Decanter Evaluation Trials at Brooklands Palm Oil Mill

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RINGKASAN

Sebuah dekanter yang berkeupayaan 20 tan metrik/jam di Kilang Sawit Brookland telah digunakan untuk kajian. Kajian yang dibuat menunjukkan bahawa jaminan prestasi oleh syarikat pengedar boleh didapati dengan menjalankan dekanter seperti sistem yang dicadangkan.

INTRODUCTION

There are many makes of decanters available for the treatment of crude palm oil either in diluted or undiluted state. All of them claimed to be advantages both in terms of capital cost and oil recovery efficiency over the present conventional system which uses settling tanks and nozzle separators.

The 3-phase decanter separates, by centrifugal action, the crude oil into three streams, namely, oil phase, heavy phase and solid phase.

The Ishikawajima Harima (IHI) decanter was selected for the trial at Brooklands Palm Oil Mill (20 tonnes FFB/hr) in Banting, Selangor. PORIM participated in the trial as an independent observer.

OBJECTIVES

The objectives of the trials were as follows:

i. To evaluate the performance of the Ishikawajima-Harima (IHI) decanter on a quantitative basis to obtain the following process information:

   a. hourly performance data for decanter
   b. determination of the decanter performance in terms of statistical upper control limit (UCL) and lower control limit (LCL).

ii. To evaluate the wear and tear characteristics.

iii. To evaluate the economics of a decanter-based clarification system

SYSTEM CONFIGURATION EVALUATED

In the quantitative evaluation of the decanter performance, the following configurations/modes of operation were studied:

- System A with 3-phase decanter operation (*Figure 1*)
- System B with 3-phase decanter and 2-phase Alfa Laval PASX 410T nozzle separator/secondary clarifier operation (*Figure 2*)
- System C with 3-phase decanter and 2- or 3-phase Alfa Laval PASX 410T nozzle separator/oil recycle operation (*Figure 3*)
- System D with static clarifier/3-phase decanter and 2-phase Alfa Laval PASX 410T nozzle separator/oil recycle operation (*Figure 4*)
- System E with static clarifier/3-phase decanter operation (*Figure 5*)

EXPERIMENTAL DESIGN

To study the hourly performance of the decanter, daily data collection were made as follows:

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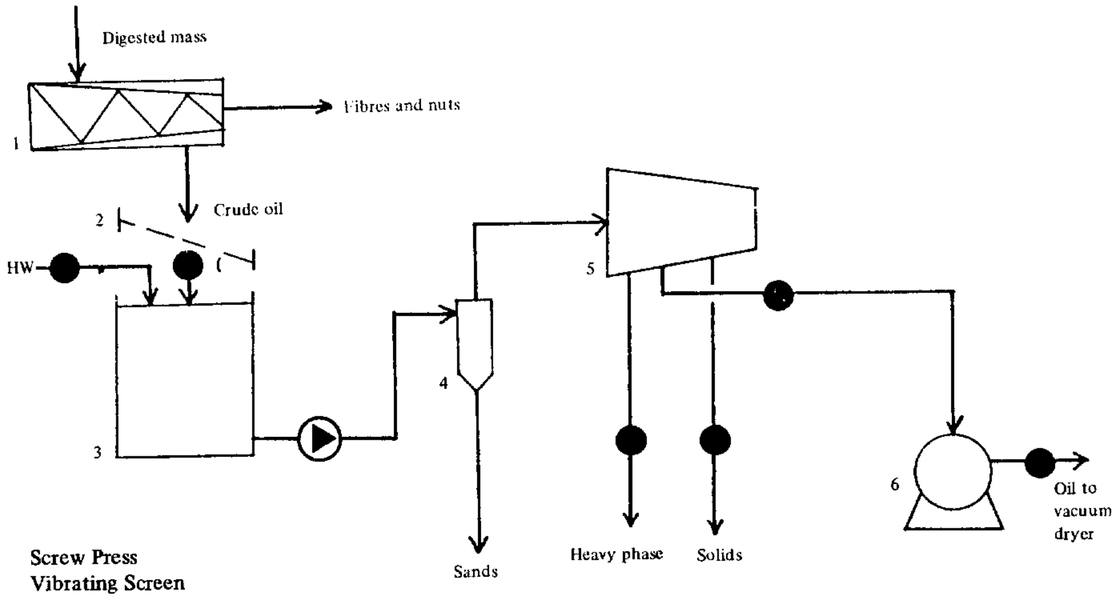
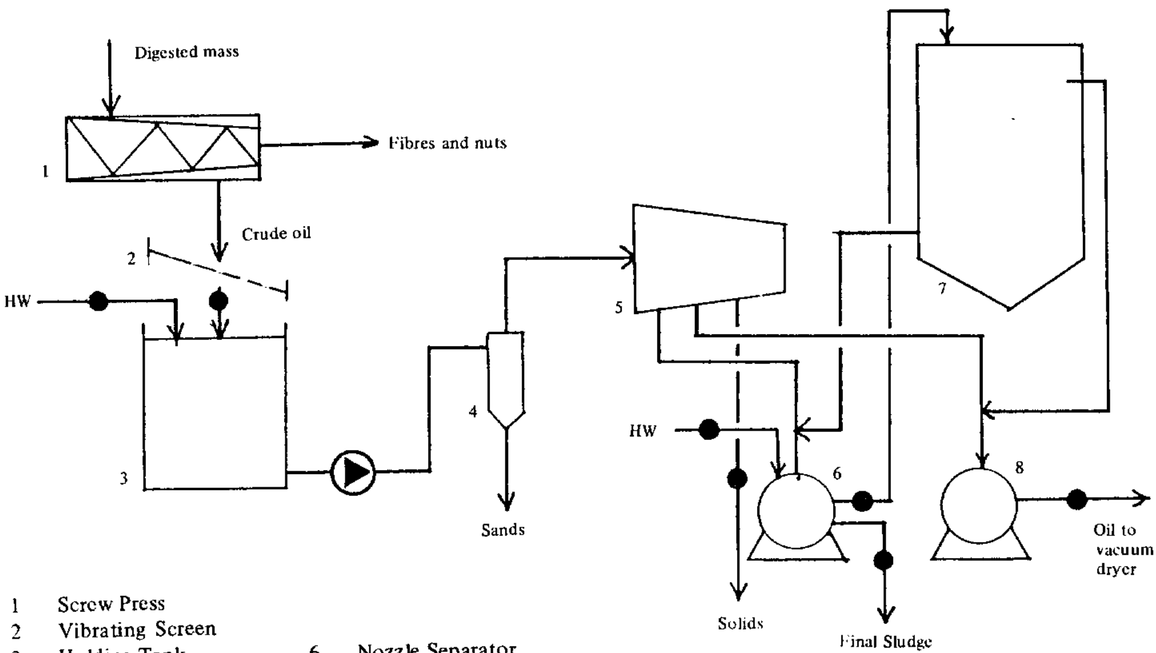
‡ *Dunlop Estate Berhad*



1 Screw Press
2 Vibrating Screen
3 Holding Tank
4 Sand Cyclone
5 Three Phase Decanter
6 Purifier

HW Hot Water
● Flowmeters

Figure 1. System with 3-Phase Decanter Operation (System A)



1 Screw Press
2 Vibrating Screen
3 Holding Tank
4 Sand Cyclone
5 Three Phase Decanter
6 Nozzle Separator
7 Secondary Clarifier
8 Purifier

HW Hot Water
● Flowmeters

Figure 2. System with 3-Phase Alfa Laval 410T Nozzle Separator/Secondary Clarifier (System B)

