NATURE OF OIL IN SLUDGE DISCHARGE

Introduction

The recent decline in Oil Extraction Rate (OER) was attributed to be caused by a multitude of factors. They range from uncontrollable factors like climate to aging of palms, field management and finally to inefficient milling process. Many of these factors are beyond the control of the mill engineers, the chief responsibility of the mill engineer lies in getting the maximum amount of oil from the incoming fresh fruit bunches (FFB).

The oil loss is computed based on the oil losses from the various sources of discharges from the mill. They are the empty bunches, fibres, steriliser condensate and sludge discharge. Normally in the mill, as long as the oil loss in the respective streams is within the limit laid out by management the oil loss is acceptable.

Oil in Sludge

Conventionally the oil content from the sludge has been determined by drying the sludge and Soxhlet extracting it with hexane/petroleum spirit.

In this exhaustive extraction which is carried out at 60°C for many hours or overnight all organic compounds that is soluble in the chosen solvent will be extracted. These possibly include much volatiles, wax esters and indigenous components of the palm fruits which should not be classified as palm oil; which fortunately is not extracted in quantity together with the crude palm oil in the milling process; otherwise refining would be extremely difficult!

Nature of Oil in Sludge

Under the optical microscope, it can be seen that sludge contains a lot of free oil droplets, plant cells either containing oil or no oil and cellular debris (*Fig 1*). The free oil droplets vary in diameter from 2 to 14 µm, with a mean of 4 µm. Laboratory study indicated that these minute oil droplets can only be separated from the water and solids by high speed centrifugation of at least 7,600G. Even then these oil droplets are very stable. They do not coalesce to form a homogenous layer of oil. The surfaces of these droplets are possibly covered by surface active compounds.

The plant cells are irregular but mainly ellipsoidal in shape. Only some of these cells contain oil. These oil droplets inside the oil cells are much larger than the free oil droplets with diameter ranging from 5-80 µm with a mean of 25 µm. Mechanical shearing, freezing followed by pounding, high speed centrifugation, or extreme pH were not able to efficiently rupture the cellular cell wall. The cellulosic cell wall is easily ruptured by a cellulase enzyme but the fine oil droplets do not separate out from the solid when centrifuged (*Fig. 2*). A detergent wash

