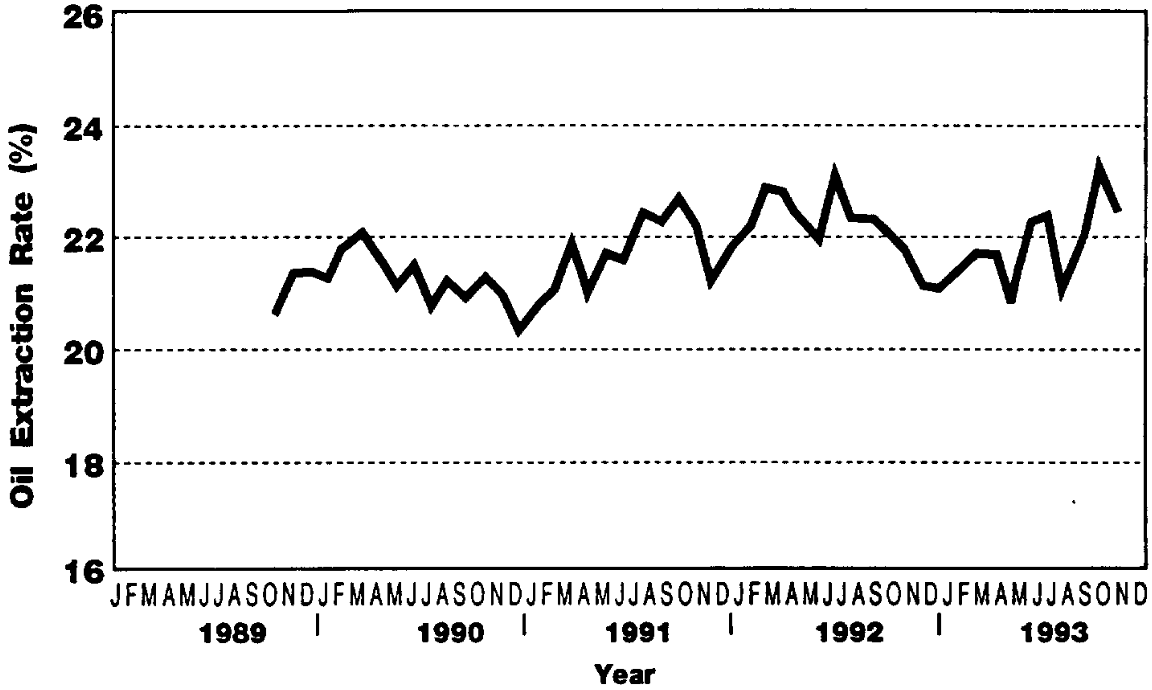
Figure 4

Oil Extraction Rate Mill D



MEASUREMENT OF OIL EXTRACTION RATIO (OER) AND MILLING LOSSES

(Abridged version of the paper given by Ir. Ng Say Bock of Guthrie Research, Chemara at the National Seminar on Palm Oil Extraction Rates : Problems and Issues held on the 21 – 22 December, 1993)

1. Introduction

The declining trend in OER is an area of great concern in the palm oil industry. While efforts are being made to identify its causes and hopefully check its decline, other aspects that come to mind are the measurement of OER itself and factors within the mill that can influence OER. This paper discusses the significance of OER, how it is measured, its problems and areas of oil losses in the mill process. It also reviews the use of OER as a management tool, offers a likely explanation on the current drop in OER together with some recommendations.

2. Why Use OER?

Profitability of any plantation group is proportional to the amount of oil realised per hectare of land under cultivation. This is represented by the following equation

$$\frac{\text{Total oil}}{\text{hectare}} = \frac{\text{FFB}}{\underset{\text{(field)}}{\text{hectare}}} \times \frac{\text{Total Oil}}{\underset{\text{(field)}}{\text{FFB}}} \quad \text{(i)}$$

Since FFB (fresh fruit bunches) cancels itself out in the equation, any change in total oil/ hectare would be a direct result of an increase or decrease in the oil content of the bunches. This would therefore reflect directly on the estate harvesting system and loose fruit collection. Clearly this is a good measure of profitability as well as a superior yardstick for gauging effectiveness of estate practices. Unfortunately there is no accurate method of ascertaining total oil at estate level. Bunch analysis have been tried but only with some degree of success. Furthermore FFB is supplied form a large number of fields, varying age groups and from estates both within the group and sometimes outside which makes the measurement impractical.

