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08677

Distr.
LIMITED
ID/WG. 282/32
2 October 1978
ENGLISH

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20–30 November 1978

WORKING GROUP No.4

APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF SUGAR

PROJECT REPORT AND FEASIBILITY STUDY OF APPROPRIATE TECHNOLOGY ON MINI-SUGAR ,

Background Paper ,

PROJECT REPORT AND FEASIBILITY STUDY OF APPROPRIATE TECHNOLOGY ON MINI-SUGAR

by

M. K. Garg

CHAPTER I

Introduction:

The sugarcane cultivation and processing was mostly confined to the Indian Penensula in ancient times and to some extent in China as well. Mention of the use of sweetening agent from sugarcane is made in Indian literature as far back as 3000 B.C. Various scholars accept that sugarcane cultivation and processing was very well established activity in India between 1500 to 1000 B.C.

Sugarcane cultivation and processing spread to other neighbouring countries after Alexander's invasion of India about 300 B.C. The following extract from the book 'Technology for sugar Refinery Workers' by Oliver Lyle indicates the condition of sugar technology in middle age in other countries :-

"Some 300 years B.C. soldiers of Alexander the Great were the first Europeans to see the sugarcane, which grew in India and China. Pliny, in A.D. 74, described sugar produced from the cane as being "White and brittle", which indicates that some sort of refining must have been going on. About A.D. 600 the boiling of cane juice to assist crystallisation was practised. The first record of any refining process seems to be by Marco Polo, the great mediaeval traveller and adventurer, who states that about A.D. 1300 Egyptians had introduced in China from Egypt a process of refining by means of ashes. In 1264 the King of England had sugar in his household. There is a record in 1319 of the importation of a cargo of sugar to London at a price of 1s.9½d. per pound. There are no records of any separate refineries during these times, except at Venice, where sugar refining was a close secret for centuries. Between A.D. 1500 and 1600 refineries were built in many of consuming countries, as the Venetians had revealed their secrets.

From ancient times the land in India was cultivated on a family basis. 50 to 100 farmers families usually grouped and built the homestead together which constituted the village, where subsequently the artisan activity also started. The land holding per family was between 20 - 50 acres generally. The same pattern still continues except that the land holdings has come down to at present 2 - 5 acres per family only.

Sugarcane is a cash crop which can withstand the vagaries of weather. It is highly remunerative and can pay higher return in comparison to other crop even in case of crop failure. For stabilizing the economy, the Indian farmer always like to put a part of land under sugarcane cultivation. Where the climatic conditions are more favourable and irrigation facilities are available, larger part of the land holdings are put under sugarcane. Under such situation the availability of sugarcane for processing, therefore, is in a scattered way and not concentrated into large quantities in a small location. The processing technology was developed to suit the sugar cane availability factor and was of two types :

Cottage Technology

It was a seasonal activity. A number of farmers joined together and crushed their cane by bulloc power. The whole juice was concentrated into a solid mass without separation of molasses and the product was called gur or jaggery. The capacity of the unit was about one ton of daily sugarcane processing.

Small-Scale Sugar Cane Processing Technology

This was also a seasonal activity. The cane was crushed jointly by farmers and the juice was sold to a central boiling nucleus operated seasonally by a rural entrepreneur. A slightly less concentrated product called massecuite or 'rab' was manufactured and stored in earthen vessel. These vessels were transported to cities where the creamy white sugar known at present as 'Khandsari Sugar' was separated from molasses and sold in the market. The name 'Khandsari' originated from the word 'Khandsala' meaning sugar manufacturing house. The capacity of central boiling house was for handling juice of 5 - 10 tons of cane per day which was obtained from nearby villages. It was a temporary affair, the Khandsari sugar was exported to other neighbouring countries and even as far as to Rome.

Development of Sugarcane Cultivation and Processing in other countries

With the discovery of new world and other islands, the sugarcane cultivation was taken up on very large plantations worked by cheap labour and not as a family cultivation by individual farmer. The processing technology was more or less on the pattern of small scale processing technology as practised in India with the difference that the juice extraction and boiling was concentrated at the same place. The masscuite prepared was originally transported to the refineries situated in consuming market in other countries. Later on separation of molasses was introduced and a kind of sugar called raw sugar was exported to refineries.

Very soon the inadequacy of this technology with regard to capacity was felt. Development of new plant and machinery to increase processing capacity was undertaken. Horizontal mills worked by steam power were developed. The real breakthrough came with the development of centrifugal machine in 1867 followed by steam boiling. The technology was completely changed and became a large scale industrial activity centrally organised. Innovation for improving recovery and quality continued and the economics of this technology soon outstripped the other traditional technologies.

Till 1894, the large scale technology was only one kind i.e. making raw sugar on the plantation and sending it for refinery in the consuming market. From that year onward, technology for manufacturing direct consumption sugar without needing any refining before use, was also developed.

The direct consumption sugar began to be imported in India in 1905 where it gradually started finding acceptance and imports grew rapidly. During 1st World war due to difficulty in import of sugar, this technology was also initiated in India. The first sugar factory for manufacturing direct consumption sugar in India was built in 1917. By 1927, there were about 23 factories in operation. These Indian factories could not stand the competition of imported sugar from Java. So, in 1931-32 India Government passed a Sugar Protection Act, by which excise duty was levied on the imports. Thereafter, the Indian Sugar industry grew rapidly and at present there are about 272 factories working in India. The production has been growing rapidly, from about 4.8 million tons in 1975, the production has gone to 6.3 million tons in 1977-78.

The large scale sugar processing technology can be classified on the basis of quality of sugar produced i.e. factories producing raw sugar and factories producing direct consumption sugar. On the organisational pattern, the classification could be of those processing their own sugar cane grow on the farm attached to the factory and those working on sugarcane purchased from outside from cultivators small, medium or big. The economics and impact on the socialconditions and such other factors are different for each type of large scale unit.

Development of large scale sugar production in India & its impact on traditional technology

The establishment of large scale sugar technology in India has two kind of impacts :

(1) on the agriculture cultivation pattern

(2) on the traditional technologies of gur and khandsari sugar.

The capacity of the Indian large scale sugar factories in 1935-37 was between 300 - 600 tons of daily cane crushing; in 1940, it rose to between 600 - 1200 tons, and now the average daily capacity of cane crushing is 1250-1500 tons. In some cases, the capacity has reached as high as 3000 tons. This is supposed to be still on the lower side as in other countries, especially where plantation type of cultivation is available, units as high as 10,000 tons are in operation. This concentration of crushing power in one location initiated the intensive cane cultivation round about the factory at the expense of food and other crops. Gradually, the cane cultivation over-reached the capacity of the large mills and the cane is in excess than the requirement of the processing unit in the area. This resulted in exploitation of the farmers by sugar units by offering a very low price for the cane. To meet the situation, the Cane Supply Act was passed and a minimum price was fixed by the government. Supplies were organised through cooperative societies of the cane growers. A radius of 11 miles was fixed from where the cane supplies can be drawn. This step reduced the chaotic condition to a certain extent but it did not control the situation completely and the cycle of over-cultivation and under-cultivation of sugar-cane has continued periodically.

The traditional khandsari got a severe blow because of the introduction of large scale technology. It was flourishing mainly in the intensive cane areas and the large scale sugar industry was also established there. Thus, khandsari units because of the low quality sugar which fetched a lower price in the market and with lower recovery from cane could not withstand the competition of the large scale technology and declined rapidly. The traditional khandsari in 1910-12 consumed about 25% of the total cane crop grown in India. But, in 1954-55 they were hardly consuming about 2%. The effect on gur manufacture was not so severe. It was because the operational area of gur industry was away from the cane areas of the mills. But still the production went down. In 1910-12, the gur industry was consuming 65-70% of the total cane crop in India and at present it is consuming 45 - 50% only.

Imbalances created by the Large-scale Technology

The establishment of the large scale sugar technology has created a number of imbalances as listed below.

In 1931-32 large scale sugar plants were consuming 6.7% of the total cane grown in India annually. At present they still consume on an average only 30% to 33% of the cane crop.

The possibility of higher coverage even to the extent of 50% of the total cane crop does not appear to be there. There are about 20 million farmers, cultivating 130 million tons cane on 2.6 million hectares of land in

India. These cultivators are scattered in far distant places and a sugar factor put up to process their cane will have to draw supplies from a long distances which will be uneconomical and will give lower recovery. Moreover, it will also mean more intensive cultivation near the sugar factory at the expense of food crops.

The mills get the supplies of cane at a price which is fixed by the Government. This price normally gives 25% to 40% higher return in comparison to other means of disposal of cane crop i.e. either conversion to gur by the farmer or the sale to the declining indigenous Khandsari sugar industry. The cane growers in the mill areas are much better off than the cane growers of non-mill areas. Naturally, this led to demand by the cane growers of non-mill areas to have somemore remunerative arrangements for the disposal of their cane crop.

