Feature Article

Mongana Basics: Part 12 - Problems Associated with Oil Separation**

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WERKSPOOR CENTRIFUGE WITH CONTINUOUS DISCHARGE OF SEDIMENTS

The bowl is a star-shaped, 6 spokes rotor. A nozzle is fitted at the end of each of the branches. A constant volume of water is (5.4 t hr^{-1}) discharged through the nozzles. The level of the interface is not set by gravity discs but by two inverted centrifugal pumps (fixed rotor and rotating liquid). One of these pumps supplies enough water to ensure full discharge of liquid through the nozzles dash - the diameter of which could vary from (2 to 2.3 mm).

This machine has been used for various types of crude oil pumping especially the crude oil discharged by the screw press. The limiting factor as regards to capacity is the amount of aqueous phase to be separated from the crude oil and not the quantity of oil. With a constant discharge of 5.4 t hr^{-1} of water, it has been possible to collect up to 7 t of oil per hour. The main advantage of the machine is its ability to deal with crude oil containing from 0% to 100% of oil without performing any adjustment in its settings. Among factors affecting the efficiency of the machine, the following are worth noting.

- Hourly throughput. Contrary to what may be believed, the efficiency of oil removal from the crude oil is directly proportional to the hourly output and therefore inversely proportional to the dwelling time in the machine. The analytical results versus the crude oil hourly output are shown in the *Table 1.*

It is difficult to give a satisfactory explanation to the fact, why a longer dwelling time of the crude oil in the bowl should lead to a reduction in the extraction of oil from the NOS. A logical explanation could be that during periods of low hourly inputs , a larger volume of make-up water is admitted into the machine to maintain its stipulated throughput. As a result, the larger intake of water might create eddies in the bowl and this could affect separation adversely. This problem has been referred to the maker of the centrifuge. The other factors are:

- the temperature. This must be kept at 95°C;
- variable feed rate. The abrupt variations in the amount of crude oil fed into

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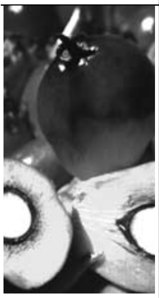


TABLE 1. EFFECT OF THROUGHPUT ON THE OIL CONTENT OF NOS

	Less then 2.5 ($t\ hr^{-1}$)	2.5 to 4.5 ($t\ hr^{-1}$)	More than 4.5 ($t\ hr^{-1}$)
Oil on NOS	23.8%	19.9%	18.9%
Percentage of results lower than 15%	15%	28%	38%
Number of samples	53	54	45

the centrifuge are not conducive to efficient separation; and

- boiling of crude oil and period of ebullition. *Table 2* gives the residual amount of oil in NOS (a) versus the time during which crude oil is boiled and also (b) versus dilution.

The 100% dilution appears to lead for getting the best results. It seems also that boiling either through direct steam injection on by means of steam coils is sufficient to induce a satisfactory extraction of oil. In the above cases involving 100% dilution, boiling was carried out either by steam injection or by steam coil (12% and 11% oil on NOS respectively). Each result is the average of eight tests carried out on samples taken whilst the machine was operating at three different throughputs.

The wear of the continuous discharge sludge centrifuge appears to be less severe than in the case of the previous one. The nozzles, although made of special metal; have to be renewed periodically. In a comparison between the resistance to abrasion of nozzles made of two different metals, it was established that tungsten carbide is eight times as durable as stellite (cobalt alloy).

In the case of crude oil containing a large amount of sediments, the strainer placed in the feeding chamber displayed a tendency to clog up although the size of the perforations were larger than that of the sediments.

The screen can be cleared by a spray of water or simply by applying slight vibrations to the chamber. At the time of the trial, a device to impart vibrations to the strainer was being designed.

The continuous discharge sludge centrifuge of the type under discussion presents a number of advantages in respect of automatic operation. After starting the machine and adjusting the self-regulating make-up water addition, all that is required is to ensure that crude oil does not overflow from the feeding chamber. By fitting an automatic float valve to maintain a constant level the machine operates by itself and requires no supervision. Several factors may however perturb the machine operation;

TABLE 2. EFFECT OF DILUTION AND BOILING TIME ON THE OIL CONTENT ON NOS (results expressed in % oil on NOS)

Dilution (%)	Not boiled	Brought to boiling	Boiled for 15 min	Boiled for 30 min	Boiled for 90 min	Boiled for 100 to 180 min
0	55	-	-	-	30	-
100	22	11	11	11	12	43
200	22	-	20	27	-	-

they are as follows: insufficient crude oil temperature, insufficient pressure of the make-up water (at least 3 m) and clogged discharge nozzles.

The last point is important. It has been observed that as soon as one nozzle gets blocked, sediments accumulate in that branch of the star and consequently eddies occur in the bowl. This induces abnormally high losses of the oil in the discharged effluent.

