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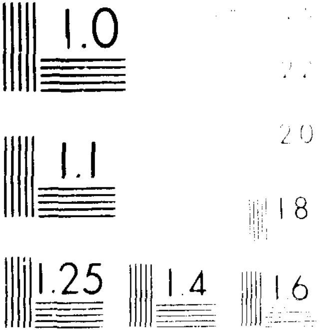
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Bangladesh

TECHNICAL REVIEW OF THE SOLVENT EXTRACTION PLANT OF THE AL MUSTAFA INDUSTRIES, CHITTAGONG

DP/BGD/80/020

BANGLADESH

Terminal report *

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

Based on the work of W. Khese, expert of the LURGI UMWELT and Chemotechnik GmbH, Frankfurt am Main, Federal Republic of Germany

United Nations Industrial Development Organization

Vienna

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1. Organization

The Bangladesh Sugar and Food Industries is coped together in the organization

"Bangladesh Sugar and Food Industries Corp." (BSFIC)

to which specialized firms have belonged since the Revolution.

Mr. Hedayet Hossain M.S. Director (Planning) is responsible for overall planning in the Corporation.

Dr. N.M. Sheikh (Chief Planning and Development)

as well as

Mr. Quazi Shahabuddin Ahmed Chief Engineer

are responsible for handling.

In addition to other edible oil processing companies,

Al Mustafa Industries

along with the

Plant General Manager Mr. Asafzah

belongs to the Corporation.

Discussions were held with Dr. Sheikh and Mr. Hedayet Hossain on 25.7.1981 and, after returning from Chittagong, on 5.8.1981. All requests regarding the content of my report were discussed with Mr. Shahabuddin and Mr. Asafzah on 6.8.1981.

The contact at UNDP Dacca was Mr. de Raad.

At present, only imported Canadian rapeseed is processed at the Al Mustafa Industries Plant, Chittagong.

2.1 Preparation

There are 140 crushing mills (called "Gunny") for the preparation of the seed. These mills, located in two halls, are driven by a central transmission shaft (one in each hall) via drive belts. The charge of 6 - 8 kg cold, unconditioned seed is filled into these mills by hand ard crushed using a mortar. After a charge period of 2 hours, the mill is emptied by hand and refilled. The output of 140 mills is thus 10,000 - 15,000 kg in 24 hours.

It is probable that cell disclosure in these mills does not take place to as high an extent as in the case of flaking in a plain roller mill. Unfortunately, no screen analysis could be carried out with a sample which had been taken, since it had already started developing fungus by the time it arrived in the Federal Republic of Germany.

2.2 Pre-pressing

Pre-pressing is carried out in screw presses of the old type, again without any prior conditioning. This extraordinary procedure is justified as follows:

The pressed oil produced is not given any further treatment after pressing, but is marketed in its crude form after mechanical impurities have been removed. The oil can only be sold locally if it has the typically acrid taste of the crude rapeseed oil. It was suggested that any conditioning with steam, or heating of the seed, would change this taste so much that it would no longer suit the consumption habits of local customers. The ffa content in the pressed oil is indicated to be 1 - 1.25 %.

The Plant Management's proposal to flake the seed in a plain roller mill after conditioning - instead of processing it in the labour-intensive mills - was also rejected for this reason.

In other Chittagong oil mills, a portion of mustard seed is still mixed in with the rapeseed in order to sharpen the flavour of the pressed oil.

The extracted rapeseed is exported. Due to regulations in most import countries, rapeseed bound for export must not contain any mustard seed. For this reason, the rapeseed pressed cakes from the other mills, which contain mustard seed, cannot be processed in Al Mustafa with a view to making full use of capacity.

The pressed cake is coarsely crushed in a cake crusher and is pressed a second and third time in the same press.

The oil content of the cake after the last pressing is given as 9 %. The free fatty acid content of the cake at the extractor inlet is given as 15 - 25 % ffa. This high ffa-content is brought about by intermediate storage periods, which may be ascribed to the fact that all transport between mills, presses, further treatment and the extractor inlet are carried out by hand in wicker-work baskets. Two samples which had been brought along indicated an oil content in the cake at the extractor inlet of 6.8 and 9.1 %, water content being 12.1 %.

The preparation unit and the pressing unit were not in operation at the time of the visit.

2.3 Extraction

Before entering the extraction unit, the cake is reduced to roughly thumb-sized pieces in a crusher.

