Current Technological Developments and Trends in the Palm Oil Processing Industry

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RINGKASAN

Kertas ini mengkaji kemajuan dan pembangunan kilang sawit, kilang penapis dan kilang pemprosesan isirong. Keperluan pengurusan kilang-kilang agak berbeza jika dibanding keadaan sekarang dengan 10-15 tahun lalu. Ini bermakna, semua pihak perlu menggembeling keseluruhan tenaga manusia, jentera, wang dan sumber-sumber lain secara lebih berkesan.

INTRODUCTION

This paper examines the progress and development of technology and changes in the following areas:

(I) Palm Oil Mills
(II) Palm Oil Refineries
(III) Palm Kernel Crushing and Processing Plants

PALM OIL MILLS

Current Progress and its Effectiveness

Milling technology has not made major changes in the last 20 years. Many people associated with the industry have used this argument to justify the idea that a new design or a new type of palm oil mill is necessary.

There are two questions that need to be answered:

i) Do we really need a new type of palm oil mill?
ii) What are the targets and goals that must be achieved by palm oil mills?

i) Do we really need a new type of palm oil mill?

Before we can answer the above question, we must have answers to the following sub-questions:

- How efficient is our existing milling process? This necessitates knowing with a certain level of confidence the quantitative losses in each unit operation.

Unit Operation	Oil Losses kg/tonne FFB	Kernel Losses kg/tonne FFB
1) Reception	?	?
2) Sterilization	?	?
3) Threshing	?	?
4) Digestion and Pressing	?	?
5) Nuts/Kernel Station	?	?
6) Shell/Kernel Separation	?	?
7) Oil Recovery Section	?	?

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- What is the optimum efficiency of our existing milling processes?
- How consistent is the performance of our milling efficiency and quality at optimum operation?
- What are the effects of existing operations on oil quality? Can we obtain a radically different oil quality if the process is changed?
- Cost per tonne?

I am afraid to say that we are only sure of the cost per tonne. There are insufficient data to tell us with confidence the effects of our current processes on efficiency, quality and consistency of performance.

Lack of Reliable Quantitative Methods

This, I believe, is one of the main reasons for the slight progress and changes in milling technology in the last 20 years. Because there are insufficient concrete data to identify the key areas for improvement, objectives and directions are vague. There are apparently few compelling reasons to warrant a 'must improve' attitude.

There are two other major reasons for the slow progress in technological advances in the palm oil milling industry.

What are the Changes?

Before I consider these other reasons, let us look at the progress achieved so far. Although there have not been many major changes (since the introduction of the screw press) many small changes have taken place, particularly in the last five years. These may be briefly summarized as follows:

Processes

(1) Sterilization
Operation — more steam, higher pressures and longer retention times.
Design — larger cages, from 2.5 – 3.5 tonnes/cage.

(2) Threshing
Operation — more even loading, double threshing.
Roller crusher.
Beater arms.

(3) Pressing/Digestion
Operation — optimization of pressures, speeds, temperatures and digestion.
Design — mainly local presses towards higher throughput.
Design — hydraulic drives and control replacing gears.

(4) Clarification
Crude oil screening — rotary screens.
Decanters — 2 to 3 phases of separation.
Oil coolers.
Magnetic traps.
Operation — better control of temperatures, residence times and cleaning intervals.

(5) Nut Cracking/Kernel Recovery
Ripple mill crackers.
Kernel recovery using greater air separation.
Kaolin bath to replace hydrocyclone.
Kernel bulk silo storage and despatch.

(6) Power Station
Boilers — larger, higher pressure and more efficient boilers.
Turbines — higher efficiency non-condensing turbines and condensing turbines.

(7) Maintenance
Condition monitoring — vibration analysis.

(8) Automation
Individual mill processes.
Sterilization.
Autofeeder and crane control.
Presses — constant pressures/amperes.

Depericarper control.
Level and temperature control.
Motor sequential start up and shut down.
Boiler control.
Dilution control.
Weighbridge computerization.
Automatic sampling.
Regular and automatic cleaning and flushing of purifiers and sand cyclones.

(9) Computerization
Accounts, data retrieval, storage and processing.

(10)Integrated Complex Processing
Sharing of common utility and infrastructure.
Sharing of power.
Sharing of manpower — particularly among mills, refineries, kernel crushing plants and rubber factories.

(11)Laboratory Test Methods
Use of faster methods of process parameter testing.

What are the Effects of these Changes?

Cost Reduction

Operating Cost — automation of sterilization and remote crane control, kernel bulk silo storage and despatch.