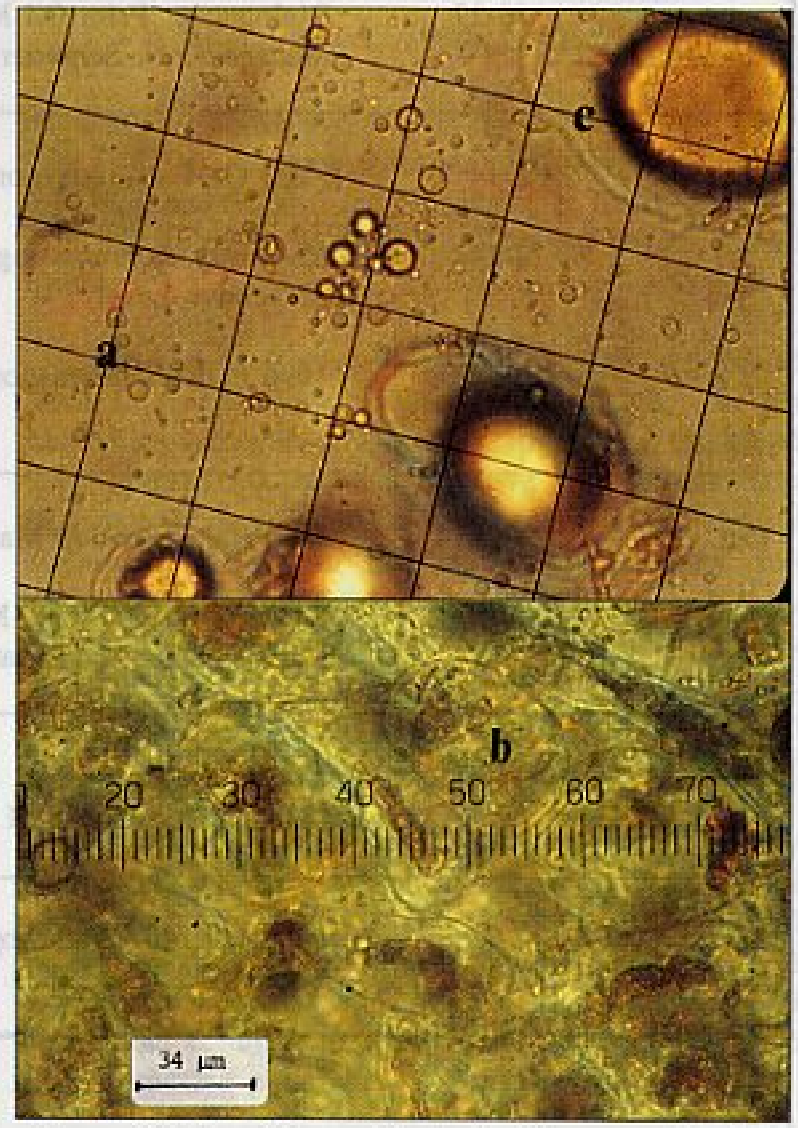

Figure 1. Sludge Observed Under the Microscope Showing a) Free Oil Droplets b) Plant Cells c) Plant Cell Containing Oil

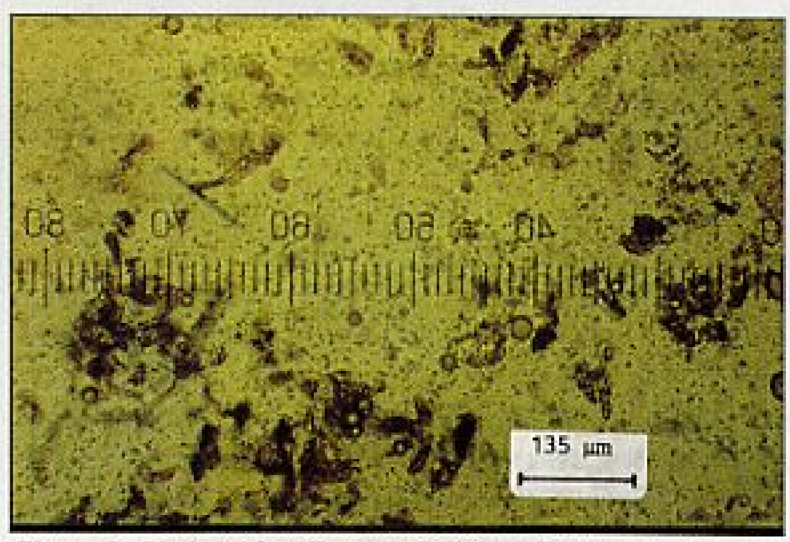

Figure 2. Sludge After Enzyme Cellulase Treatment. Note the Absence of Cell Wall but Oil droplets Enmeshed in the Cytoplasm of the Plant Cells.

followed by centrifugation was necessary to separate the oil droplets from the ruptured cells. No more oil droplet is observed in the residual cellular debris after cellulase treatment, detergent wash and centrifugation (*Fig. 3*). But on Soxhlet extraction of the solids more oil was recovered. This showed that some oil is absorbed by the cellular debris.

Thus by the procedure described, oil in the sludge can be classified into 3 types according to the procedure in which it can be separated. They are:-

Type I. Free Oil Droplets which can be separated by centrifugation at high centrifugal force.

Type II. Oil in cells which can be separated by centrifugation after cellulase treatment followed by a detergent wash.

Type III. Residual oil absorbed in the cellular debris which can be extracted by Soxhlet extraction.