The extractor is a LURGI frame belt extractor with a rated throughput of 50 tons in 24 hours. In contrast to the preparation and the pressing unit, the extraction unit gave the impression of being clean and well looked after.

As well as investigating its overall condition, the following questions had still to be cleared up:

2.3.1 The present residual oil content of the meal, given as 2 %, is too high.

2.3.2 The present loss of solvent is given as 0.9 % instead of 0.25 - 0.3 %, which were achieved shortly after the first start-up of the plant.

2.3.3 At a meal rate of 90.2 % and an oil rate of 7.0 %, the product loss is apparently 2.8 %.

On July 28, 1981, the day of my arrival in Chittagong, the whole plant was closed due to holidays, and was due to be opened again on August 15, 1981 after the holidays and the annual boiler inspection.

2.4 A manhole was opened up in the plant while it was out of operation (in the toaster, to give one example). The bottom screens and side walls were smooth and did not exhibit any noticeable corrosion damage.

As far as one could ascertain without dismantling the extractor, the extractor casing had also not been noticeably corroded. This is especially surprising since the oil contained in the pressed cake has an ffa-content of 15 - 25 %. According to experience, the sulphur content in the vapours causes damage to extractor casings after a relatively short time when rapeseed is being processed.

The miscella evaporators could not be opened because the plant had not yet been freed from hexane residue.

Since it was not possible to clear up the above questions (2.3.1 to 2.3.3) while the plant was out of operation, the plant personnel were brought back to the works despite the fact that it was the most important legal holiday, and the plant was started-up again on 29.7.1981 at 17 h. After the stable level of 40 tons throughput had been attained, and samples had been taken, the plant was again put out of operation at 24 h.

2.5 Samples and analysis

The samples were analysed in the LURGI laboratory. The results were as follows:

Description of sample	Moisture weight %	Oil content weight % dry materials
1. Canadian import rapedeed from 29.7.1981	8.5	44.9
2. Pressed cake, pressed 3 times	12.1	6.8
3. Extracted meal	10.9	3.2
4. Pressed cake between cake crusher and extractor inlet	12.1	9.1
5. Rice bran from 30.7. mixed sample from various local rice mills	18.8 +)	9.6

+) This unlikely value is probably due to a sampling error.

The miscella was not being distributed properly to the individual cells. Some cells received too much solvent, others too little. Some distributor pipes were so corroded that the miscella came out at full flow at the side, whereas other cells received practically nothing.

It was agreed that all the distributor pipes would be dismantled and inspected during the envisaged overhauling. So as to allow replacements for corroded pipes to be manufactured locally, the appropriate drawings of the pipes were removed from the folder of drawings and given to Mr. Asafzah, the General Manager.

2.6 Residual oil content

2 % was given as an average figure for the residual oil content in the meal over the last operating periods. The testing of the meal sample in the short operating period on 29.7.81 indicated a residual oil content of 3.2 % at a throughput of 40 tons and an input oil content of 9.2 % at a water content of 12.1 %.

Shortly after the first start-up of the plant in April 1970, residual oil contents of 1 - 2 % resulted at a throughput of 50 - 60 tons. (Chittagong Telex dated 6.2.1970). In this Telex, the poor preparation by the crushing mills was given as an explanation of the fact that the residual oil content was periodically above 1 %.

On page 17 of the supply contract dated 28.10.1966 between LURGI and the factory owner company, LURGI guaranteed a residual content of 1 % "on the condition that before prepressing the rape seed has been prepared by plain rollers thereby disclosing all oil cells."

However, neither the first start-up in 1970 nor operation on 29.7.1981 met this requirement (preparation by flaking with plain rollers).

In my opinion, this particularly poor result on 29.7.1981 is attributable, on the one hand to the poor distribution of the miscella in the extractor and, on the other hand, to the extremely high moisture content of 12.1 % in the pressed cake. (10 % was stipulated as a maximum moisture content in the Contract). Maybe the permeability of the screen belts has decreased, meaning that they need to be cleaned. According to Hasni's letter dated 26.4.1970, cleaning has reduced the residual oil content from 1.8 to 0.8 - 1.1 %.

If overhauling can put the miscella distribution in order, and the pressed cake has a moisture content of under 10 % - approximately 7 % is the best - there is no reason why the residual oil contents achieved on start-up should not be attained again, since the type of preparation used in the first start-up is the same as the present one.

