Screw Press Operation Optimisation for Oil and Kernel Recovery Enhancement

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ABSTRACT

Pressing operation is an interesting subject of discussion as it involves two crucial process losses parameters namely, oil loss and broken nuts. Though zero loss in palm oil milling is impossible, this does not mean that effort should not be given to find ways in reducing it even though the losses is already within specification. It must be noted that higher process losses will lead to higher operating cost and eventually be used as indicator that the processing is not being carried out efficiently. Digester operation, main screw speed, pressure cone setting and maintenance are among the crucial factors that affect the pressing operation. In addition to that, operator's effort and his responsiveness on mash and crop condition are crucial for achieving good press operation. This article reviews few variables that affect the screw press operation performance.

INTRODUCTION

Screw press operation is one of the most important processes in palm oil mill. It is responsible for extracting oil from digested mesocarp with consideration of the following objectives, minimum oil loss in pressed fibre and minimum nut breakage at the designated press throughput. The performance of the press does not only depend on the design, but also influenced by process variables, as well as wear and tear. The overall operation of pressing station consists of digestion, pressing, dilution and screening. In conventional palm oil mill, the fruits, so called (MPD) mass passing to digester are digested at 90°C for about 20 min. For a 15 t throughput press, typical volume of the digester is about 3500 litres. During digestion, the oil-bearing cells are ruptured and this will facilitate oil extraction during pressing and clarification. Digestion is carried out by stirring effect from five stirring arms that are installed alternately in opposite directions where the fruits are forced to move upward and downward (due to the 'lifting' effect of the stirring arms). This causes the fruits to strongly rub against each other, leading to severe bruising of the fruits and resulting in breaking down of the pericarp into mash. The oil bearing cells are subsequently ruptured. The digested MPD mash is then fed into the press by the digester's expeller arm. The press operation is controlled through adjusting the main screw speed and the pressure of the cones at the discharge end of the screw press. Two parameters that are monitored to indicate press performance and efficiency are the percentage of broken nuts and oil losses in press cake. Pressing operation with broken nuts percentage of below 20% and oil losses (wet basis) of below 4.5% is desirable.

TABLE 1. VARIABLE AFFECTING THE SCREW PRESS OPERATION

No.	Factors	Variable
1	Raw material/FFB	• Ripeness • Lag time between harvesting and processing • Contamination • Fibre/nut ratio
2	Sterilisation	• Sterilisation cycle • Sterilisation method
3	Digester parameters	• Digester level • Digester drainage • Temperature
4	Press parameters	• Main screw speed • Cone pressure

TABLE 2. PRESSING USING STORK SCREW PRESS FOR DIFFERENT TYPES OF CROP

Crop	Main screw (rpm)	Feed screw (rpm)	Load setting (Ampere)	OLDB (%)	Broken nut (%)
Overnight	12	18	36-38	8.52	30.35
Fresh	12	18	36-38	8.14	19.87

Note: Oil loss dry basis (OLDB).
Study done at Diamond Jubilee Mill (2002).

VARIABLES AFFECTING PRESS PERFORMANCE

There are many factors that contribute to the good performance of pressing. Though process at pressing station is optimised, it does not guarantee that oil losses and nuts breakage are at lowest range. Upstream processes such as sterilisation, crop condition and fresh fruit bunch (FFB) compositions could also contribute significant impact to the performance of the screw press operation. Most of the factors affecting screw press operation are listed in *Table 1* with only the main factor to be discussed in details.

CROP CONDITION AND BUNCH COMPOSITION

Experienced press operator knows that suitable screw press setting should be used in accordance to crop condition. In general, overnight crops require lower pressing pressure as compared to fresh crop.

Figure 1. Sterilisation of fresh fruit bunches (FFB).

This is due to the fact that fruits of overnight crop are softer than fresh crop and thus easily crushed during pressing. Study has shown that using the same press setting for both fresh and overnight crop will result in higher losses for the latter, as shown in *Table 2*.