With the diffusion of intensive cropping cycles i.e. growing 2 to 3 crops a year in place of the normal 1 to 1½, the farmer now does not find time or surplus bullock power to crush his cane for making gur. He wants to save bullock power and his labour for intensive farming, which is more remunerative. This has created a strong movement in non-mill areas for the cash sale of cane

Even in the mill areas the condition has become paradoxical. To meet the fluctuations in cane yields slightly bigger areas were alloted for the sugar mills to obtain their cane supplies. There has been an increase both in the area under cane cultivation and in the yield per hectare since 1931-32. The area under sugar cane has nearly quadrupled during the last 40 years, i.e. from 685,000 hectares in 1931-32 to 2.6 million hectares in 1971-72. The better availability of inputs in the shape of fertilizer and irrigation has also increased the yield from about 30 tons per hectare to 45 tons. The increase both in area and yields has been proportionately higher in sugar mill areas than elsewhere due to the intensive cane development work done by the sugar mills. Thus the availability of cane in sugar mill areas at present is about 175% - 180% of the installed capacity of the mills. The sugar mills are forced to extend their working days from 120 - 140 to 180 -

200 days. Well into the hot summer season when recovery percentage go down. Even then, the complete crop often cannot be entirely crushed and in some years even has to be partly destroyed. This has resulted in a strong demand by the cane grower of mill areas for alternative means of disposal of cane crop.

Above all the Government agencies who control and regularise cane supplies to the sugar mills also found it very difficult to adjust production in times of excess and shortage due to agricultural cycle variations. The also wanted some sort of safety valve to fall back upon.

These imbalances led to the demand for alternate technologies :-

(a) on the part of cane growers of non-sugar mill areas for getting a better return from their cane crop and to ensure sale of cane in place of crushing by bullock;

(b) on the part of cane growers in sugar mill areas to take care of their excess cane, especially, in time of bumper crop;

(c) on the part of traditional Khandsari entrepreneur to come back into business and keep working;

(d) on the part of govenment to find an outlet to balance and regulate the cane condition in sugar mill areas.

The problem of developing and evolving an alternative technology which would eventually be able to pay equivalent prices to cane growers as that given by large scale mill owners, was referred to the Planning Research & Action Institute in 1955.

The Planning Research and Action Institute was set up by the U.P. Government in 1954-55 with a grant from the Rockfeller Foundation. The objective of this Institute is to carry out action-research for improving and evolving techniques for rural areas both in the field of production activities as well as both agriculture and industry, community amenities and organisations.

The work of evolving a new technology for sugar cane processing was taken up by the rural industries section of the Planning Research and Action Institute in 1955. A team was constituted with the author of the case study as its team leader. The problem was studied in the following three aspects :-

(i) Product selection
(ii) Technology
(iii) Organisational pattern

The summarised details of work findings, carried out under each of the above heads are discussed in Chapter III, IV and V.

On the basis of findings, a pilot project was designed and installed at Ghosi, district Azamgarh, India. The very first year of work of the pilot plant showed promises of success. The first Technical Seminar was held to discuss the handicaps which came to light by the working of the pilot project. Solution of some of the handicaps were worked out and three more projects were started in different regions in U.P. Their working attracted attention of rural entrepreneurs and since then mini-sugar technology has been steadily growing. In the initial years the private entrepreneurs were given the facility of technical advice and free turnkey job for installing a unit by P.R.A.I. Training courses were started every year after the season. Review of the working results of various units were carried out from time to time. Uptill now five Technical Seminars have been held, which have gone a long way to establish this technology on a sound footing.

From one pilot project started at Ghosi district Azamgarh (India) in 1956-57, the number of units has grown to 2500 in India. The technology is still growing and 20 - 40 units are added every year. The basic advantage envisaged for such a technology has been fulfilled. A production of 1 - 1.3 million tons of crystal sugar as against 4.8 - 6.5 million tons by large scale technology is being done annually; seasonal job employment for about 3 lakhs of people in rural areas have been created. Other socio-economic advantages have been given at the end of Chapter II.

The mini-sugar technology has started attracting attention by other countries both developed and developing. A number of studies have been made, details of which have been discussed in Chapter II. The export of plant to the developing countries has started. Kenya, Nepal and Pakistan have already taken up this technology and put up pilot units. Other countries like Tanzania, Papua New Guinea, Carribean Islands and Ghana are showing interest in taking up this technology.

CHAPTER II

COMPARATIVE ECONOMIC GAPS AND SOCIO-ECONOMIC BENEFITS OF THE MINI-SUGAR TECHNOLOGY.

The first detailed comparative study of the mini-sugar technology vis-a-vis large scale sugar technology was made by Mr. C.G. Baron in January 1973, an Economist on the staff of the International Labour Organisation. Mr. Baron on the basis of data collected under actual operational conditions established the economic viability of the mini-sugar technology beyond doubt. He described the technique as O.P.S. Khandsari i.e. Open-Pam Sulphitation Khandsari.

Since then, a number of visits have been made by planners, economists and technologists from other countries to study these units in working. The latest study was made by a team of French Government, headed by Mr. Bernard Guerin. The team has reported that economies of the technology is almost at par with that of large scale technology and even minor improvement in recovery will give the mini-sugar technology a higher economic advantage than the large scale sugar technology.

The Planning Commission of India also made studies on this technology in September 1977. As a result, they have come out with a policy decision in the draft five-year plan of 1978-83, which is given below :-

> "The alternative technologies available for the production of sugar consistent with desirable capital-employment parameters show that future demand for sweetening agents, after allowing for fuller utilisation of the existing and licensed sugar mills can be met by necessary expansion through OPS Khandsari plants. It is proposed to work out the policy framework for the further expansion of the sugar industry in the light of these studies. For the time being, therefore, no new sugar mills will be licensed, although expansions of existing units may not be ruled out where this is necessary for maintaining their viability."

It appears to be a dream come true if one remembers the anti-propaganda carried out by large-scale mills when this technology was under development. In every meeting of the Indian Sugar Mills Association in those days and in the press, national wastage and other charges were levied against this technology and demanded the stoppage of the development work. But a small band of workers doggedly continued in their efforts with the generous help provided by some farsighted large scale technologists, especially Dr. S.N. Gundu Rao, a sugar Technologist of international fame, Sri N.C. Verma and Sri Sohanlal Saxena.

Some of the economic data is presented in the following tables :-

TABLE NO. I

(Under Indian Conditions 1977-78)

Particulars	Large scale sugar technology based on 120 days' working.	Mini-scale sugar technology based on 100 days working.
1. Capacity of maximum crushing tons/day	1,250	100
2. Output of sugar in tons in average season.	14,550	750
3. Total capital investment required for setting one unit. (in million).	60	1.3
4. Total Employment -Permanent) -Seasonal)	900	202
5. Investment per ton of sugar produced.	4,123	1,733
6. Investment per worker	66,666	6,000

The following conclusions are reached from the above date :-

1. For producing 1 ton of sugar, only 42% capital to that of large-scale is required by mini-sugar technology.
2. To create one job in mini-sugar technology, only 11% capital is required.

The Table 'I' may be presented in more illustrative way as follows :-

TABLE II

(Under Indian Conditions 1977-78)

(Rs. in million)

Particulars	Large scale sugar technology based on 120 days working.	Mini-scale sugar technology based on 100 days working
1. Total capital available for investment.	60	60
2. Capital required for installation of one unit.	60	1.3
3. No. of units which can be installed on the basis of above capital investment.	1	46
4. Total sugar output per annum (in tonnes).	14,550	34,500
5. Employment	900	9,292

The conclusions derived are :-

i) For the same capital, 2.37 times more sugar can be produced.

ii) 10.3 times more jobs can be created.

The usual working period for a large scale unit was 120 days and for khandsari 100 days but due to pressure of cane the working is now extended to 160 days in the large scale and 120 days in mini-sugar. If the above figures are revised on this basis, there may be some improvement for large-scale sugar technology.

TABLE III

Cost of processing 100 quintals of cane and cost of manufacture of 1 Quintal of sugar (Under Indian Conditions) - 1977-78.

Particulars	Large scale sugar technology based on 120 days working.	Mini-scale sugar technology based on 100 days working.
SALARY/WAGES	151.88	150.80
-Fuel and power	21.84	120.00
-Stores and Lubricants	72.89	63
-Contingency depreciation	360.00	140.59
-Administrative cost	61.50	-
-Interest charged on additional working capital required in the season.	61.14	28.00
-Cost of capital at 10%	300.00	130.00
	1,032.25	632.39

The recasting of the cost of processing of 100 quintals for mini-sugar technology on 120 days basis given a figure of Rs.585.39 in place of Rs.632.00.

The data of Table III are further computed in Table IV.

TABLE IV

Particulars	Large scale sugar technology based on 160 days working.	Mini-scale sugar technology based on 120 days working	Mini-scale sugar technology based on 100 days working
	Rs.	Rs.	Rs.
-Cost of 100 Qtls of cane	1,250.00	1,250.00	1,250.00
-Cost of processing of 100 Qtls. of cane as given in the above table.	1,032.25	585.39	632.39
	2,282.25	1,835.39	1,882.39
-Total sugar produced in Qtls.	9.6	7.5	7.5
-Cost of sugar per quintal	237.7	243	251

Projection for large scale are based on the figures of Kisan Sahkari Chini Mill, Saharanpur and for mini-sugar mill as given in Appendix III.

The cost of production is almost the same as large scale. Whatever little difference is there, can be offset by the different system of depreciation followed in these projections. The depreciation in large scale has been taken on gradual decline basis, while in mini-sugar it has been taken on a fixed basis. For a 200-ton mini-sugar plant the cost of production will be slightly lower than for large scale technology.

No figure for taxation in the cost estimates has been taken as taxation differs from country to country. In India, originally there was no taxation on mini-sugar technology, but gradually it has been increased and now on standard basis it is 50 per cent of large scale. No doubt, this gives an added advantage to khandsari and an incentive for its growth.

