Some Variables Affecting the Performance of Screw Press Systems in Palm Oil Mills

K Sivasothy *

RINGKASAN

Kesan pembolehubah-pembolehubah seperti keadaan tanaman, tahap buah sawit di dalam percerna, suhu, saliran dari pencerna dan kelajuan "Feedscrew" terhadap sistem tekanan skru dilaporkan di dalam rencana.

INTRODUCTION

The screw press system is one of the least understood processes in a palm oil mill even though it is one of the most important. Its performance is thought to be affected by a number of designs as well as process variables, some of which are listed in *Table 1.* Unfortunately, quantitative understanding of the effect of these variables on oil loss and nut breakage is almost non-existent. This is partly attributable to the fact that important variables such as crop condition cannot be easily quantified. The performance of the screw press is also affected by its wear and tear. Hence, almost no progress in the quantitative understanding of screw presses has been achieved even though they have been used in palm oil mills for about fifty years.

Without doubt, the most important variable is the pressure being applied to the digested mash in the screw press. Direct measurement of pressure is not possible, but various control schemes have evolved to regulate the pressure during pressing using indirect measurements. Control is achieved by adjusting either the position of the cones at the discharge end of the screw press or the feedscrew speed. The feedscrew speed controls the feed rate to the screw press. *Figure 1* is a plot of the oil content in press fibre over a period of 2 hours. Samples were drawn at 2-minute intervals from a Stork screw press where a kiloWatt meter was used to sense the power required to turn the main screws and control achieved by adjusting the position of the cones. It can be observed that the fluctuations in the oil content were quite large even though the power consumption remained the same.

This paper will examine some of the other parameters which are known to have an effect on the performance of the screw press.

METHODOLOGY

In general, the effect of variables such as temperature, level of fruits in the digester, *etc.* was studied by intensive monitoring of the performance of the screw press for a period of one hour before and after the introduction of a step change in the variable being studied, while all other controllable variables were held reasonably constant at their normal operating values.

The effect of sampling point and crop condition was studied by monitoring the performance of screw press systems without introducing any changes.