In the case of overnight crop, the fibre has lost its elasticity and strength thus increase the opportunity for nuts to come into contact with each other as the pressing pressure increases. This explained why the broken nuts percentage for overnight crop is higher. If the mash has high proportion of nuts (nut to fibre ratio), it will also result on the same outcome. In addition to that, fibre will be trapped in the free space between the nuts and oil that has been released adsorbed to it, resulting to higher oil losses (Olie, 1974). In this case, it is recommended to add fibre into the sterilised fruits for optimum pressing results. When the nuts ratio is low, the cake will have higher friction resistance caused by fibre to fibre contact. The force or pressure exerted during pressing cannot be transmitted deep enough into the press cake, resulting in higher oil losses (Olie, 1974). Previous study shows that the optimum nut to fibre ratio for screw press operation is 45:55 (Lokman, 2003).

STERILISATION

Sterilisation is a crucial process that if not properly carried out will affect most of the downstream processes during palm oil milling (*Figure 1*). Sterilisation helps in loosening the fibre from the nuts during pressing operation. It also ensures the oil cells are more easily ruptured during digestion and pressing for good oil recovery. Over-sterilisation will lead to over-dehydration of the nuts that makes it less elastic and easier to crack during pressing (Southworth, 1982). Sterilisation period must be adjusted according to different types of crop, *i.e.* shorter sterilisation for overnight crop to avoid over sterilisation of bunches.

On the contrary, under-sterilisation will reduce oil liberation from the cells due to inadequate conditioning of fibre cell. Thus, the retained oil that is still attached to the fibre is carried over to fibre cyclone and contribute to higher oil.


Figure 2. The digester is used to mash the sterilised fruits.

TABLE 3. PERCENTAGE OIL LOSS DRY BASIS IN RELATION TO DIGESTER LEVEL

Digester level	Main screw (rpm)	Digester temp (°C)	Load setting (Ampere)	OLDB (%)
¾	12	95	24-26	7.91
½	12	95	24-26	9.85

TABLE 4. EFFECT OF DIGESTER LEVEL IN RELATION TO STIRRER ARM CONDITION

Percentage oil loss % (dry basis)

n = 10		Level in digester	
		Half	Full
Stirrer Arm Condition	Good condition	8.02	7.64
	Poor condition	9.45	8.54

Percentage broken nut %

n = 10		Level in digester	
		Half	Full
Stirrer Arm Condition	Good condition	11.07	14.28
	Poor condition	15.59	19.10

TABLE 5. THE EFFECT OF DIGESTER DRAINAGE ON OIL LOSS AND BROKEN NUT

n= 5	Oil loss in press fibre (%) (dry)	Broken nut (%)
No drainage	7.46	13.56
Full drainage	7.25	13.91

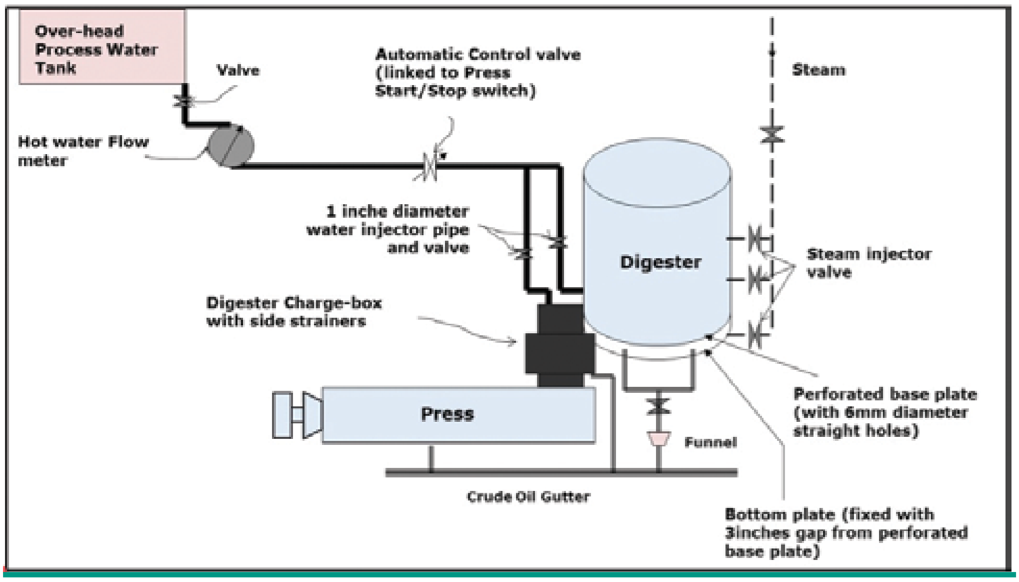

Figure 3. Hot water injection into digester.

