Feature Article

Mongana Basics: Part 10–Clarification of Crude Oil

N Ravi Menon*

Whatever the process used, crude oil must be refined. The complete refining of oil consists of the following operations:

- separation of solid impurities that is impurities not soluble in oil;
- separation of free water;
- partial separation of dissolved moisture that is dehydration or drying;
- de-gumming;
- separation of free fatty acids or neutralization;
- separation, reduction or destruction of pigments, that is bleaching; and
- separation, reduction of destruction of volatile compounds affecting odour or taste that is deodorization.

Neutralization, bleaching and deodorization are really part of the refining process and are generally carried out by the user of oil and not by the producer. They were therefore not studied.

Separation of Solid Impurities

The separation is often carried out simultaneously with that of water. It can be achieved by:

- settling;
- screening;
- centrifugation; and
- filtering.

Settling

The speed of sedimentation is governed by the Stokes Law, which is applicable to particles of any dimension except those of colloidal dimension.

The law is as under:

$$V = \frac{g D^2 (d_2 - d_1)}{18 \eta}$$

where,

V = speed of sedimentation
g = acceleration of gravity (981 cm s^2)
D = diameter of the particles
d_1, d_2 = densities of the two media
η = viscosity of the medium

The equation shows that the final speed is directly proportional to the square of the particles diameter, to the difference in density of the particles and that of the medium and inversely proportional to the viscosity of the medium with all units expressed in the c.g.s system.

* *Malaysian Palm Oil Board,*
P. O. Box 10620,
50720 Kuala Lumpur, Malaysia.

The largest solid impurities to be separated are the fibre. The cellular debris is the smallest. The length of the cell ranges from 20 to 100 microns. The width is approximately 20 microns. Calcium oxalate crystals are approximately 100 microns long often grouped into bundles of a large number of needles. The viscosity of oil is shown in *Figure 1.*

The density of fibre and cellular debris is equal or higher than 1 and sometimes is as high as 1.4. The diameter of the particles ranges from a few microns to several millimeters. The approximate density of oil is given in *Table 1.*

The equation shows that all other conditions being equal, the settling rate at 100°C is twice as high as that at 70°C and 3.5 as high as that at 50°C.

For 20 microns particles, the equation gives a settling time of 5 hr for a distance of 1 m and a temperature of 80°C. The speed of sedimentation is slowed down by convection currents in the settling tanks. These currents can be minimized by the lagging of the tanks.

The proportion of water and impurities in crude oil derived from the various extraction processes is extremely variable as shown in *Table 1.*

By measuring in identical containers, the height of oil separated in relation to the total amount of oil, the relative settling rate was determined; the results are given in

TABLE 1. APPROXIMATE DENSITY OF OIL AGAINST TEMPERATURE

Temperature (°C)	Density
20	0.925 – 0.935
30	0.910 – 0.920
40	0.900
50	0.890
60	0.883
70	0.876
80	0.869
90	0.863
100	0.857