**PORIM*
No. 6, Persiaran Institusi
43650 Bandar Baru Bangi, Selangor, Malaysia

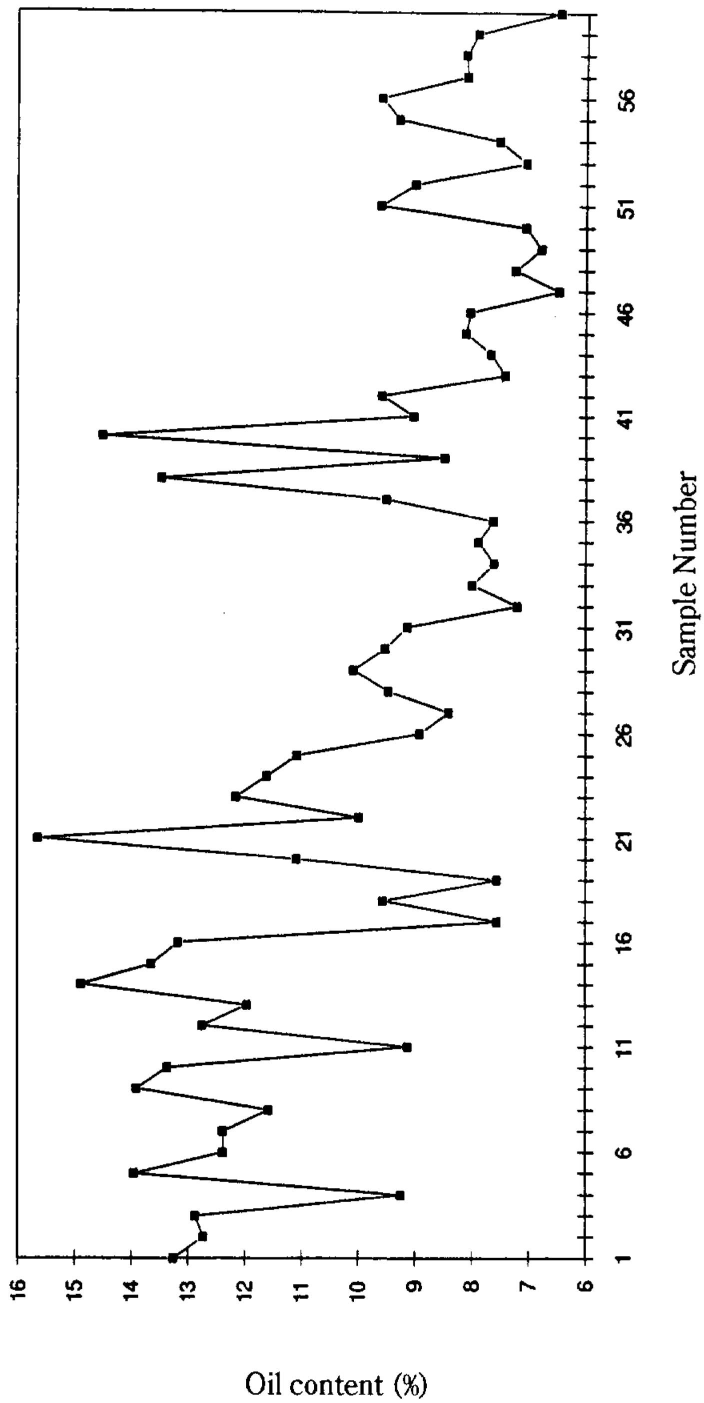

Figure 1. Plot of Oil Content in Press Fibre Over aTwo-Hour Period (dry basis).

Difficulties were faced in controlling some parameters such as temperature, but fluctuations were mostly quite small and are not expected to have a significant impact on the results.

No attempt was made to control the condition of the crop being processed due to difficulties in trying to do this on a large scale.

The output variables monitored were oil content in the press fibre and the percentage of broken nuts in the press cake. In some cases, the throughput was calculated by weighing the amount of press cake discharged over a timed interval.

Samples were taken every two minutes and the samples collected over 10 minutes were bulked and sub-sampled for analysis. Duplicate analysis of oil content in the fibre was carried out using a Fosslet Analyser. Only the average values of each parameter for the run before and after the introduction of a step change are reported.

POINTS OF SAMPLING

Samples were collected from the top, bottom and the sides of the discharge cones for analysis. Two types of twin screw press systems were examined. In the Stork screw press the screws were arranged on a vertical centre line, whereas in the Usine DeWecker press the screws were arranged on a horizontal centre line. In the case of the Stork press (*Figure 2*), the oil content in samples taken from the top was found to be consistently lower. In the case of the DeWecker press (*Figure 3*), no systematic trends could be detected.

The above results highlight the importance of proper sampling when analysing the performance of screw press systems, especially in the case of Stork presses. It is generally advisable to collect samples from all sides of the discharge cones and the bulked sample must be thoroughly mixed before sub-sampling for analysis.

CROP CONDITION

Figures 4 and *5* show the performance of two Stork screw press systems which were operating in parallel. Even though the oil losses are different, trending characteristics of both

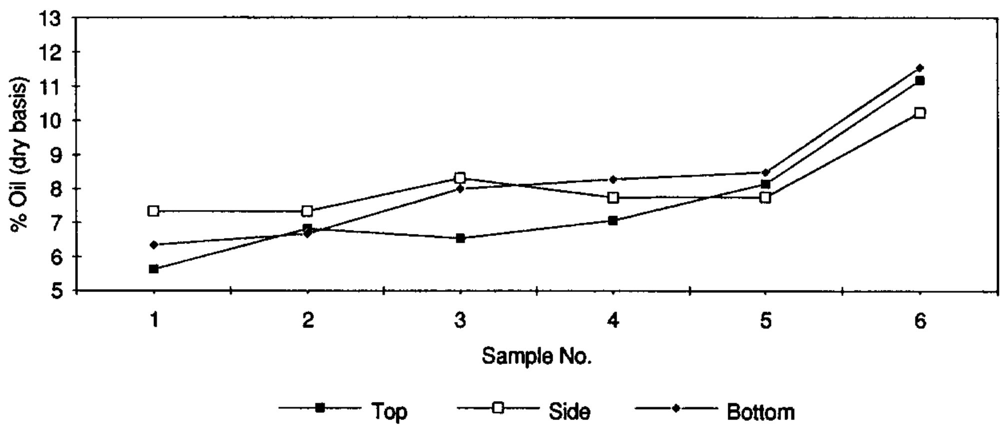

Figure 2. Effect of Point of Sampling on Oil Content in Fibre (Stork Press).