Another idea was discussed, namely to flake the pressed cake in a plain roller mill before it enters the extractor, instead of coarse crushing in the cake crusher, in order to improve cell disclosure after pressing.
In the case of rapeseed processing in the Federal Republic of Germany, only the pressed cake from one oil mill is flaked before entering the extractor. This, however, also does not reduce the residual oil content to below 1.5 %. So, I do not consider that any decisive improvement of the residual oil content can be expected as a result of this additional outlay.

2.7 Loss of hexane

A figure of 9 kg/ton feed material has been given to indicate the loss of hexane while the plant is in its present condition. **On page 28 of the UNIDO Terms of Reference,** a figure of 6 kg/ton is stipulated for hexane loss.

A few comments should be made regarding the dependence of hexane loss on the circumstances prevailing:

The amount of hexane lost with the exhaust air from the absorption column is a function only of the temperature and residual hexane content still in the mineral absorption oil when the latter is fed into the absorption column.

The enclosed graph No. 1 shows the interrelations. When, for example, the residual hexane content in the mineral oil is 2 %, the amount of hexane lost is 126 gr/m3 exhaust air at an inlet temperature of 50^{o}. If, however, the residual hexane content in the mineral oil is the same, and the temperature is only 30^{o}, only 63 gr hexane per m3 exhaust air are lost.

Since the air volume is assumed to be constant, total loss of hexane is proportional to the specific loss.

During operation on 29.7.1981, the mineral oil inlet temperature was between 50 and 55^{o}. If this temperature could be reduced to 30^{o}, the loss of hexane would fall by around 50 %, i.e. from 9.0 kg/ton to approx. 4.5 kg/ton.

In the Hasni Vanaspati Manufacturing Co. Ltd. letter dated 26.4.1970, the fact is mentioned that the loss of hexane at that time was between 3.0 and 2.5 kg/ton. At that time, either the temperature at which the mineral oil was led into the absorption column must have been lower or the stripping column functioned better, with the result that the residual hexane content in the mineral oil was lower.

An examination of the condition of the heat transfer surfaces in the stripping column/mineral oil cooler, as well as an inspection of the filling level in the absorption column should be the first steps to be taken. For trouble-free operation, the residual hexane content in the mineral oil should not exceed 1 %, and the oil should enter the column at a temperature of not more than 25 - 30°. If these steps are not successful, a higher loss of hexane can only be caused by a leakage in the exhaust air system.

2.8 Loss of material

On 29.7.1981 in Chittagong, the following figures were given for process loss:

Pressed cake input		100 %
Yield:	oil	7 %
	meal	90.2 %
Process loss		2.8 %

The different water content of pressed cake and meal is apparently not taken into account in this calculation. The analysis of samples which had been brought gave a water content of 12.1 % for the pressed cake. According to certificate 5.001/00262 of 18.7.1981, the water content of the meal delivered, batch 2, was 9.75 % (batch 1 had a moisture content of only 9.25 %). Taking into account these differences the following calculation may be made:

Input:	100 kg pressed cake with 12.1 % water	= 87.9 kg dry substance + oil
minus	7 kg oil (water-free)	= 80.9 kg dry substance
	90.2 kg meal with 9.75 % water	= 81.4 kg meal dry substance
which gives a difference of		plus 0.5 kg

between the input and output weight. This difference should be within the bounds of measuring accuracy. A 2.8 % substance loss, as indicated (at 50 to 58 kg/h), in any form other than water would certainly become noticeable during the operation of the plant.

3. Rice bran processing in the Al Mustafa extraction plant, Chittagong

As indicated by the foregoing, the total capacity of the extraction plant cannot be put to use with the existing preparation plant.

So, Al Mustafa has for a fair while been considering putting the idle capacity to use by extracting rice bran.

The following is quoted from a paper delivered by Dr. Vorwerck, Bühler-Miag:

3.1 Rice milling meal (rice bran) results when brown rice is milled. It contains the hull layers, the aleurone layer and the germ. These various layers are crushed in the milling process. The fats and enzymes which occur separately in the different cell layers are freed and mixed intimately with each other. The fat-splitting enzyme lipase can thereby attack the fats and decompose them into glycerine and fatty acid. Other enzymes such as peroxidase can bring about oxydative transformations. The large surface area of the rice bran also accelerates non-enzymatic oxydation processes; the result is that the free fatty acids increase and the rice bran becomes rancid.

In a large, modern rice mill, rice bran is extracted immediately after it is produced, thus avoiding a substantial increase in free fatty acids. However, the mills in Chittagong all have such small capacity that an extraction unit in one of the mills could not be operated economically.

