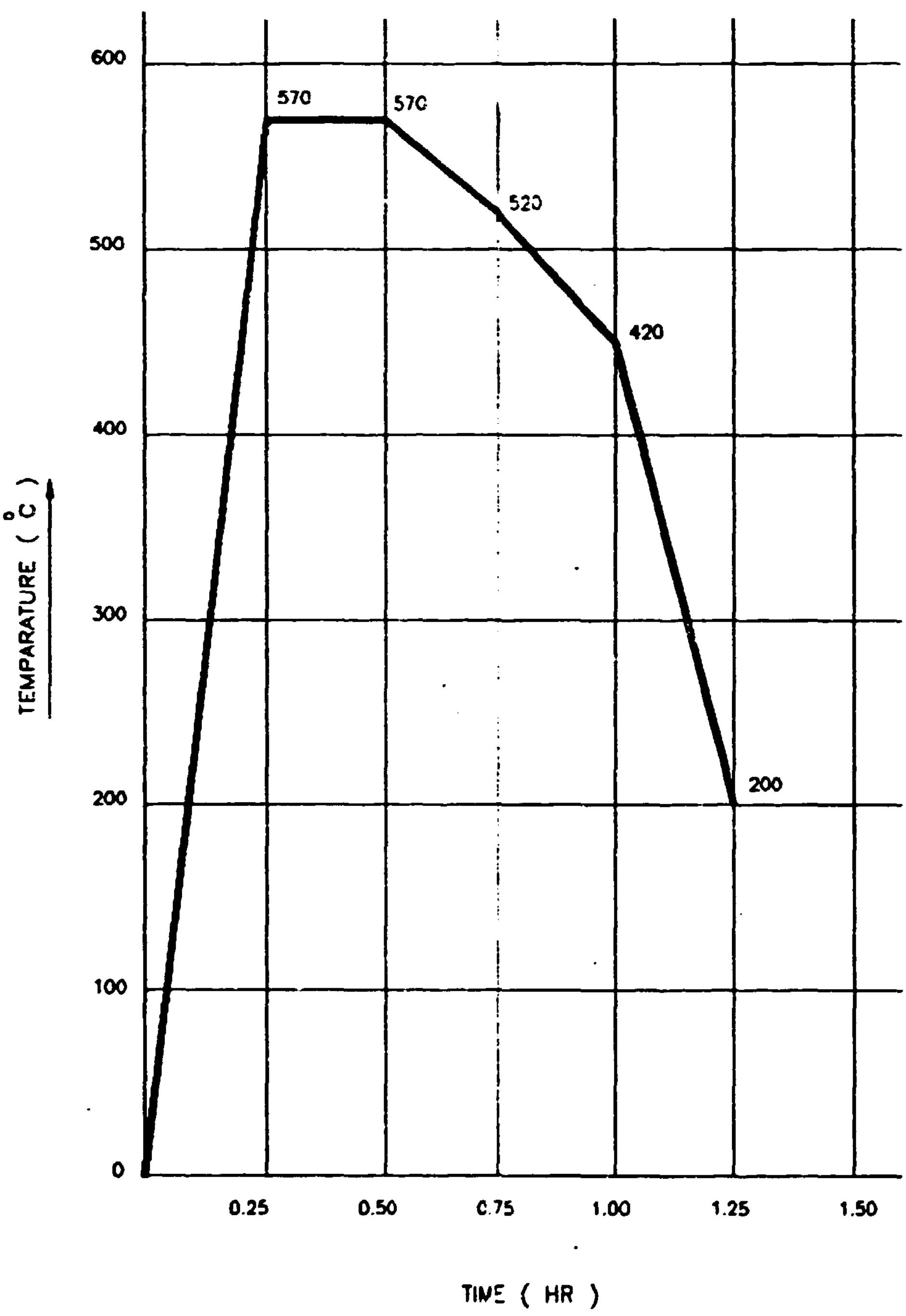
SCHEME OF REFRACTORY & INSULATION
WORKING ZONE



SCHEME OF FURNACE REFRACTORY AND INSULATION (MELTER ZONE)

DETAILS OF REFRACTORIES AND INSULATION IN TANK FURNACE

TYPICAL ANNEALING CYCLE FOR SODA LIME GLASS



V. PROBLEMS/DEFICIENCIES AND RECOMMENDATIONS

5.1 Product Design & Quality

5.1.1 Problems/Deficiencies

As discussed elsewhere in the preceeding Chapters, mostly Soda lime silica glass and glassware products are being manufactured in Firozabad. At present, there is hardly any product design and the products manufactured are generally based on the designs supplied by the customers. The high count of stones, seeds, cords and blisters present in the products have reduced the prospects of export potential. Majority of the products manufactured are of inferior quality and are sold in the domestic markets only. Because of the poor quality, there are two categories of products manufactured in Firozabad and the price differential between A & B category is in the range of 20 to 25 per cent. The reasons for inferior quality of products are batch preparation, glass melting, finishing of products - pot quality, fuel utilisation and instrumentation, technology applied, house keeping and working conditions, utilisation of labour etc.

5.1.2 Glass industry in Firozabad area, inspite of numerous drawbacks, has two significant advantages - a long established tradition of glass manufacture and availability of skilled manpower specially in glass working. The approach for any new lines of products in glass has to be based on the following considerations:

i) The new product should be in small scale in line with the Firozabad glass industry.
ii) They should offer employment to the local people and utilise the skills available in Firozabad.
iii) Hazardous activities should be avoided and the working conditions should be conducive to the workers.
iv) High value added items should be included in the product-mix.
v) Export potential should be tapped by offering quality products.
vi) Coal which is polluting the entire belt of Firozabad Agra should be discontinued and the use of oil/natural gas should be utilised for the glass manufacture.

5.1.3 Recommendations

5.1.3.1 Keeping in view the above criteria, the following products are recommended :

i) Coloured glass lenses for Railways, Airport runway and Traffic signals.
ii) Semi-crystal glassware such as Bowl, Tableware, Vases, Lampshades, Tumblers etc.
iii) Crystal glass items like Chandeliers,Globets etc.
iv) Borosilicate (plain & opal) glass for kitchenware items, Airport runway glass, HPMV lamp envelops, Laboratory ware etc.
v) Block glass for beads manufacture.

5.1.3.2 The above mentioned products could be manufactured either in pot or tank furnace to suit specific melting conditions. Being special type glasses with non-soda lime composition, adoption of these would require product design from agencies like CIGI. Product design could be directly adopted from the latest designs from European and Japanese markets. Involvement of competent agency is necesary to adopt and maintain glass composition, furnace conditions such as melting, working temperature and atmosphere (oxidising or reducing), as well as the quality of raw material and finished products. It is recommended that the facilities for raw material and finished product testing, which are already available at CIGI should be utilised for maintaining the product quality. To produce special quality glass, the fuel for the pot/tank furnace has to be either furnace oil or natural gas.

5.1.3.3 India is exporting glass and glassware items worth about Rs 700 million annually produced both in the organised and unorganised sector. The export of glass and glassware items from the unorganised sector is quite meagre and should be further increased in the future. The special glass products recommended and the existing soda lime glass products could be exported to Europe, South Africa, Germany, Egypt, Middle East countries etc. which have a good market for hand made glass. However, the quality of the finished products should be of international standards. Exports of glass and glassware items can be either directly or through reputed dealers/stockist as per the prevailing practice in Firozabad.

5.2 Raw Materials & Batching

5.2.1 Raw Materials

Problems/Deficiencies

As discussed elsewhere in the preceding chapters, the quality of most of the raw materials used by majority of the glass manufacturers is not upto the mark. Generally no test reports of the raw materials are obtained from the suppliers nor any tests are carried out in the units to determine its quality. Only a few of the units are taking the help of CIGI for getting their raw materials tested. Washing of the silica sand is not being practised, while magnetic separation is done by only a few units. No special care is being taken in storing the hygroscopic materials like soda ash, potash, nitrates and sodium sulphate. The raw materials are generally stored on open floors.

Recommendations

Needless to say that use of good quality raw materials results in quality improvement of the products. The raw materials are all available indigenously except for few like Arsenic Trioxide, Antimony trioxide, Selenium etc. which are also available locally in Indian currency through traders.

The following measures are recommended to ensure the use of good quality raw materials :

i) Glass manufacturers should insist upon the suppliers to supply the test reports from the recognised laboratory giving the details of the various parameters of quality or the certificate from the main producer, along with the materials. These parameters should match the specified standards of various raw materials laid down in Indian/International Standards.

ii) In the absence of raw material certificate of testing from the main producer, it is suggested that the raw materials should either be analysed in their own units or the raw materials should be got tested from CIGI, who have all the requisite testing facilities.

iii) All the mineral type raw materials, which had to undergo jaw crushing and pulverisation should be subjected to magnetic separation before use.

iv) The other measures recommended for various raw materials are mentioned as under :

a) Silica Sand
Silica sand/quartz is the largest constitutent,about 70% of the batch,and plays a significant role in the quality of glass.

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iv) The other measures recommended for various raw materials are mentioned as under :

a) Silica Sand
Silica sand/quartz is the largest constitutent,about 70% of the batch,and plays a significant role in the quality of glass.

It is suggested to use Grade I Silica sand as per IS:488-1980 and to keep the impurities and iron oxide content less than 0.02%, it is recommended that silica sand should be properly washed and passed through magnetic separator before use. An installation of sand washing unit of 3T/hr is recommended in the glass units.

b) Soda Ash

Soda ash is the second largest constituent of the batch and most expensive in terms of quantum input. As the particle grain size is very important in the batch, synthetic dense variety soda ash having granular material with 80% grains of 80 mesh to 20 mesh and free from dust should be used in the batch. This would reduce segregation of the mixed batch and dusting inside the furnace. The Modvat benefits available from excised material should be examined in order to save batch cost.

c) Limestone & Dolomite

Lime stone and dolomite should be used as per IS:997-1987. The iron oxide content of the crushed and demagnetised material should be below 0.10% and the grain size preferred should be 20 mesh B.S.

v) Warehouses should be moisture proof and care should be taken for storing of hygroscopic materials. The materials like Soda-ash, lime etc. are received in packed bags while high value items like selenium, arsenic trioxide and cobalt oxide are received in small packets. For hygroscopic materials lot-wise day to day estimation and requisite quantity corrections should be carried out before use.

5.2.2 Batching

Problems/Deficiencies

Most of the glass manufacturers are not aware of the required particle size of the various batch ingredients and its impact on the melting. The oversized particles take longer time to fuse and melt and therefore reduce the thermal efficiency of the furnace. The fines on the other hand are carried away by exhaust gases through flues. Weighing of the various batch ingredients is done roughly by volume rather than weight and the operators skill is vital as there are no provisions for correcting over-weighed material. Mixing of the batch ingredients is done mostly manually.

The following Table 5.1 indicates the percentage range of the major constitutents in the batch that is being followed by the glass units to produce the existing products in Firozabad for soda-lime glass.

Table : 5.1

S.No.	Constituent	Percentage Range
1.	Formers	61-70
2.	Fluxes	23-35
3.	Stabilisers	2-10
4.	Refiners	1-3

Recommendations

i) As grain sizes of various batch ingredients play a critical role in the melting process and both undersized and oversized particles are harmful, it is recommended that the grain size between 20 mesh to 80 mesh B.S.may be considered. CIGI should advise the glass manufacturers to specify the grain size while placing the order and to maintain the grain size of the batch by proper sieving.

ii) It is suggested to weigh the various raw material ingredients in accurate balances (load cell type) before mixing these in desired proportions.

iii) For homogeneous mixing of the batch ingredients, the mixing of the batch shall be done in batch mixers.

iv) It is recommended to use wet batching practice, which requires addition of 2-4% moisture at the mixing stage. This not only minimises the incidence of dusting but also reduces the chances of batch segregation at subsequent stage of handling and charging etc. Moreover, there is considerable fuel saving, as the moisture, when converted into steam inside the furnace, reacts with the hydrocrbons of fuels which causes higher release of heat and increased melting efficiency.

v) Recommended glass compositions for the soda lime glass and other new products envisaged are shown in the Table 5.2 and recommended batch compositions for superior quality tableware/pressedware and bangles are shown in Table 5.3.

Table : 5.2
Recommended Glass Compositions

(Percentages)

S.No.	Item	SiO_2	Al_2O_3	CaO	MgO	BaO	PbO	Na_2O	K_2O	B_2O_3	As_2O_3
1.	Soda lime glass	70-72	1-1.5	10	-	-	-	-	1-2	-	1-1.5
2.	Coloured glass	68-70	1-1.5	5-10	0-3	0-4	0-8	15-17	0-5	-	
3.	Semi-crystal	68-70	1-1.5	5-8	-	3-5	0-8	10-15	5-7	-	
4.	Crystal	55-57	1-1.5	0-4	-	0-2	30-35	6-8	2-4	-	
5.	Boro-Silicate	70-76	3-8	-	-	-	-	5-8	-	12-16	
6.	Block Glass	65-70	1-1.5	8-10	0-1	3-5	3-5	15-17	0-2	-	
7.	Bangles	76	-	4	-	-	-	20	-	-	

NOTE : Colours to be added as required

Table : 5.3
Recommended Batch compositions

A. Superior Quality Tablewares & Pressedwares

Quartz powder (washed)	120 kg
Soda Ash (Dense Grade)	40 kg
Potash Felspar (Kishangarh Quality)	5 kg
Potassium Nitrate	3 kg
Potassium Carbonate	5 kg
Barium Carbonate	4 kg
Calcite	25 kg
Borax	3 kg
Antimony Trioxide	0.5 kg
Selenium metal powder	5 gm
Cobalt Oxide	0.2 gm

B. Bangles From Pot Melted Glass

Silica Sand	100 kg
Soda Ash	30 kg
Borax	10 kg
Calcite	15 kg
Nitre	5 kg
Arsenic Trioxide	0.5 kg

5.3 Cullet Handling & Recycling

Problems/Deficiencies

Washing of cullets is not done properly and crushing of the cullets especially generated during forming operations is not done. Pre-processing of the foreign cullet or the purchased cullet before its use is also done manually.

Recommendations

It is recommended that cullets should be processed before use in cullet processing unit. In this machine, the cullets are first screened on conveyor for removal of unwanted inclusions like stones, coloured glass, ceramic and tramp articles. The cullets are crushed to under 30 mm x 30 mm size, well washed and subjected to magnetic separation before use.

5.4 Increased use of Cullets in the Batch

Problems/Deficiencies

At present the Firozabad glass industry is working without any norms of mixing the raw materials. They have not been able to maintain standardised mixing ratio of the batch and cullet.

Recommendations

i) It is suggested to maximise the use of properly processed cullet in the batch which would improve the production performance as follows :

* It would help in quicker fusion and faster melting of glass batch.

* This would also result in reduction of energy consumption.

ii) The amount of cullet that could be safely used varies from case to case depending upon the end product. The glass manufacturers should take the help of CIGI in working out the maximum batch to cullet ratio which could be used without impairing the quality of the resultant glass.

5.5 Charging of Batch to the Furnace

Problems/Deficiencies

At present charging of the batch and cullet to the furnace is done manually i.e. shovelled directly into the furnace. In this case, it would be difficult to maintain glass level constant and has adverse effect on glass quality.

Recommendations

It is recommended that feeding of the batch to the tank furnace, having drawing capacity between 20-25 tonnes per day, should be done with electro-magnetic vibrator fed reciprocating pan feeder or with screw feeder so that feeding could be regulated with timer according to the glass draw rate or automatic glass level controller. By deploying these devices, glass level can be maintained relatively constant, with better distribution of batch on the surface of the melt and lesser dust formation in the furnace.

In case of pot furnace, charging of the batch to the furnace can continue to be manual, aided with trough and shovel arrangement which will be hand lever operated. This will not only eliminate dusting and consequent high corrosion of the pots, but also reduce the duration for which the pot has to be kept open leading to heat losses by radiation.

5.6 Melting Furnace

5.6.1 Pot Furnaces

Problems/Deficiencies

Almost all the glass units have a symmetrical design of furnaces, which is quite old for making variety of glasswares. Coal is being used by all the units having pot furnace and the furnace temperature is in the range of 1250-1450°C. The quality of pot used for melting the glass is not good and the average life of pot is between 15-25 days. The pot is made from very coarse grog size and the alumina content in the pot body is very low, which causes leaks in the bottom or side walls. The furnaces operate on natural draft and are not equipped with any heat recovery system. In general, the efficiency of the pot furnace varies from 9 to 13% and approx 1.4 tonnes of coal is consumed for one tonne of glass draw.