The above table brings out superiority of mini-sugar technology in all respects except with the cane consumption for producing one unit of sugar i.e. in case of mini-sugar technology 13.33 unit as against 10.4 in case of large scale. Even this difference will be minimised when some of the new researches already in advanced stage are put to commercial use. The development of expeller for increasing the crushing efficiency will increase the recovery by .7% i.e. to 8.2%, manufacture of liquid sugar out of the sugar rich khandsari molasses will raise the recovery to about 9.2%. It may also be emphasised that the quality of sugar is identical with large scale.

The large scale technology took about 125 years to develop to the present efficiency. Most of the present-day resources are on its side, viz. rich infrastructure, capital & finance, control of raw material, research and development facilities, political influence and demarcation of market. The mini-sugar technology of OPS Khandsari is only 22 years old. Even if a small part of these resources and development facilities are provided to mini-sugar technology, it can even compete the large scale sugar complexes having their own cane cultivation. The mini-sugar technology is most appropriate, for cane processing in India it has already taken root and is on sound footing.

Some of the socio-economic benefits in India of the mini-sugar technology are listed below :-

(a) These units now crush 10% of the total cane grown in India and produce about one million ton of sugar.

(b) A capital of 800 million has been invested in rural areas mostly, from unorganised sector.

(c) A job employment potential for 150,000 persons has been created in the rural sector in the slack season during which this labour used to migrate to cities for supplementing their meagre income from agriculture.

(d) The tax revenues to the Central and State Governments amounting to Rs.40 million have been added.

(e) A machine manufacturing industry has been set up whose annual turn-over is in the neighbourhood of Rs.100 million.

(f) The requirements of iron and steel for the fabircation of machinery is only about 60% that of large scale industry for producing the same quantity of crystal sugar. Thus 40% of raw material has been saved.

(g) More than 60% of the cane for large-scale units is transported by trucks consuming diesel and by railway wagons. Practically no such transport is utilised by these units, as these units are within easy distance of the cane growers and carting is done by bullock power.

(h) These units act as centres of radiation to extend and make available mechanised facilities to the rural areas & provide repair services to the new types of agricultural implements being introduced.

(i) Large-scale technology sets up a trend for the movement of the capital away from rural areas. This creates a weak capital base in which improvement of agricultural technology finds it difficult to take root, The starting of these units has helped to build up the capital resources and has many times served in providing agriculture inputs to the farmers.

(j) The machinery design is of a nature which can be manufactured and maintained by small workshops in semi-urban areas.

(k) These units employ about 2 1/3 times as many labourers for the same capacity as those employed by large scale technology.

(l) The capital requirements to manufacture equivalent quantity of crystal sugar is 42% for this technology as compared to the capital required for establishing large scale vacuum pan factory.

(m) The price payable by these mills is at par with that paid by largeescale technology which is, at its minimum, 25% higher than that obtained from other means of disposal of cane. On a rough estimate it can be said that an income of about Rs.400 million has been added to the agriculture sector.

(m) Some of the technological ideas of the Small Scale Technology have filtered through to the Gur and indigenous Khandsari industry e.g. introduction of power crusher to Gur and crystallisation on in motion and improved boiling furnaces have been adopted with the result that quantity and efficiency of these old industries have also improved resulting in economic benefits.

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CHAPTER III

PRODUCT SELECTION :

Many times the question is asked, why preference should be given to set up mini sugar technology; why not improvement should be made in technology of Jaggery or traditional Khandsari sugar. These are low cost technologies and the skills to operate the plant and machinery are available in rural areas in India. The reasons are - (1) market acceptability of the product and (2) operational economics.

ECONOMICS :

Jaggery or Gur is a concentrated product of the whole cane juice. It contains about 80% sucrose or cane sugar and some other minerals having good nutritive value. It is used more as a food by the rural population than as a sweetening agent. The yield or recovery of Gur is 10% on the sugarcane processed, i.e. for manufacturing 1 Qtl. of Gur, 10 Qtls. of cane is required. The price of 10 Qtls. of cane will be Rs.125/- to Rs.135/- on the basis of standard price fixed by the Government for payment by large-scale mills. The market price of Gur fluctuates very much and during the last 5 years, it has been ranging from Rs.80/- to Rs.150/- per Qtl. Even on the peak price of Rs.150/- hardly Rs.15/- to Rs.25/- are left for processing. This means that the Gur manufacture can not meet the standard price of cane and return to the cultivator will be low. Any improvement in the technology will raise the manufacturing cost and the marketability will be reduced. Such efforts were made but they have to be given up because the improved quality of Gur did not find acceptance on higher price in the market. Efforts to increase the recovery of Gur resulted in higher investment, which again affected the cost of product and defeated the purpose of keeping it as a farmer's or cottage activity.

Khandsari sugar is a creamy white powdery sugar containing 94-98% sucrose and the rest molasses. Nutritively, it is supposed to be better than the present day white crystal sugar. The price ranges between Rs.200/- to Rs.300/- and its recovery is 5.5% i.e. for producing 1 Qtl. khandsari sugar, 18 Qtls. cane is required. The price of sugarcane on the basis of large scale mill will be Rs.225/- to Rs.243/- leaving very little margin for improving the technology within its prevalent organisational pattern.

MARKET ACCEPTABILITY

The inherent strength of large scale technology is that its products meet the requirements and changing needs of the society. On the other hand, the traditional, low cost or indigenous technologies in developing countries because of the technological limitations produce only a particular type of product whose market acceptability has declined and it does not meet the needs of the society. This fact is not usually given enough weight in the various schemes for renovating and improving the traditional technology. Most of the attempts on the part of research agencies are in the direction of improving workability, introducing some new tools, increasing productivity, and on the part of the Government, improving the marketing and providing financial measures for survival. Needless to say, such efforts all over the world have not been as successful as expected in putting low cost technology on its feet. To give an example any improvement in lime mortar technology can not make lime mortar take the place of portland cement. Unless low cost lime technology can geared up to produce portland cement, its future will remain in doubt.

The consumption of gur and its production are gradually declining. In 1930, 65-70% of the total cane crop in India was processed into Gur. At present only 45-50% is being processed and rest of the cane is consumed by large scale mills, mini-sugar technology and for seed and chewing purposes. The manufacture of traditional khandsari sugar has been declining from year to year and have not gone up in spite of very large increase in the production by large scale and mini-sugar technology. At present, the industry utilizes hardly 2% of cane grown in India.

The white crystal sugar, a product of the large scale technology has been finding increased demand. From a consumption of 2,000 tonnes of white crystaline sugar as imported from Jawa in 1905, the consumption increased rapidly and at present the annual production of Indian large scale sugar industry ranges from five million to six million tonnes. The mini sugar technology starting as a pilot project in 1956-57 is now producing the million tonnes of sugar and consumes 100% of the cane crops. The future market potential of white crystal sugar cane be judged from the fact that the annual consumption even at this high production is only 6 Kg. per head in India while in the developing countries like U.K., U.S.A. and Canada, the consumption is 50 Kg. per head.

Therefore, the only alternative from the point of view of product selection was the development of suitable technology for manufacture of similar product as compared by large scale technology i.e. white crystal sugar.

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CHAPTER IV

TECHNOLOGY :

The manufacture of sugar could be divided into the following processes :-

(i) Extraction of juice from sugarcane,

(ii) Clarification of juice,

(iii) Evaporation and concentration of juice into massecuite,

(iv) Formation of crystals and their separation from the massecuite to obtain the final product i.e. sugar.

Extraction of Juice

In large-scale technology the juice is extracted by a crushing unit, consisting of a tandem of five mills of three rollers each. The following other devices are incorporated for increasing the juice extraction :-

(a) Cane preparatory devices,

(b) Extra pressure on the roller by hydraulic means,

(c) 'Imbibition' or 'maceration' i.e. adding of water and diluted juice to the once crushed cane and re-pressing,

(d) Increased number of compression by working a number of mills in tandem.

For Jaggery manufacture, Bullock crushers are used. For traditional khandsari sugar technology the crushing units available were :-

(a) Three-roller vertical crushers driven by bullocks,

(b) Three-roller horizontal crushers driven by power,

(c) Five-roller crushers driven by power.

None of these other extraction devices for increased extraction as used by large scale industry were used in the above crushers.

The comparative efficiency of extraction is given in the following table :-

Table

Efficiency	Bullock crusher	3-roller power crusher	5-roller power crusher	Large-scale Vacuum Pan mill.
1.Juice extraction by weight	55 -60%	58-62%	60-62%	73
2.Milling* efficiency.	67-68%	68-70%	70%	89-92%

*% of sugar extraction in juice out of the total sugar in cane.

The juice extraction efficiency is directly related to the recovery.

This above table indicates that while in the large scale technique only 10% of the sugar is lost, in Bagasse in traditional technology, the loss is 30% i.e. three times more. This is one of the main reasons for the lower recovery in traditional khandsari technology.

