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ASSISTANCE TO NOWSHERA SHEET GLASS FACTORY

SI/PAK/83/801

PAKISTAN

Terminal Report*

Prepared for the Government of Pakistan
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of H.R. Persson,
Consultant in Sheet Glass Technology

United Nations Industrial Development Organization
Vienna

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I. SUMMARY

In this four months' split mission the consultant has visited Nowshera Sheet Glass Industries three times:-

August 15, 1983 to September 12, 1983

January 31, 1984 to March 23, 1984

February 5, 1985 to February 25, 1985

The counterpart has been the General Manager of the Nowshera glass plant. Production of sheet glass in the Nowshera Sheet glass plant started in April 1982. There is one furnace and three Fourcault machines at the plant. The process equipment and technology was supplied from China.

The capacity of the furnace is about 66 tons per day and about 45 tons of good quality glass sheets can be produced.

Some supervisors were sent to China for training before operation started in the plant. From the beginning some Chinese expatriates have been working at Nowshera. The number has gradually decreased and threre are now four Chinese expatriates.

About 500 people are working in the plant, but it should be possible to decrease this number, when the people have acquired more skill and experience.

The furnace campaign was guaranteed by the Chinese supplier to be at least 18 months, but probably not more than two years. The furnace is still (in February 1985) producing glass. There have, however, been two major hot repairs. The checker bricks in the regenerators have been exchanged twice and some zirconia bricks have been added outside the original blocks on the furnace walls. Without these repairs it would not have been possible to run the furnace any longer.

The present condition of the furnace is not very satisfactory and it can be assumed, that the furnace will have to be stopped before the end of the budget year (September 1985)

It will take about 4 months to carry out a rebuilding of the furnace.

The new refractories to be used have been supplied from China. These refractory materials are not of the highest quality and it is recommended, that for the second rebuilding of the furnace in 1987 or so, offers from more advanced suppliers should be evaluated as well.

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Using high quality refractory materials a furnace will last for about 5 years and can be insulated. Insulating the furnace means, that the fuel efficiency can be improved. Recommendations for improvement of the fuel efficiency of the present furnace have been given.

The quality of the glass produced has improved and is now fully accepted by the local market and some export markets. It will be possible to further improve the quality, however.

UNIDO has supplied some instruments, that will help to control the quality.

An increasing number of spare parts are being made by the glass plant and by some other companies in Pakistan. Satisfactory results have been obtained by using locally made debiteuses for the drawing of the sheets. It may as a matter of fact not be necessary to import any more debiteuses. These are made of imported clay, however, and it is recommended that a study should be made looking for suitable local clays. This could also include a search for local minerals suitable for refractory materials.

About 10 lectures have been delivered by the consultant. The skill and experience of the people have increased considerably since the mission started. UNIDO has also supplied some glass technical books to the factory.

For the 1984/1985 budget year the gross profit is expected to be Rs.16.7 million and the net result will be a loss of Rs.1.4 million. This is a great improvement from the previous years, particularly since a stop of 4 months is included for the cold repair in the running budget.

A TPR meeting was arranged on the 17th of February 1985 and it was then proposed by the participants, that some extension of the project should be recommended.

In February 1985 the currency was Rs.15.05 = US$ 1.00

II. INTRODUCTION AND BACKGROUND

Nowshera Sheet Glass Industries, Nowshera, North Western Frontier Province is a project of the National Police Foundation.

China has supplied all equipment to the plant and all technology.

The production in the plant started in April 1982 and the plant was inaugurated in May 1982.

There is one furnace in the plant and three Fourcault drawing machines. The maximum capacity of the furnace is approximately 66 tons of molten glass drawn out per 24 hours. The capacity of saleable glass sheets is 45 - 50 tons per day. The furnace is of the regenerative type and heated by natural gas.

The consultant has been present at the plant during three missions:

1. 15 August to 10 September 1983
2. 31 January to 23 March 1984
3. 5 February to 26 February 1985

The main counterpart to the consultant has been the General Manager of the glass plant, Mr. Malik M. Saeed.

There are about 500 people employed in the factory. Very few of them have had previous experience of glass manufacturing. Before operation started in the plant, 16 supervisors were sent to China for training. Since the very beginning Chinese experts have been present in the glass plant, 12 to start with and 4 in 1985. This training in China of the supervisors and the presence in Nowshera of Chinese expatriates have, of course, been of great importance for the operation of the glass factory.

The UNIDO consultant has been active in all the processing departments and has in particular given assistance and recommendations in order to obtain the following improvements.

- Improved storage, handling and control of the raw materials.
- Improvement and better control of the melting operation.
- Recommendations for better control of the furnace temperature and the firing conditions in order to improve the fuel efficiency of the furnace.
- Control of the attack of glass and flames on the refractory materials.
- Improved quality of the locally manufactured debiteuses.
- Identification of defects in the glass and recommendations how to improve the quality.

- Instructions how to use the instruments supplied by UNIDO.

- Increased knowledge of glass technology through the presentaion of 10 lectures.