One pragmatic approach for overcoming this problem is the use of OER as shown in equation (ii)

$$\frac{\text{Total oil}}{\underset{\text{(Mill)}}{\text{FFB}}} = \frac{\text{Oil recovered}}{\underset{\text{(Mill)}}{\text{FFB}}} \text{(OER)} + \frac{\text{Oil losses}}{\underset{\text{(Mill)}}{\text{FFB}}} \quad \text{(i)}$$

OER is a direct measurement that can be easily determined at the mill. For a given harvesting system under carefully controlled milling conditions, OER can be taken as a true measure of profitability.

3. Definition of OER

The oil extraction ratio of a palm oil mill is the percentage of the weight of oil physically recovered from a known weight of fresh fruit bunches (FFB) processed.

Being a ratio, it will change with a change in the weight of oil or a change in the weight of FFB as can be experienced on a dry or wet day.

4. Derivation of OER

Table 1 shows how OER is derived in the mill. Only FFB received and oil despatches are weighed over the mill's weighbridge while the rest are computed from a cage count and tank ullage *(see 6.1.1)*

5. Factors Affecting OER Measurements

It is best to discuss oil and FFB individually to see how they affect the OER measurement.

5.1 FFB

5.1.1 Crop estimation

When all the bays are full, FFB is inevitably dumped on the hopper top. This is especially so during the peak crop or when there is a lack of coordination between estate and mill. Under these circumstances, the amount of FFB left is estimated. This effect is seen in *Table 1* on 'Monday' where there was an over estimation of FFB resulting in low OER. The nett effect is a high OER on 'Tuesday' which rectifies the over estimation.

5.1.2 Filling of cages

Irregular filling of cages i.e. too full on day 1 or partly full on day 2 can also contribute to a too high or low cage count which can affect the daily OER.

5.1.3 Cage declaration

The routine counting of cages processed and those left in the yard is not spared of errors. Counting cages left in sterilisers and deducting for recycled cages can sometimes cause slip-ups. Where mills are expected to maintain high throughtput as part of their performance, altering of the cage count occasionally comes as an easy solution for meeting such expectations.

5.1.4 Moisture

A study of underripe bunches placed in the shade show a moisture loss of about 1.5% per day. The ambient conditions being between 27 to 31°C and a relative humidity ranging from 76 to 88%.

6. Oil

6.1.1 Ullage

From the difference between the height of the airspace above the oil and the known height of the tank the amount of oil can be calculated. Ullage is taken by a steel tape suspended from the top of the tank by a bob. At about 10m high, a 1cm difference in reading is not uncommon but it will affect the amount of oil by 2t *(see 6.1.2)*

Table 1

Production Data

	Mon	Tues	Wed	Notes
a. FFB received (t)	136.42	182.14	283.56	Weighbridge weight
b. FFB balance in yard (t)	516.61	336.97	104.28	Previous day [(c) − (h)]
c. Total FFB (t)	653.03	519.11	387.84	(a) + (b)
d. Cages processed	121.00	179.00	88.00	Supervisor's count
e. Cages balance	129.00	45.00	54.00	Supervisor's count
f. Total cages	250.00	224.00	142.00	(d) + (e)
g. Average cage wt	2.61	2.32	2.73	(c) / (f)
h. FFB processed (t)	316.06	414.83	240.33	(g) x (d)
i. Oil stock (t)	2552.32	2600.12	2702.00	Ullage previous day
j. Oil stock (t)	2600.12	2702.00	2656.55	Ullage
k. Oil despatched (t)	0	0	89.48	Weighbridge weight
l. Oil produced (t)	47.80	101.88	44.03	(k) + (j) − (i)
m. Oil extraction ratio	15.12	24.56	18.32	[(l) / (h)] x 100

6.1.2 Oil storage tanks

Tanks may not be perfectly vertical. The tonnage of oil will depend on its height in the tank. A typical calibration for a 2000t tank is as follows :–

(cm)			t CPO/cm
0	–	30.4	1.98
30.4	–	182.9	2.09
182.9	–	365.8	2.11
365.8	–	548.6	2.10
548.6	–	701.0	2.13
701.0	–	853.4	2.14
853.4	–	975.4	2.15

If the height of oil in the tank is 70cm, it will contain 142.96t oil (30.4 x 1.98 + 39.6 x 2.09). All tanks need to be carefully calibrated to avoid errors due to their uneven nature.