To cut down the loss of sugar during evaporation a new design of crusher '6-roller hydraulic crusher' was evolved. The cane preparation device by means of two set of cane knives and extra pressure on the rollers by hydraulic means was incorporated. The number of pressing which are generally 10 in large scale crushing was limited to only 4 by use of 2 No. 3-rollers mills in place of 5 nos. 3 rollermills. This was for the reason that higher pressings are effective only when 'imbibition' or 'maceration& is used. Introduction of imbibition required 12-18% of additional of water which diluted the juice too much increasing the the fuel consumption during evaporation. The higher consumption of fuel could probably be met by the higher recovery, but the diluted juice when evaporated in open pan furnace, lost a lot of sucrose during boiling by inversion. The inversion is a process by which the cane sugar which is sucrose or disaccaride is inverted to mono saccaride i.e. Dextrose which do not crystallise and is lost in molasses. The inversion rate increase rapidly if the juice is boiled above 60-70°C. The use of vacuum pan technology is for the purpose of lowering the boiling point to 60-70° and thus the inversion loss is checked. In open pan furnaces the juice start boiling at 100.5°C and as the concentration grown the boiling point goes upto 110-112°C. This inversion is further related to the time of boiling. Diluted juice will take much more time than the normal juice coming out of the sugarcane. The additional sugar obtained due to the use of imbibition water and increased pressing is lost because of accelerated inversion in open pan boiling. Initially only a design of 13"x18" crusher was developed by Planning Research & Action Institute with the help of National Sugar Institute but later on another design of 16"x24" was developed by Sri M.K. Garg of Appropriate Technology Development Association.

The operation data of 6-roller hydraulic crusher of 13"x18" and as well as 16"x24" are similar and are given below :-

1.	Juice extraction	66 - 68%
2.	Milling efficiency	80 - 82%
3.	Crushing capability	5 tonnes of cane per hour or 100 tonnes per day for 13"x18", and 10 tonnes of cane per hour or 200 tonnes per day for 16"x24".

The sugar loss is cut down from 30% to 20%, thus obtaining 10% more sugar in juice leading to high recovery by .8% to 1% over and above the traditional khandsari technology. Further a [illegible] expeller is being developed which on dry crushing basis has given a primary juice extraction of 72% and a milling efficiency of 87%.

JUICE CLARIFICATION

The clarification used in large scale technology is carried out by chemical agents, principally lime alone, or in combination with sulphur dioxide or carbon dioxide. The clarification is of three types

(a) Defecation - For producing raw sugar to be further refined in consuming markets.

(b) Lime sulphitation - For producing direct consumption white crystal sugar.

(c) Lime carbonation - For producing direct consumption white crystal sugar.

In India, lime sulphitation is the most widely used process in large scale vacuum pan technology.

In traditional technology, the clarification is carried out by means of mucilage prepared from vegetable barks. Some of the important barks are :-

1. Hiviscus Fiqulneus
2. Hiviscus Esculentus
3. Bombus Malbaricum
4. Grewia Asiatic
5. Kydia Calycina

These barks are soaked in water and the resulting solution which is a sort of mucileage, is added to the juice on the furnace. The impurities are brought out as scum on the surface of the heating juice and are ladled out.

A comparative efficiency of the various clarification methods is given in the following table :-

Table No. 2

Clarification system	Efficiency of removal of non-sugars.
1. Defecation by adding lime and followed by refining through carbon filteration.	60%
2. Lime sulphitation	35-45%
3. Lime carbonation	50-55%
4. Indian system of bark clarification	10-15%

Sugarcane juice contains about 2% non-sugar as insolubles, suspended and colloidal condition. This non-sugar component retards the crystallisation of sugar, thus giving a powdery sugar. Its removal to the highest possible degree from the juice is necessary for developing crystal and white colour.

Since the primary object was to manufacture crystal sugar, there was no choice except to use the chemical process of juice clarification.

The scaling down of the lime sulphitation process as used in large scale technology was experimented upon by a research unit set up by the Government of India in 1936. The process did not prove successful when commercially demonstrated. These research results were carefully examined and changes in the design of equipment, especially for lime and sulphur dioxide reaction, vessel were made. The lime sulphitation process was incorporated in the plant design.

The introduction of lime-sulphitation gave sugar similar to that of large scale. It also gave another advantage which resulted in improving the recovery further. The sugar_cane juice as they come out of the cane are acidic i.e. having pH value of 5.4. The inversion loss is related to boiling temperature, time of boiling and pH value and increases if the acidic juices are boiled. In large scale technology the pH of the juice is raised to 6.8 - 7 pH i.e.neutral to save inversion loss. By introducing lime-sulphitation, to mini sugar technology the acidity of juice is overcome and the juice pH is brought to 6.8 - 7 pH.

EVAPORATION AND CONCENTRATION OF JUICE

In the large-scale technology, the cane juices after clarification are evaporated in the first stage in a multiple effect evaporator after again passing sulphur dioxide and then concentrated into massecuite in a vacuum pan. Steam is used for heating purposes.

In the traditional khandsari the sugar juice is evaporated and concentrated on the open pan furnace over direct fire by burning dry bagasse. The efficiency of both processes is given below :-

Table no. 3

Process	Purity drop	Sugar losses.
1. Open Pan	3.5	1[illegible]%
2. Vacuum Pan	-	2%

The large scale vacuum pan boiling was found to be too complicated and capital-intensive to be adopted in mini-sugar technology. The scaling down was found to be difficult and uneconomic. So the only choice left was open pan boiling.

The open pan furnace is mainly a long inclined tunnel over which a number of pans of increased diameter starting from a small pan of 3' diameter ending with 6 ft. diameter pan are placed. The bagasse is burnt on the ground directly below the small pan. The draft is provided by a small chimney placed at the end of the last pan. The juice is fed to the big pan and then gradually transferred from the highest pan to the lowest pan manually reaching in the end to 3' dia. pan called 'parchha pan' when concentration is completed and the masscuit is ladled out in a small tank. A large no. of open pan furnace designs are available from various region in India. This design can be divided into low capacity i.e. producing about 50-90 Kg. masscuite per hour and higher capacity for producing 130 to 150 Kg. per hour. The low capacity furnace did not fit to the requirement of the plant design. The high capacity designs were analysed and were found to have two prominent handicaps :-

1. The juice capacity of the furnace for operation was 2100 Kg. for preparing of 150 Kg. of masscuite or a ratio of 1:14. This high capacity adds to the inversion loss.
2. The juice concentration pan is placed on highest heat point. This leads to loss of sugar by burning and caramalisation.

After a number of experiments, a new design called 'Standard bel or furnace' was developed in which the juice capacity was reduced to 800 Kg. and the masscuite capacity was raised to 180 Kg., thus giving a ratio of 1:4.5. The parchha pan was removed to the second place i.e. away from direct heat. The colour and caremilization was reduced and the sugar loss was cut down as shown in the following table.

Table

Process	Purity drop	Sugar loss
Open Pan standard unit	1.7 - 1.8	5% - 7%

In large scale technology, the bagasse is burnt in wet condition i.e. as it comes out from crusher, but in the open pan furnace the bagasse has to be sun-dried and th n is burnt.

Besides requiring a large labour force, the other handicap is that when the season is wet or in early winter when the dew formation is too much, the furnace does not work well. Many times the plant has to be stopped or slowed down. Attempts to burn wet bagasse in open pan furnaces were made. Early designs did not find acceptance because fuel consumption was high and juice boiling capacity was reduced to 3/4th of the dry furnace. Recently a new design was developed by Sri M.K. Garg which has started finding acceptance. By introduction of heat recovery device, the fuel consumption is reduced and by providing both forced and induced draft fan the concentration capacity has been increased to 180 Kg. per hour.

CRYSTALLIZATION -

In the large scale technique the concentrated juice called "Masscuite" is filled in a U shaped vessel where it is slowly rotated for 24-36 hours for the development and growth of crystals. In the traditional technique, crystallization is carried out by filling the masscuite in an earthen vessel where it remains stored for 2 to 3 weeks.

The large-scale crystallisation technique is called 'Crystallization in motion' while the traditional technique is called 'static crystallisation'. The relative efficiencies are given in the following table :-

Table

Oricess	Percentage loss on the available sugar.	Quality of type of sugar crystal
1.Static crystallisation	4-6%	Powdery
2.Crystallisation in motion	1%	Crystalline

The crystallisation technique directly affects the development of crystal structure and also its size. A scaled down design of the mill crystallizer was adopted. The crystal growth was much better. But a lot of very fine crystals or powdery sugar was obtained. This was due to the fact that in vacuum pan during boiling a limited number of nuclie are produced. These when grow during crystallization gives bold and big crystals. No method to develop and limit the nuclier grains in mini sugar technology could be possible. This resulted in uncontrolled production of very minute, some of which being weak do not grow, resulting in higher percentage of powdery sugar and higher loss in molasses due to small crystals passing out of the centrifugal screen. This deficiency has been overcome to some extent by development of seeding and cutting process in crystallization. But still the loss of sugar in molasses is higher. The molasses of mini sugar technology contains 55-57% of sugar while that of large scale technology have only 35% sugar.

Separation of crystals

In the large-scale technique, the separation of the crystals from the masscuite is carried out by a centrifugal machine.

In the traditonal technique, the separation was carried out initially by means of microbiological action. After the static crystallization, the masscuite was filled in woollen bags which were stacked to a height of about 8 to 10 feet. A heavy stone was placed on top to put pressure. During the course of a week, part of the molasses used to flow out. The yellowish syrupy mass was taken out of the bags and then put in masonry tanks with perforated bottoms. On the top, a layer of sewar grass, which grows profusely in ponds and still water was placed. The heat developed by microbiological action of this grass, caused the molasses to drain out, upto a depth of about 2 inches, leaving a powdery white to creamy sugar below the sewar grass layer. This layer of sugar was then removed and another layer of sewar grass put on till the whole depth of sugar in the tank was free from molasses. The molasses flowed out from the perforated bottom.