DIGESTION

Digester Level

Digestion has direct effect on the performance of pressing operation. As its main task is to rupture the oil bearing cells and loosen the pericarp from the nuts, inefficient digestion will eventually leads to oil still being trapped in the cells and could not be extracted during pressing. Digester must be filled and maintain with more than three quarter of its designed volume to ensure good performance (*Figure 2*).

The volume of the mash in the digester is directly related to the stirring effect efficiency. According to *Stork Palm Oil Review*, the stirring effect was at 55% efficiency if the filling level of the digester was at 75% and reduced to 35% efficiency for 60% filling

TABLE 6. EFFECT OF HOT WATER INJECTION INTO DIGESTER

Hot water injection into digester					
No. (n=76)	**OLWB (%)**	**OLDB (%)**	**NOS (%)**	**VM (%)**	**Fibre Nut Ratio**
Average	4.20	6.38	61.79	34.00	53:47
SD	0.68	1.05	3.90	3.94	-
Hot water dilution into oil gutter					
No. (n=49)	**OLWB (%)**	**OLDB (%)**	**NOS (%)**	**VM (%)**	**Fibre Nut Ratio**
Average	5.04	8.30	55.80	39.16	53:47
SD	0.95	1.71	3.83	3.59	-

level. The immediate result of the stirring inefficiency is the increased in oil losses. In the event of high broken nuts and high oil loss in fibre, the first thing to be taken care of is the digester filling level. Most of the time, when the optimum digester filling level is achieved, oil loss will be reduced and the only problem to be tackled is broken nuts. Likewise, it is meaningless to troubleshoot high oil loss by adjusting screw press setting without solving the digester filling level first. Results from trials carried out using CB Screw Press (P15 model) for percentage oil loss in relation to digester filling level is shown in *Table 3*.

Normally, low digester volume will result in low retention time of the mash and consequently inefficient stirring effect. Nowadays, the average retention time for digester has been reduced to about 18 to 22 min due to increased screw press capacity. Apart from low digester level, worn stirring arms can also bring down the stirring efficiency. In accordance to Stork's digester design, the clearance between the tips of the stirring arms and the liners must not exceed 10 mm.

The stirring arms and the expeller blades should not become too round (which indicates worn out) at

TABLE 7. EFFECT OF MAIN SCREW SPEED ON OIL LOSS AND BROKEN NUT IN PRESS CAKE

Oil loss (%) (dry basis)

		Main screw speed	
		9.6 rpm	**12 rpm**
Load setting	36-38 amp	6.43	8.03
	38-40 amp	7.48	7.73
Average		6.95	7.88

Broken nut (%)

		Main screw speed	
		9.6 rpm	**12 rpm**
Load setting	36-38 amp	36.90	39.89
	38-40 amp	39.15	42.81
Average		38.02	41.35


Figure 4. The screw presses are used to extract oil after digestion process.

TABLE 8. EFFECT OF MAIN SCREW SPEED ON OIL LOSS AND BROKEN NUT IN PRESS CAKE AT SUA BETUNG MILL

Main screw speed (rpm)	No. trial	Oil loss (% wet)	Broken nut (%)
7.5	15	4.44	11.27
8.5	19	4.48	11.12

TABLE 9. EFFECT OF PRESS CAGE PERFORATION SIZE ON OIL LOSS AND BROKEN NUTS

Perforation size (mm)	Main screw (rpm)	Broken nut (%)	OLDB (%)
2	15	18.12	11.14
3/4 tapered	15	18.94	9.71

the tips nor should the 'lifting' of the stirring arms decrease too much. This must be monitored from time to time. Currently, replaceable stirring arm's tip is being used for easier maintenance (Ravi, 2002). The study on effect of digester level in relation to stirrer arm condition on oil loss and broken nut is shown in *Table 4*.