The furnaces are constructed with low grade refractory bricks without any insulation which causes heavy radiation losses (20 to 40%) and the campaign life is between 10-12 months. In most of the furnaces, there is no provision of essential instruments and the temperature is monitored through workers experience.

About 50-60% heat losses take place through the flue gases.

Recommendations

i) It is suggested that the units should opt for oil fired pot furnace having forced draft with heat recovery system in place of direct coal fired down draft pot furnace, which has the following benefits:

   * Possibility of manufacturing other types of glass such as coloured glass, opal glass, crystal glass etc. in addition to soda lime glass.

   * Fuel savings are possible with provisions of total air low pressure burners and use of heat recovery system.

   * Precise control of firing is possible with the help of air fuel burner.

   * Handling of fuel and pollution problems are minimised with oil fired equipment as compared to coal.

   The oil fired pot furnace can easily be converted to natural gas firing when natural gas is made available in Firozabad.

   The conceptual design features, type of burners, heat recovery system, type of refractories to be used in side walls and crown, insulation, instrumentation required and energy requirement per kg. of glass drawn etc. have been discussed in Chapter-IV.

ii) The following measures can be adopted to improve the efficiency of the existing coal fired pot furnaces:

   a) It is recommended that crown of the pot furnace should be constructed with high duty silica bricks and the insulation should be done with one layer of silica insulating bricks plus layer of cerawool, which is available locally from M/s Murugappa organite Ceramic Fibres & M/s Orient Abrasives.

This would reduce the radiation losses in the furnace, thereby decreasing coal consumption per day. In this way there is a possibility of saving 5-10% energy.

b) It is recommended that side walls of the pot furnace should be constructed with high alumina-Sillimanite or mullite bricks.Insulation on the side walls is not suggested because the pots are required to be replaced in case of pot leaks/breaks.

c) It is recommended to instal one temperature indicator-cum-recorder on the middle of the crown, one temperature indicator in the flue path for continuous monitoring of the furnace so that fuel feeding rate could be regulated.

d) The waste heat of flue gas can be used for pre-heating the pots thereby reducing stack temperature.

e) Estimated cost of additional / modification equipment for existing pot furnaces is given in Appendix 5.1

iii) The conceptual oil fired pot furnace (12 pots) with the metallic recuperator is shown in Drawing No. FZD.2710.21.01.001.RO.

Pots

As described elsewhere in the preceeding chapters, development of longer service life pots which can withstand higher temperature and corrosion by glass was taken up at Bishenpura and Punchkula. Some success was achieved and the resultant pot life was increased from 2 weeks to 10 weeks. Pot specifications, body composition and firing schedule is given in Chapter 4. These pots are already in use at Goldstar Glass Works Pvt. Ltd., NOIDA. It is suggested that Firozabad glass manufacturers should approach them and adopt their technology of manufacturing pots.

CGCRI is also presently working on low cement castables to be used in the manufacture of pots for glass melting. If they succeed in development of longer service life pots in near future, then these can also be tried at Firozabad.

Presently the pots are being procured from local pot manufacturers and in some cases these are being manufactured in a captive facility of the glass unit. Under this practice, there is no control on the pot manufacturing procedures and on the specifications of the clays being used in their manufacture, which consequently results in the poor quality of the pots. In view of this, it is recommended that the activity of manufacturing the pots for the whole of Firozabad region should be taken up in centrallised units, under the supervision of CIGI so that the material specifications and manufacturing procedures can be kept under control and pots of better quality and reasonable life period can be made available to the glass units at Firozabad.

5.6.2 Tank Furnaces

Problems/Deficiencies

As described earlier, side port regenerative tank furnaces are all coal fired. In this, coal is gassified using insufficient air and the gas containing CO and CO_2 and some hydro carbons has low calorific value,the maximum flame temperature achieved is between 1400-1500°C. The regenerators of these furnaces are mostly of single pass type and there is inadequate provision of monitoring and controlling the inflow of secondary air for adjusting the ratio of excess air. It has been observed that the heat loss through flue gas is between 30-40% and excess air ranges 50% and above.

Some of the units have started using End Port Oil fired regenerative tank furnaces but without any substantial improvement in operating conditions.The heat losses are also not different from coal fired furnaces as the burners are locally designed and fabricated causing imperfect atomisation of oil. Adequate instrumentation is not provided and there is no scientific way of adjusting the firing rate. Lack of control on secondary air leads to high fuel consumption. The efficiency of tank furnaces varies from 10 to 24%.

Recommendations

Most of the tank furnaces in Firozabad are coal gas fired and there are few units having oil fired tank furnaces. The modern trend of glass melting in tank furnaces is towards oil/gas fired, which is described in detail in Chapter 4.

Some of the units have converted coal gas fired to oil fired system without considering other design parameters of the furnaces.

It is recommended that alteration in furnaces to other type of firing should be carried our in phases. Emphasis should be given to the design parameters of the tank furnace such as length to breadth ratio of the melting zone, drawing zone area in relation to melting zone, combustion volume and breast wall height, refractories to be used, insulation and instrumentation etc.,so as to get the maximum efficiency for that particular fuel.

For Tank furnace, whether coal/gas fired or oil fired, thefollowing measures are recommended, which would increase the campaign life to 4-5 years instead of one year at present :

i) The dimensions of melting zone i.e. length and width should be maintained in the ratio of 1.4 to 1.6:1 for good melting of glass and drawing zone area should be between 20-30% of the glass holding capacity.

ii) The drawing zone should preferably be in semi-circular shape and radius of curvature should be equal to width of the melting zone plus 300 mm.

iii) Batch charging to the furnace should be done with electro-magnetic vibrator fed reciprocating pan feeder or with screw feeder as shown in schematic sketch in Chapter 4. The width of the dog house to be modified accordingly.

iv) Melting zone and throat should be constructed from Electrocast AZS type refractories available locally from M/s Carborandum Universal Ltd.

v) The tank bottom of the melting zone should be constructed with Electrocast/Zircon available locally from M/s Carborandum Universal Ltd., Tata Refractories and Orissa Cements paving tiles and underneath this, it should be constructed with IS:8 blocks, fire clay tiles, insulating bricks and ceramic fibre insulation. Considerable bottom thickness is very important to reduce heat losses from glass melt.

vi) The crown should be constructed with high purity silica bricks. The crown of the furnace and side walls should be insulated to reduce radiation loss which would result in saving of at least 10% of fuel.

vii) The throat of the furnace should be air cooled from the start up of the furnace.

viii) The regenerator should be multi-pass instead of single pass. The checker volume in the regenertors should be suitably modified to increase heat storage capacity. The packing of the regenerator should be done with high conductivity magnesite bricks instead of presently used fire-clay based bricks. This would further raise the pre-heated air temperature thereby resulting in fuel saving.

ix) In the regenerator, the time interval between the reversals is an important aspect for energy conservation. Long time interval of reversal results in lower average temperture of pre-heat.

It is recommended that the time of reversal should be consciously studied on the basis of temperature of chamber from the existing 30 minutes interval.

x) Instrumentation, particularly for temperature monitoring and flue gas analysis should be regularly carried out as these give valuable clues regarding the condition of the furnace and help in proper furnace operation. The essential instruments recommended at different places are as under :

* Crown tempertures at soaking and hot spot.
* Flue gas inlet and outlet temperature.
* Pre-heated secondary air temperature
* Flue gas analysis at exit point.
* Chimney draft
* Glass level, if automatic production is adopted.
* Amount and rate of oil flow in case of oil fired tank furnace.

Oil Fired Tank Furnace

i) In an oil fired tank furnace, the burners recommened are of medium/high air pressure type, atomising air being in the range of 2 to 4 bars.

ii) Additional/Modification cost of equipment for existing tank furnaces is presented at Appendix 5.2.

iii) Conceptual oil fired tank furnace is shown in Drawing No. FZD.2710.21.01.002.RO.

Coal Fired Tank Furnace

i) Provision for steam injection in the hearth bed to convert coal gas into high calorific value producer gas. The arrangement would be similar to stationary gas producer plant of yester years.

ii) The design of the burner ports and the tongue arch should be properly and meticulously calculated so that the burning of the gas starts right at the port mouth.

iii) Only very superior quality Zircon or Electro-cast refractories should be used in the construction of the ports.

iv) Additional/Modification cost of equipment for existing tank furnaces is shown in Appendix 5.3.

iv) Tank furnace is shown in Drawing No. FZD.2710.21. 01.003.RO.

5.7 Subsidiary Furnaces

Problems/Deficiencies

Less importance is given to the subsidiary furnaces such as Pot pre-heating furnace, Sikai Bhatti and Belan Bhatti, which have crude design and are poorly constructed in almost all the units. The flames and smoke are seen escaping out in the working area and these are mostly not connected with the chimneys. No care seems to have been taken in selecting the refractory bricks and in most of the units, ordinary red bricks have been used. There is also no provision of insulation which affects the ambient temperature.

Recommendations

Pre-heating Pot Furnace

The pre-heating of longer service life pots should be done according to a set heating pattern as explained in Chapter-4. It is suggested that pots should be pre-heated, before transferring to the pot furnace, in an oil fired chamber type furnace, which can accommodate one pot at a time. The furnace should be natural draft, with vertical rising or side ways sliding doors. The furnace should have the provision for raising the temperature upto 1350°C in the last stage of firing and it should be equipped with temperature indicator.

Sikai Bhatti and Belan Bhatti

With the introduction of semi-automatic/automatic spiralling machines for bangle manufacture, Sikai Bhatti and Belan Bhatti would scarcely be used after a few years. It is suggested that the following measures may be taken to save energy consumption and improve the working conditions around these furnaces :

i) Diesel oil Kerosene oil/LPG can be used in place of coke/coal or wood used presently.

ii) Good quality sillimanite or fire clay bricks should be used in place of red bricks and should be properly insulated to reduce radiation losses.

5.8 Forming

Problems/Deficiencies

The forming operations such as blowing, moulding, drawing and pressing are manual and highly labour- intensive except in some units where semi-automatic presses are being used. The forming operations performed by drawing by hand, pressing in lever operated presses etc. result in defective glass products having inconsistency in thickness, size, quality, under-formed and over heavy/thick wares.

Recommendations

The modern trends pertaining to forming operations of tubes including thermometer capillary, tablewares, thermo-refills, bulb shells, chimneys, laboratory-ware, bangles etc. have been discussed in Chapter-4. Automation is very vital for other forming operations in conserving the energy. This aspect is, however, not given weightage due to the following constraints :

a) The Firozabad Glass Industry is essentially labour-intensive and both skilled and unskilled manpower is available cheap and in plenty.

b) Most of the units are small scale units operating on very low quantum. Internationally, the units having an average production capacity of more than 50 TPD justify the automatic operation. Automation in Firozabad has no relevance until the plant capacity is increased.

c) Firozabad industry is producing diverse range of glasswares which have selective market. Mass production of these is not justified. Market demand of various products play an important role in deciding the capacity of the furnace and degree of automation in the forming process.

In the forming operations the following recommendations are suggested which would not only improve the quality of glasswares but also reduce the rejection rates :

i) Special alloy steels should be used for manufacturing moulds and plungers. The moulds should be hard chrome plated as the mould quality and hard chrome plating can help a lot in making articles with high lustre. Moreover, colloidal graphite based lubricating oil should be used in place of present practice of using mobil oil.

ii) Mould heating should be done in electric ovens and plunger heating in gas fired ovens before use, instead of existing practice of heating the moulds with molten glass. By adopting this technique, molten glass wastage would be less and productivity will be increased specially in units, where semi-automatic presses are in operation.

iii) In small units where lever operated hand presses are used, it is suggested that at least the plunger operation should be converted to either pneumatic or hydraulic operation.

iv) The mouth blowing techniques and methodology adopted in manufacturing mouth blown glass articles weighing less than 60-70 gms should be modified by introduction of foot pedal operated mould closing-opening device and use of nozzles at the blowing pipe gathering end in place of existing practice of bubble making and bubble gathering of gobs. Nozzle gathering would facilitate marvering, which would help in achieving the desired thickness in sides and bottom of the glassware. In nozzle gathering there would be labour saving and the defects such as obliquity arising out of defective bubbles could be avoided.

v) For improving the quality of tablewares produced, it is suggested that mould pasting with charcoal layer application, instead of present practice of insertion of moistened strip of paper in the mould, before commencement of production should be done. As smoke produced by burning of paper strips provides a poor cushion between the Parison and the metal but paper after burning leaves behind ash and carbon which affects the parison and blowing results in blemishes on the blown ware.

vi) It is suggested that compressed air pressure used in forming operations should be maintained constant specially where semi-automatic pressing will be there, because in semi-automatic presses, forming pressure sometimes varies according to compressed air pressure.

vii) It is recommended that comparatively bigger bangle making units should switch over immediately for spiralling of bangles on semi-automatic/automatic machines used at Firozabad presently as discussed in Chapter-4. Adoption of this technique would eliminate the taxing and uncomfortable working conditions prevailing presently at Firozabad. The other units should at least go in for better designed Sikai Bhatti and Belan Bhatti for manual spiralling of bangles, as mentioned in para above.

5.9 Annealing

Problems/Deficiencies

Most of the units are not conscious of the annealing cycle for soda-lime glassware. Annealing chambers are poorly designed and fabricated without any insulation. These are neither equipped with any chimneys nor there is any provision for measuring inside temperature of the chamber. Most of the annealing lehrs in use are oil fired, but there is no provision for proper air circulation, which causes non-uniform heat distribution. The volume of annealing chamber/lehr is found to be large compared to the volume of the product annealed.

Recommendations

i) CIGI should advise the entrepreneurs and managers of the glass units about the annealing cycle for soda lime glass. Thickness of the glass articles is the main consideration for deciding the annealing temperature and time required for annealing of any composition of glass.

ii) The annealing chambers/Lehrs should be got properly designed and fabricated from a reputed manufacturer, taking into consideration, the type of glass to be annealed, size and thickness of the product and product output/shift etc.

iii) The burners of the annealing Lehrs/Chambers should be properly selected. The oil pressure and air pressure should be maintained properly.

iv) The annealing lehrs should be properly insulated in order to avoid heat losses. Rock wool or mineral wool can be used as insulating material.

v) Temperature gradient should be maintained along the lehr and the glasswares should be subjected to controlled temperature.

vi) Proper ventilation should be provided at the exit side of the lehr to control the temperature.

vii) It is suggested that medium heat duty fire bricks (IS:6 or IS:8) should be used in the Annealing Chambers.

viii) The other measures to be taken for energy savings are :

* Reduction of distance between forming operation and the annealing lehr/chamber by judicious layout

* Immediate charging should be there in the hot zones of the lehrs.

5.10 Finishing

Problems/Deficiencies

Ring off and finishing operations used are labour-intensive, quality damaging and sometimes product damaging in most of the units. The equipment used are locally fabricated individual workstations for manual operations.

Recommendations

The following recommenations are suggested :

i) Ring off should be rarely used for large size glasswares.

ii) Grinding, if required on special tablewares and some pressware should be carried out with the help of endless abrasive belts, which perform the job precisely and fast.

iii) The entire finishing operations including detaching of Moil, mouth grinding and melting should be changed over to single stage Dyna melting machine.

iv) Cutting and polishing should be retained as is being done presently, however, for superior finish and value addition of cut glasswares, acid polishing and fire polishing could be adopted with significant advantage.

5.11 Testing, Inspection & Quality Control

Problems/Deficiencies

Testing facilities and quality control are missing in almost all the units. Only a few units have facility for conducting annealing test on glass products. Occasionally, some tests on glass composition by a few entrepreneurs are got done from CIGI, but guidance regarding the correct batch composition is not taken.

Recommendations

i) One of the main requirement for a good quality product is the use of suitable raw materials. Hence raw materials procured should be tested as per requirements for quality material. In view of small scale operation, the units cannot afford sophisticated testing facilities. It is proposed that they should make use of supporting facilities from the CIGI.

ii) To minimise wastage of materials and manpower, it is recommended that the inspection should be carried out after every stage of production so that necessary corrective action is taken without further inputs going into the product.

iii) It is recommended that glass units should develop an inspection record system which would be useful in relating the quality of various batches of products with the raw material used and processes adopted for the batches. These data so collected would be very useful for management decisions and would help in making improvements in the quality of the products in the subsequent batches.

iv) Proper use of moulds and dies and their proper maintenance would certainly improve the product quality.

v) In order to ensure that the customer is getting fair deal and good quality products, which would ultimately enhance the reputation of the manufacturing units, it is imperative that small scale units should at least have Polariscope for testing annealing strain quality of the glasswares and Impact Resistance testing equipment for impact testing for automobile head light lenses.