The above separation technique is too slow and required a lot of space. The traditional khandsari sugar manufacture started to use centrifugal machines as early as 1925. By 1932 a proper design was evolved and it gradually replaced the traditional separation technique. In 1950, hardly 20% khandsari sugar was produced by microbiological separation and by 1960 the process completely disappeared.

There is no difference between large scale vacuum pan technology and mini-sugar technology in the process of crystal separation by centrifugal. The centrifugals in large scale industry is of very high capacity and fully automatic. In the mini-sugar technology the centrifugal is a batch type, the main operation of feeding, washing and sugar removal is done manually. The economic of the manually operating centrifugals in mini sugar technology is favourable because of low capital investment per unit of sugar centrifuged.

CHAPTER V

ORGANISATIONAL PATTERN

The organisational pattern for working a technology could be divided into two categories - (i) entrepreneur ownership and (ii) producers' ownership type.

The organisational pattern of the large-scale technology is completely of the entrepreneur ownership type. The responsibility of raising the capital, management and operations rests on a strong central group who have got the required expertise and incentive. Such an organisation hardly takes into consideration the interests of the producer or even the consumer. At times an element of exploitation enters into its working.

In the producer-ownership pattern, the ownership is either wholly by producer or is divided into a number of levels between producer and artisan type or small entrepreneur. The capital investment is low and management system also is simple. The surplus formed in such an activity is divided at various levels in place of being collected in a centralised pool. The surplus is available for capital formation in the region and can be reinvested locally. This type of organisation can work at low efficiency and can exist even when the odds are too high. Because of this type of organisation many of the indigenous low efficiency technologies are still working in India and other developing countries against heavy competition from the sophisticated large scale technologies.

The organisation for gur i.e. Jaggery and traditional technology or khandsari sugar manufacture in India is of producers' ownership type as explained in the following paras :-

Gur manufacture :

10 to 15 cane growers of a village combine together to hire a bullock-driven kohlu and a set of pans for boiling juice, from the nearby town where the traders keep stock of such articles for seasonal hire. This equipment is installed in a hut in the village. The group of cultivators, harvest

sufficient cane daily to meet the crushing needs of the day, by rotation from the various fields of the members. Cane is transported by bullock carts from the field to the crushing unit. The crusher is worked by bullocks provided by various farmers on a two to three hours rotation basis. The gur produced out of cane harvested from the field of a particular member is his property after manufacture. There is hardly any hired labour employed except the gur boiler who is mostly paid not in cash but on a percentage basis on the amount of gur made. The rest of the labour is provided from the families of the cultivators.

The organisational pattern for indegenous khandsari sugar manufacture is divided into three levels.

(a) Juice extraction by the cane growers,
(b) Clarification, boiling and concentration into massecuite by small village entrepreneurs,
(c) Separation of sugar and marketing by urban entrepreneurs.

A village entrepreneur installs a juice furnace in the village and enters into a contract with the cane-growers to purchase their cane juice, not cane. The cultivator hires a bullock crusher for crushing the cane and supply juice on a volume basis to the furnace man. The juice is boiled into massecuite and then filled up in earthen vessels.

The earthen vessels containing the massecuite are then transported to the cities where they are purchased by the urban entrepreneurs who separate the sugar from molasses and market it. The molasses is then re-boiled for a second crystallisation. Some times the third sugar is also manufactured by a second boiling of the molasses.

From the above, it is clear that gur manufacture is a completely producer ownership type of cottage industrial activity. In case of traditional khandsari sugar manufacture the activity is carried out partly under producer ownership and then partly by rural small private entrepreneur and the last portion by the city entrepreneur.

The mini-sugar technology as developed is of the nature where the various processes can not be scaled down to the cane producers level. Neither they can be separated out between number of levels as is practised in the manufacture of khandsari sugar. The crushing unit is a costly one and have to a permanently installed feature. The transport of juice to furnace housed separately will induce loss of sugar. Therefore, the entrepreneur ownership type pattern has to be adopted. Initially some units were organised on cooperative basis so as to keep the start of ownership with canegrowers. But the pattern did not succeed. Some of the reasons of the failure could be identified as below :-

(a) The cane supply to be received from a member was related to the share capital contributed by the member. In general cane growers could not find sufficient capital so as to be able to sell their complete crop of cane to the unit. The membership, therefore, had to be increased to collect the necessary capital. The increase in membership led a situation in which hardly 15-20% crop of the members could be processed. The member had, therefore, to depend on other alternatives for disposing of the cane, or to continue making jaggery.

(b) The cane-grower did not feel confident in getting the price on the basis of the operational result of the unit. He insisted on selling the cane outright. To meet the requirements of cane the practice of direct purchase had to be introduced.

(c) Both the above factors resulted in a lukewarm attitude of the cane grower towards these co-operative units.

(d) When the programme was started, the administrative and executive responsibility of working these units rested with the Planning Research and Action Institute who had naturally a strong motive to implement the programme successfully. Later on the programme was transferred to the Co-operative Department and the department passed on the management responsibilities to the cane growers. The skill and expertise of the cane growers was not of the level to take up the administrative and executive responsibility successfully, with the result that the efficiency of the units began to fall.

(e) Though the administrative and executive responsibility was transferred, the overall administration remained in the hands of the department workers who were more or less forced on the society. These workers did not feel responsible many times to the cane growers or to the unit. They were more interested in working according to the departmental rules.

In large scale vacuum pan technology, co-operative ownership of the units were also introduced and their number is increasing rapidly because of government policy of granting licence for further installation of new unit only to cooperative organisation.

A review of large scale cooperative sugar mills brings out the fact that producers ownership is only in the name. The share capital of the producers are hardly 20% of the investment and rest of the capital is provided as loan etc. Cane growers do not have any access to the surplus formed. He is having the same relationship as he is having with the private entrepreneur type of large scale industry. His entire cane crop is not covered and he has to depend many times on his own arrangement for processing his cane crop. At best it can be said that the concentration of sugar industry in the hands of few industrial houses is avoided by the cooperative structure and the managements has been passed to a class of social and political workers. This class becomes of vested interest, provides a highly paid and efficient management to the large scale cooperative sugar factories which was possible due to very high turnover. This cooperative organisation has yet to prove to be the higher benefits to the producer.

In an industry where the loan amount is very high, all extra surplus formed goes out for the re-payment of loan. It takes more than 10-15 years to repay the loan and then only some extra [illegible] is available to farmer shareholders. During this long period the farmers develop the mentality of being only a cane supplier to the factory and does not have the feeling of ownership and is not effective at all in controlling the management etc.

The introduction of cooperative structure in the mini-sugar technology could be possible if :-

(1) the membership is limited to a group of farmers so the entire cane crop of the members coule be process by the unit.

(2) Either major part of the share capital is collected by the cane-growers or loan repayment is so arranged that a part of the profit could be paid as annual dividend and bonus over and above the cane price to the cane growers.

(3) Apex body is formed to provide efficient management to a number of cooperative units at least in the initial stages till the technical feasibility and economic viability is fully established and management is taken over by the cane growers.

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CHAPTER VI

PROJECT DETAILS

The mini-sugar units have been standardised in two capacities :-

1. 100-ton cane crushing per day of three shifts.
2. 200-ton cane crushing per day of three shifts.

The capital investment and details of the plant and machinery with specifications have been given in Appendix 1 & 2. The summary of capital investment is given in the following table :-

TABLE

Capacity	Capital investment with working capital.
100-ton capacity	Rs.12,00,000/-
200-ton capacity	Rs.19,00,000/-

In case no electricity from public utility is available, the generator is required to be installed. Diesel engine drive is not preferred from layout efficiency point. The investment on generating set will be on :-

100-ton capacity	Rs.	2,20,000/-
200-ton capacity	Rs.	3,65,000/-

The depreciation and other operational cost of the sets will be met from the power expenses provided.

The operational details for the 100-ton units are given in Appendix 3. The operational details of 200-ton unit will be more or less similar and are not being included.

Plant capacity	Cane consumed in a season	Sugar produced	Gross return	Net return.
		Rs.	Rs.	Rs.
100-Ton	1,00,000 Tons	Rs.750/- per ton	4,54,000/-	1,00,151/-

During the last 21 years of research & development, plant specifications have been gradually changing. Some new machineries have been developed to have better control on the working and to reduce the personnel factor.

Not all the manufacturers in India have adopted these changes. A new entrepreneur has to face difficulties at the time of purchasing of the plant andinstallation. For his guidance, a few notes are given below.

Location - Before deciding location, a survey of the c ane crop should be carried out. Within a radius of 5 Km. atleast 20,000 tonnes sugarcane should be available and within a radius of 8 Km. about 30,000 tonnes of sugarcane should be available. Based on the experience in India, only 40% of the cane grown in an area is available for processing. Dependence on transport of cane from long distances should not be placed.

Buildings - There are a number of designs developed. Blue-prints of the latest design are available with the Appropriate Technology Development Association, Gandhi Bhawan, Lucknow and the Planning Research & Action Division, Kalakankar House, Lucknow. Special attention should be given to the plinth level of the building. It has been found that if the plinth level is raised by 3 ft., the furnace work better because their depth is about 7 ft, and if they are taken to the depth below the ground level, then the fuel consumption increases due to perculation of sub-soil moisture. The roofing should be from Asbestos Cement sheets. The galvanised iron sheets, because of two much production of steam, get corroded and hence have to be replaced within 6-7 years.