If the bran cannot be extracted immediately, the increase in free fatty acids can only be prevented if the rice bran is stabilized by treatment with water vapour, which causes the enzymes (lipase) to be inactivated to a large extent. However, since no water vapour is available in the local mills, the only alternative is to dispatch the bran from the mill as quickly as possible and to stabilize it in a central stabilization plant immediately after arrival.

Rice bran cannot be processed in the existing percolation extractor in the powdery form it is supplied in. In order for percolation to be sufficient, the rice bran must be compressed in a pellet press before extraction. Its volume is thereby reduced to about half the original volume.

It would seem obvious to associate the conditioning necessary before compression with the stabilization process. In this way, an intermediate product with limited suitability for storage is produced. A few comments will be made later on this product's properties.

3.2 Resulting amounts of rice bran

A study dated 7.7.1979, drawn up by Mr. Asafzah, General Manager of Al Mustafa Ind., indicates that there are 38 fairly large semi-automatic rice mills in operation in Chittagong, which produce rice bran that can be used for extraction. Three of these mills, providing typical examples, were visited and samples of the rice bran produced were taken. The sample analysis revealed the following:

Moisture:	18.8 %
Oil content:	9.6 %

Only brown rice is processed in these mills. Only a few mills are able to produce parboiled rice as well, and this only in summer when the rice can be dried in the sun after boiling. This is beneficial in so far as the pellets from parboiled rice do in fact have a higher fat content, but are not as stable mechanically, and their intermediate storage and transport would require greater care.

The following is taken from the study compiled by Mr. Asafzah:

"Output of Rice Bran from 38 major Rice Mills:

(a) The daily milling capacity of these mills is approximately 20 000 Pounds per day.

(b) These mills are capable in producing No. 1 quality ricebran suitable for extraction. The percentage of the Bran recovered from Rice will be about 3 - 5 %.

(c) On the basis of (a) and (b) the daily output of Rice Bran from 38 mills will vary from 22 to 37 tons per day.

Availability of Rice Bran during seasons:

(a) The Following operational data of these mills will reflect some ideas about availability.

Year of operation	Length of operation
1977	3 - 4 months
1978	12 months
1979	6 months (anticipated)

(b) Season of availability of No. 1 Rice Bran quality

According to variety of crops is as follows:

Aman Paddy	December to March
IRRI	May and June
Aus	August and September

In the Al Mustafa plant, ripeseed and rice bran are to be processed alternately.

3.3 Rice bran oil

Efforts should be made to process the rice bran oil produced into a good edible oil by means of lye refining and bleaching.

This does not give rise to problems provided that the free fatty acid content is low. If, however, the free fatty acid content is more than 10 to 15 %, processing cannot take place without considerable refining losses.

The possibility of processing rice bran oil to edible oil can be of crucial importance for rice bran extracting.

An oil with a high free fatty acid content can also have a particularly negative effect since the danger of corrosion damage in the extractor and the miscella distillation system increases as the ffa-content rises.

3.4 Stability

It is particularly important to be aware of the behaviour of the pellets during intermediate storage.

Graph 2 shows the increase in free fatty acids in tests carried out by Dr. Vorwerck, Bühler-Miag, on rice bran and pellets over a period of up to 90 days. These samples underwent various stabilisation processes. This example shows that pelletizing was effected straight after steam treatment, which is the best procedure. With this treatment, the ffa-content only rose to 10 % after 60 days' storage.

Similar results are shown by the following table (storage in sacks at $30^{o} \pm 2^{o}$ and a relative humidity of 85 $\pm$ 10 % in the ambient air):

		untreated	steam treated and pelletized
fresh	moisture %	13.1	12.1
	Lipase	18.3	0.9
	Peroxidase	268	0
	ffa %	5.9	1.2
after 2 months	Lipase	22.3	4.8
	Peroxidase	281	0
	ffa %	58.2	9.7
after 3 months	Lipase	24.9	6.2
	Peroxidase	295	0
	ffa %	68.4	15.3

When assessing these results, one should nevertheless bear in mind that stability properties vary amongst d- sorts of rice bran: for example, the stability of ric from parboiled rice is considerably better, even without stabilization, than the bran produced by the milling of ordinary brown rice.