5.12 Plant Layout/House-Keeping/Working Conditions

Problems/Deficiencies

Layouts are generally cramped and haphazard and not according to any rational basis in most of the units.

Floor areas are paved with brick rubble and there is no hard flooring. In a few units, there is difference in the levels of working areas and transportation becomes quite risky. House-Keeping in almost all the units is non-existant. Materials and scrap are cluttered inside the working areas, which are quite smoky. There is lack of ventilation, man-coolers, toilets, first aid and exhaust fans in most of the units. Ambient temperature is quite high particularly near the molten glass drawing/forming area, dog house etc.

Recommendations

Layout

i) Care should be taken to have uni-directional flow of materials to the extent possible;

ii) All the equipment, aisles for movement of material and men should be arranged in an orderly manner, and all the spaces should be clearly defined.

iii) Safety of the workers should be given prime importance to reduce risk due to accidents.

iv) The space allocated for various operations and storages should be adequate according to type and volume of production.

v) The characteristics of a model layout have been given for guidance of the entrepreneurs to develop suitable layouts to match their manufacturing activities.

House-Keeping/Working Conditions

i) Simple measures such as good house-keeping will be significant, not only for improved material flow but also in terms of producing a safer and healthier working environment more conducive to higher production.

ii) Unwanted materials, scrap etc. should be removed immediately as this disrupts the flow of in-process materials.

iii) The working areas should be quite clean free from smoke and dust. Proper ventilation, man-coolers and other infrastructure facilities such as toilets, first aid, comfort cooling etc. should be provided.

5.13 Fuel

Problems/Deficiencies

Erratic supply and inconsistant quality of coal from Coal India are the major problems faced by the glass units, as coal is the major fuel used by most of the units. Glass units have to buy coal from the open market at a higher price. Steam coal of 'B' grade quality is recommended for glass factories but quality of coal received is never checked by the glass units. High percentage of ash, sulphur shales and dust not only result in excess fuel consumption but also possess serious hazard of air pollution.

Recommendations

The following measures are recommended :

i) Directorate of Industries, Coal India Ltd. and Indian Railways should ensure the supply of selected 'B' grade coal quality in time to industrial units in Firozabad belt.

ii) In view of suggestion to convert coal fired furnace to oil/gas fired in phases, the requirement of oil would increase due to obvious advantages. It is recommended that Indian Oil Company should timely release quota of furnace oil of requisite quality to the glass units.

iii) The use of natural gas will greatly help the small scale manufacturing units to effect substantial savings in fuel and enhance their capacity to compete. It is strongly recommended that natural gas pipe line be extended to the Firozabad area at the earliest.

iv) It is understood that previous quota for supply of kerosene oil to the glass units has been reduced. It is recommended that LPG and kerosene oil should be made available to the glass units.

5.14 Safety Aspects

Problems/Deficiencies

Workers employed in the units are exposed to dust, pollution and high temperature without any safety measures leading to respiratory diseases. The workers working in batch house mix various raw materials ingredients without knowing their effect and inhale toxic substances.

Recommendations

The following measures are recommended :

i) The workers working in batch house and near the furnace should wear gum boots, masks, gloves, goggles etc.

ii) It is recommended that fire fighting facilities such as sand buckets, portable fire extinguishers etc. should be installed in the factory premises as per guidelines.

iii) Medical check-up of batch house workers should be done regularly.

iv) Good house-keeping and improved working conditions would minimise the risk of accidents.

5.15 Training

Problems/Deficiencies

The skill base is generally eroded and workmen are not encouraged to take pride in their work. There is no training activity. The technical personnel at various levels such as operators, furnace supervisors etc. need to be educated so that they can understand the difference between the present activities performed and improved production or productivity.

Recommendations

The following measures are recommended :

i) Education and training of technical personnel at various levels in areas such as correct batch aspects, glass blowers/hand workers, efficient furnace operation, burner maintenance aspects, effective monitoring of regenerators/recuperators, importance ofcorrect application of instruments and control etc. should be given. These programmes may be sponsored by Firozabad Glass Manufacturers Association.

ii) Seminars/symposia are recommended for the entrepreneurs and managers. Such meetings would not only provide opportunities to discuss some of the common problems faced by them in different fields but would also give knowledge of the latest technologies and management techniques adopted elsewhere.

5.16 Manufacturing Systems

Problems/Deficiencies

There are no formal systems for Planning and controlling of Production, and no ways of ensuring that maximum use is made of the resources in most of the units. There are also no proper systems for materials management and there is no control at the shop level. Similarly, there is no schedule for preventive maintenance followed and only break-down maintenance is carried out in all the units. No history cards are maintained even for furnaces. Accepted quality products sometimes form only 10% of the production but even then reject analysis has not been done in any of the units.

Recommendations

Practice of modern management techniques is essential to improve overall productivity. There is no doubt that it would be beyond the capacity of small scale units to employ specialists in all the above areas. The following measures are recommended :

i) The glass units should make use of assistance available from various Governmental/private agencies in such areas.

ii) It is necessary to employ or associate technically qualified personnel for at least comparatively larger units in some important and functional areas.

5.17 Energy Conservation

Problems/Deficiencies

Glass melting roughly accounts for 90-95% of the total energy input in the glass unit. From the energy balance of the furnace, it is found that more than 80% of the heat is dissipated in the following areas:

* Radiation losses from the bottom, walls and crown
* Stack losses from the flue gases

In general, the efficiency of the pot furnace varies from 8.8 to 13.0% and that of tank furnace from 10 to 24%.

The main parameters affecting energy consumption in glass melting furnace are as follows:

* Furnace Design
* Refractories and insulation in the various parts
* Fuel Utilisation
* Monitoring & control

Recommendations

The glass industry is highly energy intensive and percentage of energy cost as related to manufacturing cost comes between 20 to 40%. As per the Standing Committee Report of European countries on glass industry, the total energy consumption of glass furnace ranges from 1000 to 2000 kcals/Kg of glass as compared to 3000 to 5500 kcals per Kg in Firozabad glass industry. High cost of energy compells to search for materials, systems and designs for energy conservation, hence vigorous and effective endeavours are made to ensure that the consuming industries are competitive and profitable despite persistant rise of energy prices.

The recommendations suggested pertaining to improvement of the batch, furnace etc. are mentioned earlier under those heads. The other recommendations suggested are as under :

i) Feasibility of using melting additives should be worked out to reduce the melting temperature. In this regard the glass owners should take the advise of CIGI.

ii) Making maximum use of calorific energy supplied by the glassware leaving the forming operation.

iii) Reduction of distance between forming operation and the annealing lehrs/chambers by judicious layout.

iv) Immediate charging without delay in the hot zones of the annealing lehrs.

v) Proper utilisation of waste heat through better design layout.

vi) Considerable reduction in energy consumption in terms of energy requirement per unit of production can be obtained if the rejection rate is minimised and glass products (like containers) are reduced in weight.

vii) Apart from introducing new features related to furnace design and instrumentation, automation is very vital for other forming operations. This aspect, however, has been discussed in the recommedations for forming process.

5.18 Pollution

Problems/Deficiencies

Ambient Air Quality :

- Suspended particulate matter concentration is very high and is maximum near the work place
- The Sulphur Dioxide concentration in some cases exceeds the limits of 120 ug/m^3, and is high near the work places
- Carbon monoxide concentration is appreciable at work places.
- Fluoride concentration is appreciable within the factory premises as well as near work places
- Ambient temperature is high (50 - 55°C) near the work places
- The city ambient air is also polluted due to suspended particulate matter

Stack Emissions :

- High concentration of SPM
- Moderately high concentration of SO_2
- Appreciable concentration of NO_x and CO
- Inadequate sampling platform and points in the stacks
- Stack gas temperature is very high

Water :

Water pollution is negligible or nil except presence of suspended solids and fluoride in high concentration exceeding the permissible limit.

Solid Waste :

In one case, the volatile matter in coal ash was very high. Aluminium and Silica concentrations in the ash are found to be high.

Recommendations

- Furnaces should be leak free and properly insulated to avoid thermal problems and fluoride concentration in the work zone.

- Coal feeding should be proper.

- Boiler burning efficiency should be checked regularly including gas analysis and furnace temperature.

- Stack should incorporate measures for arresting dust as well as alkaline scrubbing to reduce the SO_2 and NO_x concentration, which in turn would also reduce the flue gas temperature.

- Provide adequate stack height in light of mean mixing height

- Provide proper sampling point and sampling platform for the stack gases, as per CPCB regulations.

- Adequate work place should be provided for trouble-free working of the workers.

- Proper segregation in terms of storage of raw materials, fuels, mixing areas and work places

- Raised work place to arrest dust entering from nearby areas

- Proper clothing, masks and goggles should be made compulsory for the workers.

- Proper resting place with primary amenities for the workers

- Tree plantation in vacant areas inside the factory premises to be made compulsory, and also tree plantation should be done along the roads.

- Periodical environmental monitoring to be practised.

- Present system of solid waste to be maintained.

- Proper drainage system should be evolved inside the factory which in turn should connect with the municipal sewage system

- Medical fitness should be ensured for the workers.

VI. MODEL GLASS UNIT AND ITS ECONOMIC VIABILITY

6.1 In view of the present prevailing conditions in Firozabad, a model plant has been recommended by the Consultants which could be adopted by the existing units in order to improve the overall performance. Where it is possible to afford higher cost of modernisation, the units concerned could replace some of the existing equipment by those indicated in the model unit. The existing units could also install additional equipment indicated in the model units to augment their existing production facilities.

6.2 Glass furnaces are tailor made as their capacity and design features are governed by the type of glass and stipulated output capacity of manufacturing process. The size of the model plant has been based on the existing plants at Firozabad viz. pot furnace of 4 tpd and tank furnace of 10/20 tpd.

6.3 In view of the above mentioned objectives, two separate model plants have been recommended - 4 tpd pot furnace having 12 pots and 10 tpd tank furnace using furnace oil/natural gas as fuel for heating purposes. As discussed in the preceeding Chapter, the new products recommended for commercial production and the type of furnace to be used is as given below :

Pot Furnace	-	Coloured glass lenses, Crystal glass, Opal glass (borosilicate) and Block glass
Tank Furnace	-	Semi crystal glassware and Plain borosilicate glass

In addition to the new products, the model plant could also manufacture high value added soda lime silica glass items including Automobile products, Tumblers, Thermo-flask refills, Bangles etc.

6.4 The main features of the pot and tank furnaces are as follows :

<u>Pot Furnace</u>

a) Mixer ([illegible] kg) batch size

b) Sand and cullet washing plants having capacity of 3 tpd and 2 tpd repectively.

c) Pot furnace (4 tpd) including refractories (IS 6/IS 8, Sillimanite and Silica), burner, induced draft chimney, instrumentation, metal recuperator etc.

d) Annealing lehr (1.5 m width x 26 m length)

e) Tempering furnace for opal glass.

f) Furnace oil storage (20 kl), heat tracing, pumping unit etc.

<u>Tank Furnace</u>

a) Mixer (200 kg) along with skip hoist for feeding the raw materials.

b) Sand & cullet washing plant having capacity of 3 tpd and 2 tpd respectively.

c) Tank furnace (10 tpd) including refractories (Electrocast, IS 6/IS 8, Sillimanite & silica) metal recuperator, chimney, instrumentation etc.

d) Annealing lehr (1.5 m width x 26 m length)

c) Semi-automatic spiralling machine for bangles

d) Mouth melting machine

e) Eindrucking machine

f) Tube joining machine

g) Furnace oil storage (20 kl), heat tracing, pumping unit etc.

6.5 Utilities and service facilities equipment including 125 kVA DG set for each plant has been provided along with the production equipment.

6.6 Cost of civil works has been estimated on the basis of an average covered area of about 1500 Sq.m for each plant. However, no provision of cost of land has been made in the cost estimates. The basis of working out the capital cost estimates and cost of production has already been discussed in Chapter-II of the report. A contingency provision of 5 per cent has been reckoned on the basic cost to account for unforeseen cost and escalation. Capital costs for the pot and tank furnaces are estimated at Rs 12.16 million and Rs 18.01 million respectively.

6.7 For the new products, the cost of production has been worked out only for Opal glass - Tableware and oven products and Semi-crystal glassware - Tableware, Flowervase, Bowl & lamp shade etc. Cost of production per tonne/kg of glass manufactured have been worked out also for soda lime glass products and a comparison has been made between the existing plants and the model plant cost and the results summarised below :

(A) Soda Lime Glass Products

			Existing Plants	Model Plant
i)	Pot Furnace	:	Rs. 8,677/tonne (Closed type)	Rs.8,110/tonne
ii)	Tank Furnace	:	Rs.10,297/tonne (Regenerative)	Rs.7,522/tonne (Recuperative)

(B) New Products

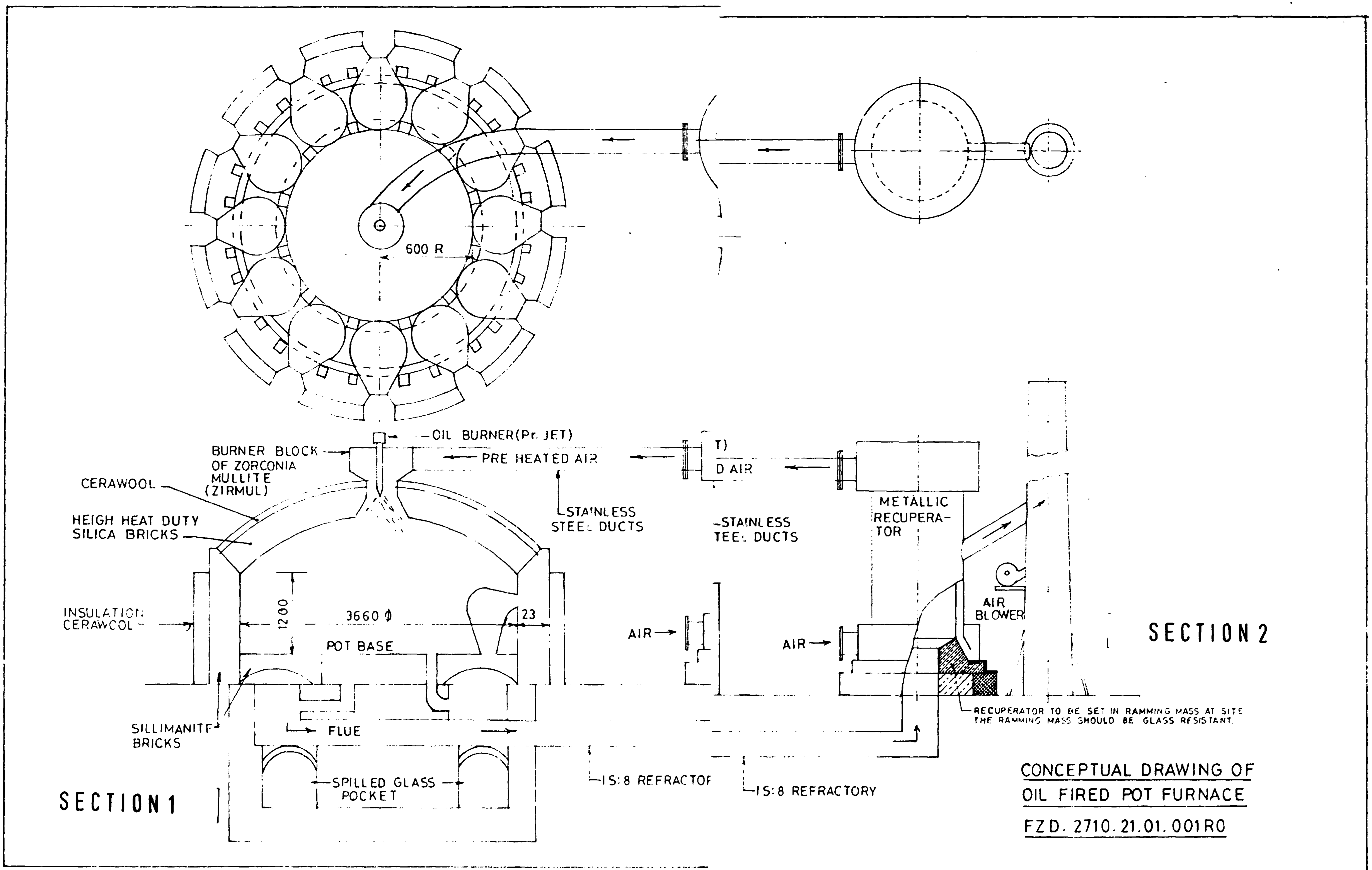
i)	Pot Furnace	:	Rs. 73/Kg. (Borosilicate Opal Glass)
ii)	Tank Furnace	:	Rs. 19/kg. (Semi-crystal glass)

6.8 It may be seen from the above, that the cost of production per tonne of soda lime glass produced for model plant is comparatively cheaper than that manufactured by existing units. This is quite evident as high level technology would be adopted and by using furnace oil higher energy conservation would be achieved thus producing superior quality products.