Integrated complex processing can reduce cost substantially, particularly overheads and common sharing facilities.

Capital Cost — for new mills, there is likely to be an increase in capital cost if mills adopt mill-wide automation, larger boilers, more efficient turbines and decanters.

Efficiency Improvement

- With improved steam management and utilization in sterilization, better strippability is obtained. However, losses of oil in blow-off, empty fruit bunches and condensate may have increased.
- Automatic control of temperatures and levels may have improved efficiency of oil recovery and kernel recovery.
- Use of rotary screens has improved the clarification operation, reducing chokages.
- Re-introduction of the clay bath (an old technology) has improved recovery of kernels, particularly of broken kernels. However, the cost has gone up due to usage of kaolin.
- Use of decanters has smoothed operation in the clarification station but the improvement in efficiency has not been significant. In some cases, it caused problems of footings in oil storage tanks.

Quality Improvement

Improvement of quality of oil is generally indirect as a result of smoother operation (fewer interruptions and breakdowns) and better efficiency, except in the case of certain specific changes such as the installation of oil coolers, close control of tank heating, use of magnetic traps and strict control of cleanliness of processing equipment and the mill environment.

Overall there has been improvement in cost reduction, efficiency of oil and kernel recovery and quality. But there have been no drastic changes or really significant improvements.

Lack of Top Management Support and Direction

The second main reason for the slow progress or lack of major advancement in milling technology is the lack of Top Management participation in directing technological advances. Management and Technology cannot be separated.

I am of the opinion that the top management of most plantation companies is isolated or separated from technological development in milling. In the planting sector, top management is involved in decisions and directions regarding replanting, type of planting material, expected target yield, and which direction plantation technology such as tissue culture should be heading. Such decisions and directions are also backed by the Research and Development departments.

In milling, such participation and direction are lacking and in most instances, there is no R & D support.

Top Management seldom sets targets or gives directions in matters such as:

- What type of mill is required.
- Expected oil recovery efficiency.
- Expected kernel recovery efficiency.
- Target quality of CPO and PK.
- What technological advancement should effort be directed towards?

As a result, work or advances in milling technology are undertaken on an *ad hoc* basis, objectives and directions are conceived by mill managers and technical management executives — the directions may not coincide with the company's or the industry's overall objectives. Different technical executives look at different areas for improvement. Objectives become diffuse, and the limited resources are spread thin and wide. Further, technological improvements are undertaken on a part time basis by executives who have routine production as their bread and butter.

This piecemeal trend in technology development is likely to continue until someone or some organization achieves a breakthrough in some direction and then the industry will start to focus its effort in that direction.

Lack of Goal Congruency

The third major reason for the slow advancement in technological development in the milling industry is the lack of Goal Congruency.

What does Goal Congruency mean? For a plantation company its ultimate goal is to achieve highest profit per hectare ($/ha).

Illustration 1

In an Estate — Productivity is based on yield of FFB per hectare per year (tonnes FFB/ha/yr). Cost control is based on cost per tonne of FFB ($/tonne FFB).

Are these bases congruent in relation to the overall goal of maximizing profit ($/ha)? I say NO!

If a company has 30 000 hectares of oil palm, situation B (below) would give an additional yield of 13 200 tonnes CPO/year. This is equivalent to an ad-

	Situation A	Oil to Bunch (O/B)	Tonnes Oil/ha
Yield	22 tonnes FFB/ha	22%	4.84
Harvesting and handling cost		$15 /tonne FFB	$68.18 /tonne CPO

	Situation B	Oil to Bunch (O/B)	Tonnes Oil/ha
Yield	22 tonnes FFB/ha	24%	5.28
Harvesting and handling cost		$15 /tonne FFB	$62.5 /tonne CPO

ditional income of $11 880 000/year (at CPO price of $900/tonne) or $396 extra per hectare.

Situation B will result in significantly higher profit ($/ha) than Situation A but the basis of productivity measurement in terms of yield of FFB in tonnes/ha and cost in terms of $/tonne of FFB cannot distinguish the better of the two situations.

Illustration 2

In a Mill - Which is better for higher overall profitability per hectare for the company:

Cost Reduction or Efficiency Improvement?

Assume a mill processes 100 000 tonnes FFB/year. Total production cost = $30/tonne FFB or $3 000 000/year.

(a) *Cost reduction* — control — assume there is an objective to reduce cost by $1/tonne FFB.

See *Table 1.*

TABLE 1.