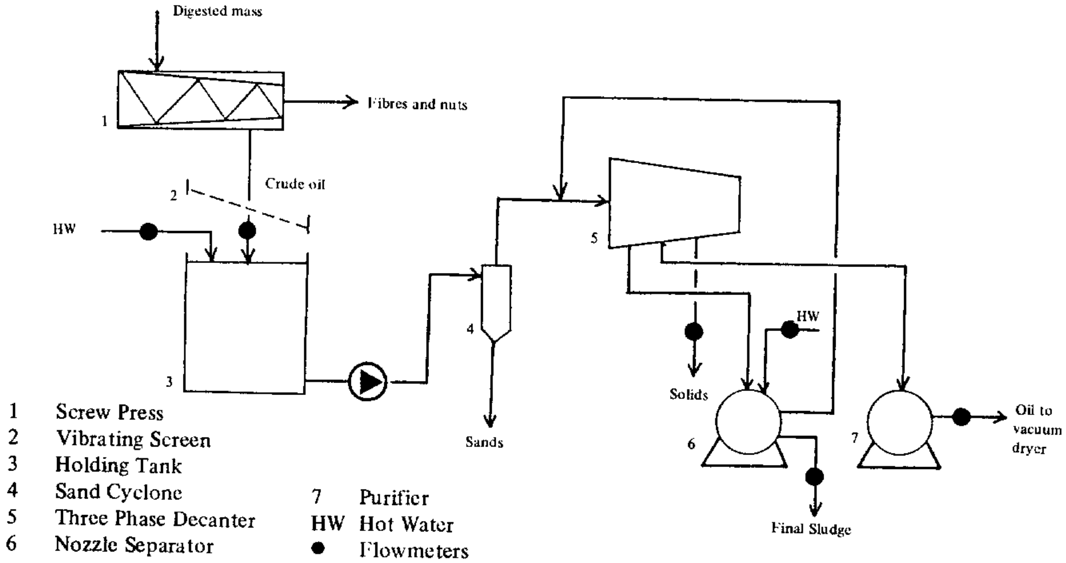


Figure 3. System with 3-Phase Decanter and Alfa Laval 410T Nozzle Separator/Oil Recycle Operation (System C)

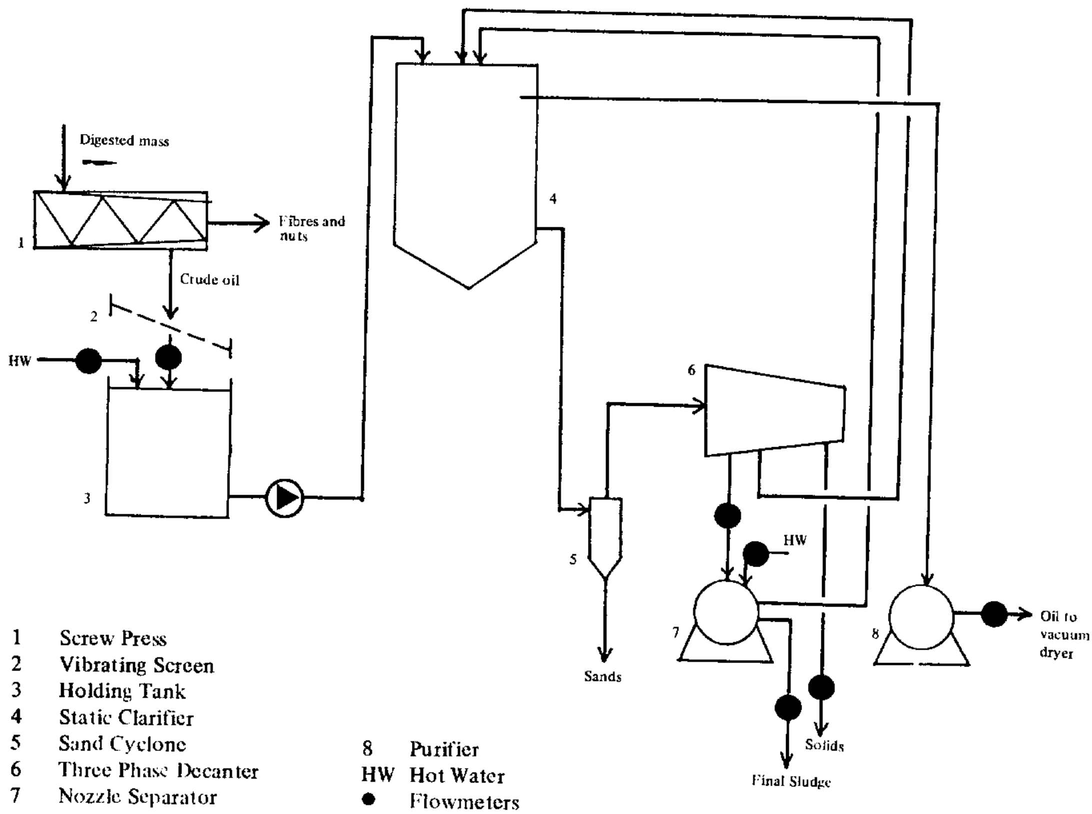


Figure 4. System with Static Clarifier/3-Phase Decanter and Alfa Laval 410T Nozzle Separator Recycle Operation (System D)

i. Half-hourly collection of samples, which are bulked for hourly composition analysis, for the relevant flow streams;

ii. Hourly recording of quantitative flow rates (*kg/hr) for relevant flow streams.