6.9 Capital cost estimates, cost of production , sales realisation and financial analysis for the soda lime glass and special glass are appended at Appendix 6.1 to 6.20.

6.10 A typical plant layout for a pot/tank furnace is depicted in Drawing No. FZD.2710.21.02.001.R0.

DRAWINGS

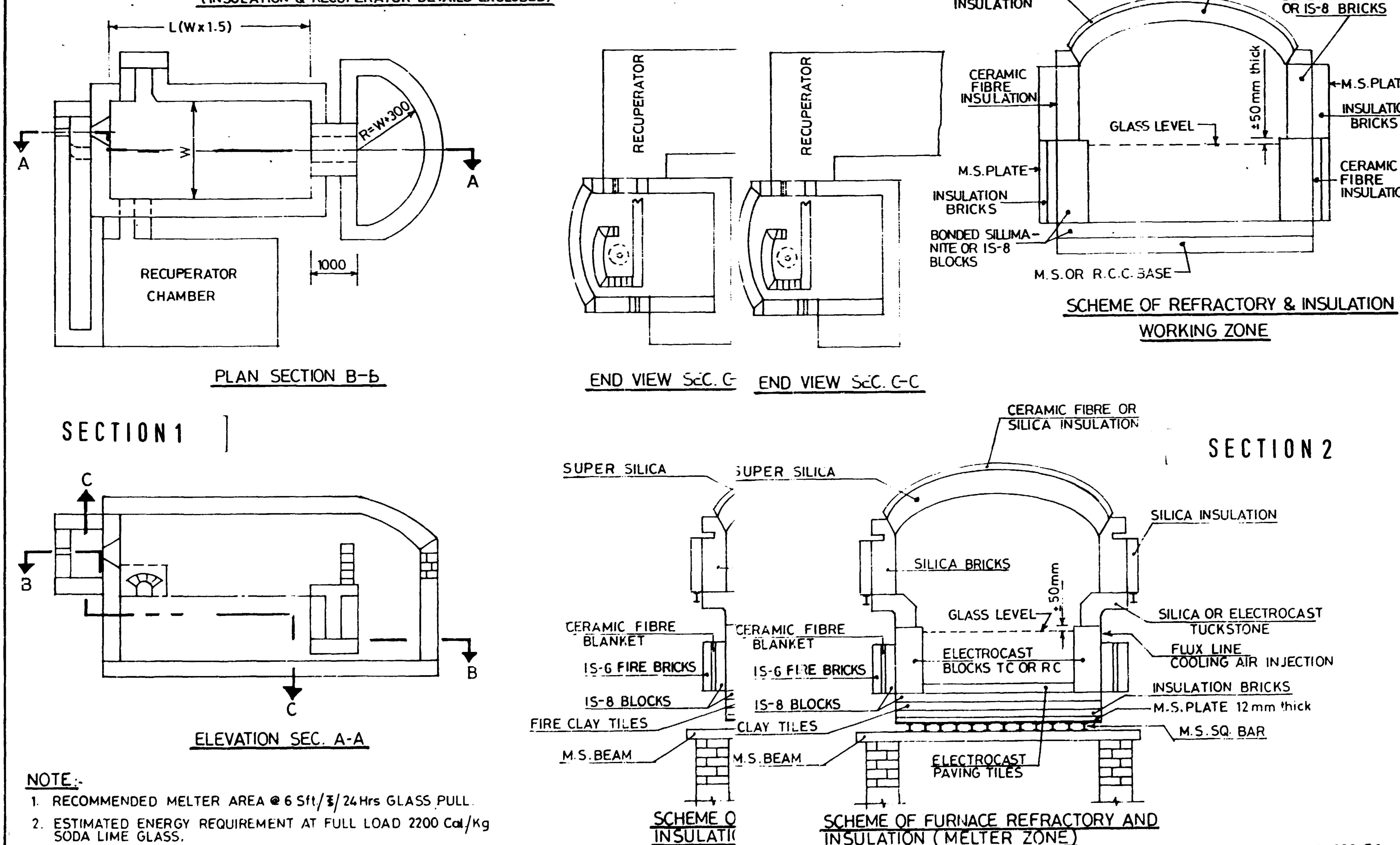


CONCEPTUAL DRAWING OF OIL FIRED POT FURNACE

FZD. 2710.21.01.001R0

CONCEPTUAL DRG. OF OIL FIRED END PORT RECUPERATIVE FURNACE

(INSULATION & RECUPERATOR DETAILS EXCLUDED)



NOTE:-

1. RECOMMENDED MELTER AREA @ 6 Sft/T/24Hrs GLASS PULL.
2. ESTIMATED ENERGY REQUIREMENT AT FULL LOAD 2200 Cal/Kg SODA LIME GLASS.

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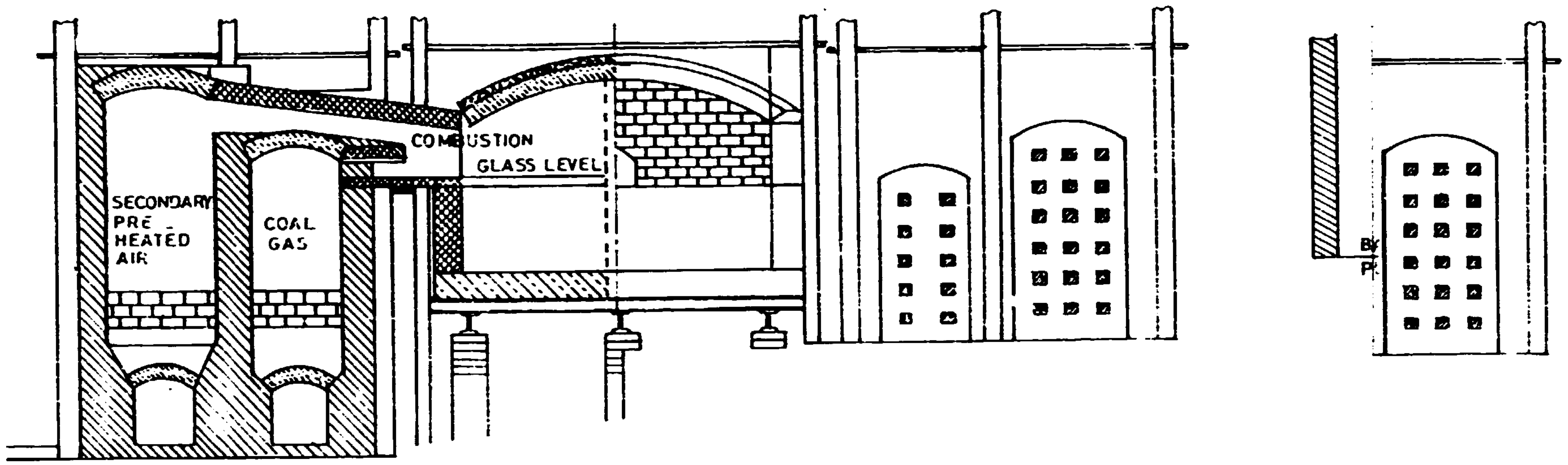
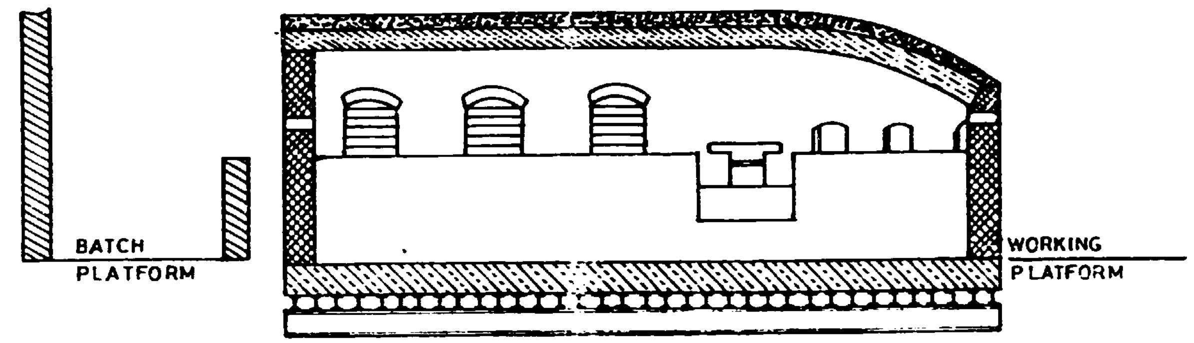


ELEVATION



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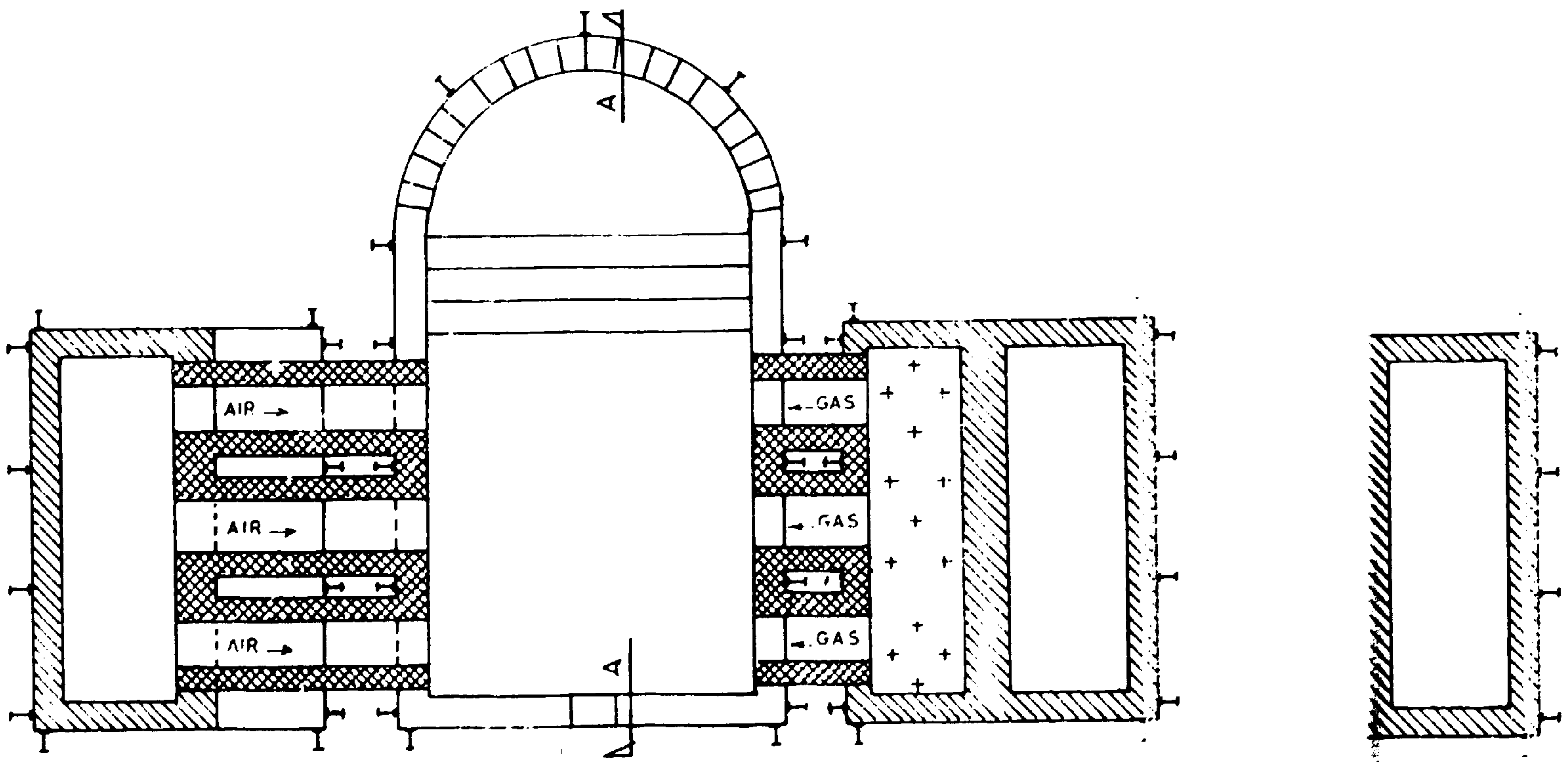

PLAN

SECTION 1

LEGEND:

- IS_8 (G. T. QUALITY)
- SILLIMANITE
- H. T. INSULATION
- SILICA
- INSULATION

SECTION 2

NOTES:

1. THE DETAILS OF REFRACTORIES & INSULATION FOR MELTING AND DRAWING ZONE ARE SAME AS THAT OF OIL FIRED TANK FURNACE.
2. THE RATIO OF LENGTH TO BREADTH OF MELTING ZONE IS 1.4 TO 1.6 : 1

CONCEPTUAL DRAWING OF COAL FIRED REGENERATIVE TANK FURNACE

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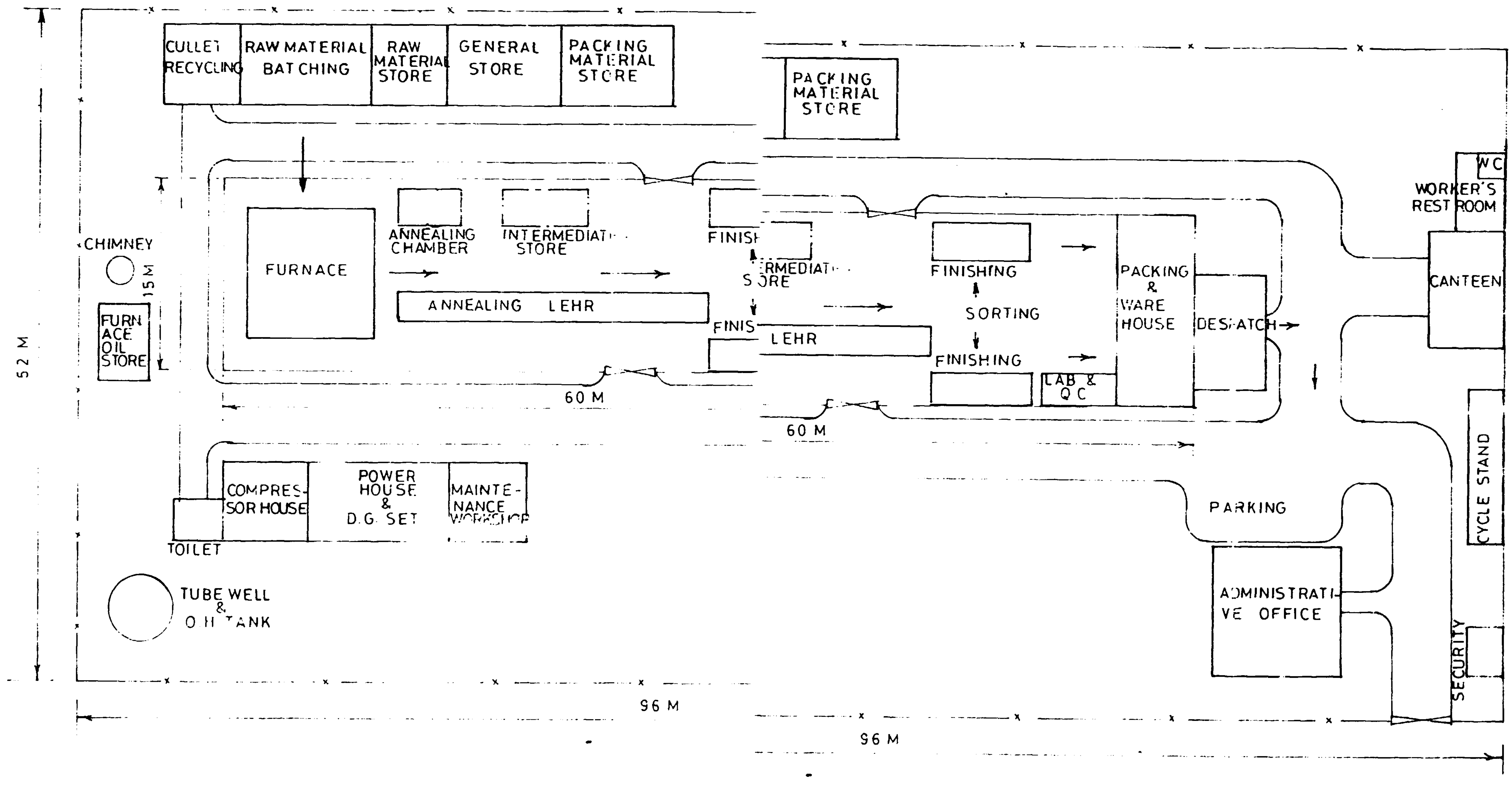