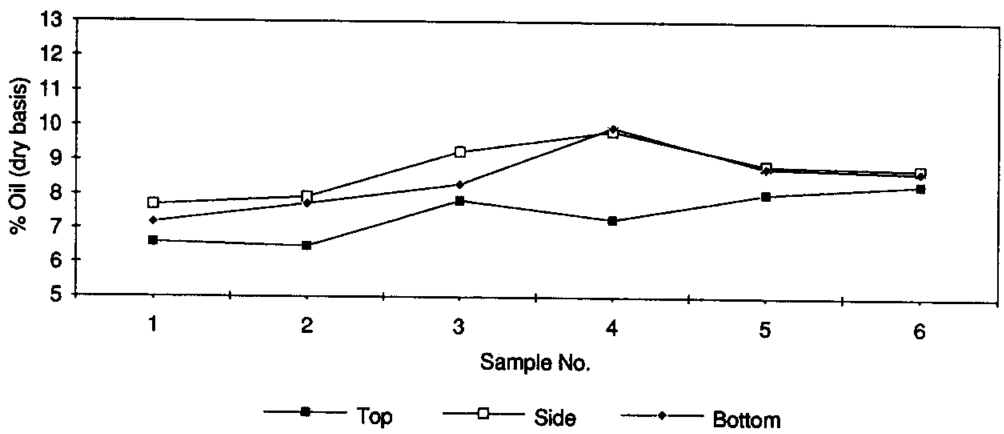

Figure 3. Effect of Point of Sampling on Oil Content in Fibre (Usine DeWecker Press).

presses are quite identical. This is most likely due to common characteristics of the crop being processed. Unfortunately, no simple measurements could be used to characterize the crop. Factors such as bunch ripeness, the time delay between harvesting and sterilization, contamination with sand and stones, nut/fibre ratios, *etc.* are probably important.

It was often observed that there is a reasonably good correlation between residual oil content and residual moisture content in the pressed fibre (*Figure 6*). This is probably because the factors responsible for high oil content are also responsible for high moisture content since pressing squeezes out both oil and water from the digested mash.

That crop condition can have a significant impact on oil losses is evident from the wide fluctuations in oil content observed in *Figures 4* and *5*.

LEVEL OF FRUITS IN DIGESTER

Two Stork screw press systems incorporating identical digesters were studied. The main difference between the two digesters was that the stirring arms and baffle plates in one of the digesters had been recently changed. In the other digester, the baffle plates were completely worn off and the stirring arms had become significantly shortened by wear and tear.

The performance of both presses was monitored for one hour with the level of fruits in the digester maintained at the maximum level and for another hour with the level of fruits maintained at half the maximum level.

Tables 2 and *3* summarize the results of the study and show that a significant overlapping of results occurs if the stirring arms and baffle plates are in good condition. The difference in mean values is not significant (*Table 4*), and this shows that the screw press can tolerate digester level fluctuations between the maximum and half the maximum level without deterioration in performance if stirring conditions are good.

However there is a significant difference in oil loss if the stirring conditions are poor. Digester level fluctuations are therefore more critical than in the first case.

TABLE 1. SOME VARIABLES AFFECTING SCREW PRESS OPERATION

1. Digester parameters:
   - Temperature
   - Level
   - Digester drainage

2. Press parameters:
   - Feedscrew speed
   - Main screw speed
   - Cone pressure

3. Raw material
   - Delay between harvesting and processing
   - Degree of ripeness
   - Fibre/Nut ratio
   - Contamination with sand and stones

4. Sterilization
   - Length of sterilization cycle
   - Type of sterilization cycle
   - Delay between sterilization and threshing

TABLE 2 . EFFECT OF LEVEL IN DIGESTER
(stirrer arms and baffles plates in good condition)