Each experiment would run, as far as practicable, for eight hours everyday.

For the duration of each run the following process parameters were also monitored:

i. the actual FFB processed;
ii. the decanter running hours;
iii. the temperature of the crude oil fed to the decanter;
iv. the accumulation and reduction in the process vessels; and
v. the dilution rate for crude oil.

The metering devices used for the experimental evaluation were rotary basculators, droppler flowmeters, magnetic flowmeters and water flowmeters.

PERFORMANCE GUARANTEES

The supplier guarantees that the performance of the IHI 3-phase decanter model HS 55 TP will meet the following specifications:

a.	Feed capacity	12 m^3/hr *i.e.* 20 tonnes FFB/hr at crude oil to FFB ratio of 0.6.
b.	Scroll life	6000 hr operations minimum (sand must be removed before decanter using a desanding cyclone)
c.	Oil loss (overall)	Less than or equal to 4 kg/tonne FFB (*i.e.* 0.5 kg/tonne FFB better than conventional system)
d.	Solid moisture content	Less than or equal to 80%
e.	Light phase composition	Final production oil quality must meet SIRIM CPO specifications: Moisture 0.2% max; NOS (dirt) 0.02% max

EXPERIMENT RESULTS

Appendix I summarizes the detail experiment results for various system configurations evaluated.

The experiment results for total oil losses ex-system are as follows:

System A	6.97 kg/tonne FFB
System B	5.16 kg/tonne FFB
System C	4.39 kg/tonne FFB
System D	3.16 kg/tonne FFB
System E	3.41 kg/tonne FFB

System D and E meet the performance guarantee of 4 kg/tonne FFB. The other performance guarantee are easily met.

ECONOMIC CONSIDERATION

Appendix II summarizes the detailed computation for payback time for systems D and E.

The payback times are as follows:

	Payback	CPO price
System D	2.83 yr	$700.00
System E	3.20 yr	$700.00

CONCLUSIONS

a. The performance guarantees given by the manufacturers can be met by operating the decanter with system D and E.

b. For existing mills, configuration D is recommended. For new mills, an economic incremental analysis would be required in order to select configuration D and E. However,