More details about these activities are given in section III. Observations.

Since the UNIDO mission started in 1983, the quality of the glass has improved and the quantity of glass produced has increased.

Spare parts and debiteuses are now being made to a substantial in the glass factory or by other companies in Pakistan. The quality of these spare parts is similar to that of the Chinese spare parts and the cost is roughly 35 - 45 % of the price of the imported products.

The skill of the labours and of the supervisors has increased considerably since the mission started. Still more training, however, is required.

The fuel consumption is quite high in the furnace and it has not been possible to decrease it to any great extent. The reason for the high fuel consumption is that the furnace can not be insulated due to the relatively low quality of refractory materials used.

The quality of the refractory materials used for the furnace has been discussed with the management. It has been decided to ask for offers for high quality refratory materials for the second rebuilding of the furnace. In order to decrease the total cost of refractory materials at the second rebuilding of the furnace, it is recommended, that local refractory materials should be used as much as possible in those parts of the furnace, where there is no severe attack from the glass or the flames.

The average revenue of the sales in the last three months of 1984 was about 100 % higher per month compared to the average value for the period October 1983 - September 1984.

The level of management and of production at Nowshera sheet glass plant is at the end of the mission at a stage, where it is quite appropriate to plan for further processing of the glass sheets into more sophisticated products and also to prepare for a stepped up technology to meet the continuously increasing quality demands of glass products in Pakistan and neighbouring countries.

III. OBSERVATIONS.

1. The Raw Materials

The batch is composed of the following raw materials:-

Sand.	-	351.3 Kg.
Dolomite.	-	99.6 "
Soda ash.	-	103.8 "
Limestone.	-	1.2 "
Feldspar.	-	36.7 "
Salt cake.	-	16.5 "
Coal.	-	0.8 "
Total:	-	609.9 Kg.

Approximately 600 Kg. of cullet was added to the batch. The storage conditions for the raw materials were not ideal to start with. Sand and feldspar were not fully covered for rain.

The storage conditions were improved after recommendations, however.

The dolomite and the limestone are received in big lumps and have to be crushed, ground and screened. A certain proportion of the dolomite stones are covered by a brown layer containing a high percentage of iron oxide. These stones are removed manually.

In general the handling of the raw materials in the batch plant is quite satisfactory. Various adjustments and maintenance work have to be carried out from time to time. This is quite normal for a batch plant.

All raw materials except salt cake are available locally.

2. The Furnace

The furnace has a melting area of 87.6 m^2 and a working area of 48.6 m^2. Its melting capacity is 66 tons per day. This is equivalent to a melting rate of 753 Kg glass per square metre melting area per day. This is a normal efficiency.

The furnace is side fired and of the regenerative type. There are four ports to each regenerator. Natural gas is used for the heating of the furnace. At the beginning the furnace consumed about 2950 Kcal to melt one kilogram of glass counted on the total output of glass from the furnace. After three years of operation the fuel efficiency of the furnace has decreased and the furnace needs about 25% more gas.

The furnace is not insulated and the fuel efficiency is therefore comparatively low. The furnace life was estimated by the supplier to be about 1½ - 2 years. Due to continuously improved control and maintenance of the furnace it has been possible to run it for almost three years and it may still be run for another 6 months or more. This, however, will require very careful control of all the furnace operations (see section IV.2).

Table III.2 shows the gas consumption by the furnace and its fuel efficiency. In 1982 the gas consumption was about 19750-20050 cubic metre per 24 hours. In 1985 this has increased to more than 25000 cubic metre (+25%). The fuel efficiency has decreased from about 2950 kcal/Kg. glass to 3800 kcal. The best fuel efficiency (2650 Kcal/Kg glass) has been obtained when the furnace has been working at full capacity of 66 tons of glass per 24 hours.

Table III.2 Gas consumption by the furnace

Date	Gas consumption M^3/24 hours	Total glass production, tons/24 hrs	Gas M^3 per ton glass	Kcal/Kg glas
22-9-82	20042	58.0	345.6	2937.2
7-10-82	19839	57.2	346.8	2948.1
14-11-82	19735	56.2	351.2	2984.8
7-1-83	20640	66.2	311.8	2650.2
1-6-83	22539	47.1	478.5	4067.5
1-12-83	21639	57.2	378.3	3215.6
17-1-84	25008	56.9	439.5	3735.8
16-2-84	21459	59.0	363.7	3091.6
1-10-84	23856	52.6	453.5	3855.1
4-12-84	25125	57.1	440.0	3740.1
3-1-85	25137	54.8	458.7	3899.0
8-2-85	25215	57.6	437.8	3721.0

The furnace was heated up in February 1982 and glass production started in April 1982.

3. Debiteuses

To produce the glass sheets, the glass is drawn vertically upwards from the glass melt through a debiteuse. A debiteuse is a refractory floater with a slot through which the glass is drawn. There are three drawing machines and therefore three debiteuses in the furnace.