Furnaces - The furnaces are most important because of fuel economy as well as boiling capacity which effect the colour and recovery of sugar. Standard designs have been developed after intensive field testing. The drawings are available with the Appropriate Technology Development Association and the Planning Research & Action Division. Many times sugar boilers insist on making their own design which some time work and some time do not.

Plant & Machinery - Quite a large portion of the machinery is fab ricated from M.S. sheets. Their weight is less and volume is high and, therefore, the transport cost is out of proportion. These can be manufactured at the site. A list of such machinery which can be fabricated at site is given in Appendix IV. The fabricated machinery drawings are available with the Appropriate Technology Development Association and the Planning Research & Action Division.

Crusher - There are two standard designs of crusher (i) 13"x18" for 100-ton capacity and 16"x24" for 200-ton capacity. The 13"x18" design was developed by the National Sugar Institute and the Planning Research & Action Institute in collaboration. Lateron substantial changes were made to improve the efficiency. The crusher should be purchased after ensuring that all these efficiencies have been incorporated. 16"x24" crusher was developed by the industry but its efficiency was poor, so at the recommendations made in the 5th technical seminar, the design was scrutinised and a standard design was evolved by Sri M.K. Garg which has been field tested and found to be as efficient as 13"x18" crusher.

The crusher alongwith all other machinery is manufactured by a number of firms in India. In case if it is intended to take up the manufacture in other countries, complete set of drawings of both the crushers are available with the Appropriate Technology Development Association.

The following points should be checked when purchasing the plant :-

Crusher

1. **Cane carrier chain** - The cane carrier chain should be made from die cut parts, not by hand beating parts.
2. **Cutter** - The cutter knives should be hard surfaced by electrodes having atleast 30% cobalt in its composition. The cutter knives should be at an angle of 30° from each other and not 60°.

3. Foundation bed - The foundation bed of both mills and gears should be preferably of cast iron heavy channel type. If made from M.S. Steel, it should not be girder or I beam type but fabricated channel from 10-12 mm. thick M.S. plate.

3. Brasses - The top roller brass should be half hexagonal, not round on the resting surface side. All side brasses should have forced lubrication system.

4. Appex Angle - The crushers originally designed were having Apex angle of 82°-84°. This apex angle has been reduced to 74° which is better from extraction and power point of view.

5. Trash Plate - The trash plate should be of the new design recommended by the 5th Technical seminar to suit the above apex angle.

6. Head Stock - The head stock of the mills were originally designed on cast iron but later on replaced by M.S. plate. Many times, the thiner plates are used by manufacturers and no internal ribs are provided to balance the stresses. The head stock should be of 18-20 mm thick M.S. plate with internal ribs.

7. Roller grooves - A number of chenges have been made and the final recommendations are as follows :-

   1st Mill - 1" pitch with 55° angle groove,
   2nd mill - ½" pitch with 55° angle groove.

   Differential angle grooves did not work well. Chevron grooves should be cut on the feed and top rollers of both the mills. Juice grooves on the side of the rollers should invariably be provided.

8. Setting gauge - Setting gauge should be obtained along with setting diagram and the mills should be set accordingly.

9. Hydraulic system - In the 5th technical seminar, the lift ratio of accumulators has been changed from 1:48 to 1:17.5. The new accumulator should be purchased alongwith one ton loading weight for each accumulator. The hydraulic pipe should be of seamless type with 3/8" bore.

10. Juice sieve - The juice is usually sieved by hand. To avoid fermentation and viscosity development, the juice sieving should be done with DORR OLIVER type of sieve with 2 mm apparture. The sieve is automatic without any moving parts.

11. Juice weighing equipment - To keep the working efficiency of the crusher at the correct point, automatic juice weighing machine should be installed. They are not generally used.

12. Pumps - Pumps should invariably be Open Impeller type.

13. Sulphitation Tanks - The sulphitation tanks should invariably be provided with a parabolic juice, circulating plate baffle. Both juice and gas entry should be from below.

Lime addition tank should be attached to the sulphitation tank. Many times the workers because of some operational difficulties remove them but their removal will effect the efficiency of the process.

14. Lime solution making equipment - The lime solution is generally made by hand but it gives uncertain quality of lime solution and sometimes have particles which do not disolve. Mechanised equipment for this purpose has been developed and be installed.

15. Heating of muddy juice - The muddy juice left in settling tanks is generally sent directly to filteration. A mud heating tank should be installed behind the sulphitation bel and if necessary provide with additional small furnace.

16. Filteration equipment - There are two types of equipment available - (1) Bag filters, and (ii) filter press. The washing of the mud cakes has been found beneficial due to increased inversion loss of the diluted juice. The juice removal efficiency from the mud, therefore, from both bag filter and filter press are similar. The bag filters are labour intensive but can handle any kind of juice.

Filter presses are costly and some times there is difficulty in filteration when the sulphitation process has not been properly carried out. The cost is also high. In case the filter presses are to be used, the size of the filter press should be limited so that the operational cycle should not be longer than $2\frac{1}{2}$ - 3 hours.

17. Juice boiling bels - There are two types of juice boiling bels - with round pans and with tubular pans. The tubular pans are more efficient in boiling as well as fuel consumption. The furnaces are generally worked with dry bagasse for drying of which 20-30% of the total labour force is involved. Moreover, when the weather is wet or the dew formation is too much in early winter, the bagasse do not dry properly and the boiling capacity goes down and the fuel consumption increases. Wet burning equipment was evolved but it did not find acceptance because the fuel consumption was high and the boiling capacity was lower than the dry bagasse burning. The latest equipment developed by Sri M.K. Garg has overcome these handicaps. The working of this equipment requires skilful handling which many times is not available with the sugar boilers. So, in the beginning only 2-3 bels should be fitted with this equipment and as soon as experience is gained, other dry bagasse furnaces should be changed.

18. Molasses bel - The pans of the molasses bel should be of of cast iron of the standard design i.e. 42"x$7\frac{1}{2}$", 36"x7" and 30"x$6\frac{1}{2}$". Bigger pans do not increase the boiling capacity and should be avoided. Molasses bels can also be worked with rice-husk if it is available in the locality. It gives fuel economy.

19. Crystallizers - Initially smaller crystallizers of 5'x$3\frac{1}{2}$'x$3\frac{1}{2}$' were used but now the size has been increased. Bigger crystallizers of 6'x4'x4' and 8'x5'x5' have been standardized. The stirring arrangement of the crystallizers should not be of ribbon type but fan type with proper placing of stirring plates.

20. Centrifugal - For increasing the efficiency of the centrifugal, the massecuite from the crystallizers should be conveyed by Magma pump to the feeding arrangement attached with

the centrifugal. This arrangement has recently been put in practice and is very effective to cut down the cost and further the purging of 2nd, 3rd and 4th sugar is improved.

21. Drier - At present the sugar is generally dired in sun. Development of rotary drier was made but it resulted in reducing the crystal size and producing more dust in the sugar. The latest Hopper type drier does not have this handicap and should be used.

22. Grading of sugar The practice of grading of sugar after drying is a recent introduction which fatches slightly higher price of sugar in the market. The grader could be a separate one or can be attached with the Hopper drier.

23. Gear Pump - The molasses is generally transferred manually. It will be preferable to transfer it by gear pump.

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APPENDIX I

PROJECT ESTIMATE FOR A MINI SUGAR PLANT DAILY CANE CRUSHING CAPACITY - 100 TONNES. A DAY IN THREE SHIFTS 10,000 TONNES PER SEASON.

CAPITAL INVESTMENT

Particulars	Cost	Total cost.
	Rs.	Rs.
LAND		
Cost of 3 acres of land	30,000/-	30,000/-
BUILDINGS		
(a) Working Shed - Total building area 14,400 sq.ft. @ Rs.25/-	3,50,000/-	
(b) Office	20,000/-	
(c) Manager's and Labour quarters	20,000/-	
(d) Boundry wall partly of barbed wire and partly of masonry work	20,000/-	4,10,000/-
OTHER CONSTRUCTION		
(a) Molasses tank and drying platform.	20,000/-	
(b) Masonary foundation of machinery and bel construction with chimney and other miscellaneous work including firebricks.	25,000/-	
(c) Tubewell with overhead tank	15,000/-	60,000/-
		5,00,000/-

PLANT & MACHINERY

Particulars	Cost	Total cost.
1. CRUSHING UNIT - One no.		
A. Cane crushing unit 13"x18" size 6-roller hydraulic loaded complete with cane carrier, double cane cutter and intermediate carrier, fitted with equalizer with new type of hydraulic accumulator and other changes as recommended in the 5th Technical Seminar.		1,25,000/-
B. Electric Motor 70/75 H.P. Slippering, 960 rpm complete with starter and switch - One no.		30,000/-
C. Electric Motor 10 H.P., 1440 rpm - Two Nos.		6,000/-