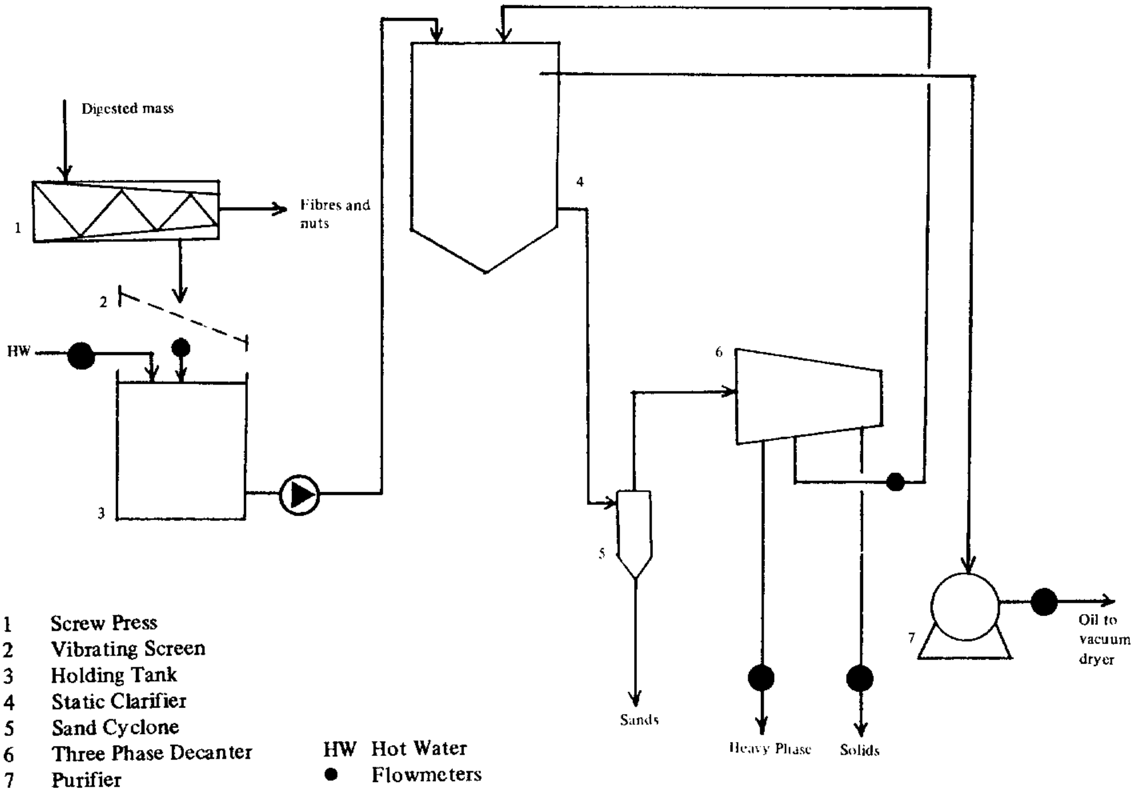


Figure 5. System with Static Clarifier/3-Phase Decanter Operation (System E)

the selection criteria is very dependent on the price of crude palm oil which is rather volatile as with most commodities.

c. The decanter solids can be utilized in the field as fertilizer substitute. The quantity available is 4% to FFB at about 80% moisture content.

PORIM would be undertaking further studies on other decanters to verify the performance figures quoted by the manufacturers. However, it must be noted that evaluation by PORIM does not constitute endorsement of such equipment by PORIM.

Decanter bowl speed = 3 300 rpm
(a) System with 3-phase decanter operation (System A)

Run number		1	2	3	4	5	6	7	8	9	10	11	Overall		
													$\bar{x}$	γ	CV
Orifice plate setting (LP/HP)		8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	–	–	–
Temperature of feed (°C)		96	98	92	92	88	95	91	96	89	97	93	93	3	3.53
Dilution rate (% HW/DCO)		5.4	8.2	9.0	6.3	12.6	*19.3	*26.5	5.2	11.8	8.1	6.9	10.85	6.60	60.90
Throughout (tonne FFB/h)		21.0	19.6	20.4	20.4	20.5	18.6	17.6	19.5	20.7	17.5	20.6	19.67	1.25	6.35
Oil content in feed (%)		49.22	48.98	48.13	49.27	48.30	53.34	51.34	43.42	51.01	55.76	50.39	46.38	14.10	30.41
Oil loss in solids ex-decanter (kg/tonne FFB)		1.10	1.37	1.15	1.46	1.34	*1.55	*1.79	1.23	1.05	1.47	1.46	1.36	0.22	16.07
Oil loss in heavy phase ex-decanter (kg/tonne FFB)		5.30	5.70	5.50	3.56	4.75	*8.23	*6.14	5.76	6.68	4.27	5.81	5.61	1.23	21.98
Total oil losses ex-decanter (kg/tonne FFB)		6.40	7.07	6.65	5.02	6.09	*9.78	*7.93	6.99	7.73	5.74	7.27	6.79	1.27	18.16
Light phase ex-decanter	VM%	0.35	0.25	0.36	0.29	0.33	0.30	0.39	0.86	0.35	0:35	0.20	0.37	0.17	47.11
	dirt (%)	0.048	0.072	0.047	0.039	0.021	0.025	0.049	0.157	0.040	0.028	0.050	0.052	0.04	71.60
Solids ex-decanter	VM %	76.40	77.53	75.95	75.81	75.93	76.94	77.45	75.78	77.95	77.78	76.91	76.76	0.83	1.08

* Dilution exceedingly high

(b) **System with 3-phase Alfa Laval 410T nozzle separator/secondary clarifier operation (System B)**