The quality and performance of a debiteuse is very important for the quality of the glass sheet. Normally a debiteuse can be used for 3-6 months. After then it must be removed from the furnace and replaced with a new one.

When operation started at the plant, Chinese debiteuses only were used. It has been possible for the glass factory to prepare its own debiteuses. The quality of the local debiteuses is gradually being improved and is now quite similar to that of Chinese debiteuses. It may not be necessary any more to import debiteuses. The locally made debiteuses, however, are prepared from imported clays.

There is a satisfactory equipment in the glass plant for the manufacturing of debiteuses. More skill is still required, however, before high quality debiteuses can be made. It will also be of interest trying to identify Pakistani clays suitable for the manufacturing of debiteses.

4. The Drawing Machines.

There are three drawing machines at the furnace working according to the Fourcault system. The width of the sheets drawn is 2200 mm for each of the machines.

Glass sheets having a thickness of 2-8 mm can be made. The supplier has stated, however, that 2 mm can be produced in small quantities only. In principle the only difference in producing glass of different thickness is the speed of drawing. The speeds used at the plant are:-

2 mm	-	65.3	Metre per hour
3 mm	-	50.5	-"-
4 mm	-	32.5	-"-
5 mm	-	28.5	-"-
8 mm	-	14.9	-"-

A 2 mm glass sheet is more difficult to make because the speed of drawing is so high. The operation of the machine is more complicated and it is more difficult to obtain a satisfactory annealing of the glass. Strain will easily be introduced in the sheets and cracking of the sheets can occur.

At the top of the drawing machines the sheets are cut automatically and transported to conveyor belts in a vertical position.

The dimensional cutting is carried out manually.

The finished glass sheets are packed in wooden crates filled with straw, before they are delivered to the customers.

5. The Glass Quality

The composition of the glass produced at the plant is the following:-

SiO_2	72.0 - 72.4 %
Al_2O_3	1.9 - 2.1 %
Fe_2O_3	0.15-0.20 %
CaO	6.4 - 6.6 %
MgO	3.9 - 4.2 %
Na_2O	14.6 - 15.0 %
SO_3	0.3 - 0.5 %

The composition is controlled by carrying out chemical analysis twice a week. Variations in the chemical composition are also checked by the daily measurements of density. The glass may contain a few stones and seeds. These defects are produced in the furnace during the melting operation. There are also some optical defects being caused by non-homogeneous glass. These defects are produced in the furnace as well.

Defects on the glass sheets are also caused by irregularities in the debiteuse and by the asbestos rollers in the drawing machines.

The glass produced is not of the highest quality, but it is fully acceptable by the local market and some export markets.

IV. ACTIVITIES

1. Raw Materials and Batch Handling

Since there was not enough space originally to keep all raw materials under cover, some changes have been made by the technical management, which has improved the situation.

If raw materials are wet due to rain, it is difficult to weigh them accurately and problems will also occur in the mixing process. The situation has been much improved, but with heavy rain, the sand may still be wet, if much sand is present at the plant.

Sand from two different suppliers is used. This is necessary in order to get a safe delivery of the sand. The small difference in the sand compositions is known by the laboratory. It is tried to mix the two different sands so that it is not necessary to adjust the batch composition each time there is a change in the type of sand used.

The dolomite, limestone and feldspar are received in lumps and therefore have to be crushed, ground and sieved. The dolomite may sometimes contain a brown surface layer on some stones. This layer is so rich in iron oxide, and therefore dolomite stones with a brown mineral layer are rejected.

The laboratory has been asked to carry out a full chemical analysis on every new supply of raw materials. If the analysis is outside the normal specification, the supply of raw material will not be accepted. For small differences in the chemical composition it may not be necessary to carry out a change of the batch composition.

The equipment in the batch plant is adequate and a well mixed and homogeneous batch can be delivered to the furnace. Small defects do sometimes occur, however, in the batch plant but these can usually be repaired easily, if they are detected at an early stage. Qualified engineers have been stationed in the batch plant for trouble shooting.

The cullet is not mixed with the batch, but added on top of it on the batch conveyor belt. The cullet is not always evenly distributed on the batch at the charging end. This is being corrected.

2. The Furnace

It is well known by the Chinese supplier and Nowshera Sheet Glass Industries, that the refractory materials in the furnace are not of the highest and most uptodate quality. For this reason the supplier could not guarantee a furnace campaign longer than 18 months.

The furnace was heated up in February 1982 and glass production started two months later. The same furnace is still in operation in February 1985 and may last for another half year or so. This is a unique and a very satisfactory achievement.

The furnace is quite well equipped with measuring and recording instruments necessary for a good control and operation of it. Instruments for the following measurements are installed:-

The temperatures in the melting area, the cooling area and the canal.

The glass level

The gas pressure

The gas consumption

The pressure of the compressed air

The draught in the chimney

The furnace pressure

The temperature of the waste gas at 4 places

The change over system

In addition to these instruments UNIDO has supplied a pyrometer for spot control of the temperature at various places in the furnace and an Orsat gas analyzer to check the composition of the waste gases. Both instruments are very valuable for a good control of the furnace operation.