FFB (tonnes/yr)	OER (%)	CPO (tonnes)	Total Cost ($)	$/tonne FFB	$/tonne CPO
100 000	20	20 000	3 000 000	30.0	150.00
100 000	20	20 000	2 900 000	29.0	145.00

Saving : - $100 000/year

TABLE 2.

FFB (tonnes/yr)	OER (%)	CPO (tonnes)	Total Cost ($)	$/tonne FFB	$/tonne CPO	Additional Revenue ($)
100 000	20.0	20 000	3 000 000	30.0	150.00	-
100 000	20.3	20 300	3 000 000	30.0	147.78	*270 000

Saving :- NIL

* Assume CPO sells for $900/tonne
Additional revenue of $270 000/year or $2.70/tonne FFB saving.
To save $100 000/year it is only necessary to increase OER or reduce oil loss by 0.112%.

TABLE 3.

FFB (tonnes)	OER (%)	KER (%)	PK (tonnes)	Total Cost ($)	$/tonne FFB	$/tonne CPO	Additional Revenue ($)
100 000	20	6.0	6000	3 000 000	30	150 000	-
100 000	20	6.4	6400	3 000 000	30	150 000	*200 000

Saving :- NIL

* Assume PK sells at $500/tonne
Additional revenue of $200 000/year or $2.0/tonne FFB saving.
To increase revenue by $100 000/year it is only necessary to increase KER by 0.20%.

(b) *Efficiency improvement in oil or kernel recovery* — assume oil losses reduced by 0.3% OER with no reduction in total cost; or assume kernel losses reduced by 0.40% KER.

See *Table 2* and *Table 3*.

Efficiency improvement is superior to cost reduction control to achieve maximum profitability of a company in terms of $/ha, yet most companies prefer to practise cost control rather than efficiency improvement. Why?

The table below shows the equivalence between reducing cost of production by $1/tonne FFB and reducing losses of oil and kernel at various selling prices of CPO and PK.

CPO $/tonne	% OER Saving	PK $/tonne	% KER Saving
400	0.25	250	0.40
500	0.20	300	0.33
600	0.17	350	0.29
700	0.14	400	0.25
800	0.125	450	0.22
900	0.11	500	0.20
1000	0.10	550	0.18
1100	0.09	600	0.17
1200	0.08	650	0.15

Because greater emphasis is placed on cost control than on efficiency improvement, less will be achieved through efficiency improvements.

Summary

To summarize, the three reasons for slow advancement in milling technology are:

(i) Insufficient data to gauge with confidence actual effects of processes on efficiency, quality and consistency.

(ii) Insufficient participation and backing by top management in deciding and directing technological advances.

(iii) Lack of Goal Congruency — milling viewed as contributing to cost (hence cost control) rather than contributing to profit (increase efficiency and quality).

As most plantation companies are run by rational hard-headed profit orientated executives, why should there be such wide deviations in management and goals away from maximizing profitability?

I believe that cost control has been taken to be more important by top management because it is the only factor known with confidence.

Top management does not have sufficient confidence in efficiency measurement and control because of the lack of a reliable quantitative monitoring system in most oil mills at present.

Why is there a lack of quantitative methods? There are two reasons: (i) systems in mills are non-homogeneous; hence it is difficult to monitor with confidence, and (ii) lack of top management backing in terms of financial and human resources to develop the methods of reliable quantitative measurement, and lack of top management targets to achieve acceptable ratings in terms of profit contribution by mills. So a vicious cycle exists. Until it is broken, there will continue to be lack of goal congruency in maximizing profitability and inadequate top management support and direction in technological advancement in milling.

What technological advances do we want for Palm Oil Mills?

I would like to propose that the criteria to decide should be based on :-

- What is possible? **and**
- What is critical?

Here, I will discuss only the first criterion — What is possible?

This is the same as setting of targets and goals. This is the most important step. Once a target is set, the direction and type of technological pursuit has also been decided. For example, if current oil loss in fibre is equivalent to 0.70% OER and we set a target to reduce it to 0.50% OER, it is possible to achieve this target by rearranging/modifying the existing technological system with some optimization of operation.

However, if the target is to reduce the oil loss in fibre to 0.20% OER, the existing mechanical extraction is probably not possible and a breakthrough in process development such as solvent extraction or a biochemical process is necessary.

Technological advances should be pursued in the direction of achieving 'true optimum' operation. What do I mean by 'true optimum' operation?