2.	RAW JUICE TANK - One no. Size: 8'x2'x1½' made from 10 Gauge M.S.Steel	800
3.	DORR OLIVER TYPE JUICE STRAINER - One no. 2 mm Apperture	6,000
4.	AUTOMATIC JUICE WEIGHING MACHINE - One no.	5,000
5.	JUICE PUMP - Two nos. 2" Open Impeller for pumping the juice to sieve and then to sulphur tank.	12,000
6.	HOT JUICE PUMP - One no. 3" size 3-MK-10 Pump.	7,000
7.	ROTARY POSITIVE BLOWERS - Two Nos. 36 c.f.m. complete fitted with motor, starter and switch.	9,000
8.	SULPHUR FURNACE - One no. Tray area 2 sq.ft. complete with water cooling arrangement.	1,500
9.	SCRUBBER - One no. 18"x48" double walled with water cooling arrangement.	800
10.	SULPHITATION TANK - Two nos. 3' dia. x 8' high fitted with lime addition tank and parabolic circulation baffle and also various operating valves, made from 5 mm thick M.S. Plate.	6,400
11.	SULPHITATION BEL - Two sets consisting of :- (a) Channel type pan 8'x3½' made from 6/8 mm plate - 2 nos. (b) Gutter Pan 8'x3x1½' made from 6/8 mm plate - 2 nos. (c) Mud Heating tank - 4'x4'x2' - 1 no. (d) Fire bars .. .. -16 nos.	24,000
12.	MACHANICALLY LIME SOLUTION MAKING EQUIPMENT - One no. complete with driving arrangement.	2,000
13.	SETTLING TANKS - 12 nos. Size - 4'x4'x2'	12,000

14. FILTERATION EQUIPMENT WITH MUD PUMP 2"x2"	9,000
(a) BAG FILTERS OR FILTER PRESS	
Filter Press, size 18"x18"x3 plates -2 nos.	
Bag Filters - Size 4'x4'x2' -10 "	24,000
(b) Refilteration Filter Press - One no.	
18"x18" with 24 plates.	10,000
15. JUICE BOILING BELS - 7 sets consisting of	
(a) Round Pan 54" dia. 40/50 mm thick mild steel - 1 no.	
(b) M.S. Round pan 42" dia. 40/50 mm thick plates - 1 no.	
(c) Channel Pan 6'x2' - 3 nos.	70,000
*Wet bagasse burning equipment for 2 furnaces only. Wet bagasse furnace complete with step grates, recouperator forged draft fan 2,000 cfm at 4" WG and induced draft fan 4,000 cfm at 4" WG @ Rs.12,000/- each	24,000
16. MOLASSES BEL - 5 sets consisting of	
3 cast iron pans - 42"x7½", 36"x7½" and 30"x7½".	9,000
17. CRYSTALLIZERS - Eight nos. @ Rs.5,000/- each, Size: 8'x5'x5' made from 3 mm and 8 mm plate.	40,000
Crystallizers - Ten nos. @ Rs.4,000/- each, Size: 6'x4'x4' made from 3 mm and 6 mm plate	40,000
Countershaft complete with M.S. Bracket, Pulleys, Ball bearing and Belting,	6,000
ELECTRIC MOTOR - 6 nos. @ 2,000 each 5 H.P. with switch and starter, 960 rpm	12,000
Seed crystallizer 5'x3½'x3½' made of 3 mm and 6 mm plate - Four nos.	
Electric motor 3 H.P., 960 rpm with switch and starter.	2,000
18. CENTRIFUGALS - Two nos., Size: 12"x24"	22,000
19. MAGMA PUMP - One no. Motor 5 H.P., 960 rpm.	6,000
20. RAB FEEDING EQUIPMENT WITH DRIVING ARRANGEMENT - One no.	6,000

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*In the initial stage only 2 sets wet bagasse of burning equipment to be fitted with 2 of the 7 standard bel provided. Later on as per requirement atleast 5 furnace should be fitted with wet bagasse equipment.

21.	GEAR PUMP FOR MOLASSES - 1 no. Motor 5 HP, 960 r.p.m.		3,000
22.	HOPPER DRIER - One no. 50' long in 2 parts of 25' each separately driven with sugar classifier complete with driving motor and air heating arrangement and fan of 2,000 cfm at 4" WG. Motor - 5 H.P., 960 rpm - Two nos. Motor - 4 H.P., 1440 rpm - One no.		25,000
23.	WEIGHING BRIDGE - 20-ton capacity		40,000
24.	PLATFORM BALANCE - Two nos.		6,000
			5,77,800

WORKSHOP AND FITTINGS

1.	**Workshop** Lathe - One 12'; Bed drill - One 1½", Tools, Welding set - One	25,000	25,000
2.	**Fittings**		
	1. Pipe fittings	10,000	
	2. Electric fittings	35,000	
	3. Mill stores	10,000	
3.	Contingencies, freight and other charges.	10,000	
4.	Erection charges	15,000	80,000
	Total		1,20,000

If filter presses are used their investment will be higher by (24,000 - 9,000) = 15,000/-

In case electricity is not available, Two Diesel Generating sets will have to be installed as given below.

100 K.V.A.	1,50,000	
35 K.V.A.	60,000	2,20,000

1. Land & Buildings	-	4,80,000	
2. Plant & Machinery	-	5,77,800	
3. Workshop & fittings	-	1,20,000	
4. Working Capital	-	1,23,000	13,00,000

APPENDIX II

PROJECT ESTIMATE FOR A MINI SUGAR PLANT DAILY CANE CRUSHING CAPACITY 200 TONNES A DAY IN THREE SHIFTS 10,000 TONNES PER SEASON.

CAPITAL INVESTMENT

Particulars	Cost	Total cost.
	Rs.	Rs.
LAND		
Cost of 5 acres of land	50,000/-	50,000/-
BUILDINGS		
(a) Working shed total building area 18,000 sq.ft. @ Rs.25/- per sq.ft.	4,50,000/-	
(b) Office	30,000/-	
(c) Manager's and labour quarters	50,000/-	
(d) Boundary wall partly of barbed wire and partly of masonry work.	35,000/-	
Other construction		
(a) Molasses tank and drying platform	40,000/-	
(b) Masonary foundation of machinery and bel construction with chimney and other misc. works including fire-bricks.	35,000/-	
(c) Tubewell with overhead tank	20,000/-	6,60,00/-
		7,10,000/-
PLANT & MACHINERY		
1. CRUSHING UNIT - One no.	2,00,000/-	
A- Cane crushing Unit, 16"x24" size 6-roller hydraulic loaded complete with cane carrier, double cane cutter and intermediate carrier, fitted with equaliser with new type of hydraulic accumulator and other changes as recommended in the 5th Technical Seminar.		
B- Electric Motor 100 H.P. slippering, 960 rpm complete with starter & switch - One no.	60,000/-	
C- Electric Motor 15 H.P, 1440 rpm - Two Nos.	15,000/-	

2. RAW JUICE TANK - Two nos. Size: 8'x2'x1½' made from 10 Gauge M.S. Steel. — 1,600/-

3. DORR OLIVER TYPE JUICE STRAINER - One no., 2 mm aperature — 6,000/-

4. AUTOMATIC JUICE WEIGHING MACHINE - One no. — 8,000/-

5. JUICE PUMP-2 (Two) nos. 2" Open Impeller for pumping the juice to sieve and then to sulphur tank. — 12,000/-

6. HOT JUICE PUMP - Two nos. 3" size 3-NK-10 Pump. — 14,000/-

7. ROTARY POSITIVE BLOWERS - 3 Nos. 36 c.f.m. complete fitted with motor, starter and switch. — 13,500/-

8. SULPHUR FURNACE - Two nos. Tray area 2 sq.ft. complete with cooling water arrangement. — 3,000/-

9. SCRUBBER - Two nos. 18"x48" double walled with water cooling arrangement. — 1,000/-

10. SULPHITATION TANK - 4 nos. 3' dia. x 8' high fitted with lime addition tank and parabolic circulation baffle and also various operating valves, made from 5 mm thick M.S. plate. — 12,800/-

11. SULPHITATION BEL - Two nos. — 24,000/-
   (a) Channel type consisting of pan 8'x3½' made from 6/8 mm plate - 2 nos.
   (b) Gutter Pan 8'x3'x1½' -2 nos.
   (c) Mud Heating Tank -4'x4'x2'-One no.
   (d) Fire bars - 16 nos.