Much time has been spent by the General Manager and the various technical managers in securing a good operation of the furnace.

The consultant has in particular given the following recommendations:-

-Control all the measurements of the furnace instruments and check every irregularity.

-Measure the temperature with the UNIDO pyrometer every shift.

-Check the direction and length of the flames. Make necessary adjustments if they are too long (hit the opposite wall of the furnace) or if they touch the glass surface.

-Make correction (decrease the quantity of gas) if the flames are yellowish luminous(reducing condition).

-Close all inspection openings when they are not used for inspections (save energy).

-Control the waste gas composition with the Orsat analyzer every day. Alter the gas-air ratio if the conditions are reducing (presence of CO).

-Make detailed inspection of the furnace every month and measure the attack by the glass and the flame on the refractory bricks at the glass level.

-Increase the quality of cooling air at those spots, where the attack on the refractory bricks are most severe.

-Try to keep all conditions in the furnace as constant as possible.

-Plan well in advance for the rebuilding of the furnace.

Hot repairs have been carried out on the regenerators twice. The first one was in January 1984 and the second one in December 1984. The repairs were necessary due to the bad condition of the refractories in the regenerators. The repairs were carried out most successfully by the plant personnel. When using high class refractory materials such repairs are not necessary.

In February 1984 when measuring the attack on the brick walls, it was found that in 22 months the thickness of the wall had decreased from 300 mm to 80 mm. This shows an attack of about 10 mm per month. The furnace should therefore have lasted for a maximum of 6-8 months (August-October 1984) if this attack was not decreased or some other measures taken.

In December 1984, the management decided to put 8 additional bricks outside those bricks on each side of the furnace, where the attack was most severe. Such an operation is very difficult, but it was carried out successfully under the guidance of the General Manager.

When measuring the thickness of some other bricks at the glass level in February 1985, it was found to be 80 mm. It can therefore be assumed that the furnace may last till about July 1985. The furnace campaign could easily be shorter, if there are any problems with the refractories, but another successful hot repair could even lengthen it.

When rebuilding the furnace similar Chinese refractory materials as used for the first construction will be used. It may therefore be assumed that the next furnace campaign will not be substantially longer than that of the present furnace. It will also not be possible to insulate the furnace since this requires a high quality of the refractory materials. It may therefore also be assumed, that the fuel efficiency of the furnace will not be much better, than that of the present furnace.

The fuel efficiency of the present furnace is shown in Table III.2. The supplier has stated a maximum consumption of gas as 28800 cubic metre per 24 hours on the official drawings of the furnace. It is seen from the first column of table III.2 that the gas consumption has never been that high. If the consumption of gas at the selected dates are used to calculate a rough annaul average, the following figures for gas consumption are obtained:-

Year	Consumption, cubic metre per 24 hours
1982	19872
1983	21606
1984	23862
1985	25176

The actual consumption of gas consumed per ton of glass output will of course depend to a large extent on the quality of glass drawn out from the furnace. With a maximum output of glass (66.2 tons per 24 hours) on the 7th of January 1983, the quantity of gas used is 311.8 cubic metre per ton of glass. This is equal to 2650.2 Kcal per Kg of gas.

With an output as low as 47.1 ton of glass per 24 hours (on the 1st of June 1983) the gas consumption is 478.5 cubic metre per ton of glass or 4067.5 Kcal per Kg of glass. The calorific value of the gas is 8500 Kcal per cubic metre.

The figures show, that the fuel consumption of the furnace does not vary very much with the output of glass from the furnace. This is normal for all glass furnaces. To obtain a good fuel efficiency of a glass furnace, it should be run at the highest possibl output of glass. The Nowshera furnace was designed for a maximum output of 66 tons per 24 hours. The output will of course depend on the thickness of the glass sheet drawn and on the speed of drawing. The drawing should of course be carried out at an optimum speed in order to get glass sheets of high quality. The fuel efficiency of the furnace is of secondary importance in this respect.

It is of course difficult to make comparisions with other types of sheet glass furnaces. Very roughly, however, it can be mentioned, that a furnace made of high class refractory materials and well insulated may have a fuel efficiency of about 2500 Kcal per Kg glass to start with. After five years this figure may increase to 3000 Kcal per Kg glass. In such a furnace it would not be necessary to have any major hot repairs. The furnace campaign may be estimated to be 5 years.

The figures given in Table III.2 indicate, that the heat consumption of the furnace has increased by about 27% in three years. For a more modern furnace the increase in consumption in five years would be about 20% $\left(\frac{3000}{2500} \times 100\right)$.

With all the care taken by the Management to run the furnace as smoothly and efficiently as possible there is no doubt that this has improved the fuel efficiency of the furnace. One example of this can be seen from table III.2. A hot repair (mainly on the regenerators) was carried out at the beginning of January 1984. The figures in the table indicate, that the gas consumption decreased from 25008 cubic metre before the hot repair to 21459 cubic metre after the hot repair.