PLANT LAYOUT FOR MODEL GLASS UNIT (POT/TANK FURNACE)

FZD. 2710. 21.02.001 R0

SECTION 2

APPENDICES

Appendix 2.1

LIST OF GLASS UNITS AT FIROZABAD

A. Glassware Units

1. Mahesh Glass Works
   S.N. Marg,
   Firozabad

2. Indira Scientific Glass Works
   Coal Siding
   Firozabad

3. Vimal Glass Works
   Coal Siding
   Firozabad

4. Ashok Glass Works
   Coal Siding
   Firozabad

5. Golden Glass Works
   Coal Siding
   Firozabad

6. India Electrical Glass Works
   Coal Siding
   Firozabad

7. Unique Glass Industries
   Coal Siding
   Firozabad

8. Swastik Glass Industries
   Coal Siding
   Firozabad

9. General Traders
   A-10, Industrial Estate
   Firozabad

10. Chandra Glass Works
Agra Road,
Firozabad

11. Popular Glass Works
Agra Road
Firozabad

12. Akash Deep Industries,
Station Road,
Firozabad

13. Manohor Lal Glass Works,
Station Road,
Firozabad

14. Girdhar Glass Works
Station Road,
Firozabad

15. Sanjay Glass Works
Station Road,
Firozabad

16. Advance Glass Works
Station Road,
Firozabad

17. B.M. Glass Works
Station Road,
Firozabad

18. Nanumal Virendra Kumar Glass Works
Firozabad

19. Hariom Glass Works
Agra Road
Firozabad

20. Pooja Glass Works
Agra Road
Firozabad

21. Jaina Scientific Glass Works
Labour Colony
Firozabad

22. Everest Glass Works,
Hajipura
Firozabad

23. Electronic Glass Works
A 24-25, Industrial Estate
Firozabad

24. Jain Enterprises
A-5, Industrial Estate
Firozabad

25. A.V.M. Glass Works,
19-21, Industrial Estate
Firozabad

26. Wardhman Project India
A-11, Industrial Estate
Firozabad

27. Om Glass Works
Haja Ka Tal, Agra Road
Firozabad

28. The Suntech
Agra Road,
Firozabad

29. Glass Tube
Agra Road,
Firozabad

30. Jagdish Glass Works
No. 2, Agra Road,
Firozabad

31. Rajdhani Glass Works,
Station Road,
Firozabad

32. Oriental Glass Works,
Station Road
Firozabad

33. Shri Durga Glass Works
Station Road,
Firozabad

34. Adarsh Kanch Udyog,
Coal Siding,
Firozabad

35. Quality Glass Works
Nai Basti
Firozabad

36. Ruby Novelty Glass Works,
S.N. Marg,
Firozabad

37. India Optical Glass Works
S.N. Marg
Firozabad

38. Gopi Nath Glass Works,
Makkhanpur
Firozabad

39. Star Glass Works
S.N. Marg,
Firozabad

40. Shiv China Glass Manufacturing Co.
Coal Siding
Firozabad

41. Shyam Glass Works
Coal Siding
Firozabad

42. Jain Block Glass Works,
Coal Siding
Firozabad

43. New Bright Glass Works
Coal Siding
Firozabad

44. C.A. Glass Works
S.N. Marg
Firozabad

45. Technical Glass Works
Agra Road
Firozabad

46. Jaina Glass Udyog
Agra Road,
Firozabad

47. Meera Glass Industries
Bye-pass Road
Firozabad

48. Swastik Glass Enterprises
Firozabad

49. West Glass Works
Labour Colony
Firozabad

50. Naveen Glass Project
Labour Colony
Firozabad

51. M.K. Glass Works
Labour Colony
Firozabad

52. Shanker Novelty Glass Works
Labour Colony
Firozabad

B. **Glass Bangles Units**

1. Yadav Glass Works
Murli Nagar
Firozabad

2. Saran Glass Works
Coal Siding
Firozabad

3. Hally Glass Works
Coal Siding
Firozabad

4. Pushkar Glass Works
Coal Siding
Firozabad

5. Refusee Glass Works
Coal Siding
Firozabad

6. Mittal Glass & Chemical
Lesser Goodwill Glass Works
Coal Siding
Firozabad

7. Mukesh Glass Industries
Coal Siding
Firozabad

8. Ram Harihar Glass Works
Coal Siding
Firozabad

9. Eastern Glass Industries
O.A. Firozabad

10. Navjeevan Glass Works
O.A. Firozabad

11. Gopal Glass
Works No. 2, Station Road
Firozabad

12. Gori Shankar Ram Gopal Glass Works
Firozabad

13. New Azad Glass Works
Station Road
Firozabad

14. Ganga Glass Works
Station Road
Firozabad

15. Prem Glass Works .
Station Road
Firozabad

16. Shalini Glass Works
Station Road
Firozabad

17. Satya Narayan Glass Works
Station Road
Firozabad

18. Vijay Glass Works
Station Road
Firozabad

19. Veer Glass Works
Station Road
Firozabad

20. Kaphan Glass & Chemical Works
Agra Gate
Firozabad

21. Madina Glass Works
Nai Basti
Firozabad

22. Jagdish Glass Works
Nai Basti
Firozabad

23. Ram Lal Har Prashad Chobey Glass Industries
Nai Basti
Firozabad

24. Guru Nanak Glass Works
Nai Basti
Firozabad

25. Rama Glass Works
Nai Basti
Firozabad

26. Goyal Glass Works
Shivaji Marg
Firozabad

27. B.R. Glass Works
Shivaji Marg
Firozabad

28. Ajanta Glass Works
S.N. Road
Firozabad

29. Savitri Glass Works
S.N. Road
Firozabad

30. Deluxe Glass Works
Bhu Ka Nangla
Firozabad

31. Sand Glass Works
Bhu Ka Nangla
Firozabad

32. Balbir Glass Works
Purshotam Nagar
Firozabad

33. Santosh Glass Works
Purshotam Nagar
Firozabad

34. Rustom Glass Works
Dev Nagar
Firozabad

35. Crown Glass Works
Karvala
Firozabad

36. New Agarwal Glass Works
Karvala
Firozabad

37. Decent Glass Works
Islamganj
Firozabad

38. Bhurekhan Glass Bangles Factory
Agra Gate
Firozabad

39. Express Glass Works
Agra Gate
Firozabad

40. Coronation Glass Works
Agra Gate
Firozabad

41. Sunrise Glass Works
Purshotam Nagar
Firozabad

42. Sugar Glass Works
Agra Gate
Firozabad

43. Mateshwari Glass Works
Agra Gate
Firozabad

44. Guruji Glass Works
Agra Gate
Firozabad

45. G.K. Glass works
Parmeshwar Gate
Firozabad

46. N.S. Glass Works
Parmeshwar Gate
Firozabad

47. Tiger Sons
Parmeshwar Gate
Firozabad

48. S.S. Glass Works
Parmeshwar Gate
Firozabad

49. U.P. Union Glass Works
Parmeshwar Gate
Firozabad

50. Suhag Kanch Udyog
Parmeshwar Gate
Firozabad

51. Rajiv Glass Works
Parmeshwar Gate
Firozabad

52. Waris Glass Works
Mainpuri Gate
Firozabad

53. New Super Glass Works
Mainpuri Gate
Firozabad

54. Universal Glass Works
Mainpuri Gate
Firozabad

55. Embassy Glass Works
Mainpuri Gate
Firozabad

56. Mahadev Pipe Factories
Ashfabad

57. Mathur Glass Works
Ashfabad

58. Haideriya Block Glass
Ashfabad

59. Labour Glass Works
Ashfabad

60. Ganesh Glass Enterprises
Ashfabad
Firozabad

61. Naini Glass Works
Bye Pass Road
Firozabad

62. Nirmal Glass Works
Bye Pass Road
Firozabad

63. Hind Glass Works
Bye- Pass Road
Firozabad

64. N.U. Glass Works
Bye Pass Road
Firozabad

65. Akashwani Glass Works
Bye Pass Road
Firozabad

66. Anil Kumar Ramesh Chand Glass Works
Firozabad

67. Dinesh Glass Industries
Bye Pass Road
Firozabad

68. Zindal Glass works
Firozabad

69. Z.A. Glass Works
Firozabad

70. Gopal Glass Works
No. 1, Bye Pass Road
Firozabad

71. Shivaji Glass Works
Mathura Nagar
Firozabad

72. Pavansut Kaunch Udyog
Mathura Nagar
Firozabad

73. Coin Glass Beads
Jalesar Road
Firozabad

74. Alok Glass Works
Jalesar Road
Firozabad

75. Mahavir Glass Works
Shitalkhan
Firozabad

76. Mirza Glass Works
Firozabad

77. K.S. Mirza Glass Works
Circular Road
Firozabad

78. Ahwab Glass Works
Hajipura
Firozabad

79. Shimla Glass Works
Hajipura
Firozabad

80. Commercial Glass Works
Hajipura
Firozabad

81. Nagina Glass Works
Hajipura
Firozabad

82. Bhagya Glass Works
Hajipura
Firozabad

83. Sikandar Bux Nadar Bux Glass Works
Muhalla Husaini
Firozabad

84. Bharat Glass Works
Kotla Road
Firozabad

85. Veshnya Glass Works
Firozabad

86. Supreme Glass Works
Firozabad

87. Shyam Glass Works
Purshotam Nagar
Firozabad

88. Nannu Mal Glass Works
Firozabad

89. R.K. Glass Works
Firozabad

90. Geeta Glass Works
Agra Gate
Firozabad

91. Amut Glass Works
Agra Gate
Firozabad

92. Bhagwati Glass Works
Firozabad

93. Jindal Refractories
Bye Pass Road
Firozabad

94. Bhawani Glass Works
Firozabad

95. Kohinoor Glass Works
Firozabad

96. Shivcharan Lal Ambica Prasad Glass Works
Firozabad

97. Sapna Glass Works
Firozabad

98. Saraswati Glass Industries
Shitlakhan
Firozabad

99. Muslim Glass Works
Circular Road
Firozabad

100. Binova Glass Works
Hajipura
Firozabad

101.Nasar Glass Works
Firozabad

102. M.U. Parlad Works
Firozabad

103. Jeevan Glass Works
Hajipura
Firozabad

104. Baby Glass Works
No. 2, Galib Nagar
Firozabad

105. Girnar Glass Works
Purshotam Nagar
Firozabad

106. Anand Glass Works
O.A.
Firozabad

107. Gian Chand Mahavir Prasad
O.A.
Firozabad

108. Neelam Glass Industries
Firozabad

109. Som Glass Works
Firozabad

110. Raja Glass Works
Firozabad

111. International Glass Works
Firozabad

112. Industrial & Building Glass Works
Firozabad

113. Jai Glass Works
Firozabad

114. Durgesh Block & Chain Glass Works
Firozabad

115. R.R. Glass Works
Agra Road
Firozabad

116. Anup General Glass Works
Firozabad

117. Shanti Glass Works
Parmeshwar Gate
Firozabad

118. K.V. Glass Works
Parmeshwar Gate
Firozabad

119. Sufi Glass Works
Parmeshwar Gate
Firozabad

120. Anul Glass Works
Parmeshwar Gate
Firozabad

121. S.R. Glass Works
Mainpuri Gate
Firozabad

122. Raijuddin Sahabuddin Glass Works
Firozabad

123. Jain Industries
Mainpuri Gate
Firozabad

124. Nadar & Co. Glass Works
Firozabad

125. Paras Nath Glass Works
Mainpuri Gate
Firozabad

126. Jai Glass Works
Bye Pass Road
Firozabad

127. M.M. Patel Glass Works
Bye Pass Road
Firozabad

128. Seema Glass Works
Bye Pass Road
Firozabad

129. Elora Glass Works
Bye Pass Road
Firozabad

130. Gopal Glass Works
No. 3,
Firozabad

131. Sri Krishna Glass Works
Firozabad

132. Kamla Glass Works
Nai Basti
Firozabad

133. Shankar Glass Works
Nai Basti
Firozabad

134. G.M. Glass Works
No. 2 Nai Basti
Firozabad

135. Bansal Electrical Glass Works
Nai Basti
Firozabad

136. Anuradha Glass Works
Nai Basti
Firozabad

137. Vaishali Glass Works
Firozabad

138. Shiva Glass Works
Chandravar Gate
Firozabad

139. G.M. Glass Works
Firozabad

140. Novelty Glass Works
S.N. Marg
Firozabad

141. Central Sovery Glass Works
S.N. Marg
Firozabad

142. Ansar Glass Works
S.N. Marg
Firozabad

143. Irfan Glass Works
S.N. Marg
Firozabad

144. Wonder Glass Works
S.N. Marg
Firozabad

145. Radha Glass Works
Coal Siding
Firozabad

146. Indian Glass Works
Coal Siding
Firozabad

147. Fancy Glass Works
Coal Siding
Firozabad

148. Rameshwar Dayal Glass Works
Coal Siding
Firozabad

149. Panchsheel Glass Works
Coal Siding
Firozabad

150. Baby Glass Works
Agra Road
Firozabad

151. Sita Ram Glass Works
Agra Road
Firozabad

152. Devi Sahai Glass Works
Firozabad

153. Sarvodaya Glass Works
Agra Road
Firozabad

154. Narayan Glass Works
A-7, Industrial Estate
Firozabad

155. Rashmi Glass Works
Dida Mai
Firozabad

156. M.B. Glass Works
Coal Siding
Firozabad

157. Avon Glass Works
Coal Siding
Firozabad

158. Pitamber Glass Works
Agra Road
Firozabad

159. Govind Glass Works
S.N. Marg
Firozabad

C. **Beads Units**

1. Rama Beads Industries
Karvala
Firozabad

2. Shelendri Glass Works
Agra Gate
Firozabad

3. Taj Glass Works
Hajipura

4. Jagdamba Glass Beads
Hajipura

5. Panchsheel Beads Industries
P. Nagar
Firozabad

6. Ganesh Beads Industries
Firozabad

7. Indira Beads Industries
Dev Nagar
Firozabad

8. Chandra Glass Beads
Firozabad

9. Maheshwari Moti Udyog
Karvala
Firozabad

10. Saraswati Beads Industries
Firozabad

11. Krishna Beads Industries
Jalesar Road
Firozabad

12. Imperial Beads & Globe Industries
Firozabad

13. Durga Glass Beads Industries
Station Road
Firozabad

14. K.S. Beads
S.N. Nagar
Firozabad

15. Sunshine Beads
Firozabad

16. Parvati Moti Udyog
Agra Road
Firozabad

17. Choudhery Glass Works
Firozabad

D. <u>Block Glass Units</u>

1. Refusee Glass Works
Coal Siding
Firozabad

2. Jagdamba Glass Works
Nai Basti
Firozabad

3. R.B. Glass Works
Nai Basti
Firozabad

4. Nanak Works
Nai Basti
Firozabad

5. Dada Glass Works
S.N. Marg
Firozabad

6. Sarojini Naidu Glass Works
S.N. Marg
Firozabad

7. Avinash Glass Works
S.N. Marg
Firozabad

8. Luxmi Glass Works
S.N. Marg
Firozabad

9. Empala Glass Works
Jain Nagar
Firozabad

10. S.N. Refractories
Jain Nagar
Firozabad

11. Akhileswar Glass Works
Labour Colony
Firozabad

12. Shakti Glass Industries
Purshotam Nagar
Firozabad

13. Padmavati Kanch Udyog
Purshotam Nagar
Firozabad

14. Wardhman Glass House
Agra Gate
Firozabad

15. Pankaj Glass Works
Agra Gate
Firozabad

16. Hajisoudullah Sahabuddin Glass Works
Agra Gate
Firozabad

17. Alite Glass Works
Mainpuri Gate
Firozabad

18. Wasya Glass Works
Mainpuri Gate
Firozabad

19. Wenketeswar Glass Works
Firozabad

20. Haji Glass
No. 1, Jalesar Road,
Firozabad

21. Haji Glass No. 2
Jalsari Road
Firozabad

22. Kamal Kanch Udyog
Hajipura

23. Juprator Glass Works
Agra Road
Firozabad

24. Moti Sons Glass Works
Firozabad

25. K.P. Jain Glass Works
Firozabad

26. Alankar Industries
Firozabad

27. M.N. Industries
Firozabad

28. Vishambhar Glass Works
Agra Road,
Firozabad

29. Ganesh Block Glass Works
Coal Siding
Firozabad

30. Shiva Industries
Coal Siding
Firozabad

31. Ramdoot Glass Works
Station Road,
Firozabad

32. Asia Glass Works
Jain Nagar
Firozabad

33. Raghav Glass Works
Station Road
Firozabad

Appendix 2.2

LIST OF MANUFACTURERS/SUPPLIERS OF MACHINERY & EQUIPMENT

1. Electromag Devices
   404, Unique Industrial Estate
   Off. Veer Savarkar Marg, Post Box 9141
   Prabhadevi, Bombay-400025.