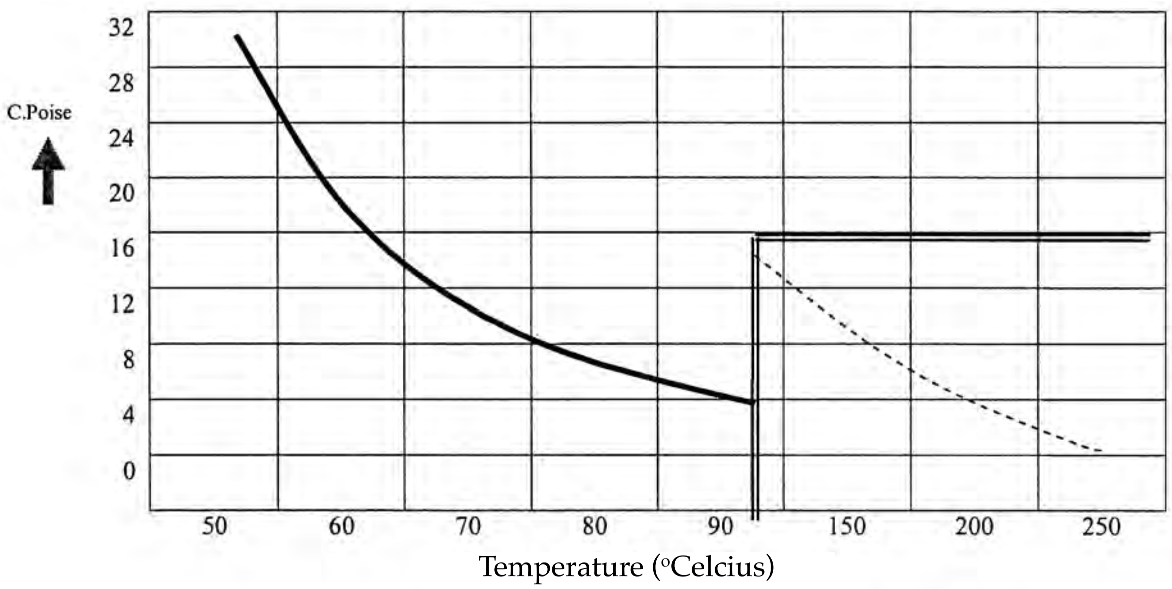

Figure 1. Effect of crude oil temperature on viscosity.

the last column of *Table 2*. The procedure is not very accurate. Moreover, in the case of crude oil from continuous presses, a number of factors affect the rate of settling, particularly screening, which improves separation, boiling, dilution *etc.* This question has been studied in detail.

SETTLING OF SCREW PRESS CRUDE OIL

It should be stated again that in the continuous pressing process, approximately three-quarter of the pericarp find their way into the crude oil. In other words, the production of 1 t of clean oil by that process implies the removal of oil from approximately 150 kg of dry solids derived from the crude oil (30 to 40 kg in the case of oil from the centrifugal extraction process).

Dilution of Crude Oil

Dilution of crude oil greatly affects settling. The study of the settling of press crude oil in relation to dilution shows that the rate of separation is highest for the undiluted crude oil that it slows down for a 50% dilution then increases again if dilution is further increased. From that point, the rate of settling appears to remain constant.

A close relationship seems to exist between the viscosity of crude oil and rate of settling. The variations in the viscosity of crude oil are plotted in *Figure 2.*

TABLE 2. COMPOSITION OF CRUDE OIL

Extraction process	% Oil		% Water		% NOS		Rate of settling in arbitrary nuts
	Range	Average	Range	Average	Range	Average	
Centrifuge	70 – 90	80	10 – 25	17	1 – 4	3	8.5
Press	65 – 90	75	10 – 30	20	3 – 6	5	7.5
Screw press	40 – 75	66	10 – 40	24	6 – 25	10	0.5
Wet extraction	10 – 25	16	70 – 85	-	3 – 7	-	2.0