With the present milling process using centrifuges or separators at a G-force of approx. 2,000 G, extremely small oil droplet would not separate out. Oil in cells and oil absorbed in the cellular debris will not be separated easily in the clarification station by mild mechanical shearing and high temperature treatment.

A comparison of the sludge discharged from the stack disc nozzle separator and star shaped nozzle centrifuge indicated that oil in the sludge is similar in nature but compositionally different. (*Tables 1 and 2*).

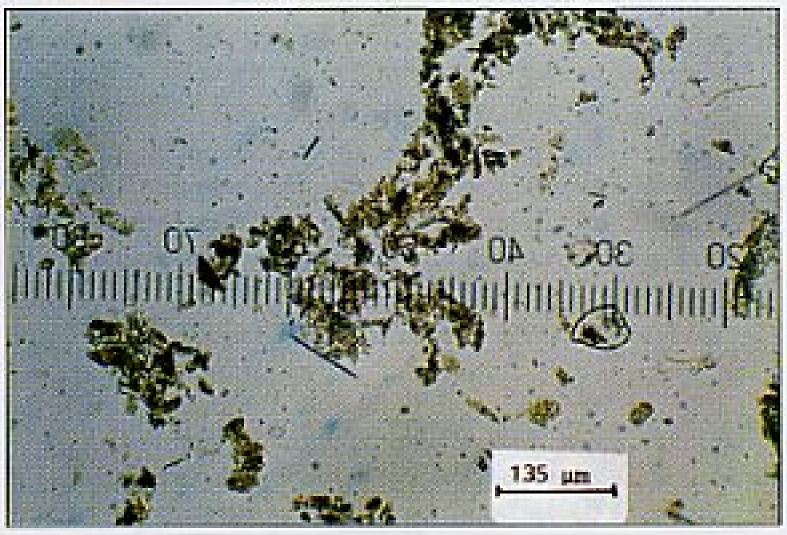

Figure 3. A Centrifuged Sample of the Residual Cellular Debris after Cellulase and Detergent Wash of the Sludge Oil Droplet is Absent.

TABLE 1. OIL CONTENT AND TYPE OF OIL FROM NOZZLE STACK DISC SEPARATOR

	Oil Content		Non Oil	Moisture	Oil Type		
	Dried basis (%)	Wet Basis (%)	Solids (%)	(%)	Type I wt. (%)	Type II wt. (%)	Type III wt. (%)
Range	13.1-17.3	0.95-1.38	5.1-7.1	91.9-93.9	29-47	21-50	15-46
Mean	15.4	1.1	6.3	92.0	35	39	26

TABLE 2. OIL CONTENT AND NATURAL OF OIL FROM STAR SHAPED NOZZLE CENTRIFUGE

	Oil Content		Non Oil	Moisture	Oil Type		
	Dried basis (%)	Wet Basis (%)	Solids (%)	(%)	Type I wt. (%)	Type II wt. (%)	Type III wt. (%)
Range	12.3-18.5	0.80-1.39	5.7-6.5	92.5-93.5	14-39	13-39	41-61
Mean	14.3	1.1	6.1	92.8	22	25	53

The compositional difference of the sludge discharged is due to the operational factors of the separator/centrifuge which can be adjusted. In the machines, it is not possible to distinctly separate the aqueous phase from the oil phase and thus much oil cells and bigger oil droplets are separated out as the 'recycle' back to the clarification tank; while the aqueous phase which consists of smaller oil droplets and plant cells of relatively higher density is discharged as sludge.

(Contributed by Chow Mee Chin of PORIM)

Conclusion

From the characteristics of the nature of the oil in the sludge, oil loss via the sludge is inevitable in the present milling process. A detailed characterization of the nature of oil in the sludge would be useful in assessing the efficiency of the separator/centrifuge used. If very large oil droplets or a high number of oil cells are present in the sludge, the oil loss would be high. These could possibly be due to improper milling practise or nature of the FFB.