2. Eleind Engineering Pvt. Ltd.
   D-20/2, Okhla Industrial Area
   Phase-II, New Delhi-110020.

3. Erich Magnetics
   178/6B/10, Old Tijab Mill
   Bhola Nath Nagar, Shahdara
   Delhi-110032.

4. Fabrocon Baroda P. Ltd.
   Ganesh Wadi, Behind Khanderao Market
   Baroda-390001

5. Farbest Agencies
   117-119, Mody Street, Fort,
   Bombay-400001.

6. Fortune International Ltd.
   C-2, Community Centre, Naraina Vihar
   New Delhi-110028.

7. General Industrial Equipment P. Ltd.
   T-22, MIDC,Bhosari,
   Pune-411026.

8. Glacera Engineers
   2557, H-1, "Himanchan"
   191-A, Yerwada,
   Pune-411006.

9. Glass Equipment (India) Ltd.
   P.O. Box No. 7, Bahadurgarh-124507
   (Haryana)

10. Glass Machine Spares
B-2/3, Acme Industrial Estate,
Minerva Premises Bunder Road,
Sewri(E), Bombay-400015.

11. Innotech Engineers Pvt. Ltd.
G-12, Lajpat Nagar-III
New Delhi-110024.

12. Indheatrol Engineers (P) Ltd.
202-Patel House,
B-11 Ranjitnagar Commercial Complex,
New Delhi-110008.

13. KTG (India) Ltd
Sriram Chambers,
R.C. Dutt Road
Alkapuri, Baroda-390005.

14. Labinstruments
9, Ratnadeep, Ist Floor
78-A, I.S. Seth Road
Bombay-400004.

15. Labman Industries
24/1B, Manmatha Nath Ganguly Road
Calcutta-700002.

16. Lakshmi Engineering Works
301/1, Lal Kuan,Mehrauli Badarpur Road
New Delhi-110044.

17. Lectrotek Systems (Pune) Pvt. Ltd.
9, Kaka Halwai Industrial Estate
Pune-411009.

18. Manilal Maganlal & Co. (P) Ltd.
387/7, I.S.S. Road
Bombay-400002.

19. Shamvit Glasstech Ltd.
157, Maker Chambers VI, 14th Floor,
220, Nariman Point
Bombay-400021.

20. M.P. Shah & Co.
A-3, Neelkanth Vihar, 28/29, Garodia Nagar
Ghatkopar (E), Bombay-400077.

21. Mehndiratta & Associates
Hathras Road, Naraich,
Agra-282006.

22. Mukul Industries
103-B, Tejpal Industrial Estate
Sakinaka, Bombay-400072.

23. National Industrial Products
2, Anandapuram, Madras-600004.

24. Precision Engineering & Chiming Equipment
Unit No. 31, M.M. Indutrial Estate
Jaya Nagar, 7th Block, Bangalore-560082.

25. R.D.Ashar Engineering Divn.
10, Homi Modi Street, Fort,
Bombay-400023.

26. Sanshi Exim Ltd.
"Sanshi House" 78/1, Benson Cross Road
Bangalore-560046.

27. Sayaji Iron & Engineering Co. Ltd.
Chhani Road
Baroda-390002.

28. S'cube Engineers
B-5, Surat Singh Estate,
Behind Agarwal Estate
Off. S.V. Road, Jogeshwari (West)
Bombay-400102.

29. Shiv Industries
206, Veena Dalvai Industrial Estate, Oshiwara,
Jogeshwari(W), Bombay-400102.

30. Shreno Limited (Unit No.1)
3/23-24, Industrial Estate
Gorwa Road, Baroda-390016.

31. Technovation
4, Paramel, ST Cyril Road, Bandra,
Bombay-400050.

32. TNF Engineering
72-B, CIDCO Service Industrial Area
Turbhe, New Bombay-400705.

33. Toshniwal Industries Pvt. Ltd.
Industrial Estate, Makhupura,
Ajmer-305002 (Rajasthan)

34. Utility Engineers
210, Veena Chambers, 21, Dalal Street, Fort,
Bombay-400001.

35. Veer Workshop
B-53, Naraina Industrial Area, Phase-II,
New Delhi-110028.

36. Vulcan Engineers Ltd.
427, Unique Industrial Estate, Prabhadevi,
Bombay-400025.

Appendix 2.3

LIST OF SUPPLIERS/MANUFACTURERS OF MOULDS AND SPARES

1. Glass Engineering Company
   C-221,222/5, G.I.D.C. Estate, Naroda
   Ahmedabad-382330.

2. Groversons Engineering Works
   208, Indo-Saigon Industrial Estate
   Marol-Naka
   Bombay-400059.

3. India Iron Foundry
   Sultanganj
   Agra-282004.

4. Indo-Compressed Tools Pvt. Ltd.
   7-1-24/2/B, Greenfields, Begumpet
   Hyderabad-500016.

5. Sant Engineering Works
   1, Balaji Darshan, 99, Peston Sagar,
   P-L Lakhande Marg, Chembur
   Bombay-400089.

6. Shingadia Engineering Works
   Opp. Firesse Co. Deonaor Govandi
   Bombay-400088.

7. Swami Engineering Works
   17, Uttam Chendane Thane (E)
   Bombay-400603.

8. Universal Engineering Works
   c/o Bhara Glass Works
   Tilak Nagar
   Bombay-400089.

9. Victory Engineers
   7, Udyog Mandir No.2
   7C, Pitamder Lane, Mahim
   Bombay-400016.

Appendix 2.4

LIST OF MANUFACTURERS/SUPPLIERS OF REFRACTORIES

1. Arora Refractories
   261 Balarajeshwar Road, Mulund (W)
   Bombay-400080.

2. Arun Refractories
   P.O. Chirkunda-828208 (Bihar).

3. Ashok Refractories
   P.O. Chirkunda-828208(Bihar)

4. The Associated Cement Companies Ltd.
   CRS Complex, L.B. Shastri Marg,
   Thane-400604 (Maharashtra).

5. Associated Ceramics Pvt. Ltd.
   507, Meghdoot Building, 94, Nehru Place,
   New Delhi-110019.

6. Associated Refractories
   Naroji Lane, Ghatkopar (West)
   Bombay-400086.

7. Bharat Minerals & Ceramic Industries
   P.O. Mahilong-835103 (Distt. Ranchi).

8. Bhaskar Stoneware Pipes Pvt. Ltd.
   Ishwar Nagar, 10/1 Km , Mathura Road,
   New Delhi-110065.

9. Carborundum Universal Limited
   28, Rajaji Road, Madras-600001.

10. Ceramic Engineering Enterprises
    18, Ratnavilas Building (P.B. No. 150)
    Railway Station Road, Trichur-680001.

11. Chirkunda Ceramic Works
    P.O. Chirkunda-828208 (Bihar).

12. Corporated Ceramics
50/2, Lenin Sarani, 2nd Floor,
Calcutta-700013.

13. Dalmia Magnesite Corporation
11th & 12th Floors, Hansalaya,
15, Barakhamba Road, New Delhi-110001.

14. Dynamic Sales Service
International (P) Ltd.
210, DD Upadhyaya Marg, Rouse Avenue
New Delhi-110002.

15. Fire, Gas & Kiln (I) Ltd.
156, Jodhpur Park,
Calcutta-700068.

16. Furbrix (India) Pvt. Ltd.
5/2, Russel Street,
Poonam Building, 5th Floor,
Calcutta-700071.

17. Furnace Fabrica (Bombay) Pvt. Ltd.
506-507, Swastik Chambers,
C.S.T. Road, Chembur,
Bombay-400071.

18. Hindustan Produce Company
9, Jagmohan Mullick Lane
Calcutta-700007.

19. Hyderabad Asbestos Cement Products Ltd.
Ballabgarh-Faridabad-121004 (Haryana).

20. Hyderabad Industries Ltd.
Sector 25, Faridabad-121004 (Haryana)

21. Indian Agencies Corporation
Sir Sobha Singh Building
G.B. Road,
New Delhi-110006.

22. Indo Flogates Ltd.
3, Netaji Subhash Road,
Calcutta-700001.

23. Industrial Associates
238-B, AJC Bose Road, 4th Floor,
Calcutta-700020.

24. Kothari Ceramic & Chemical Industries
21, Industrial Area Post Birgaon
Raipur-493221.

25. Kumardhubi Fireclay & Silica Works Ltd.
Kumardhubi, Dhanbad-828203 (Bihar).

26. Mahakoshal Potteries
Post Box 62, Industrial Area
Katni-483501.

27. Mahavir Insulations Pvt. Ltd.
Office-721, Tulsiani Chambers
Nariman Point
Bombay-400021.

28. Mahavir Refractories Corporation
Maker Bhavan No. 2, 18, New Marine Lines,
Bombay-400020.

29. Maithan Ceramic Ltd.
P.O. Chirkunda-828202
Distt. Dhanbad (Bihar).

30. Mascot Engineering Company
T 5/2, World Trade Centre
Cuffe Parade,
Bombay-400005.

31. Murugapa Morganite Ceramic Fibres Limited
28, Rajaji Road,
Madras-600001.

32. Naveen Refractories
P.O. Mugma-828204 (Distt. Dhanbad)
Bihar.

33. Nutech Refractories Pvt. Ltd.
5 Km Ajmer Road, Post Box 63,
Bhilwara-311001 (Rajasthan).

34. Orient Abrasives Ltd.
1212, Chiranjiv Tower
43,Nehru Place
New Delhi-110019.

35. Orissa Cement Limited
P.O. Rajgangpur-770017
Distt. Sundargarh,
Orissa.

36. Orissa Industries Limited
P.O. Barang-754005 Distt. Cuttack
Orissa.

37. Orissa Refractories
14-B, Ganesh Sarkar Lane
Calcutta-700023.

38. Pyroceramics & Pamposh Refractories
& Ceramic Works
P.O. Maithan Dam, Distt. Dhanbad
Bihar.

39. Rajasthan Ceramic Industries
Near Kamal Kakuwa, Bhopalganj,
Bhilwara-311001.

40. Rajhans Refractories (P) Ltd.
Rajganj Road, P.O. Katrasgarh,
Distt. Dhanbad
Bihar.

41. Refractory Specialities (I) Ltd.
Refractory House,
Sitarampur-713359
Distt. Burdwan, West Bengal.

42. Shri Nataraj Ceramic & Chemicals Industries Ltd.
4, Scindia House,
New Delhi-110001.

43. Special Refractories Ltd.
P.Box 1, Kassar-124507
Distt. Rohtak (Haryana)

44. S.K. Gupta (Pvt.) Ltd.
Refractory House, L.B. Shastri Marg,
Kurla, Bombay-400070.

45. S.V. Refractories & Ceramics
C-19, Industrial Estate
Vishakhapatnam-530007.

46. Taktawala Exports P. Ltd.
Atlanta, 5th Floor, Nariman Point,
Bombay-400021.

47. Tata Refractories Ltd.
Tata Centre (11th Floor),
43, Chowringhee Road,
Calcutta-700071.

48. Valley Refractories Ltd.
P.O. Chirkunda-828202
Distt. Dhanbad (Bihar).

49. Vesuvius France
68, Rue de la Gare, BP 19
59750 Feignies, France.
Indian Contact:
T 8/1, Kaveri Road, Basant Nagar,
Madras-600090

50. Vison Refractories Pvt. Ltd.
144/EBS Maker Chamber III, Nariman Point
Bombay-400021.

51. VRW Refractories
15, Reddy Street
Virugambakkam-Madras.

Appendix 2.5

LIST OF INDIAN STANDARDS ON GLASS

S.No.	Standard No.	Description
A.	Raw Materials	
1.	IS:488	Glass Making Sands
2.	IS:997	Limestone and Dolomite
3.	IS:1760	Dolomite
4.	IS:1917	Sand , Quartzite and Silica
5.	IS:6135	Soda Ash, Fused, Technical
6.	IS:251	Soda Ash, Technical
7.	IS:1109	Borax
8.	IS:9157	Sodium Nitrate and Potassium Nitrate
9.	IS:12928	Barium Carbonate, Precipitated
10.	IS:9425	Selenium
B.	Products	
1.	IS:6917	Lenses for Automobile Headlights
2.	IS:7374	Rods for Laboratory Glass Ware
3.	IS:1112	Shells for General Lighting Service Lamps
4.	IS:5984	Shells for Miniature Lamps
5.	IS:1961	Table Ware
6.	IS:5081	Tubes for Fluorescent Lamps
7.	IS:4529	Tubes for Medical Thermometers
8.	IS:7374	Tubing for Laboratory Glass Ware
9.	IS:7840	Laboratory Apparatus Drawing Convention
10.	IS:5428	Glass for Gauges,Circular,Sight & Light
11.	IS:3608	Alcoholometers
12.	IS:489	Ampoules
13.	IS:7840	Laboratory apparatus, drawing convention
14.	IS:2619	Beakers
15.	IS:11307	Cellular block glass thermal insulation
16.	IS:2091	Beer bottles
17.	IS:10133	Glass bottles, dimensions and tolerances
18.	IS:1106	Distilled water bottles
19.	IS:1107	Bottles for aerated water
20.	IS:1945	Bottles for fluid ink
21.	IS:11984	Bottles for free flowing liquids
22.	IS:1392	Bottles for milk
23.	IS:5168	Bottles for feeding
24.	IS:11102	Bottles for sugar standard
25.	IS:9780	Bottles for tomato ketchups
26.	IS:11985	Bottles and Jars for pickles
27.	IS:2351	Marble stoppered bottles
28.	IS:1108	Medicinal bottles with narrow mouth

29.	IS:57150	Carboys
30.	IS:6052	Glass condensers
31.	IS:3423	Containers for transfusion fluids
32.	IS:2835	Flat transparent sheet
33.	IS:1116	Globes for hurricanes
34.	IS:5870	Globes for internal lighting of passenger coaches
35.	IS:11369	Heavy jars
36.	IS:9621	Hydrometers
37.	IS:6981	Jars for caustic soda primary cells
38.	IS:9781	Jars for jams, jellies, and marmalades
39.	IS:6917	Lenses for automobile headlights
40.	IS:1662	Liquor bottles
41.	IS:6472	Ophthalmic glass, tinted
42.	IS:4382	Ophthalmic glass, non-tinted
43.	IS:1400	Optical glass
44.	IS:3702	Refills for vacuum flasks
45.	IS:2553	Safety glass
46.	IS:6180	Toughened safety glass
47.	IS:5984	Shells for miniature lamps
48.	IS:3438	Silvered glass mirrors for general purpose
49.	IS:1996	Stop-cocks
50.	IS:2480	Thermometers, solid stem
51.	IS:1761	Transparent sheet for glazing and framing
52.	IS:4529	Tubes for medical thermometers
53.	IS:3740	Tubes for pathological thermometers
54.	IS:4610	Tubes for reference thermometers
55.	IS:7708	Vacuum flasks
56.	IS:1984	Vials for pharmaceutical preparations
57.	IS:1574	Weighing bottles
58.	IS:4426	Laboratory glass wire for sampling
59.	IS:5437	Wired and figured glass
60.	IS:3690	Wool mats
61.	IS:8729	Volumetric glass, principle of construction & adjustment
62.	IS:8897	Volumetric glass, tables for calibration & method of verification

C. <u>Furnace Applications</u>

1.	IS:1522	Fireclay Tank Blocks for Glass
2.	IS:1050	Zircon Mullite Refractories
3.	IS:9930	Zircon Refractories
4.	IS:6	Moderate heat duty fireclay refractories, Group A
5.	IS:7	Moderate heat duty fireclay refractories, Group B
6.	IS:8	High heat duty fireclay refractories
7.	IS:2044	Sillimanite refractories
8.	IS:2045	Sillimanite (natural) blocks
9.	IS:10551	Zircon mullite refractories