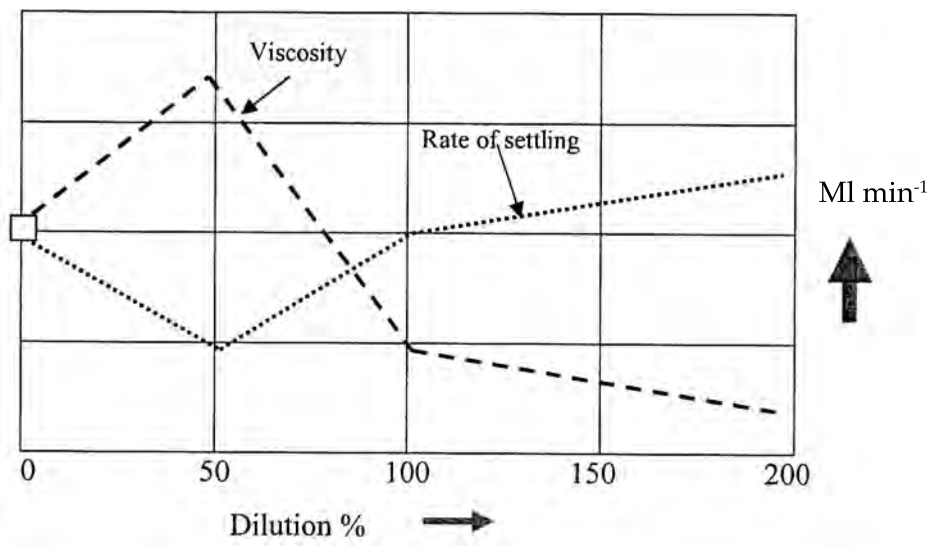

Figure 2. Dilution rate and rate of separation of crude oil.

What explanation can be found for the marked variations (increase then decrease) in crude oil viscosity as a result of water addition? The centrifuging of press crude oil in a laboratory centrifuge gives some insight into the problem.

After a sufficiently long time of centrifugation, a supernatant layer of clarified oil and a plug of sediments can be observed. If the same treatment is applied to the crude oil from centrifuges, three components and not two as before can be seen. A third one, water occupies a portion of the tube between the oil and the sediments. It may be concluded that in the crude oil from centrifuges there is an excess of water over that of the saturated sediments, whereas in the case of press crude oil, the sediments are at the most saturated without excess of water.

Referring to the data in *Table 2*. It can be noted that the ratio of NOS to the water in centrifuge and press crude oil is 3 to 17 and 10 to 24 or 25 respectively that is 1/5.6 and 1/2.4. The ratio of water to sediments is therefore higher for centrifuge crude oil.

In order to increase that ratio in the press crude oil, let us add 10%, 20%, 100% and 200% of water for instance. The centrifugation of the diluted samples shows that when dilution reaches 50%, that is when 50 parts of water have been added to 100 parts of crude oil, a middle layer of water starts forming between the supernatant oil and the sediments. At that point, the sediments are saturated with water containing five times (centrifuge) and seven times (press) their weight of water.

At the beginning of dilution, the sediments absorb water (increase in viscosity and decrease in rate of settling). When they are saturated, the rate of settling increases (increase in density, decrease in the viscosity of the sediments and of the medium).

It has been further observed that in the case of dilution close to saturation, the viscosity continues to increase up to certain limit in the course of heating. It may be inferred therefrom that water absorption or swelling is probably not an instantaneous reaction.

It may be added at this stage that sterilized fruit (dry or wet) also absorb water under the pressure existing in the digester. At Mongana, contrary to some assertions, the addition of water into the digester (up to 150 kg of water per tonne of fruit) has never been observed to induce a flow of sludge.

The dilution of crude oil appears to decrease the stability of the suspension of impurities in the oil-water mixture. In the case of static separation, the aim is to speed up sedimentation but for the centrifugation of crude oil, it is advantageous to maintain the maximum amounts of solids in suspension (vide experiments on increasing stability through addition of carboxy-methylcellulose).

The fact that extensive dilution of crude oil decrease the stability of the suspension can be explained by changes in superficial (or inter-facial) tension and by the exchange of electric charges with the water contained in the fruit. The latter water is highly laden with protective colloids.

As stated in the preceding section, static separation of press crude oil does not lead to satisfactory recovery of oil from the sludge. The process could not therefore be used industrially. However, it is probably possible to recover a large amount of oil from the settled crude oil and then centrifuge the sludge.