6.1.3 Density of oil

Density of oil varies with temperature. If the tank's temperature is taken as 50°C when in actual fact it is 80°C, there will be an overcalling of oil. For example at 30cm height of oil in the storage tank the incorrect density reading for the 2000t tank mentioned above will give an additional 1.3t of oil.

6.1.4 Dead weight

Some storage tank are designed with conical bases. Sediment (dirt and water) settles out at the bottom and is drained out regularly. The oil in the tank bottom is taken as dead weight and is normally between 3 to 5t. Where recycling of this is done, the monthly oil produced will have to be adjusted accordingly.

6.1.5 Tank expansion

The starge tank being made of mild steel will expand or contract depending on the weather. This difference is not taken into account but it can also affect the daily OER.

6.1.6 Weighbridge vs ullage difference

Differences do exist between weighbridge weight and tank ullage. Since weighbridge weight is always taken as actual, adjustment, if any will be made on the production data at the end of each month.

6.1.7 Oil in process tanks

Not all tanks are emptied at the end of processing. Take the clarification tank, for example, where oil ad sludge are separated. The oil layer needs to be maintained for effective separation during processing. At the end of processing, some mills skim – off the oil with water but the majority of the mills leave them as they are for convenience of starting up the following day. For a 2.4m diameter clarification tank, the oil layer at the end of the day can vary from 60 to 150cm. This difference is equivalent to about 3t of oil. Emptying a 2m diameter pure oil tank (holding tank for oil before drying) can increase oil produced by as much as 7t. Other holding tanks are fat oil tank (for oil recovered from separators) and sludge tanks. It can be seen here that cleaning of such tanks can lead to a substantial increase in OER for that day.

7. General Factors Affecting OER

Apart from the harvesting system and loose fruit collection, other factors influencing OER are as follow :–

7.1.1 Security

One cannot rule out the possibility of malpractices associated with oil or FFB. If such malpractices involve FFB that has already been weighed in, then there will be a corresponding reduction in OER.

7.1.2 Contamination

A neglected but nonetheless important area is the presence of non oily foreign matter with the incoming FFB. *Table 2* below shows three checks of FFB lorries analysed for their contents.

Table 2

FFB Contamination

Estate	A	B	C	Total/Mean
Lorry wt (tonne)	5.00	5.24	6.20	16.44
Average bunch wt.	23kg	23kg	20kg	22kg
FFB	86.2%	73.7%	82.5%	80.8%
Loose fruit	9.9%	21.1%	16.6%	16.0%
Cut stalk (remnants)	0.3%	0.1%	0.1%	0.2%
Trash*	3.6%	5.1%	0.7%	3.0%

* *sand, stones, debris, dead inflorescence, etc.*

Assume 20% to be the true OER, the presence of cut stalk and trash would give an OER of 19.36 or a drop of 0.64%!!

7.1.3 Long stalks

If an acceptable length of stalk is taken to be less than 7.5cm, then stalks longer than this will cause and increase in FFB weight and thus OER will be lowered. However it must be noted that, whilst OER will reduce, oil per hectare will not change as the reduction in OER will be exactly compensated for by an increase in the weight of FFB.

From the above, it can be concluded that the daily OER is subject to large variations. It is only meaningful to interpret OER on a weekly, and more accurately monthly basis when the effects due to daily variations are cancelled out. Another area that is continually under management scrutiny is milling losses.

8. Milling Losses

All mechanical extraction processes will give rise to losses whether they are used for the extraction of palm oil or any other type of oil. Under these circumstances, the mill's role is to minimise losses. A typical oil loss in the mill and the quantum expressed as a percentage of FFB is given in *table 3*.

With the exception of unstripped bunches, very high losses cannot go on indefinitely without affecting the process. The presence of USB in EB during field application is a good check for USB problems. Losses from USB alone can be substantial if left unchecked. Poor oil recovery from sludge or high spillage will ultimately lead to the anaerobic ponds becoming sour. High oil in fibre on the other hand will hamper fibre/nut separation and may even jam up the fibre/nut conveyor causing the mill to come to a stand still. Having said that, it has been shown that through stringent field and process audits, OER can be improved.

Table 3

Source of Oil Losses

	Source	% of loss/FFB
a.	Fruit trapped in empty bunches (EB)	0.20
b.	Unstripped bunches (USB)	0.05
c.	Oil absorbed on the surface of EB	0.45
d.	Condensate from sterilisation	0.10
e.	Nut surface after pressing	0.05
f.	Fibre after pressing	0.55
g.	Sludge from separator	0.45
h.	General oil spillages or washing from tanks	0.10
	Total milling losses	1.77

8.1 Loose fruit spillages

An area that has been ignored is spillage of fruits in the mill. Loose fruits can be seen below the hopper base and the marshalling yard. Although they are recovered some are inevitably run over and smashed up. It is very difficult to quantify this loss but some attempts should be made to monitor or overcome this.