Since the furnace was assumed by the supplier to have a life time of 18-24 months and a maximum gas consumption of 28800 cubic metre per 24 hours, it may be assumed that this gas consumption would have been reached after 18-24 months.

The gas consumption after three years operation is about 25250 cubic metre per 24 hours. The saving of about 7340 cubic metre from February 1984 and 3660 cubic metre from January 1985 may be taken as a very rough estimate of the savings achieved in gas consumption due to good maintenance and operation of the furnace.

The most important result obtained, however, is the prolonged furnace campaign.

The price paid for the gas is Rs.88.58 per cubic metre. The cost of the gas is approximately 19% of the total cost of manufacturing.

3. Debiteuses

At the start of the operation Chinese debiteuses only were used. In 1982 14 debiteuses were used, the first ones for about a week and the later ones for upto 15 weeks.

As a total 27 Chinese debiteuses have been used from the start of the factory till February 1985. Since 1983 the debiteuses have been in use as an average of 79 days, ranging from 42 to 136 days.

Equipment and technology for the manufacturing of debiteuses were included in the supply from China. Two debiteuses manufactured by the glass factory were put into operation at the end of 1982 and they were used for a few days only.

The skill to manufacture debiteuses has gradually increased and since 1983 upto February 1985 19 debiteuses made by Nowshera glass plant have been used. They have been used for an average time of 43 days, ranging from 2 days to 123 days.

For the locally made debiteuses imported clays have been used. Some local clay has been added to a few debiteuses, but their life time has been very short. There may be local clays suitable for debiteuses available, but it will be necessary to carry out proper mineralogical and chemical analysis in order to decide which clays, that are suitable to be used.

Great care is now taken in preparing the clays and in shaping, heating and polishing the debiteuses. There are still chinesedebiteuses available in the factory, and most probably it may not be necessary to import any more debiteuses.

The cost at site for imported debiteuses is Rs.42734 per unit (1984) and the total cost for locally made is Rs.18750. With these figures there is a cost for imported debiteuses of about Rs.540.90 per operating day and of locally made of Rs.436 per operating day using the above given average life times).

The quality of the locally made is now(February 1985) very similar to that of the imported debiteuses. If the locally made are used as an average of 79 days as well (the life time for 1984 was 73 days) as the imported ones, the cost would be Rs.237.30 per day. There will thus be a saving of Rs.303.60 per debiteuse and per day. This is equal to an annual saving of about Rs.332400 (in foreign currency). There will of course be more saving if local clays can be identified and used.

4. The Glass Quality.

The quality of glass sheets depend to a large extent on the following aspects:-

-Quality of raw materials

-Accuracy of the balances when weighing the raw materials

-The mixing of the batch and the homogeneity of it when delivered to the glass furnace

-The melting condition of the batch and the thermal conditionsin the furnace

-The chemical composition, the physical properties and the homogeneity of the glass as supplied to the drawing machines

-The quality and conditionsof the debiteuses

-Presence of devitified glass at the debiteuses

-Conditions in the drawing machines(speed of drawing, cleanliness of the asbestos rollers, air draught in the vicinity of the sheet surface)

-Accuracy of the automatic cutting and breaking of the sheets

-Control of the thickness of the sheet(influenced by the speed of drawing)

-Accuracy of the manual dimensional cutting of the sheet

-Accuracy regarding the selection of the glass sheet for acceptable quality, C quality (for puttees) and rejection

All these quality aspects have been discussed with the appropriate people and recommendations have been given how to carry out the various controls.

-The control of the raw materials is mentioned in section III.1.

-The accuracy of the balances is checked every day.

-The homogeneity of the batch and the batch/cullet ratio is checked every month.

-The melting and thermal conditions in the furnace are checked continuously by installed instruments and manually several times every shift.

-The chemical composition of the glass is controlled every week. The density of the glass is controlled once a day.

-The quality and conditions of the debiteuses are controlled every day by the machine operators and by the supervisors.

-Any presence of devitrified glass at the debiteuse is controlled by the machine operator and by the quality control inspector. The laboratory does also identify stones in the glass as originating from theraw materials, the refractory bricks or from devitrified glass.

-The speed of drawing of the sheet cleanliness of the asbestos rollers and air draught are controlled by the machine operator, the quality control inspector and the supervisor.

-The automatic cutting and breaking of the sheet is continuously controlled by the operators and the supervisors.

-The thickness of the sheet is measured every two hours by the quality control man.

-The accuracy of the manual cutting is checked by the quality control man.

-Correct quality selection is carried out several times every shift by the quality control man and his supervisors

Quality specifications are available for each of these items and the responsible personnel know what steps that should be taken if quality is not upto standard. Regular reports are written for each item that is controlled and these are distributed to a selected group of managers including the General Manager.

There is sufficient equipment and instruments to carry out the most important control necessary for the glass production. The technical people have the necessary skill to carry out the tests mentioned and it should therefore be possible to continue to improve the production and the quality of glass sheets.