The following is a passage from a feasibility study on rice bran extracting in Bangladesh, dated November 28, 1978, Peking, and carried out by a Chinese team with the aid of UNDP. The extract appears at the bottom of page 4:

"After heat treatment as parboiling, deterioration of Rice Bran would be relatively slow."

time after being milled	1 h	24 h	3	5	10	15	days
ffa %	1.27	1.85	2.25	2.39	2.49	3.91	

However, the following is quoted at the top of page 5:

"Rice Bran from ordinary brown Rice processed in Chittagong is high in oil content and starch content, low in fiber content and in small size. Deterioration develops very quickly."

(The sample brought from Chittagong had only an average oil content of 9.6 %.)

Time after being milled	24 h	5	10	15 days	
sample 1	23.1	38.7	58.1	68	% ffa
sample 2	26.6	34.0	32.5	63.4	% ffa

These figures refer to the unstabilized bran. Notwithstanding this, the rates of deterioration are so high that more tests with rice bran from Chittagong mills will definitely have to be carried out so as to ascertain the ffa-increase during storage.

The results received make it evident that stabilization should be effected as soon as possible after the bran has been produced/delivered to the works. So as to make this possible and to ensure that not too much time elapses between the time of delivery and treatment, the stabilization and pelletizing plant should be designed to have roughly double the output of the extractor.

An output of 3.5 to/h is suggested.

3.5 The pellets leave the press at a temperature of 100^{o} and must be cooled and dried before being stored. The cooler - drier located downstream is designed such that the temperature at the outlet - depending on the humidity of the ambient air - is around 5 to 10^{o} above the ambient temperature.

The drying rate is set in such a way that the pellets discharged have roughly the same moisture content as the bran fed into the stabilization screw.

The pellets can be stored in a bulk bed. However, the bed height should not exceed 0.8 m, or 1.0 m at the most. If the bed is too high, there may be a risk of self-ignition.

Mr. Asafzah ascertained the current amount of usable rice bran obtained per day to be between 22 and 37 tons. This is less than the throughput of the extractor (50 tons in 24 h). So that the extractor can always be operated at full capacity, it is necessary to wait until there is a stock of 100 to 200 tons of finished pellets in storage before switching from rapeseed to rice bran processing.

3.6 Necessary measures

The following steps must be taken if the extraction capacity is to be used to the full at all times:

1. Arrangements must be made to ensure that the amount of rice bran obtained in the mills can be dispatched twice a day.

2. Appropriate agreements must be made with the Management of rice mills.

3. The rice bran delivered to the works must be processed there without delay in the stabilization and pelletizing plant.

4. The pellets should be stored in the works until the stock is large enough to enable the extractor to operate at full capacity.

3.7 Specification

A stabilization and pelletizing plant necessary to equip Al Mustafa Industries for the purpose of processing rice bran in the existing extraction plant would consist of the following individual pieces of equipment:

1. Coarse screen, designed as a vibrating screen, with a mesh width of 8 - 10 mm, to keep back coarse lumps from the delivered rice bran.

2. Magnet, designed as a shaft magnet, to intercept iron particles in the delivered rice bran.

3. Elevator, operating at a rate of 10 m3/h.

4. Feed tank, volume approx. 5 m3.

5. Conditioning and stabilizing screw for treating the rice bran with dry steam, heating up to a temperature of 100°, including a variable speed drive unit and a device for automatically closing off steam feed when the screw is out of operation.

6. Pellet press operating at a rate of 3.5 to/h. Mould with 8 mm drill holes, power rating 55 kW.

7. Screen to separate fine particles from the finished pellets.

8. Cooler/Drier designed as a cooler without involving mechanical movement of pellets, for cooling to 5 - 10° above ambient temperature, discharge hopper with level control.

9. Cooling fan, 7,500 m3/h, 22 mbar, with 12 kW drive motor.

10. Cyclone, diameter 1200 mm for separating entrained fine particles.

11. Rotary valve, diameter 200 mm for discharging fine particles which are returned to the feed tank.

12. Conveyor belt for transporting pellets at approx. 6 m3/h from the drier to the storage area.

13. Conveyor belt for transporting the pellets from the storage area to the extractor inlet.

Offers for the main equipment from the following firms have been submitted to the authorities as recommended by the contractor.

3.7.1 Amanaus Kahl Successor
D 2057 Reinbek Bez. Hamburg, Postfach 1246

3.7.2 Bühler-Miag Gmbh
D 3300 Braunschweig, Ernst-Amme-Str. 19

Both firms have experience in building plants for stabilizing and pelletizing rice bran.