A diagram of static separation of boiled undiluted press crude oil in a 200-litre vertical tank made of plexiglass is in *Figure 3* and *Table 3.*

TABLE 3. STATIC SEPARATION OF UNDILUTED PRESS CRUDE OIL

Time	% Oil	Differential
5	13	13
10	21	8
15	25	4
20	28	3
25	31	3
30	33	2
40	35	2
60	35	0
80	35.4	0.4

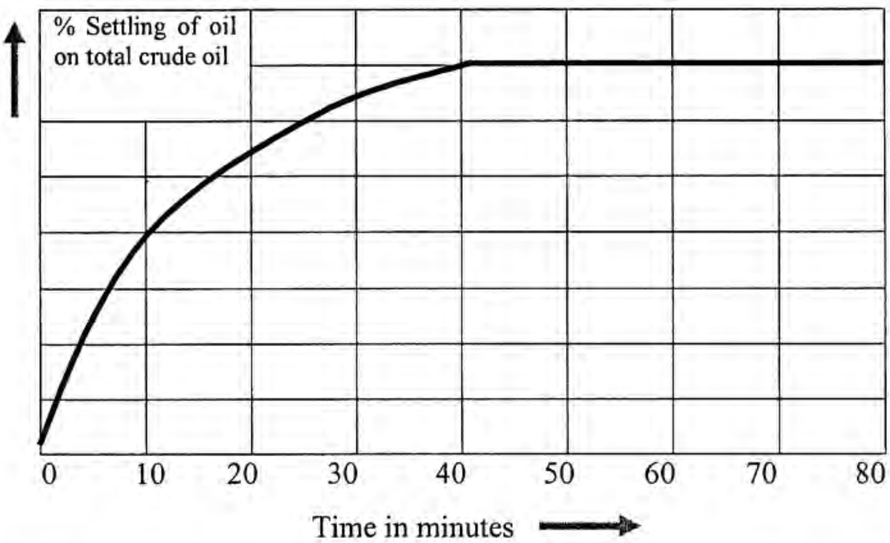

Figure 3. Static dilution of undiluted press crude oil.

Figure 3 show that after 40 min, almost all the oil that can be separated has come up to the surface. At the point, there remains 65% of homogeneous sludge. After dilution of that sludge with an equal volume of water and a period of rest of 12 hr, oil to the extent of 2.5% of the initial amount is recoverable at the surface. The secondary sludge contains the following:

- 16.5% oil in the top portion;
- 9.0% oil in the middle portion; and
- 8.0% oil in the bottom portion.

A further period of settling does not lead to the recovery of additional oil. Further dilution has practically no effect. This confirms the statement made previously. Approximately 70% to 75% of the oil settles quite easily but the balance of 25% cannot be separated by dilution and static settling.

The static separation of screw press crude oil does not present much practical interest. By contrast, continuous settling possesses numerous advantages. For this reason, it was tried industrially as an experiment and was studied in the pilot plant. In the trial at industrial scale, the crude oil subjected to settling was a mixture derived from a continuous press of 14 t bunch per hour capacity and centrifuges (Bosondjo).

The separation of crude oil was carried out in a 5 m^3 settling tank. The crude oil was produced by the press working at 67% of its capacity and from two to four basket centrifuges of 1.2 m diameter. Settling proceeds at normal rate for about 4 hr. At that point, sediments find their way into the decanted oil. It is thus necessary to stop the crude feed for about 4 hr approximately. That installation operated for several weeks. It made it possible to establish the following. A settling tank of 5 m^3 is not sufficient to separate effectively the crude oil output of a 12 to 14 t capacity press. The tank volume must be at least doubled. The oil layer in the settling tank (adjustable by the height of the skimmer) must be thicker than that selected for the decantation of centrifuge crude oil. It is not important to remove the sludge but the separated oil should not contain more than traces of impurities. The sludge containing approximately 10% of oil and 5% of non-oily solids does not settle further. Finally, the NOS content of sludge is virtually the same for the top and the bottom portions.

This last observation indicates that the removal of sand from Colin press crude oil diluted with an equal volume of water is not possible by static settling.