For example, the present practice in screw press operation is to compromise in pressing to maximize oil extraction and minimize nut breakage. It is very difficult to obtain minimum oil loss in fibre as well as minimum nut breakage. So the present pressing method cannot be 'truly optimized' no matter what automation and drive system is utilized.

In my view, the objectives or goals for cost reduction, efficiency improvement and quality improvement should be directed towards true optimized processes rather than retaining the present compromise systems.

Since optimum processes mean a combination of machine and set-up, technological advances should be geared towards development or adaptation of technological systems rather than towards individual machine development or usage.

I suggest that we should:

1) Set goals based on a projected true optimum system of operation.
2) Pursue technological advances in the direction of true optimum operation.
3) Technological advances should be developed or adapted as a system rather than related to the uniqueness and/or superiority of individual machines.

Our current milling technology consists of a series of compromise processes — such as the screw press operation — which are very difficult to optimize.

It is my view that the following systems in the mill are compromise processes in terms of recovery efficiency and quality of the final products:

1) Reception/storage
2) Sterilization/threshing
3) Digestion/pressing
4) Nut drying/cracking
5) Kernel/shell separation
6) Clarification for oil recovery

What are the possibilities in terms of:

a) Cost reduction in operation and capital.
b) Efficiency of oil and kernel recovery.
c) CPO and PK quality.

(a) Cost Reduction

	$/tonne* FFB	Possible Reduction ($)
(1) Mill management	1.41	
(2) Process staff	1.36	
(3) Process labour	2.84	1.40
(4) Upkeep of machinery	4.90	1.00
(5) Upkeep of buildings	0.10	
(6) Utilities	2.50	0.50
(7) Kernel bagging	0.54	0.40
(8) H.O. cost	3.00	
(9) Depreciation	10.00	3.00
(10) Miscellaneous	3.35	
TOTAL	$30.00	?

* JH Maycock — SLDB/PORIM Workshop, 21-22 June 1988

Without upgrading and modification of mill systems and machinery, a significant reduction in the cost of mill operation is difficult.

However, possible areas for potential cost reduction are:

1) Labour — with automation of processes such as the reception and sterilization, and the crane and boiler feed system;
2) Machinery upkeep can be reduced by modification of reception and the pressing and nut cracking system;
3) Utility cost reduction by less labour and more efficient power generation;
4) Kernel bagging cost can be eliminated by use of bulk silo storage and bulk delivery;
5) Depreciation cost can be reduced substantially if the mill receives only loose fruit for processing.

(b) Efficiency Improvement

I envisage potential improvement in milling efficiency in the following areas:

	Possible Reductions	
	Oil (%)	**Kernel (%)**
Sterilization/threshing	0.70	0.80
Digestion/pressing	0.20	
Nuts		
Clarification	0.20	
Kernel/shell separation		0.20
TOTAL	1.10	1.00

(c) Quality improvement

It is difficult to predict how much improvement can be achieved in oil and kernel quality with introduction of possible new technology.

I personally believe Milling Technology can make a big difference to oil quality.

Our limited experience in the realm of possible improvement in oil quality may be illustrated with the following two examples:

Examples :

(1) Lauric Acid Contamination in CPO

	Fatty Acid Composition							
CPO samples from	C12	C14	C16	C18	C18-1	C18-2	C20	C18-3
Mill A	0.5	1.3	44.9	4.3	39.2	9.4	0.2	0.2
Mill B	0.1	1.1	44.8	4.4	39.3	9.8	0.2	0.3

(Mill B has lower C12 than Mill A)

(2) High Carotene Content of CPO

	IV	DOBI	Carotene	Tocopherol
CPO				
sample from	(52.73	3.0	575	623
Mill B	(52.40	3.0	516	623
Condition I	(52.86	3.1	556	634
	(53.61	3.6	1727	683
Condition II	(53.07	4.0	2118	710
	(53.99	3.5	1657	714

PALM OIL REFINERY

Technological advances in the refinery have resulted in significant improvement in cost reduction and process efficiency.

Advances in the Refinery

Refining

- Alkali to physical refining.
- Improvement in physical refining with introduction of sieve tray and packed column prestrippers and packed column deodorizer.
    - Higher throughput
    - Steam usage
      - 240 kg/tonne < 80 kg/tonne
    - Diesel usage
      - 5.5 litres/tonne < 3 litres/tonne

• Electricity usage	
- 18 kWh/tonne	< 9 kWh/tonne
• Losses	
- 0.90%	< 0.50 %
• Refining factor	
- 1.40	< 1.10
• FFA in PFAD	
- 80%	< 90 %

- Reduction in bleaching earth dosages without affecting final colour and FFA of RBD PO. This is also related to the quality of CPO.
- Overall production cost significantly reduced. Efficient refineries can operate at a direct cost of less than $20/ tonne.