Run	Digester current (Amps)		% Oil content in press fibre (dry basis)		% broken nuts (on total nuts)	
	Full	Half	Full	Half	Full	Half
1	2.92	24.5	5.76	7.27	13.53	9.91
2	29.7	24.0	6.97	6.33	20.21	14.46
3	29.2	23.3	7.32	6.89	11.81	11.15
4	29.0	24.2	12.24	12.46	1.93	1.99
5	29.3	23.7	12.79	11.03	7.05	8.99
6	30.5	23.8	8.59	10.37	13.80	10.34
7	28.2	23.7	11.62	10.27	10.89	9.51
8	27.2	24.2	11.13	9.29	8.21	16.01
Av.	29.0	23.9	9.55	9.24	10.93	10.29

TABLE 3. EFFECT LEVEL IN DIGESTER (stirrer arms and baffle plates in poor condition)

Run No.	Digester Current (Amps)		% oil content in press fibre (dry basis)		% broken nuts (on total nuts)	
	Full	Half	Full	Half	Full	Half
1	27.2	26.0	7.74	8.48	28.82	18.24
2	26.8	25.8	8.56	8.88	12.46	12.38
3	27.8	26.2	8.51	8.46	17.51	22.99
4	28.2	26.0	7.34	9.06	32.98	13.98
5	29.5	26.0	9.20	9.94	24.20	15.33
6	27.8	25.8	8.46	9.09	27.51	22.33
7	26.0	25.0	7.52	9.67	13.85	18.25
8.	26.8	25.8	9.97	10.62	8.21	10.17
9	27.3	26.5	9.82	9.99	11.98	11.61
10	30.0	29.8	8.30	10.11	13.43	10.58
11	30.8	30.8	10.29	7.60	20.09	36.32
Av.	28.0	26.7	8.70	9.26	19.19	17.47

TABLE 4. SUMMARY OF EFFECT OF LEVEL IN DIGESTER

	% oil content (dry basis) in press fibre Full	Half	Difference in means values	Significance of difference in mean at 95% confidence level based on signs test
Digester in good condition	9.55	9.23	0.32	Not significant
Digester in poor condition	8.70	9.26	0.56	Significant

TABLE 5. EFFECT OF TEMPERATURE

Run On	Temperature (deg c)		% oil content in press fibre (dry basis)		% broken nuts (on sample)	
	High temp	Low temp	High temp	Low temp	High temp	Low temp
1	96.3 7	87.7	10.13	10.69	9.39	14.8
2	99.7	75.2	12.15	12.65	5.31	8.44
3	100.8	85.2	14.69	10.90	4.79	7.52
4	100.8	87.5	10.28	9.33	7.61	12.45
5	100.8	91.3	12.65	10.40	5.58	6.94
Av.	99.7	85.4	11.98	10.79	6.54	10.03

TABLE 6. OVERNIGHT STERILIZED FFB VERSUS FRESHLY STERILIZED FFB

Run No.	Temperature (deg C)		% oil content in press fibre (dry basis)		% broken nuts (on total nuts)	
	Overnight	Fresh	Overnight	Fresh	Overnight	Fresh
1	–	–	9.59	9.28	16.93	8.43
2	–	–	9.31	9.46	16.79	16.58
3	87.9	92.3	12.12	10.42	5.66	6.73
4	84.7	92.2	7.94	9.13	15.69	8.37
5	88.3	91.7	7.84	9.13	15.69	8.72
6	73.0	78.8	11.91	12.02	6.63	10.27
Av.	83.5	88.8	9.79	9.89	12.89	9.85
S.D.	7.2	5.8	1.87	1.14	5.27	3.48

TABLE 7. EFFECT OF DIGESTER DRAINAGE (drainage versus no drainage)

Run No.	Digester current (Amps)		% oil content in press fibre (dry basis)		% broken nuts (on sample)	
	Drainage	No drainage	Drainage	No drainage	Drainage	No drainage
1	16.3	17.3	9.46	8.99	5.27	5.44
2	18.7	18.0	9.02	9.27	3.98	3.60
3	17.5	17.0	10.76	11.41	2.75	1.91
4	17.0	17.0	11.95	12.21	2.95	3.70
5	16.8	17.0	9.05	9.41	4.60	3.16
Av.	17.3	17.3	10.05	10.26	3.91	3.56