D. Others

1.	IS:6945	Packaging for glasswares
2.	IS:9154	Alkali resistance, determination of
3.	IS:8540	Cleaner liquid
4.	IS:5623	Coefficient of linear thermal expansion
5.	IS:1382	Glossary
5.	IS:2303	Grading for alkalinity
6.	IS:10584	Marking pencils
7.	IS:5428	Protector for tubular glass
8.	IS:7999	Testing for liquid samples
9.	IS:9153	Polariscopic examination of glassware
10.	IS:6506	Thermal shock test
11.	IS:5983	Eye protectors
12.	IS:1975	Colours for signai glasses for use in railways
13.	IS:1922	Bright liquid gold
14.	IS:7524	Method of test for eye protectors
15.	IS:9154	Method of determination of Alkali resistance

Appendix 3.10.1

ANNUAL SALES REALISATION

I. REGENERATIVE FURNACE

	Price (Rs./Kg.)	Qty. (Kg./day)	Value (Rs.million)
1. Automobile Products	15	7,000	31.50
2. Bangles	4	1,500	1.80
3. Tube	8	1,500	3.60
4. Tumblers etc.	15	2,000	9.00
Total			45.90

II. POT FURNACE (Closed)

	Price (Rs/Kg.)	Qty. (Kg/day)	Value (Rs million)
1. Automobile Products	15	1,000	4.500
2. Scientific Glassware	20	500	3.000
3. Tumblers	15	1,000	4.500
4. Tube/Rod	8	760	1.824
Total			13.824

III. POT FURNACE (Open)

	Price (Rs./Kg.)	Qty. (Kg./day)	Value (Rs.million)
1. Bangles	20	1,850	11.100

Appendix 3.10.2

WORKING CAPITAL

S.No.	Item	Inventory Level (Months)	Cost (Rs. million)		
			Regener-ative	Pot Closed	Pot Open
A.	Raw Materials	1 month	0.719	0.361	0.164
B.	Fuel	15 days	0.281	0.122	0.083
C.	Lubricants	1 month	0.162	0.008	0.002
D.	Labour	1 month	0.770	0.099	0.121
E.	Packing Material	1 month	0.208	0.075	0.046
F.	Stock of goods in process & finished goods	15 days	1.265	0.404	0.308
G.	Accounts Receivable	1 month	2.530	0.808	0.616
	Total		5.935	1.877	1.340
	Working Capital	Say	6.000	1.900	1.300
	Margin Money		1.500	0.400	0.300
	Short-term Borrowings		4.500	1.500	1.000

Appendix 3.10.3

COST OF PRODUCTION

S.No.	Item	Price (Rs./tonne)	REGENERATIVE - COAL Cap. of Tank : 20 t/day		
			Qty. (Tonne)	Value (Rs. million)	Cost of Prod. per tonne of glass melted(Rs)
1.	2.	3.	4.	5.	6.
A.	Raw Materials				
1.	Soda Ash	7,665	720	5.518	
2.	Silica Sand (Quartz)	450	2340	1.053	
3.	Calcite	1,000	330	0.330	
4.	Felspar	600	100	0.060	
5.	Borax	30,600	-	-	
6.	Barium Carbonate	12,000	40	0.480	
7.	Sodium Nitrate	12,000	60	0.720	
8.	Potassium Nitrate	12,000			
9.	Arsenic Trioxide	95,000	5	0.475	
10.	Dolomite	600	-	-	
	Sub-Total A'	-	3,600	8.636	2,398
B.	Synthetic Materials				
1.	Cullets				
	- Recycled	-	2,400	-	
	- Purchased	-	-	-	-
C.	Fuels				
1.	Coal	1,500	4,500	6.750	1,875

Appendix 3.10.3 (Contd.)

1.	2.	3.	4.	5.	6.
D.	Lubricants				
1.	High Speed Diesel Oil	6.35/lit.	1,50,000 lit.	0.952	264
2.	Kerosene Oil	6.00/lit	400 lit/day	0.720	
3.	Other oil	6.15/lit.	150 lit/day	0.276	
E.	Labour	Rs.1100 per month Avg.	700 Nos.	9.240	2,555
F.	Packing				
1.	Boxes & Sheet	] @ 5% of	Rs 49.00	2.500	
2.	Others etc.	] sale realisatio	million		
G.	Repair & Maintenance		L.S.	0.400	
H.	Jurai Expenditure	Bangles (L.S.) 1 Tora = Rs.2.50		0.940	
I.	Depreciation				
	3% on civil works			0.001	
	10% on Plant & equipment			0.013	
J.	Interest Charges				
	On Short-term Borrowings	Rs 4.5 mill.		0.810	
	Total			31.238	Rs.8,677 per tonne

Appendix 3.10.4

COST OF PRODUCTION

S.No.	Item	Price (Rs./tonne)	POT FURNACE - COAL (CLOSED) Cap. of Tank : 4 t/day		
			Qty. (Tonne)	Value (Rs. million)	Cost of Prod. per tonne of glass melted(Rs)
1.	2.	3.	4.	5.	6.
A.	Raw Materials				
1.	Soda Ash	7,665	235	1.801	
2.	Silica Sand (Quartz)	450	590	0.265	
3.	Calcite	1,000	15	0.015	
4.	Felspar	600	15	0.009	
5.	Borax	30,600	20	0.612	
6.	Barium Carbonate	12,000	5	0.060	
7.	Sodium Nitrate	12,000	15	0.180	
8.	Potassium Nitrate	12,000	35	0.420	
9.	Arsenic Trioxide	95,000	10	0.950	
10.	Dolomite	600	30	0.018	
	Sub-Total 'A'		978	4.330	4.427

1.	2.	3.	4.	5.	6.
B.	Synthetic Materials				
1.	Cullets				
	- Recycled	-	318	-	
	- Purchased	-	-	-	
C.	Fuels				
1.	Coal	1,500	1,956	2.934	3,000
D.	Lubricants				
1.	High Speed Diesel Oil	6.35/lit.	15,000 lit.	0.095	-
2.	Kerosene Oil	6.00/lit.	50 lit. per day	0.090	
E.	Labour	Rs. 1100 per month Avg.	90 Nos.	1.188	1.215
F.	Packing				
1.	Boxes & Sheet] @ 5% of		Rs 17.50	0.900	
2.	Others etc.] sale realisation				
G.	Repair Maintenance		L.S.	0.250	
H.	Depreciation				
	3% on civil works			0.001	
	10% on Plant & equipment			0.013	
I.	Interest Charges				
	On Short-term Borrowings		Rs 1.5	0.270	
	Total			10.071	10,297 per tonne

Appendix 3.10.5

COST OF PRODUCTION

S.No.	Item	Price (Rs./tonne)	POT FURNACE - COAL (OPEN) Cap. of Tank : 4 t/day		
			Qty. (Tonne)	Value (Rs million)	Cost of Prod.per tonne of glass melted(Rs)
1.	2.	3.	4.	5.	6.
A.	Raw Materials				
1.	Soda Ash	7,665	216	1.655	
2.	Silica Sand (Quartz)	450	446	0.201	
3.	Calcite	1,000	-		
4.	Felspar	600	-		
5.	Borax	30,600	4	0.122	
6.	Barium Carbonate	12,000	-		
7.	Sodium Nitrate	12,000	-		
8.	Potassium Nitrte	12,000	-		
9.	Arsenic Trioxide	95,000	-		
11.	Dolomite	600	-		
	Sub-Total 'A'		666	0.178	2,969

1.	2.	3.	4.	5.	6.
B.	Synthetic Materials				
1.	Cullets				
	- Recycled	-	666	-	
	- Purchased	-	-	-	
C.	Fuels				
1.	Coal	1,500	1,332	1.998	3000
D.	Lubricants				
1.	High Speed Diesel Oil	6.35/lit.	3,600 lit.	0.023	-
E.	Labour	Rs. 1100 per month Avg.	110 Nos.	1.452	2,180
F.	Packing				
1.	Boxes & Sheet	@ 5% of sale realisation	Rs.11.100	0.555	
2.	Others etc.				
G.	Repair & Maintenance		L.S.	0.150	
H.	Jurai Expenditure	Bangles L.S. 1 Tora = Rs.2.50	1850 tora/ day	1.387	
I.	Depreciation				
	3% on civil works			0.001	
	10% on Plant & equipment			0.013	
J.	Interest Charges				
	On Short-term Borrowings		Rs. 1.0 mill.	0.180	
	Total			7.587	11,392 per tonne

Appendix 5.1

ADDITIONAL/MODIFICATION COST OF EXISTING POT FURNACES

(Pot Furnace - Coal to Oil/Gas - 4 TPD)

		Cost Rs million
A.	Raw Material & Batch Preparation	
	1. Mixer	0.05
	2. Sand washing plant	0.05
	3. Cullet washing plant	0.04
B	Furnace	
	1. Refractories	0.77
	2. Insulation	0.10
	3. Instrumentation	0.20
	4. Oil storage, oil supply & burner equipment	0.70
	5. Blowers	0.10
C.	Miscellaneous	
	1. Miscellaneous Equipment	0.10
	Total	2.10

Appendix 5.2

ADDITIONAL/MODIFICATION COST OF EXISTING TANK FURNACES

(Tank Furnace - 20 TPD - Coal to Oil/Gas)

		Cost Rs million
A.	Raw Material & Batch Preparation	
	1. Mixer along with skip hoist	0.15
	2. Sand washing plant	0.05
	3. Cullet washing plant	0.04
B.	Furnace	
	1. Refractories	3.50
	2. Insulation	0.10
	3. Instrumentation	0.20
	4. Combustion system	0.05
	5. Regenerator reversal cycle	0.50
C.	Miscellaneous	
	1. Furnace oil system	0.70
	2. Blowers for cooling	0.10
	Total	5.44

ADDITIONAL/MODIFICATION COST OF EXISTING TANK FURNACES

(Tank Furnace - 20 TPD - Coal Gas to Producer Gas)

		Cost Rs million
A.	Raw Material & Batch Preparation	
	1. Mixer along with skip hoist	0.15
	2 Sand washing plant	0.05
	3. Cullet washing plant	0.04
B.	Furnace	
	1. Refractories	3.50
	2 Insulation	0.15
	3. Instrumentation	0.20
	4. Combustion system	0.03
	5. Regenerator refractories	0.50
C.	Miscellaneous	
	1. Miscellaneous Equipment	0.05
	Total	4.67

Appendix 6.1

CAPITAL COST ESTIMATES
(Tank Furnace-10 TPD)

		Cost Rs million
A.	**CIVIL WORKS**	
1.	Land development charges	0.40
2.	Buildings 1500 Sq.m	3.75
3.	Contingencies @ 5%	0.21
		4.36
B.	**PLANT AND EQUIPMENT**	
1.	Production plant & equipment (as erected)	9.04
2.	Utilities & service facilities equipment	2.15
3.	Contingencies @ 5%	0.56
	Sub-Total 'B'	11.75
C.	**PRE-OPERATING EXPENSES**	
1.	Pre-operating expenses	1.90
	TOTAL (A + B + C)	18.01

Appendix 6.2

PRODUCTION PLANT AND EQUIPMENT

		Cost Rs million
A.	**Raw Materials & Batch Preparation**	
1.	Cullet crusher, sieving & magnetic separator, weighing machine, mixing machine, silos & bunker conveyor etc.	o.20
2.	Batch feeder	0.05
3.	Mixer along with skip hoist	0.15
4.	Sand washing plant	0.05
5	Cullet washing plant	0.04
	Sub-Total	0.49
B.	**Production Equipment**	
1.	Tank furnace (10 TPD) with recuperator, refractories, oil burning equipment, chimney, instrumentation etc.	6.00
2.	Oil storage, pH unit, LPG storage and pipeline	0.50
3.	Blowers	0.10
4.	Press moulds & plunger for pre-heating	0.05
5.	Water softening plant	0.10
6.	Anealing lehr & chamber (1 No. each)	0.50
7.	Semi-automatic spiralling machine	0.05

8.	Equipment for thermos flask - Mouth melting - Eindrucking machine - Tube joining	0.15
8.	Miscellaneous Equipment	0.10
	Sub-Total	7.55

C.	<u>Furnace Oil Handling System</u> (including storage, heat tracing pumping unit)	0.80
D.	Testing Facilities Equipment	0.20

Appendix 6.3

UTILITIES AND SERVICE FACILITIES EQUIPMENT

		Cost (Rs million)
1.	DG Set (125 kVA) with electricals	0.60
2.	Compressor house 1.42 cu.m/min. (2 Nos.)	0.45
3.	Workshop equipment	0.40
4.	Water distribution equipment	0.30
5.	Office equipment	0.10
6.	Misc. equipment	0.30
		2.15

Appendix 6.4

COST OF PRODUCTION
(Soda Lime Glass)

		Qty. (Tonne)	Price (Rs/tonne)	Cost (Rs million)
A.	Raw Materials			
	1. Soda Ash	420	7665	3.219
	2. Silica sand	2130	450	0.958
	3. Calcite	300	1000	0.300
	4. Felspar	40	600	0.024
	5. Arsenic Trioxide	10	95000	0.950
	6. Potassium Nitrate	40	8500	0.340
	7. Dolomite	60	600	0.036
				5.827
B.	Cullet	-	-	-
C.	Fuel Furnace Oil	66,000 Lit.	5.50/Lit.	3.630
D.	Lubricants			
	1. High speed diesel Oil	75,000 lit.	6.35/lit	0.475
	2. Kerosene oil	60,000 lit.	6.00/lit	0.360
	3. Other Oil	22,000 lit.	6.15/lit	0.135
E.	Labour	450 Nos.	1100/month	5.940
F.	Packing Cost (@ 5% of Sales realisation)			2.565

Appendix 6.4 (contd.)

		Qty. (Tonne)	Price (Rs/tonne)	Cost (Rs million)
G.	Depreciation			
	(On civil works @ 3%)			0.131
	(On Plant & equipment @ 10%)			1.175
H.	Interest Charges			
	(On long-term loan @ 18%)			1.620
	(On short-term borrowing @ 19%)			0.610
I.	Sales Expenses			0.100
J.	Cost of Sales			22.568
K.	Cost per tonne of glass produced		Rs. 7522 /tonne	

Appendix 6.5

COST OF PRODUCTION

(Semi-Crystal Glassware
-Sixth Year of Production)

S.No.	Item	Qty.	Price	Cost (Rs.Million)
1.	2.	3.	4.	5.
A.	Raw Materials			
1.	Silica sand]			
2.	Aluminium Oxide]			
3.	Calcite]			
4.	Boron]	8,000 Kg./day	Rs.8.50/ Kg.	20.400
5.	Barium Oxide]			
6.	Lead Oxide]			
7.	Sodium Oxide]			
8.	Potassium Oxide]			
B.	Cullets	4,000 Kg/day	Rs.2.60/Kg.	3.120
C.	Fuel			
	Furnace Oil	900,000 lit.	Rs.5.50/lit.	4.950
D.	Utilities			
	Electric Power & Water	L.S.		0.650
E.	Lubricants			
1.	High speed diesel oil	75,000 lit.	6.35/lit.	0.475
2.	Kerosene oil	60,000 lit.	6.00/lit	0.360
3.	Other Oil	22,000 lit.	6.15/lit	0.135
F.	Labour	450 Nos.	1100/month	7.581
G.	Administrative Expenses	L.S.		1.200

1.	2.	3.	4.	5.
H.	Maintenance			
	a. On Civil works @ 1%			0.044
	b. On Plant & Equipment @ 2-1/2%			0.294
	Sub-Total 'H'			0.338
I.	Depreciation			
	a. On Civil Works @ 3%			0.131
	b. On Tank Furnace @ 20%			1.200
	c. On Other equipment			0.575
	Sub-Total 'I'			1.196
J.	Packing Cost (5% of Sales realisation)			3.525
K.	Consumables (2% of direct cost of production)			0.750
L.	Amortization	L.S.		0.190
M.	Interest Charges			
	(On long-term loan @ 18%)			0.810
	(On short-term borrowings @ 19%)			0.836
	Sub-Total 'M'			1.646
N.	Sales Expenses			0.700
O.	Cost of Sales			47.926
P.	Cost per Kg. of glass produced			Rs. 26.62 per Kg.