What are the possibilities in terms of cost reduction, efficiency improvement and quality improvement?

(a) Cost reduction

- Direct manufacturing cost has been reduced significantly and further significant reduction is difficult to achieve.
- Indirect cost excluding depreciation may be an area for cost reduction if it is high. More and more refineries, particularly those associated with plantations, are operating their refineries like a palm oil mill with only a plant manager and technical and production personnel. This is one way to reduce cost.

  Another way is to integrate the refining operation with the milling complex for use of shared facilities.

(b) Efficiency improvement

With a refining factor of 1.1, diesel usage of 3 litres/tonne, steam of less than 100 kg/tonne and losses of 0.50%, significant improvement in these areas is difficult.

(c) Quality improvement

I believe one of the key factors for the poor margin of RBD PO is the mediocre quality of RBD PO at arrival which necessitates reprocessing, hence, further handling and processing costs and losses.

I understand one or two companies have been able to produce and provide RBD PO with very superior landed specifications which accordingly enjoys a handsome premium.

I believe the essential aim of technological advances should be to produce an RBD PO acceptable to the customer that requires no further processing.

What is required is not a small but a significant improvement. For our discussion, I will put forward a specific requirement to be met.

Landed Specifications

FFA	0.05 % max.
M & I	0.05 % max.
IV	51 to 55
MP +	33 to 39
Colour ($5^1/_4$" Lovibond)	1.5R max.
	15 yellow max.
PV (meq/kg)	1.0 max.
Rancimat 22 hours minimum at 110°C	

I shall propose three possible approaches to achieve the landed specifications :-

(1) Good quality CPO from mill with FFA less than, say, 1.5%, low PV, low phosphorus and low iron content. By conventional thinking, this can only be achieved if good and fresh FFB are received by the mill and some segregation of loose fruit from FFB is done in the estate or at the mill ramp for separate processing. With such quality CPO, a good refinery should be able to produce a good RBD PO to meet the landed specification, incorporating nitrogen sparging and blanketing and taking proper care of the oil during transport and shipment.

(2) Can some work be done to polish the normal quality CPO fresh from production so that when it is sent to the refinery, it can be refined to the acceptable landed specifications with the necessary stability?

(3) Is it possible that the average quality CPO received by the refinery be processed to give the RBD PO which can meet the landed specifications?

We all accept approach (1) as the logical choice, if not the only way, to achieve the required stringent quality requirement, based on the principle of 'Garbage in, garbage out'.

I do not have the answers but would like to argue for work to be done in approaches (2) and (3) by quoting an analogy in the rubber industry.

Production of rubber gloves

- Many glove manufacturers experienced high reject rates. One of the main factors identified is the quality of the compounded latex.
- To achieve a low rejection rate, those factories that do their own compounding need to buy good quality latex concentrate.
- However, there is one compounding company in Malaysia that has the magic process. It uses normal or average field latex for compounding. But it always produces a compounded latex that gives low reject rates.

What is needed is that 'Magic Process' that can convert average CPO to a fully refined and stable oil acceptable to the customer.

I believe there are certain leads that need to be investigated :-

(1) Bleaching Earth
How good and how consistent is the bleaching earth in terms of oil decolourization? What is the quality and variability of your bleaching earth? When the quality of your refined oil is variable or poor, how sure are you that it is not related to the earth?

(2) What is considered a fully refined oil? The smaller the increase in extinction of oils containing linoleic acid at 268 nm after treatment with bleaching earth the clearer and more stable the final refined oil.

We are not yet able to define the increase of the triene absorption at which an oil of the linoleic group can be designated unstable. However, it is certain that the height of this threshold value depends on the linoleic acid content and the oleic acid content respectively of the oils in question.

The constancy of the extinctions in the oleic and triene regions in testing oils ready for use is a sign that one is dealing with a fully refined oil.

(3) The present Physical Refining Plant is a compromise process regarding the colour, FFA and stability of the RBD PO. It is not a truly optimum process.

This conclusion is based on a preliminary optimization trial carried out at full-scale plant operation and tested on seven variables.

The preliminary trial results showed that no one set of refining conditions could give RBD PO with low colour, low FFA and high stability.

The development of an optimum refining process is necessary.

Fractionation

Technical advances in fractionation have centred around the membrane filter press which can yield between 77% and 80% olein.