9. OER Comparison Between Mills

In any discussion on OER, it is imperative to consider the following :–

9.1 Age and type of planting material

Previously published data (KGSB techniques, 1969) on OER and planting material is shown in *table 4.*

This method provides the basic groundwork for establishing theoretical OER from a known age of planting and planting material.

Table 4

Estimated Mill OER

Age	OER (D x P)	OER (D x D)
3	16.0	14.0
4	18.0	15.0
5	19.5	16.0
6	21.0	16.5
7	22.0	16.5

9.2 Theoretical OER

Using data from table 4 and from input of age of planting, a set of theoretical OER can be drawn up. A simple example of young crop in a new mill is as follow :–

Year	D x P Est. OER	FFB Tonnage	Theoretical Oil
3	16	200	32
4	18	2400	432
5	19.5	1400	273
		4000	737

Theoretical OER = 18.43%

So long as the same estimated OER is used in the exercise, it will provide a relative basis for comparing different mills. The results here are more meaningful than looking at actual OER alone.

9.3 **Milling efficiences**

For a given crop, if the oil losses are accurately assessed, mills can be compared as follows :-

	Mill C	Mill D
OER	18.25	19.18
Milling losses	1.75	2.03
Total oil	20.00	21.21
Milling efficiency*	91.25%	90.43%

** (OER /Total oil) x 100*

Although mill C has a lower OER, it is a more efficient mill.

10. OER – A Management Tool?

It must be stressed that since OER is a direct measure of profitability, it will come under constant review by top management especially when there is a decline.

Given due allowance for daily OER changes, the monthly OER also fluctuates for which there are no ready explanations. Take the case of two mills within the same geographical location. A plot of 3 monthly moving average to smooth out variations, showed the following distinct pattern (*see appendix 'A'*).

i. There is a gradual decline in OER.

ii. The OER 'peak' and 'troughs' are very similar

Is it reasonable then to conclude that mill 'A' is better than mill B?

On face value, the answer seems to be yes, but for the above mentioned situation to exist, the following must happen.

- The harvesting of underripe and overripe bunches from different supplying estates into the two mills are similar.
- The loose fruit left uncollected are the same for all eatates supplying to the mill.
- The two mills lose the same amount of oil.

It is inconceivable for this scenerio to exist month in and month out. The likely answer is that there is **nothing seriously wrong** with both the mills or the supplying estates. This does not discount the fact that there is room for estate and mill improvements in increasing OER, taking cognizance of the current labour shortage and the need for more stringent process control.

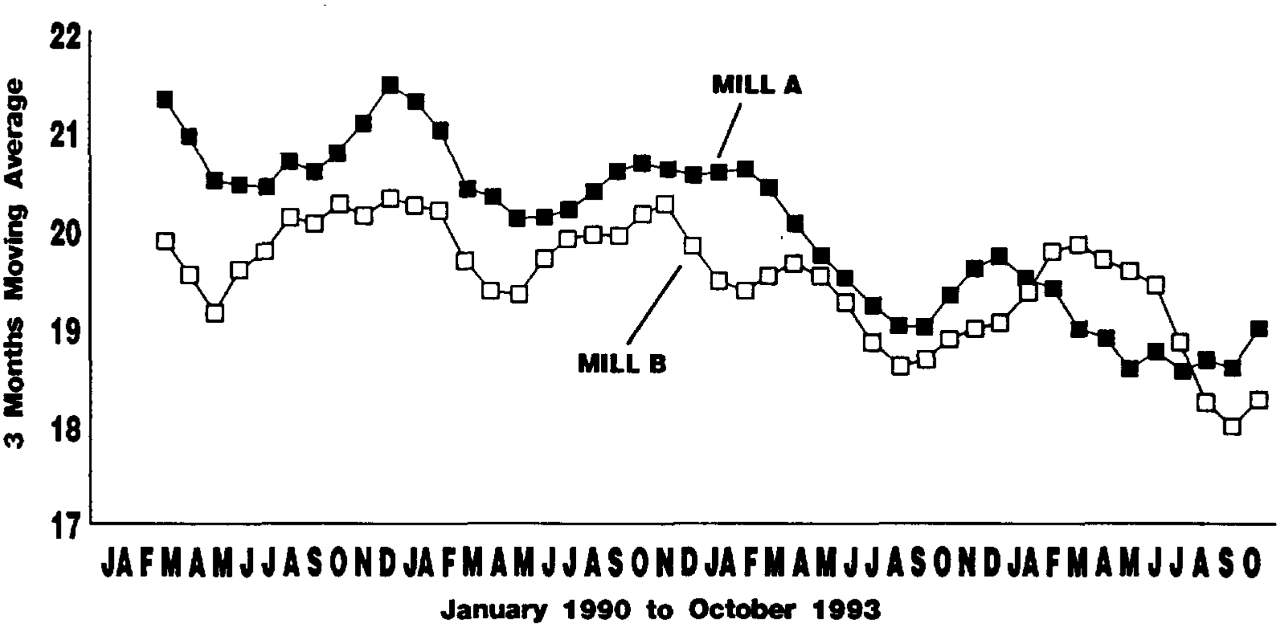
Apart from the cyclical nature of OER, a likely explanation for the downward trend in OER is FFB moisture.