In order to avoid them, the strained crude oil must be protected from exposure to sources of contaminations. Moreover, a quick response indicator must be fitted to signal a drop in the throughput of the nozzles. Such an indicator may consist of the bell controlled by the time of filling the recording basculators. The inertia of such a system is low since it is at worst equal to the time taken for one of the basculator compartments to fill up. At Mongana, the time to fill up one section was 40 s when operating the centrifuge at 5.4 t hr^{-1}. The clogging of one of the nozzles was therefore detected by the increase in the time required to fill up one compartment (48 s).

A number of problems specific to the machine have still to be studied. Among these:

- reason for the sudden emulsifications of some oil;
- effect on oil removal of plates with perforations close to the centre (lengthening of the zone of oil extraction);
- gurgling sounds detected in the bowl; and
- slow and recurring variations of the machine capacity.

A flow meter was fitted on the upper water pipe and a tachometer was also provided. They were not standard equipments but were however, necessary to maintain efficient control of the machine. The centrifuge can be converted into a purifier by increasing its speed of revolution, charging the plates and reversing the direction of the pumps. Difficulties are experienced however as a result of these modifications.

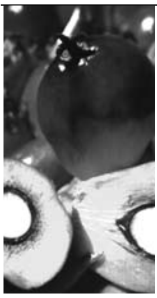
The Star-rotor Sludge Centrifuge (Stork)

This machine discharges effluent continuously as the previous centrifuge but operates without a pump. The evacuation of oil from the bowl is controlled through a valve placed on the outlet pipe located at the centre of the bowl. Its disadvantage compared to the previous machine is to yield oil containing more moisture and more impurities (several percentage units against 0.7% moisture and less than 0.01% impurities); also the absence of a regulator of the oil water interface. It may happen therefore that through the throttling of the oil discharge, the bowl fills up with oil and the latter is eventually discharged through the nozzles. The machine is particularly adapted to the treatment of sludge or oily water. No make-up water is required. The water content of sludge is high enough. Its efficiency of separation is slightly lower than that of bowl and plate centrifuges.

Compared to the intermittent discharge centrifuge (Titan), these machines offer the advantage of being rugged, continuous and less prone to wear. Its operation requires only limited supervision. The very principle on which it is designed precludes its utilization as a purifier.

Settling Characteristics of Crude Oil that is Study of the δ-Coefficient

Clarification losses occur in the sediments trapped in the centrifuge bowl and in solids of the discharged effluent. In both cases, the loss consist of the free oil, which can be recovered and of the 'oil bound to the NOS'. Methods are evolved to assess them separately. They consist in the prolonged centrifugation in a laboratory machine of the material to be analysed. They made it possible to evaluate also the γ-coefficient or the centrifuge efficiency. The latter is solely governed by the amount of free oil lost since



the amount of oil bound to the NOS is practically constant.

The efficiencies of three different types of centrifuges were determined and was found to the close to 1 or at any rate higher than 0.99. The δ-coefficient or the settling characteristics was determined in the case of the oil derived from various types of fruit processed according to various extraction techniques.

The settling characteristics are not constant. They are governed by the NOS content of the crude oil and by the composition of the NOS. In the best possible conditions, cellular debris are likely to retain 15% to 25% of oil, whereas the oil content of the insoluble constituents of the NOS (fibre for instance) can be brought down to approximately 10%. As regards the water soluble constituents of the NOS (pectin for instance), their oil content after centrifugation is close to nil.

As has been mentioned before, half of the constituents of the NOS are soluble in water or at least can be solubilized. The amount of oil bound to the NOS is therefore close to 10%. The settling capacity can therefore be established by calculation. Its reliance has been established experimentally.

Purification

It consists in removing traces of impurity and a few tenths of percentage unit of water still present in oil after static settling or centrifugal separation. Four different machines were tested, three with bowl and plates revolving at 6000 rpm (de Laval, Titar, Melotte) and one with a spindle shaped bowl revolving at 15 000 rpm (Sharples).

The separation of the solids is equally effective in any of these four machines with an output ranging from 350 to 3500 kg of oil per hour. A slightly brighter oil appears to be derived from the machine with plateless bowl in which accelerations higher than 10 000 g are applied.

The chief difference between the machines is the amount of solids that can be retained in the bowl and the eventual dehydration that may occur therein.

Two of the centrifuges can hold 2 kg of wet sediments, *i.e,* 0.4 kg of dry solids in the bowl (Melotte and Sharples). These two machines do not permit direct dehydration. The other two provide for dehydration, the first through the natural air draught created by the rotation of the bowl and the second through provision of fan since natural ventilation is not sufficient. The advantage of the latter machine is to eject the sediments automatically through the operation of a suitable valve (Titan).

All these centrifuges yield purified oil containing less than 0.01% impurities, which is the detection limit of the standard determination procedure and less than 0.35% of water. The moisture content can be reduced to about 0.05%, if the centrifuges are used at low throughput.

DEGUMMING

It is a well-known fact that crude oil contains substances of a complex nature, which are soluble or at least dispersible in freshly produced oil but which precipitate under certain conditions, particularly through ageing of the wet oil. These substances are described in the palm oil industry as mucilage. They consist mainly of phosphatides. Some oils (soyabean oil for instance) contain exceptionally high amounts of mucilage. Before use, they should be suitably treated in order to remove them. The mucilage content of palm oil is very low, hardly more than a few hundredth of a percent. A number of users of palm oil have however, complained about the deposit found in oil which they regard as just another impurity similar to sand, fibre and organic debris, which are normally present in the oil.