It will be an advantage, however, for the glass plant to receive some further technical information and recommendations.

5. The Packaging of Glass.

The glass sheets are packed in wooden crates filled with straw. This is quite a good but a somewhat old fashioned and expensive way of packaging glass sheets.

One way of packaging glass sheets is to use returnable metal frames. The glass is placed on the metal frame without any packaging material.Before this system can be used it will be necessary to arrange for safe return of the metal frames to the glass factory.

A second alternative is to use a few wooden planks at the bottom and the top of the vertical glass sheets. The glass sheets and the wooden planks are then bound together using three thin metal bands. This gives a strong package.

These two alternative methods of packaging have been tried experimentally by the glass plant and they have also been discussed with some customers.

It may still take some time before more large scale tests can be carried out due to the market situation.

6. Spare Parts

Many different types of spare parts were included in the original supply from China. The plant management has successively tried to manufacture new spare parts at the glass plant or at some other companies in Pakistan. These trials have been quite satisfactory.

One of the first spare part to be manufactured locally was debiteuses. This is described in section IV.3.

Refractory bricks have been manufactured in the same department. The clays used for these bricks and other refractory products like plugs for the inspection holes and arch bricks may be Attock clay and clay from Mianwali. Only local clay has been used for these refractory products.At the last hot repair of the regenerators (in December 1984), about 1500 locally made refractory bricks were used.

Water coolers for the furnace, air and gas dampers for the gas reversal system in connection with the regenerators and rubber conveyor belts have been made by local companies. The price for the imported dampers is about Rs.60000 and for the local ones about Rs.22000.

Many different types of spare parts have been made in the workshop at the glass plant. Bucket elevators for the batch plant, water coolers for the furnace, tools for the cold repair, chisels, rollers for the belt conveyors in the batch plant, cutting machines (at the top of the drawing machines) and may other sparts have been made.

It is estimated by the management that more than half of the required types of mechanical spare parts can be made in the workshop at the glass factory. For many of these spare parts, the individual prices for imported products are not available. There is a rough estimation, however, that the local price is about 35-45% of the price of the imported products.

Increasing the proportion of locally manufactured spare parts, will of course decrease the cost of manufacturing. The cost of spares and maintenance is roughly 2-3% of the cost of manufacturing. The cost of manufacturing is about Rs.4000-per ton of glass. Some more information the cost of manufacturing is mentioned under section 17.8.

7. The Personnel

There are approximately 500 people employed at the Nowshera glass plant. Most of the people did not have any industrial experience before being employed at the glass factory. Only a few had some previous experience from a glass factory.

16 of the supervisors were sent to China for training before the operation started at Nowshera. Some Chinese expatriates have been working at the Nowshera plant. At the beginning there were about 12 experts and in 1985 there are 4 working in the plant.

The Chinese experts give good guidance to the local people. It is recommended, that this arrangement continues for some more time.

During his second mission at Nowshera, the consultant gave 10 lectures to a selected group of engineers and supervisors. The following lectures were given at the plant:-

1. Introduction-glass history
2. Definition of glass. Glass composition
3. Chemical properties
4. Physical properties
5. Raw materials and batch preparation
6. Furnaces (refractories, fuel efficiency)
7. Melting and refining
8. Forming of glass
9. Annealing and tempering
10. Quality control

All the lectures were recorded and typed and will be translated to the Urdu language to be of further use for the plant personnel.

UNIDO has also presented some glass technical books to the glass plant. The knowledge about glass manufacturing and the individual skill of the people employed have increased in a most satisfactory way, since the glass operation started.

A glass seminar was arranged by the National Police Foundation on March 11, 1984 in Islamabad. Representatives of the local glass industries, UNDP and other organizations interested in glass were invited. Five lectures were presented, two of these by the glass consultant.

With increased skill of the people it may be possible to run the factory with a decreased number of personnel.

8. Economic Aspects

Besid s Nowshera Sheet Glass Industries there are two o ner sheet glass manufacturers in Pakistan. Nowshera is running all the three machines producing glass sheets and there are no marketing problems for Nowshera.

The three sheet glass plants can cover the total market in Pakistan. There are, however, 2 or 3 more plants planning to start manufacturing sheet glass. If these plants start, there will most probably be over production of sheet glass in Pakistan and there will of course then be a hard competition.

The average monthly production of saleable glass for the Nowshera plant has been the following:-

October 1983 to September 1984	Average 858 tons/month
October 1984 to December 1984	Average 1133 - " -

The average sales revenue has been as follows:-

October 1982 to September 1983	Rs.4.3 million/month
October 1983 to September 1984	Rs.7.3 million/month
October 1984 to December 1984	Rs.8.5 million/month

The sales price of glass sheets has been increased three times as shown below calculated for 5 mm sheets. One square metre of 5 mm glass is equal to 12.5 Kg.

May 1982	67.81	Rs.per Sq.metre
August 1983	80.75	-"-
March 1984	93.00	-"-
June 1984	96.00	-"-

The original feasibility study was based on Rs.31.50 per square metre in 1981.