10.1 **FFB moisture**

FFB is made up of about 50% moisture. It is also obvious that bunches processed during wet periods will have a lower OER compared to those during the dry spells due

Appendix 'A'

Variations In Monthly OER (3 mths Moving Average)



to incresed moisture content in bunches at the time of weighing. Since moisture is a major component, any change in moisture content in a bunch will have a pronounced effect on OER. A 5% increase in FFB moisture for instance can bring down OER by 1%. Has there be any increase in FFB moisture over the last few years both externally and internally?

11. Conclusion and Recommendations

OER is a practical management tool to monitor directly the profitability of an organisation. Severe daily fluctuations however limit its use as a measure of field and mill performances. Comparison of monthly trends especially for mills within the same locality do provide useful information but it should be viewed with caution before drawing conclusions. Other methods for comparing mills such as theoretical OER, achievements and milling efficiencies would complement OER comparison.

The high water content of FFB has a pronounced effect on OER measurement. Moisture changes in bunches with time should be monitored carefully. Its effect (both internal and external moisture) on rate of fruit detachment, ripeness and total oil needs to be studied in detail.

The method of measuring OER too needs reviewing for improvements. Weighing of FFB before and after sterilisation to derive the 'true FFB processed' and the use of oil/ sterilised FFB ratio merits consideration. It is also a good check for spilled loose fruits and moisture loss on FFB. Fresh data on theoretical extraction ratio vs age groups for various soil conditions are required for better comparison between mills.

TITBITS

WRITING – THE ENGINEERS "INVISIBLE" ACTIVITY

(A Provocative Article by Ir. J.H. Maycock)

According to conventional wisdom the engineers of today avoid reading, speaking and most of all writing. Perhaps we have our ancestors to blame because I read the other day that a medical doctor practicing in a German town in the 16th century noted that the miners he attended had stores of knowledge about metals and engineering not recorded in any book. He took it upon himself to collect and master this knowledge and published his findings under the title "De Re Metallica" in 1556.

In 1991 Harwood Frost wrote a book "Good Engineering Literature" and in the chapter, Literary Expression, asserted that "The Professional Engineer is naturally looked upon as an educated man" and concluded the chapter with "Literary expression should, therefore, be considered as one of the most practical problems with which the engineer has to deal".

An engineer who thought the same as Harwood Frost was John Waddell, a Canadian who occupied the chair of civil engineering at the Imperial University of Tokyo in the Mid—1880s. Waddell believed that the engineering profession had an obligation to communicate engineering to the public and stated this in no uncertain terms viz, "Whenever an engineer learns something new in technics, it is his bounden duty to put it in writing and see that it is published where it will reach the eyes of his confreres and be always available to them. It is absolutely a crime for any man to die possessed of useful knowledge in which nobody shares. Every established practicing engineer should also, on occasions, contribute to magazines or the daily press timely descriptions, discussions, or statements of local or important engineering projects or construction, clearly showing to the layman the vital features, advantages, disadvantages, and probable or possible results".

Another famous engineer, Othmar Ammann who designed the George Washington Bridge, identified the engineer's number one problem as the need for an ability to communicate more easily both with his colleagues and the public.

From this article you will learn that, as engineers you have "a bounden duty to put in writing" any new findings or ideas you have and you will not find a better avenue to do this than "Engineering News". We expect to be inundated with articles for the next issue of our newsletter.