TABLE 8. EFFECT OF FEED SCREW SPEED

Run No.	Presscake through (tonne/ha)			% oil content in press (dry basis)			% broken nuts (on sample)		
	12 rpm	16 rpm	20 rpm	12 rpm	16 rpm	20 rpm	12 rpm	16 rpm	20 rpm
1	2.92	3.38	4.99	9.10	12.58	12.58	6.28	3.05	2.81
2	4.18	4.96	5.40	11.05	11.80	11.11	3.14	2.27	3.45
3	4.02	5.29	4.82	8.91	12.12	8.91	10.48	2.78	4.14
4	4.27	4.61	5.72	7.64	9.71	12.81	6.72	3.23	3.04
Av.	3.85	4.56	5.23	9.18	11.55	11.35	6.65	2.82	3.36

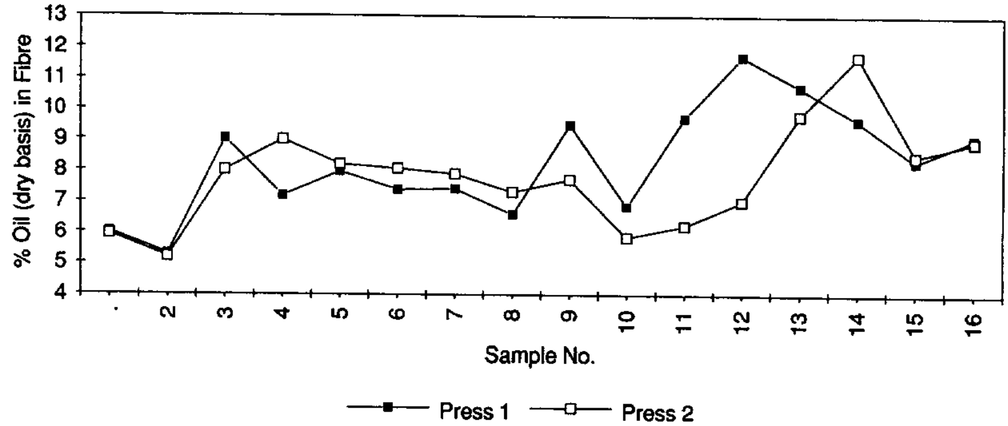

Figure 4. Comparison of Two Presses Operating in Parallel.

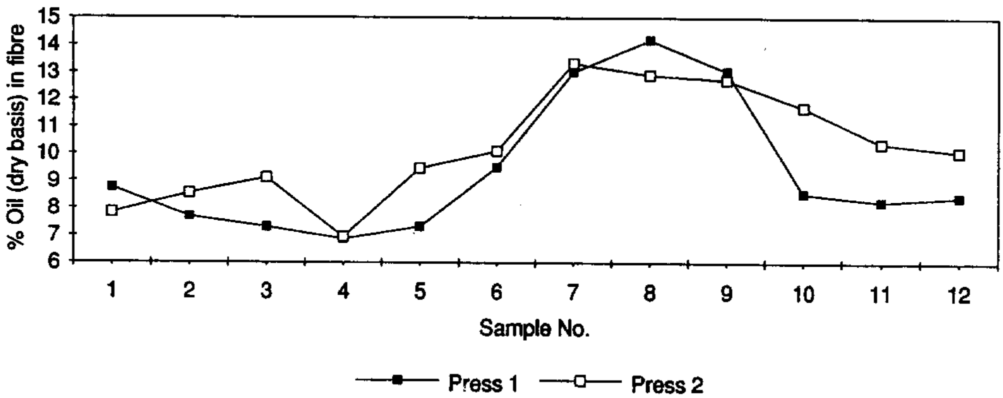

Figure 5. Comparison of Two Presses Operating in Parallel.