Problems with cracks in the membrane were encountered. This problem appears to have been solved through proper operating techniques and by redesigning the frame.

KERNEL CRUSHING PLANT

The three methods of oil extraction in use are:

(a) 100% mechanical extraction using
 (i) two stage pressing (mainly local)
 (ii) kernel precooking followed by single stage pressing (Rosedown type and local type)

(b) Solvent extraction.

(c) First stage mechanical extraction followed by solvent extraction.

There are few technological advances in the local kernel crushing plant industry because:

(i) Kernel crushing is undertaken mainly as a backyard-type industry.
(ii) The low and often negative margins.

Most of the crushers use the mechanical extraction process because of lower capital and running costs.

The problems faced by the kernel crushers are :-

(1) Low and often negative margins.
(2) High power cost ($15 to $18 per tonne PK).
(3) High wear rate of machines ($5 to $10 per tonne PK).
(4) 10% duty on CPKO.
(5) Limits of oil extraction rate by method and presses in use (41% to 43.5% PKO yield).

To improve the viability of the kernel crushing industry, we need to:

(1) Eliminate the 10% duty on CPKO to encourage export.
(2) Improve extraction rates to at least 44%.
(3) Reduce processing cost to not more than $20/tonne PK.
(4) Refine the PKO.
(5) Fractionate the PKO.

There is need for technological breakthroughs by PORIM or the industry to:

(1) Develop a method of oil extraction using less power and hence causing less wear on machines yet giving a higher oil yield. A biochemical process? Use of an enzyme? Target oil yield 44% minimum. Cost of manufacture $20/tonne maximum.

(2) Through breeding or improved processing techniques, increase the protein content of palm kernel meal (currently 14% to 17%) significantly so that it fetches a higher value in the market.

(3) Through breeding, reduce the hardness of palm kernel.

Economics of Kernel Crushing

PK =$680/tonne ex-basis
CPKO =$1300/tonne ex-basis
PKC =$260/tonne ex-basis

Processing cost =$35/tonne
Oil extraction =42.5%
PKC extraction =53%

(1) Net from kernel crushing
 = (1300 x 0.425) + (260 x 0.53) – 35
 = $655.3

 Net gain/(loss)
 = ($24.70)/tonne PK processed

(2) If CPKO exported:-
 Net from kernel crushing
 = (1300 x 0.425 x 0.9)
 + (260 x 0.53) – 35
 = $635

 Net gain/(loss)
 = ($45/-)/tonne PK processed

Palm Kernel Oil Fractionation

The table below indicates the great

potential for processed PKO products. Although a few organizations have gone into the game, many are still unable to invest due to lack of technology and market knowledge.

PORIM should carry out more work in this area and at least provide more technological data to the industry to encourage greater participation in this possible lucrative activity.

Premiums of PKO Products over Crude

	1983 M$	1984 M$	1985 M$	1986 M$
RBD PKO/CPKO	-	118	257	85
CPKS/CPKO	1367	1141	1432	1445
RBD PKST/CPKO	-	-	2144	1300
HRBD PKST/CPKO	-	2411	3125	2113
CPK OL/CPKO	-	- 404	+ 331	- 94
RBD PKOL/CPKO	-	130	133	70
HRBD PKOL/CPKO	1158	-	960	837

CONCLUDING REMARKS

The requirements of the industry 10 - 15 years ago and now are quite different. For example, for a palm oil mill the requirements 15 years ago were (i) a mill must run smoothly and be able to cope with peak crop. This was the main objective. Now, the demands on palm oil mills are:

(1) A mill is assumed to be able to run smoothly and cope with peak crop.

(2) A mill must be efficient in oil and kernel recovery, *i.e.* minimum losses.

(3) A mill must ensure minimum quality deterioration of CPO and PK.

(4) A mill must be cost-efficient.

(5) A mill must produce CPO and PK to meet more stringent market demands on quality and consistency.

This means we must be able to make the best and full use of all our resources in the mill - **People, Machines, Raw Material** and **Limited Money.**

This means that we must do the following:

(1) Get the best out of people, through training, motivation and leadership;

(2) Keep up-to-date with proven technology within and outside the Industry;

(3) Know the capabilities of our machines;

(4) Identify and quantify causes and effects;

(5) Apply optimization techniques;

(6) Introduce systems to monitor, check and lock-in for consistency of performance;

(7) Be able to tie in people and machines for best performance.

Such demands on the Industry rest squarely on the shoulders of you and me, the executives of the Industry.

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