ANNUAL SALES REALISATION

S.No.	Item	Price (Rs./Kg.)	Qty. (Kg./day)	Cost (Rs.Million)
A.	OLD PRODUCTS (Soda Lime Glass)			
1.	Automobile Products	15	5,000	22.500
2.	Bangles	4	1,500	1.800
3.	Tumblers	15	2,000	9.000
4.	Thermos flask refill	40	1,500	18.000
	Total			51.300
B.	NEW PRODUCTS (Semi-Crystal Glassware)			
1.	Tableware	35	4,000	42.000
2.	Flowerwase	50	500	7.500
3.	Bowls	45	1,000	13.500
4.	Lampshades	50	500	7.500
	Total			70.500

Appendix 6.7

PROJECTED PROFIT AND LOSS ACCOUNT
(Semi-Crystal Glassware)

(All figures in Rs Millions)

S.No.	Description	Year of Operation										Total
		1	2	3	4	5	6	7	8	9	10	
1.	PRODUCTION BUILT-UP %	80	90	100	100	100	100	100	100	100	100	
2.	ANNUAL SALES EARNING	56.400	63.450	70.500	70.500	70.500	70.500	70.500	70.500	70.500	70.500	683.850
3.	COST OF SALES:											
	a. RAW MATERIALS	16.320	18.360	20.400	20.400	20.400	20.400	20.400	20.400	20.400	20.400	197.880
	b. CULLETS	2.496	2.808	3.120	3.120	3.120	3.120	3.120	3.120	3.120	3.120	30.264
	c. FUEL	3.960	4.455	4.950	4.950	4.950	4.950	4.950	4.950	4.950	4.950	48.015
	d. UTILITIES	0.520	0.585	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650	6.305
	e. LUBRICANTS	0.776	0.873	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	9.409
	f. ADMINISTRATIVE EXPENSES	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	12.000
	g. WAGES AND SALARIES	5.940	6.237	6.548	6.876	7.220	7.581	7.960	8.358	8.776	9.215	74.711
	h. CONSUMABLES	0.600	0.675	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	7.275
	i. PACKING COST	2.820	3.172	3.525	3.525	3.525	3.525	3.525	3.525	3.525	3.525	34.192
	j. DEPRECIATION	1.906	1.906	1.906	1.906	1.906	1.906	1.906	1.906	1.906	1.906	19.060
	k. MAINTENANCE	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338	3.380
	l. SALES EXPENSES	0.560	0.630	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	6.790
	m. AMORTIZATION	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	1.900
	TOTAL '3'	37.626	41.429	45.247	45.575	45.919	46.280	46.659	47.057	47.475	47.914	451.181
4.	EARNINGS BEFORE INTEREST AND TAXES	18.774	22.021	25.253	24.925	24.581	24.220	23.841	23.443	23.025	22.586	232.669

<u>Appendix 6.7</u> (Contd.)

S.No.	Description	Year of Operation 1	2	3	4	5	6	7	8	9	10	Total
5.	INTEREST CHARGES:											
	a. ON LONG-TERM LOAN	1.620	1.458	1.296	1.134	0.972	0.810	0.648	0.486	0.324	0.162	8.910
	b. ON SHORT TERM BORROWINGS	0.668	0.752	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	8.108
	TOTAL '5'	2.288	2.210	2.132	1.970	1.808	1.646	1.484	1.322	1.160	0.998	17.018
6.	EARNINGS BEFORE TAXES	16.484	19.811	23.121	22.955	22.773	22.574	22.357	22.121	21.865	21.588	215.651

RETURN ON INVESTMENT
(Semi-Crysal Glassware)

S.No.	Description	Amount (Rs.Million)
1.	Profit before taxes during 10 years	215.561
2.	Interest on Long-term loan during 10 years	8.910
3.	Gross Operating surplus over 10 years period (Item 1 + 2)	224.561
4.	Average gross operating surplus	22.456
5.	Capital Investment	18.010
6.	Average annual return on capital investment	124.68%

Appendix 6.9

DISCOUNTED CASH FLOW
(Semi-Crystal Glassware)

(All figures in Rs. Million)

Year from start of Operation	Outflows	Inflows	Net
-2 to -1	9.609	-	(-) 9.609
-1 to 0	8.401	-	(-) 8.401
0 to 1	-	20.202	20.202
1 to 2	-	23.365	23.365
2 to 3	-	49.878	49.878
3 to 4	-	26.185	26.185
4 to 5	-	25.841	25.841
5 to 6	-	25.480	25.480
6 to 7	-	25.101	25.101
7 to 8	-	24.703	24.703
8 to 9	-	24.285	24.285
9 to 10	-	23.846	23.846
10 (At an instant)	-	23.618	23.618

Internal Rate of Return : 62.48%

Net present value at 18% : Rs.108.191 million

NOTE: Value of IRR & NPV have been calculated by LOTUS 1-2-3

Appendix 6.10

BREAK-EVEN ANALYSIS

(Based on 6th Year of Operation
- Semi-Crystal Glassware)

			Rs. Million
A.	Fixed Cost		
	1.	Wages & Salaries	7.581
	2.	Administrative Expenses	1.200
	3.	Maintenance	0.338
	4.	Depreciation	1.906
	5.	Amortization	0.190
	6.	Interest Charges	1.646
		Sub-Total	12.861
B.	Variable Cost :		35.065
C.	Sales Realisation :		70.500

D. Break Even Point

$$= \frac{12.861}{(70.500 - 35.065)}$$

$$= 36.29\%$$

Appendix 6.11

CAPITAL COST ESTIMATES
(Pot Furnace-4 TPD-12 Pots each)

		Cost Rs million
A.	CIVIL WORKS	
	1. Land development charges	0.400
	2. Buildings 1500 Sq.m	3.750
	3. Contingencies @ 5%	0.210
		4.360
B.	PLANT AND EQUIPMENT	
	1. Production plant & equipment (as erected)	4.040
	2. Utilities & service facilities equipment	2.150
	3. Contingencies @ 5%	0.310
	Sub-Total 'B'	6.500
C.	PRE-OPERATING EXPENSES	
	1. Pre-operating expenses	1.300
	TOTAL (A+B+C)	12.160

PRODUCTION PLANT AND EQUIPMENT
(Borosilicate Glass-Opal Glass)

		Cost (Rs million)
A.	Raw Materials & Batch Preparation	
	1. Mixer	0.050
	2. Sand Washing Plant (3 tpd)	0.050
	3. Cullet washing plant (2 tpd)	0.040
	4. Cullet crusher, sieving & magnetic separator etc.	0.200
	5. Batch feeder	0.050
	Sub-Total	0.390
B.	Production Equipment	
	1. Pot furnace (4 tpd) including refractories, burner, chimney, instrumentation, metallic Recuperator	1.000
	2. Blowers, Pot pre-heater	0.100
	3. Forming tools, moulds & dies, Plunger for pre-heating etc.	0.100
	4. Water Softening plant	0.100
	5. Annealing Lehr (1.5 m width x 26 m)	0.400
	6. Tempering Furnace	1.500
	7. Fire Polishing (Dyna machine)	0.150
	Sub-Total	3.350
C.	Furnace Oil Handling System (Storage, heat tracing pumping heat unit)	0.050
D.	Miscellaneous Equipment	0.050
E.	Testing Facilities Equipment	0.200

Appendix 6.13

UTILITIES AND SERVICE FACILITIES EQUIPMENT
(Borosilicate Glass-Opal Glass)

		Cost (Rs million)
1.	DG Set (125 kVA) with electricals	0.600
2.	Compressor house 1.42 cu.m/min (2 Nos.)	0.450
3.	Workshop equipment	0.400
4.	Water distribution equipment (Softening equipment)	0.300
5.	Office equipment	0.100
6.	Miscellanious equipment	0.300
		2.150

Appendix 6.14

COST OF PRODUCTION
(Soda Lime Glass)

S.No.	Description	Qty. (Tonne)	Price Rs/Tonne	Cost (Rs Million)
A.	Raw Materials			
	1. Soda Ash	168	7665	1.290
	2. Silica sand	858	450	0.390
	3. Calcite	120	1000	0.120
	4. Felspar	15	600	0.009
	5. Potassium Nitrate	14	12000	0.168
	6. Arsenic Trioxide	5	95000	0.475
	7. Dolomite	20	600	0.012
				2.364
B.	Cullet	-	-	-
C.	Fuel Furnace Oil	330,000 Lit.	5.50/Lit.	1.815
D.	Lubricants			
	1. High speed diesel oil	75,000 lit.	6.35/lit	0.475
	2. Kerosene oil	60,000 lit.	6.00/lit	0.360
	3. Other Oil	22,000 lit.	6.15/lit	0.135
E.	Labour	80 Nos.	1100/ month	1.056
F.	Packing Cost (@ 5% of Sale realisation)			0.920

G.	<u>Depreciation</u>	
	(On civil works @ 3%)	0.131
	(On Plant & equipment @ 10%)	0.650
H.	<u>Interest Charges</u>	
	(On long-term loan @ 18%)	1.080
	(On short-term borrowing @ 19%)	0.646
I.	<u>Sales Expenses</u>	0.100
J.	<u>Cost of Sales</u>	9.732
K.	<u>Cost per tonne of glass produced</u>	Rs 811,062/ tonne

Appendix 6.15

COST OF PRODUCTION
(Borosilicate Glass - Opal Glass)

S.No.	Item	Qty.	Price	Cost (Rs.Million)
1.	2.	3.	4.	5.
A.	Raw Materials			
1.	Silica sand]			
2.	Aluminium Oxide]			
3.	Boric Oxide]			
4.	Borax]	2,600 Kg./ day	Rs.55/kg.	42.900
5.	Cryolite]			
6.	Felspar]			
7.	Arsenic Trioxide]			
8.	Colours]			
B.	Cullets	2,000 Kg./ day	Rs.2.60/Kg	1.560
C.	Pots	150 Nos.	Rs.2000/No.	0.300
D.	Fuel	450,000 lit.	Rs.5.50/lit.	2.475
E.	Utilities			
	Electric Power & Water	L.S.		0.750
F.	Lubricants			
1.	High speed diesel oil	75,000 lit.	Rs 6.35/lit.	0.475
2.	Kerosene oil	60,000 lit.	Rs 6.00/lit	0.360
3.	Other Oil	22,000 lit.	Rs 6.15/lit	0.135

Appendix 6.15 (Contd.)

1.	2.	3.	4.	5.
G.	Labour	80 Nos.	Rs 1100/month	1.348
H.	Administrative Expenses	L.S.		1.000
I.	Maintenance			
1.	On Civil works @ 1%			0.044
2.	On Plant & Equipment @ 5%			0.325
	Sub-Total 'I'			0.369
J.	Depreciation			
1.	On Civil Works @ 3%			0.131
2.	On Pot furnace @ 40%			0.400
3.	On Other Furnace @ 20%			0.300
4.	On Other Plant & Equipment @ 10%			0.400
	Sub-Total 'J'			1.231
K.	Packing Cost (5% of Sales realisation)			[illegible].687
L.	Consumables (2% of direct cost of production)			1.000
M.	Interest Charges			
	(On long-term loan @ 18%)			0.548
	(On short-term borrowings @ 19%)			1.102
	Sub-Total 'M'			1.650
N.	Amortization			0.130
O.	Sales Expenses			1.000
P.	Cost of Sales			61.370
Q.	Cost per Kg. of glass produced			Rs. 82/Kg.

Appendix 6.16

ANNUAL SALES REALISATION
(Borosilicate Glass - Opal Glass)

S.No.	Item	Price (Rs./Kg.)	Qty. (Kg/day)	Cost (Rs.Million)
1.	2.	3.	4.	5.
A.	OLD PRODUCTS (Soda Lime Glass)			
1.	Automobile Products	15	1,500	6.750
2.	Scientific Glass	20	1,000	6.000
3.	Tumblers	15	1,000	4.500
4.	Tube/Rod	8	500	1.200
	Total			18.450
B.	NEW PRODUCTS (Opal Glass)			
1.	Tableware and Oven ware	125	2,500	93.750

Appendix 6.17

PROJECTED PROFIT AND LOSS ACCOUNT

(Borosilicate Glass - Opal Glass)

(All figures in Rs Millions)

S.No.	Description	Year of Operation										Total
		1	2	3	4	5	6	7	8	9	10	
1	PRODUCTION BUILT-UP %	80	90	100	100	100	100	100	100	100	100	
2	ANNUAL SALES EARNING	75.000	84.375	93.750	93.750	93.750	93.750	93.750	93.750	93.750	93.750	909.375
3.	COST OF SALES:											
a.	RAW MATERIALS	34.320	38.610	42.900	42.900	42.900	42.900	42.900	42.900	42.900	42.900	416.130
b.	CULLETS	1.248	1.404	1.560	1.560	1.560	1.560	1.560	1.560	1.560	1.560	15.132
c.	FUEL	1.980	2.227	2.475	2.475	2.475	2.475	2.475	2.475	2.475	2.475	24.007
d.	UTILITIES	0.600	0.675	0.750	0.750	0.750	0.750	0.750	0.750	0.750	0.750	7.275
e.	LUBRICANTS	0.776	0.873	0.970	0.970	0.970	0.970	0.970	0.970	0.970	0.970	9.409
f.	POTS	0.240	0.270	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	2.910
g.	WAGES AND SALARIES	1.056	1.108	1.164	1.222	1.283	1.348	1.415	1.485	1.560	1.638	13.279
h	CONSUMABLES & ADMN. EXPENSES	1.600	1.800	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	19.400
i.	PACKING COST	3.749	4.218	4.687	4.687	4.687	4.687	4.687	4.687	4.687	4.687	45.463
j	DEPRECIATION	1.231	1.231	1.231	1.231	1.231	1.231	1.231	1.231	1.231	1.231	12.310
k.	MAINTENANCE	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	3.690
l	SALES EXPENSES	0.800	0.900	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	9.700
m	AMORTIZATION	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	1.300
	TOTAL '3'	48.099	53.815	59.53	59.594	59.655	59.720	59.787	59.857	59.932	60.010	580.005

Appendix 6.17 (Contd.)

S.No.	Description	Year of Operation										Total
		1	2	3	4	5	6	7	8	9	10	
4.	EARNINGS BEFORE INTEREST AND TAXES	26.901	30.560	34.214	34.156	34.095	34.030	33.963	33.893	33.818	33.740	329.370
5.	INTEREST CHARGES:											
	a. ON LONG-TERM LOAN	1.098	0.988	0.878	0.768	0.658	0.548	0.438	0.328	0.218	0.108	6.030
	b. ON SHORT-TERM BORROWINGS	0.882	0.992	1.102	1.102	1.102	1.102	1.102	1.102	1.102	1.102	10.690
	TOTAL '5'	1.980	1.980	1.980	1.870	1.760	1.650	1.540	1.430	1.320	1.210	16.720
6.	EARNINGS BEFORE TAXES	24.921	28.580	32.234	32.286	32.335	32.380	32.423	32.463	32.498	32.530	312.650

Appendix 6.18

RETURN ON INVESTMENT

(Borosilicate Glass - Opal Glass)

S.No.	Description	Amount (Rs.Million)
1.	Profit before taxes during 10 years	312.650
2.	Interest on Long-term loan during 10 years	6.030
3.	Gross Operating surplus over 10 years period (Item 1 + 2)	318.680
4.	Average gross operating surplus	31.868
5.	Capital Investment	12.160
6.	Average annual return on capital investment	262%

Appendix 6.19

DISCOUNTED CASH FLOW
(Borosilicate Glass - Opal Glass)

(All figures in Rs. Million)

Year from start of Operation	Outflows	Inflows	Net
-2 to -1	6.059	-	(-) 6.059
-1 to 0	6.101	-	(-) 6.101
0 to 1	-	28.180	28.180
1 to 2	-	31.829	31.829
2 to 3	-	35.473	35.473
3 to 4	-	35.415	35.415
4 to 5	-	35.354	35.354
5 to 6	-	35.289	35.289
6 to 7	-	35.222	35.222
7 to 8	-	35.152	35.152
8 to 9	-	35.077	35.077
9 to 10	-	34.999	34.999
10 (At an instant)	-	17.840	17.840

Net present value at 18% : Rs.142.239 million

Internal Rate of Return : 77.37%

NOTE: Value of IRR & NPV have been calculated by LOTUS 1-2-3

BREAK-EVEN ANALYSIS

(Based on 6th Year of Operation - Borosilicate Glass Opal Glass)

			Rs. Million
A.	**Fixed Cost**		
	1. Wages & Salaries		1.348
	2. Administrative Expenses		1.000
	3. Maintenance		0.369
	4. Depreciation		1.231
	5. Amortization		0.130
	6. Interest Charges		1.650
	Sub-Total		5.728
B.	Variable Cost	:	55.642
C.	Sales Realisation	:	93.750

D. Break Even Point

$$= \frac{5.728}{(93.75 - 55.642)}$$

$$= 15.03\%$$

BIBLIOGRAPHY

1. W. Trier : Glasofen, 1984, Springer Verlag.
2. Fay. V. Tooley : Handbook of Glass Manufacture.
3. W. Trinks & M.H. Mawhinney : Industrial Furnaces.
4. George W. McLellan, E.B. Shand : Glass Engineering Handbook.
5. Martin Grayson : Encyclopedia of Glass, Ceramics, Clay and Cement
6. Indian Environmental Society : Environmental Management In Glass Industry.