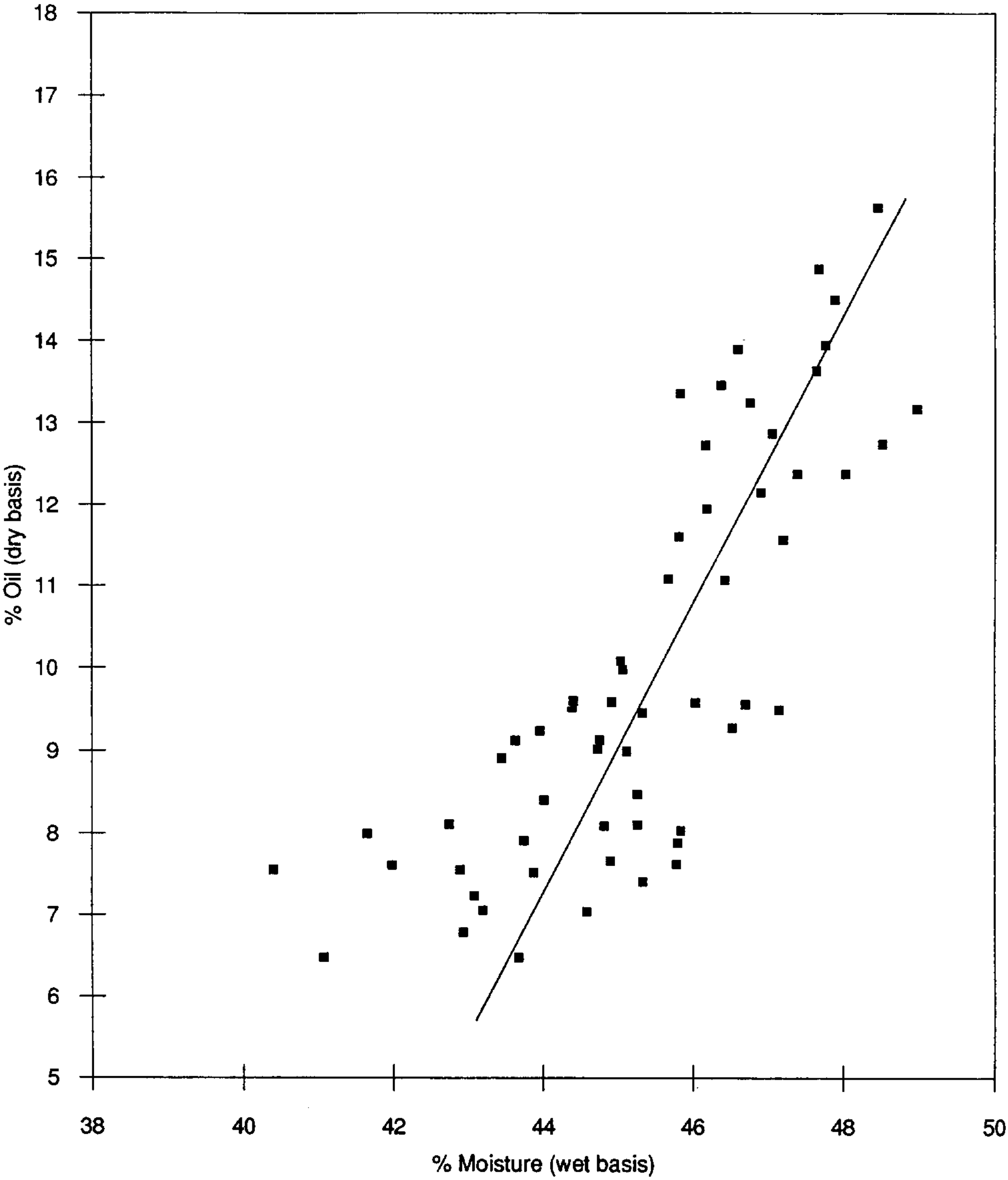

Figure 6. Relationship Between Moisture and Oil Content in Press Fibre.

The effectiveness of digestion is a function of both the intensity of digestion as well as retention time. The intensity of digestion is dependent on the condition of the stirring arms, baffle plates, *etc.* The retention time is a function of the level and the throughput. The intensity of digestion can therefore be expected to be better in a digester maintained in good condition. Evidence of this is provided by the electric current consumed by the stirring arms. The difference in electric current before and after the change in level is 5.1 amperes if stirring conditions are good whereas it is only 1.3 amperes if stirring conditions are poor.