12. MECHANICALLY LIME SOLUTION MAKING EQUIPMENT - One no. complete with driving arrangement. — 3,000/-

13. SETTLING TANKS - 16 nos. Size - 4'x4'x2' — 16,000/-

14. FILTERATION EQUIPMENT
   (a) Bag Filters - 16 nos. — 16,000/-

   Filter Press
   Size:24"x24"x30 plates)
   size:18"x18"x30 plates) 2 nos.
   = Rs.40,000/-

   (b) Refilteration Filter press - 2 nos. — 20,000/-

15. JUICE BOILING BELS - 7 sets consisting of - (a) Round Pan 54" dia. 40/50 mm thick mild steel - 1 no. (b) M.S. Round pan 42", dia. 40/50 mm thick plates - 1 no. (c) Channel Pan 6'x2' - 3 nos.	14,000/-	
*Wet bagasse burning equipment for 2 furnaces only.	36,000/-	
Wet bagasse furnace complete with step grates, recouperator forged draft fan - 2,000 c.f.m. at 4"WG.		
16. MOLASSES BEL - Set - 8 nos. consisting of 3 cast iron pans 42"x7½", 36"x7½" and 30"x7½".	38,000/-	
17. CRYSTALLIZERS - 16 nos. @ 5,000/- Size: 8'x5'x5' made from 4 mm and 8 mm plate.	80,000/-	
Crystallizers - 18 nos. @ 4,000/- Size: 6'x4'x4' made from 3 mm and 6 mm plate. countershaft complete with M.S. Bracket, Pulleys, Ball Bearing and belting.	72,000/-	
Electric Motors - 6 nos. 5 H.P. with switch and starter 960 r.p.m.	12,000/-	
Seed Crystallizers - 6 nos. Size: 5'3¼'x3½' made from 3 mm and 6 mm plate. Electric Motor 3 H.P., 960 r.p.m. with switch and starter.	18,000/-	
18. CENTRIFUGAL - 3 nos. Size: 12"x24".	33,000/-	
19. MAGMA PUMP - Two nos. Motor 5 H.P. 960 r.p.m.	12,000/-	
20. RAB FEEDING EQUIPMENT WITH DRIVING ARRANGEMENT - 2 nos.	12,000/-	
21. GEAR PUMP for molasses - 2 nos. Motor 5 H.P., 960 r.p.m.	6,000/-	
22. HOPPER DRIER - 2 nos. 75' long in 3 pieces, 50' long in 2 parts of 25'each separately driven with sugar classifier complete with (Contd.)	40,000/-	
		8,28,900

*Note: In the initial stage only 2 sets wet bagasse of burning equipment to be fitted with 2 of the 7 standard bels provided. Later on as per requirement atleast 5 furnaces should be fitted with wet bagasse equipment.

driving motor and air heating
arrangement and fan of 2,000
c.f.m. at 4"WG.
Motor - 5 H.P., 960 R.P.M. - 3 nos.
Motor - 3 H.P., 1440 r.p.m. - 1 no.

23. Weighing Bridge - 20 tonnes capacity.

24. PLATFORM BALANCE - 3 nos.

WORKSHOP AND FITTINGS -

WORKSHOP

Lathe - One 12' bed Drill - One 1½" dia. Tools Welding set one	30,000/-	30,000/-

FITTINGS

1. Pipe fittings	28,000/-	
2. Electric fittings	60,000/-	
3. Mill Stores	22,000/-	
4, Contingencies, freight and other charges.	25,000/-	
5. Erection charges	20,000/-	1,55,000/-
		1,85,000/-

NOTE: If filter presses are used, their investment will be higher by (Rs.40,000 - 16,000) = Rs.24,000/- In case electricity is not available, 3 Diesel generating sets will have to be installed as given below :-

150 K.V.	2,50,000/-	
35 K.V.	65,000/-	
25 K.V.	50,000/-	3,65,000/-

Abstract of expenditure

1. Land & Building	Rs.7,10,000/-	
2. Plant & Machinery	8,28,900/-	
3. Workshop & fittings	1,85,000/-	
4. Working Capital	1,75,000/-	18,98,900/- or 19,00,000/-

APPENDIX III

(WORKING DETAILS UNDER INDIAN CONDITIONS)

Working Expenses details:

	Cost Rs.	Total Rs.
1. Cane -1,00,000 Qtls @ Rs.12.50 per Qtl. (average)	1,25,000/-	1,25,000/-
2. Stores -		
(i) Lime 20 Kg. per 100 Qtls. cane = 200 Qtls @ Rs.30/- per Qtl. - 2% on cane.	6,000/-	
(ii) Sulphur 5 Kg. per 100 Qtls. cane, 50 Qtls. @ Rs.130 per Qtl. - 05% on cane	6,500/-	
(iii) Caster seed - 2½ Kg. per 100 Qtls cane - 25 Qtls. @ Rs.180/- per qtl. 025% on cane.	4,500/-	
(iv) Gunny bags, 7500 bags @ Rs.600/- per 100.	45,000/-	
(v) Lubricants.	10,000/-	72,000/-
CONTINGENCIES		
For the season	10,000/-	10,000/-
POWER & FUEL		
1. Electricity & Diesel	60,000/-	
2. Extra Fuel - 3% -3000 Qtls. @ Rs.20/- per quintal.	60,000/-	1,20,000/-
STAFF		
1. Manager @ Rs.600/- p.m. for 12 months	7,200/-	
2. Accountant -cum- Cashier. @ Rs.400/- p.m. for 12 "	4,800/-	
3. Weigh Bridge Clerk-cum-Accountant @ Rs.200/- for 12 months.	2,400/-	
4. Assistant Mechanic @ Rs.150/- p.m. for 5 months. - 3 nos.	2,250/-	
5. Store Keeper @ Rs.300/- p.m.	3,600/-	
6. Mechanic @ Rs.450/- p.m.	5,400/-	
7. Head Karigar (Rab) @ Rs.600/- p.m. for 5 months.	3,000/-	

8. Assistant Karigar (Bel) @ Rs.250/- p.m. for 5 months - 8 nos.	10,000/-	
9. Karigars for molasses @ Rs.250/- p.m. for 5 months - 6 nos.	7,500/-	
10. Sulphitation Mate @ Rs.300/- p.m. for 4 months - 3 Nos.	3,600/-	
11. Centrifugal Driver @ Rs.200/- p.m. for 5 months - 6 nos.	6,000/-	
12. Electrician @ Rs.250/- p.m. for 12 months.	3,000/-	
13. Settling Mate @ Rs.150/- p.m. for 4 months. - 3 nos.	1,800/-	
14. Chaukidar (Three) @ Rs.150/- p.m. for 12 months.	5,400/-	65,900/- or 66,000/-

Daily labour	1st Shift	IInd shift	IIIrd shift.
1. Loading and unloading	4	-	-
2. Crushing Section	15	15	15
3. Sulphitation Section	5	5	5
4. Settling Section	4	3	3
5. Juice Bel	14	14	14
6. Molasses Bel	8	-	-
7. Crystallizer Section	2	2	2
8. Centrifugal	3	3	3
9. Bagasse Drying	8	-	-
10. Sugar Drying	6	-	-
11. Reserve Labour	4	3	3
	73	45	45

= 163 labours @ Rs.5/- per day for 120 days = Rs.97,800/-

Abstract of working expenses.	Total cost Rs.	Direct processing expenditure on 100 Qtls. Cane. Rs.
1. Cane - 1,00,000 Qtls @ Rs.12.50 per qtl.	12,50,000/-	
2. Stores (clarification)	72,000	62/-
3. Power & Fuel	1,20,000/-	120/-
4. Staff	66,000/-	66/-
5. Daily Labour	97,800/-	97.80
6. Contingencies	10,000/-	10/-

7. Excise duty Rs.2950/- per week per centrifugal for one centrifugal for 18 weeks.	53,100/-	53/10
		409.90
	16,68,900/-	

INCOME

First Sugar -	100,000 qtls. Cane @ .4.75% sugar recovery 4750 Qtls.@ Rs.300/- per quintal.	14,25,000/-
Second Sugar -	100,000 Qtls Cane @ 1.75% sugar recovery, 1750 Qtls @ Rs.270/- per Qtl.	4,72,500/-
Third Sugar -	100,000 Qtls. cane @ .7% sugar recovery 700 Qtls. @ Rs.220/- per qtls.	1,54,000/-
Fourth Sugar -	100,000 Qtls.cane @ 3% sugar recovery, 300 Qtls @ Rs.190/- per qtl.	57,000/-
Molasses -	100,000 qtls cane @ 3% molasses - 3000 Qtls. @ Rs.15/- per Qtl.	45,000/-
		21,53,500/-

GROSS PROFIT - Rs.21,53,500/- minus 16,68,900 = Rs.4,84,600/-

	Cost	Total cost	Indirect process Exp. on 100 Qtl.cane.
DEPRECIATION		Rs.	Rs.
1. Buildings - Rs.4,70,000 @ 5%		23,500/-	
2. Machinery - Rs.6,97,800 @ 10%		69,780/-	
		93,280/-	93,280/-
REPAIRS & RENEWALS			
1. Building - Rs.4,70,000 @ 2%		9,400/-	
2. Machinery -6,97,800/- @ 4%		27,912/-	
		37,312	37,312/-

OVERHEAD CHARGES

1. Auditors Expenses	2,000/-		
2. Other statuarycharges	5,000/-		
3. T.A.	10,000/-		
4. Office expences	8,000/-		
5. Entertainment	2,000/-		
6. Insurance	2,000/-	29,000/-	29/-
7. Purchase Tax @ 50 Paise per quintal of cane.		50,000/-	50/-
8. Interest on additional capital of Rs.4,00,000/- required during the season to be arranged as cash credit limit or short term loan @ 14% for 6 months.		28,000/-	28/-
9. Interest on capital investment of Rs.13,00,000/- @ 10%		1,30,000/-	130/-
		2,74,312/-	
	+	93,100/-	
		3,67,592/-	

NET PROFIT Rs.4,84,600 - Rs. 3,67,592/- = 1,08,159/-

NEW RETURN on Rs.13,00,000

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APPENDIX IV

LIST OF MACHINERY WHICH CAN BE FABRICATED AT SITE AND WILL BE MORE ECONOMICAL DUE TO TRANSPORT FACTOR.

1. Raw Juice tanks
2. Scrubber
3. Sulphitation tank
4. Sulphitation bel
5. Settling tanks
6. Bag filters
7. Juice boiling pans
8. Crystalliser
9. Rab feeding equipment
10. Recuperator

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