The profitability of Nowshera Sheet Glass Industries has been as follows:-

Year	Gross Profit	Net profit/(Loss)
1982/1983	Rs.7.3 million	(Rs.8.8 million)
1983/1984	Rs.15.7 million	(Rs.3.1 million)
1984/1985 (Budget)	Rs.15.7 million	(Rs.1.4 million)

A cold repair in 1985, when the furnace is estimated to be stopped for 4 months, is included in the 1984/1985 budget.

A rough information about the manufacturing costs is given below:-

Raw materials	30%
Fuel and power	23%
Labour	16%
Depreciation	24%
Other costs	7%
Total:	100%

The approximate manufacturing cost(1985) is Rs.4000.- per ton of glass.

V. RECOMMENDATIONS

1. It is necessary for Nowshera Sheet Glass Industries to continue to improve the quality of the glass sheets. The defects must be identified in order to be able to make necessary corrections of the manufacturing processes. A more advanced quality control system should be introduced. The required laboratory equipment is available at Nowshera.

   Statistical quality control should be introduced. The testing methods and the number of acceptable defects for various quality standards are well described in the Pakistan Standard for ordinary sheet glass.

   This standard classifies the sheet into 4 qualities:

   a) AA Quality or Special Selected Quality (SS Q) - Intended for use where superior qua-lity is required, such as safety glass for wind-shields, high quality mirrors, photographic plates and projection slides.

   b) A Quality or Selected Quality (SQ) - Intended for selected glazing and manufacture of mirrors, safety glass (other than wind-shields), etc.

   c) B Quality or Ordinary Quality (OQ) - Intended for glazing and framing purposes.

   d) C Quality or Greenhouse Quality (GQ) - Intended for greenhouse glazing, production of frosted glass, strips for flooring, etc.

2. The laboratory and some other technical departments should be more engaged in trouble shooting.

   Defects do occur quite frequently in glass sheets. It is important to define the defects and to find the reason for their occurence.

   All the supervisors should be involved in trouble shooting activities in their own department. The production manager should organize trouble shooting activities. Reports over the activities and results should be written. This will help when the defects occur at a later stage.

   Trouble shooting activities will also be very beneficial for the people taking part in it since their skill and processing knowledge will increase considerably.

3. The manufacturing processes should be improved, in particular the following:

   a) Handling of raw materials

   b) Batch mixing

   c) The melting process

   d) The drawing operation

   The consultant has discussed this with the laboratory manager. Recommendations how to improve the processes have been given by the consultant and how to test and investigate the results obtained after various alterations.

4. The furnace should be well controlled in order to keep it running for at least another six months.

   At the end of the third UNIDO mission, the furnace has been in operation for almost three years. Instructions how to operate and control the furnace in order to increase its time of operation as much as possible, have been given to the production department. With careful handling of the furnace and some more limited hot repairs, it may be possible to run it for another half year or more.

   It is important, however, to prepare already now for the rebuildning of the furnace. All materials must be available and the Chinese furnace builders should be notified well in advance, so that they can come to Nowshera quite quickly when called for.

5. The offer from the Government of Turkey regarding a technical assistance agreement should be studied and evaluated.

   It is recommended, that appropriate contacts are taken with the Turkish-Pakistan Joint Commission for Technical Co-operation.

   It appeared from the preliminary invitation, that the Turkish glass industry was willing to enter into a technical assistance agreement with Nowshera Sheet Glass Industries.

6. Continued efforts should be done in order to improve the quality of the debiteuses. It should be tried to find suitable local clays.

   Satisfactory results have been obtained with debiteuses made in Nowshera from imported clays. A qualified mineralogical institute in Pakistan should be asked to look for suitable local clays.

   Accurate reports for each debiteuse (type of clay, composition, manufacturing details and when and how long it was used in the furnace) should be recorded.

7. Further studies of local clays suitable for refractory materials should be carried out with the assistance of suitable experts.

   Refractory bricks are being made at the glass plant and have been introduced in the regenerators and other parts of the furnace at different hot repairs.

It is recommended, that more extensive mineralogical investigations should be carried out in order to identify suitable local minerals to be used for refractory materials for glass furnaces. This could possibly be combined with a similar investigation for other types of refractories suitable for other industrial furnaces. Such an investigation should benefit from the assistance of a UNIDO expert.

8. Preparations should be started for the second rebuilding of the furnace. Selected furnace suppliers should be invited to give an offer in about two years.

   Similar refractory materials used for the original furnace, will be used for the first rebuilding of the furnace. It can therefore be assumed, that the furnace campaign after the rebuildnig will not be substantially longer, than the present campaign.

   It is therefore recommended, that offers for high quality refractory materials are invited from well recognized furnace suppliers for the second rebuilding of the furnace. Locally made refractory materials can then be used at places where there is no attack from the glass or flame. This will decrease the total cost of refractory materials. It can be estimated, that if high quality refractory materials are used the furnace campaign should be at least 5 years.