Carefully controlled shipments of oil, in which strict conditions of cleanliness were achieved, failed to induce a marked

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improvement. In the course of storage and transport, precipitates materialized at the bottom of the land or ship tanks.

These precipitates are described as impurities of maturation. Users of palm oil eliminate mucilage in the course of the alkaline refining in the case of utilization as a basic material for margarine production or by treatment with surfactants in the case of industrial utilization (metallurgy and plating).

An attempt was made to separate the impurities of maturation into basic constituents. The oil was mixed with water at a high temperature (90°C). The resulting substance consisted mainly of soap. *Table 3* gives the relevant information.

Industrial techniques of mucilage removal (degumming) are numerous. They are covered by a number of patents (30, 31, 32).

The industrial techniques can be classified as follows:

- degumming by alkaline treatment;
- degumming by acid treatment;
- degumming by organic and mineral salts;
- degumming by absorption;
- degumming by physical methods (ultrafiltration, passage through an electric field); and
- degumming by aqueous treatment.

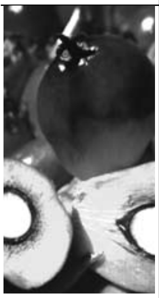
The last of the above methods was implemented at industrial scale at Mongana although to our knowledge it has never been used for palm oil before.

This involves the following steps:

- precipitation of the mucilages by aqueous treatment;
- separation of the precipitate and possible; and
- the purification of the precipitate.

TABLE 3. IMPURITIES OF MATURATION

			%
100%	Ether extract 13.85%	FFA	1.51
		Soap expressed in g for 100 g of FFA (molecular weight 256)	2.92
		Nitrogen: 0.53% as proteins	3.44
		Phosphorous	0.11
		Ash	3.01
			10.99
	Extraction residue 86.15%	Soap expressed in g for 100 g of FFA (molecular weight 256)	38.4
		Not readily hydrolysable soap	4.5
		Ash 30.9% FeO_3	9.10
		SiO_2	3.51
		CaO	0.60
		MgO	0.00
		Residue	17.69



Dry mucilage dissolve or are dispersible in oil. They swell under the effect of moisture absorption and form substances, which agglomerate and become insoluble in oil. As a result of the high moisture content, their density is higher than that of oil.

Mucilage can be made to absorb moisture through the following processes:

- intimate mixing of purified oil with water;
- addition of water during the centrifugal extraction of the digested mash;
- centrifugation of oil coupled with addition of water in the machine using a suitable gravity disc;
- steam injection using an ejecto-mixer; and
- centrifugal straining of a water and oil mixture through a fine strainer.

Several of the above methods are continuous.

The time of contact between oil and water varies from one process to another. Strict control of temperature must be achieved failing which the hydrated mucilage can re-disperse in the oil.

The separation of the precipitate can be made by static settling or better still and quicker by centrifugation. In that case, the precipitate can either be retained in the centrifuge bowl or eliminated together with excess treatment water. The raw mucilage can be partially dehydrated by centrifugation.

Unlike some vegetable mucilage, such as the lecithins of soyabean and groundnut, those of palm oil after exposure to air and are not hydroscopic. They consist of waxy white coloured powder, which keeps indefinitely.

Degumming modifies the physical properties of palm oil, particularly as regards the characteristics of solidification. It does not seem to affect bleachability but leads to markedly lower Wesson loss. It may quite possibly to have an effect on the oil resistance to oxidation and consequently in an indirect manner on bleachability. It should be noted that the drying of oil to less than 0.1% moisture as is required to avoid acidification totally prevents the separation of maturation impurities.

CLARIFICATION OF SCREW PRESS CRUDE OIL

The clarification is organized according to the process flow in a palm oil mill. Crude oil is collected in a tank where dilution with hot water takes place. Dilution is continuous and can be controlled by an appropriate equipment (double tank basculator). The diluted crude oil is brought to boiling point by live steam injection. It is then strained through a 20 mesh rotary screen (3000 rpm). The strained material is then fed into a large capacity sand cyclone and recycled from two to three times through it with the overflow returned to the strained oil receiving tank. That tank is provided with steam injection. All steam injectors are equipped with a silencer, which reduced noise and also vibrations.

The diluted crude oil is centrifuged in a bowl and plates centrifuge with continuous discharge of the solids. The make-up water is provided by a constant level tank fitted with a heat exchanger controlled by a thermostatic steam valve. The amount of effluent discharged by the machine is recorded by a basculator. The amount of make-up water is measured by a flow-meter of the mercury column type.

The instantaneous throughput of the crude oil is therefore known at all times. Clarified oil is collected in a calibrated tank. It is then heated up by a thermostatically controlled device and passed through a centrifugal purifier and finally to a drier after which it is pumped into the storage tank.

Clarification and purification are completely automatic and continuous and only require supervisory labour.