Digester Drainage

Oil drainage system is another important feature of digester. If the oil is not released from the digester, the stirring arms will agitate the oil for a considerable period of time and emulsion will be formed which will reduce the oil extraction efficiency. In addition to that, excessive oil in screw press will act as lubricant and reduces pressing efficiency. In earlier Stork's digester design, it is expected about 22% - 32% of digester volume is discharged before being fed into the screw press. The oil will be discharged through the drainage at the bottom of the digester and at the perforation body of the feed-screw press. The study on effect of digester drainage on oil loss and broken nut is shown in *Table 5*.

Hot Water Injection into Digester

Trial was conducted to improve press operation by introducing hot water injection into digester as tabulated in *Figure 3*. This new method is carried out by injecting hot water at the lower side of the digester to maximise the removal of free oil from the

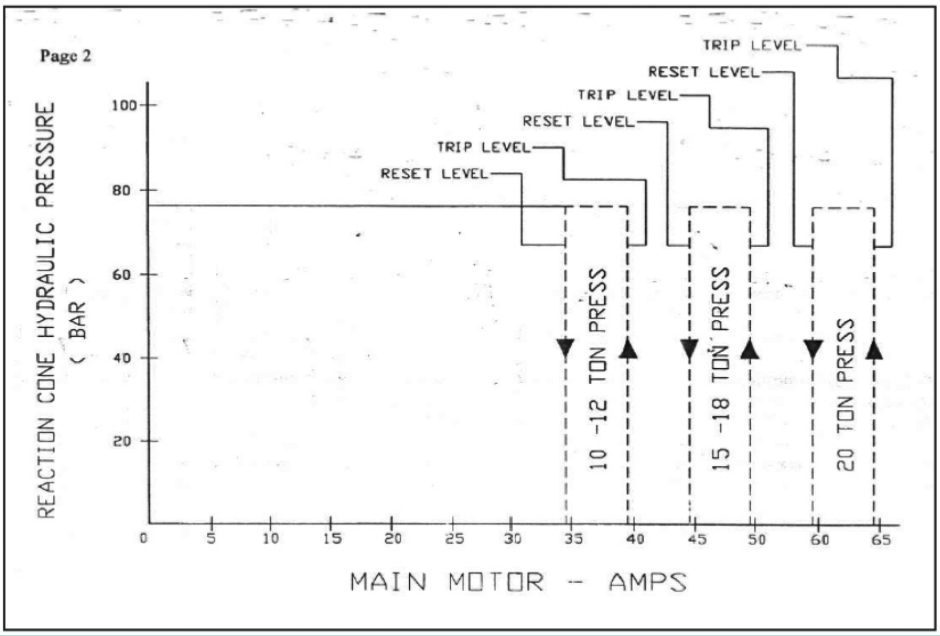

Figure 5. The recommended cone pressure and motor load setting for three types of screw presses.

Figure 6. Maintenance of screw press.

fruit mash resulting in less oil entering the screw press. The number of drainage holes at the bottom plate were increased to improve oil removal. This new method will maintain the dilution ratio, where the difference lies in introducing dilution before the press operation.

Trial conducted at one of the mill (*Table 6*) showed significant reduction in oil loss, at 4.20% (OLWB) and 6.38% (OLDB) against conventional method at 5.04% (OLWB) and 8.30% (OLDB), respectively. There was no significant impact on non-oily solid (NOS) and volatile matter (VM) ratio. The results also showed that there was no significant difference in oil loss in sludge. Spin test indicated that there was no significant difference in formation of emulsion in the oil for both dilution methods.

Temperature

The temperature of the digester must be maintained high at 90°C to reduce viscosity of the crude oil in order to facilitate oil removal at the bottom of the digester and improve pressing operation. It will also increase the elasticity of the nuts thus minimise nut breakage in the screw press (Maycock, 1987).