It is necessary to make clear that the results should not be extrapolated to mean that level in the digester is not important at all if stirring conditions are good, since this study has only compared the digester operating at the maximum and half the maximum level. Visual observation of the presscake when the level is too low shows signs of undigested pericarp and pieces of pericarp still attached to the nuts. Further, there may be a problem in ensuring that the press is kept completely filled at all times since the digester acts as a buffer for the screw press.

TEMPERATURE

The effect of temperature was studied using a similar methodology to that used for studying the effect of level of fruits in the digester, except that the study was carried out on a single screw press system. The temperature was maintained at approximately 100°C and 85°C by controlling the amount of live steam being injected into the mash in the digester.

Table 5 shows that the oil loss is slightly lower at 85°C but the percentage of broken nuts is considerably higher. At the lower temperature, the presscake tends to offer greater resistance to flow making it possible to squeeze out more oil. On the other hand, the reduced elasticity of the shells at the lower temperature tends to increase the percentage of broken nuts.

Visual examination showed that the flow rate of presscake is probably lower at 85°C.

OVERNIGHT VERSUS FRESHLY STERILIZED FRUIT

Table 6 shows that the percentage of broken nut is slightly higher with overnight sterilized fresh fruit bunches (FFB) as compared to freshly sterilized FFB. The oil loss in fibre is not much affected. A likely explanation for this phenomenon could be the softening of nuts as a result of the long delay between sterilization and threshing. However, it should be borne in mind that overnight sterilized FFB is processed during the mill start-up period when conditions have not yet reached a steady-state. *Table 6* shows that the average temperature in the digester while processing overnight sterilized FFB was 83.5°C, whereas the average temperature while pressing freshly sterilized FFB was 88.8°C. Earlier studies have shown that temperature can have a significant influence on the percentage of broken nuts.

DIGESTER DRAINAGE

The Stork screw press system under investigation allowed a limited amount of drainage from the digester which could be controlled with a valve. A substantial quantity of oil was being drained from the feedscrew section, but no control could be exercised over this during normal operation.

Table 7 compares the effects of keeping the digester drainage valve fully opened versus fully closed. There is no change in the current consumed by the stirrer indicating that the amount of drainage must be quite small. In spite of this, the oil loss is slightly lower with drainage.

A study carried out to determine the relationship between the rate of digester drainage and oil loss had to be abandoned because of the highly unpredictable rate of digester drainage due to factors such as valve chokage and change in the level of fruits in the digester.

FEEDSCREW SPEED

The feedscrew is unique to certain makes of screw presses and it allows the throughput to be easily varied. This can be seen from *Table 8* which shows an increase in the presscake throughput from 3.85 tonnes/hr to 5.23 tonnes/hr when the feedscrew speed is increased from 12 to 20 rpm. Increasing the throughput generally results in a higher oil loss and a lower percentage of broken nuts.

CONCLUSION

Even though it was initially planned to study as many variables as possible, difficulties faced in trying to organize experiments and modifying process conditions in a commercial mill tended to limit the scope of research that could be carried out.

Under normal operating conditions, crop condition tends to have a significant impact on the performance of the screw press. This is obvious from the trending characteristics of presses operating in parallel. The fluctuations observed in *Figures 1, 2* and *3* are most likely due to changes in the crop condition.

An important consideration when studying the effect of any variable is the quantum of change in the variable. If the quantum of change is too small, then no visible change in the output will be noticed, especially if superimposed with the effect of disturbances, such as crop condition, which can have more significant impact on the output. In many of our experiments, the quantum of change in the variable being studied was quite small, being dictated by mill operation requirements, and no attempt was made to control the crop condition. Hence, the direction of change observed in the output variable when a step change in the input variable was introduced often did not match our expectations. In spite of such problems, this study has managed to examine the effect of some important parameters such as level of fruits in the digester, temperature and digester drainage. Other parameters were also examined but are not discussed in this paper because the results were inconclusive.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions of Golden Hope Plantations Berhad and Malaysian Institute of Microelectronic Systems (MIMOS) towards this study. Thanks are also due to the Director-General of PORIM for his permission to publish this paper.