9. Market studies for the following products should be carried out:

   Tempered glass

   Laminated glass

   Sand blasted glass

   Edge working and bevelling

   Heat reflecting glass

   Tinted glass

   Figured flat glass

   Glass wool

   Local market institutes can carry out such studies if they are assisted by a glass technologist. Offers can then be invited from engineering companies for the most interested types of glass products. Feasibility studies should be carried out and the most suitable and profitable product can then be selected for implementation.

10. Continued systematic efforts to train personnel further should be done.

    The production manager has been sent to Japan to attend a well recognized course in glass technology (about 3 months). There may be opportunities for other engineers from Nowshera glass plant to attend that course as well. Some more training in China would also be beneficial for some of the supervisors. If a technical assistance agreement is signed with a Turkish sheet glass company, this could involve training of personnel as well.

    A good training can also be arranged within the glass factory. It is recommended, that a certain rotation of the engineers and supervisors is organized in the plant. Such an arrangement is usually found to be very beneficial for the plant and most interesting for the people involved.

APPENDIX 'A'

APPENDICES

UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNIDO

JOB DESCRIPTION
SI/PAK/83/801/11-51/32.1.B.

Post title	Consultant for Sheet Glass Technology.
Duration	Four months on split mission.
Date required	ASAP
Duty Station	Islamabad with travel
Purpose of project:	To improve the general situation of glass industry in Pakistan by assisting the Nowshera Sheet Glass Factory in the preparation of training programmes and in the establishment of appropriate energy management/conservation, quality control, spare parts procurement and stock control systems in line with the plant's immediate and future requirements.

The consultant will be attached to the Management of Nowshera Sheet Glass Factory/ Ministry of Industries and during the first three months of his assignment, he will be expected to take action in the assessment of:

-present operational condition of the plant and its technology and required manpower situation

-present production planning and programming techniques being utilized by the Plant's management

-spare parts procurement and Debiteuse of replacement methods and their relevant cost to the production

-local manufacturing capabilities of spare parts and debiteuse for the furnace

Determination of:- energy requirements of the plant

- present raw material, product and waste utilization techniques and necessary measures to be taken in reducing the volume of rejects

Development and introduction of appropriate methods and techniques in order to establish sound systems of:-

-energy consumption/management

-raw materials handling

-spare parts handling

-quality control system

Preparation of programmes for:

-regular training of skilled and unskilled personnel

-on-the-job training of technicians and with respect to energy based monitoring of the process through the proper utilization of measuring equipment and control devices

-energy management and conservation in the plant

Following the completion of the above activities, those programmes and systems recommended by the consultant and approved by the plant's management, are expected to be implemented and tested by the plant's management during the consultant's absence from the field for six months.

Upon his return to the project for one month, the achievements and results obtained will be examined and evaluated jointly by the plant's management and the consultant and further necessary recommendations to strengthen the adopted programmes, methods, will be provided by the consultant.

During this final assignment, the consultant will investigate further development and expansion possibilities of the plant with respect to the diversification of its products.

The expert will also be expected to prepare a final report setting out the findings of the mission and recommendations to the Government for further actions which might be taken.

Language: English.

Qualifications: The consultant should have long experience in sheet glass manufacturing techniques with knowledge of qualities of raw materials and means to control quality of products as well as in the local production of expendable items particularly the Debiteuse.

Background and justification: The Nowshera Sheet Glass Factory, one of the few industrial units in NWFP, was commissioned with a loan from China at 60:40 equity share. All equipment are of Chinese origin. The plant was officially inaugurated by the President on 18th May 1982.

The installed capacity is 40 tons/day, products 3 to 8 mm glass sheets. The furnace 20x70 feet is gas fired. The plant is running on three shifts basis engaging 500 workers, most of them are unskilled having no prior experience in this field.

Presently, the plant's management is facing serious production problems, due to lack of trained skilled and unskilled personnel, non-availability of established systems and/or techniques of energy management/conservation, local spare parts procurement and manufacturing, quality control of raw material and products. These problems are adversely affecting the planned production of the plant.

The Government of Pakistan therefore requested UNIDO to provide technical assistance in identifying the basic requirements to bring this new plant to an organized level and in setting out programmes to train the plant's personnel and in establishing systems to improve the technical operational problems.

APPENDIX 'B'

Equipment Purchased by UNIDO for the Project.

1. 6 Fisher laboratory gas burners

2. A pyrometer for the furnace

3. An Orsat gas analyzer

4. A Digital spectro-photometer

5. A Muffle furnace for the laboratory

6. Glass Literature

a) Volume 1-7 of "Books for the glass industry"
Published by Ashlee Publishing Co.
310 Madison Avenue
New York, N.Y.10017

b) "Glass Engineering Hand Book" by
George W. McLellan and E.B. Shand
Publ- by Mc Graw Hill, London

c) Glass Technology, by H.Rune Persson
Published 1983 by
Cheong Moon Gak Publ. Co.
481-9 Gilum-Dong
Seong Buk-Ku
Seoul, Korea