Pressing Operation

There are many combinations of setting for the main screw speed and cone pressure that should be considered for good pressing operation (*Figure 4*). In general, increasing the main screw speed will increase mill throughput and oil losses. Increasing cone pressure does not affect throughput but will reduce oil loss and increase kernel loss (Southworth, 1982). Nevertheless, it is not advisable to simply adjust main screw speed every time the oil loss or broken nut ratio exceeded the allowed specification. Most of the time, good screw press operation depends on alertness and responsiveness of the operator towards the screw press discharge conditions. The operator must always check the wetness of the press cake and adjust the pressure setting accordingly. If the mash looks oily, the operator needs to check the temperature and increase cone pressure. If the mash looks dry and contains crushed kernels, the operator should reduce the cone pressure.

Main Screw Speed

The setting of main screw is very crucial as it does not only influence the oil loss and broken nut in press cake but also mill's throughput. Thus, it is important to set the main screw at the right speed to attain the mill designated throughput and optimum oil extraction. Study on the effect of main screw speed and load setting (amp) on oil loss and broken nut was conducted earlier at Diamond Jubilee Mill. The results are shown in *Table 7*.

Generally, the study showed that low main screw speed and low load setting resulted in lower oil loss and broken nut. Another study on different main screw speed was conducted at Sua Betong Mill. The trial was to compare the speed of 8.5 rpm with 7.5 rpm with cone pressure maintained between 50 bar to 60 bar. The result is shown in *Table 8*. It was found that there was no significant effect on oil loss and broken nut when the main screw speed was reduced to 7.5 rpm from the earlier setting of 8.5 rpm.

Hydraulic Cone Pressure

Increasing the hydraulic cone pressure could increase the pressure exerted to the cake, which could reduce oil loss. However, very high cone pressure could cause kernel to pulverise resulted in lauric acid contamination. Ideally, optimum cone pressure should not be set higher than 70 bar to obtain acceptable oil loss in press cake as well as broken nut of less than 20%. At high cone pressure, the kernel could be crushed into powder and produce kernel oil which would contaminate the crude oil stream. The lauric acid ratio in CPO production should be controlled to lower than 0.4%.

It is recommended that the ideal operating hydraulic pressure is between 50 bar - 70 bar with the motor load setting at 35 amps - 40 amps, 45 amps - 50 amps and 60 amps - 65 amps respectively for P10, P15 and P20 screw presses, as shown in *Figure 5*.

Press Cage

Many assumptions have been made on the optimum numbers and perforation size of the press cage for good pressing operation, but so far no proper study has been made to justify any claim on the matter. A study was conducted to determine the effect of cage perforation size on the oil loss and broken nuts percentage (*Table 9*).

From the table, it can be seen that oil loss was reduced when the press uses 3 mm - 4 mm tapered perforation size. This may be due to easier oil release through bigger perforation size. Clearance between worm screw and press cage when both are new must not be more than 5 mm and should not be allowed to exceed 12 mm clearance to minimise oil loss and nut breakage (Wilson, 1993).

MAINTENANCE

Maintenance of screw press is detrimental to the performance of pressing operation (*Figure 6*). Indications such as reduced throughput, high broken nuts and oil loss must be observed not only on the operation setting but also as maintenance element. It is important to overhaul when necessary as higher loss will usually incur higher cost than the cost to replace press cage or worm screw. The recommended period to change the worm screw is 800 hr for normal material and 1000 hr for 3% chromium material. However, it is expected that the life span of the worm screw could be reduced due to poor condition of FFB processed with higher contaminants.

CONCLUSION

Being competitive means being able to produce products of required quality and most importantly at lowest cost. Pressing station is where loss can easily be out of control if certain process conditions were not given adequate attention. Digester operation, main screw speed, cone pressure setting and maintenance are among the crucial factors that affect pressing operation. In addition, operator's effort and responsiveness to the mash and crop condition are also important for good pressing operation.

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