Run number	1	2	3	4	5	6	7	8	9	10	Overall		
											$\bar{x}$	δ	CV
Orifice plate setting (LP/HP)	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	8/14	–	–	–
Temperature of feed ($^{\circ}$C)	96	98	92	92	88	95	91	96	89	97	93	3	3.72
Dilution rate (% HW/DCO)	5.4	8.2	9.0	6.3	12.6	19.3	26.5	5.2	11.8	8.1	11.24	6.82	60.71
Throughput (tonne FFB/h)	21.0	19.6	20.4	20.4	20.5	18.6	17.6	19.5	20.7	17.51	19.58	1.28	6.52
Oil content in feed (%)	49.22	48.98	48.13	49.27	48.30	53.34	51.34	43.42	51.01	55.76	49.88	3.31	6.64
Oil loss in solids ex-decanter (kg/tonne FFB)	1.10	1.37	1.15	1.46	1.34	*1.55	*1.79	1.23	1.05	1.47	1.35	0.23	16.87
Oil loss ex-separator discharge (kg/tonne FFB)	3.86	3.82	3.15	2.64	3.01	*5.19	*6.56	3.52	4.53	1.84	3.81	1.35	35.41
No. of nozzles and nozzle size for separator (only 1 unit in operation each time)	4×1.8	4×1.8	4×1.6	4×1.6	4×1.6	8×1.6	8×1.6	4×1.6 4×1.15	4×1.6 4×1.6	4×1.6 4×1.45	–	–	–
Total oil losses ex-system (kg/tonne FFB)	4.96	5.19	4.30	4.10	4.35	*6.74	*8.35	4.75	5.58	3.31	*5.61*	1.45	28.14

* Dilution exceedingly high

(c) System with 3-phase decanter and 2- or 3-phase Alfa Laval 410T nozzle separator/oil recycle operation (Data for 3-phase operation of separator) (System C)

Run number		1	2	3	4	Overall		
						$\bar{x}$	γ	CV
Orifice plate setting LP/HP		8/14	8/14	8/14	8/14	–	–	–
Temperature of feed ($^{\circ}$C)		92	94	93	93	93	1	0.88
Dilution rate (% HW/DCO)		5.1	2.6	4.5	8.6	5.20	2.50	48.17
Throughput (tonne FFB/h)		23.4	20.3	25.4	21.1	22.55	2.31	10.24
Oil content in feed (%)		45.34	39.16	38.37	43.76	41.66	3.42	8.20
Oil loss in solids ex-decanter (kg/tonne FFB)		1.14	1.36	1.04	1.45	1.25	0.19	15.23
Oil loss ex-separator discharge (kg/tonne FFB)	Water phase	1.00	1.72	3.42	0.92	1.77	1.16	65.75
	Sludge phase	1.66	1.42	0.75	1.63	1.37	0.42	31.04
No. of nozzle and nozzle size for separator (only 1 unit in operation each time)		4×1.6	4×1.6	4×1.6	4×1.6	–	–	–
Total oil losses ex-system (kg/tonne FFB)		3.80	4.50	5.21	4.00	*4.39*	0.64	14.63
Light phase ex-decanter	VM(%)	0.26	0.32	0.47	0.35	0.35	0.09	25.23
	Dirt (%)	0.069	0.046	0.085	0.055	0.064	0.017	26.72
Solids ex-decanter	VM (%)	75.50	75.09	76.88	76.64	76.03	0.87	1.14

(d) **System with static clarifier/3-phase decanter and 2- or 3-phase Alfa Laval 410T nozzle separator recycle operation (System D)**

Run number		1	2	3	4	5	6	7	Overall		
									$\bar{x}$	γ	CV
Orifice plate setting LP/HP		8/14	8/14	8/14	8/14	10/14	10/14	10/14	–	–	–
Temperature of feed (°C)		92	95	95	96	97	97	97	96	2	1.90
Dilution rate (% HW/DCO)		24.8	20.7	22.6	18.5	15.5	19.6	16.5	19.74	3.28	16.64
Throughput (tonne FFB/h)		19.6	21.4	21.1	22.6	20.8	22.7	22.5	21.53	1.15	5.33
Oil content in feed (%)		6.58	5.33	5.23	5.56	6.10	–	–	5.76	0.57	9.87
Oil loss in solids ex-decanter (kg/tonne FFB)		1.08	0.97	1.05	1.09	0.82	0.94	1.03	1.00	0.10	9.59
Oil loss ex-separator discharge (kg/tonne FFB)		2.95	2.07	2.18	1.96	1.97	1.86	2.16	2.16	0.36	16.86
Total oil losses ex-system (kg/tonne FFB)		4.03	3.04	3.23	3.05	2.79	2.80	3.19	3.16	0.42	13.27
No. of nozzle and nozzle size for separator (only 1 unit in operation each time)		8×1.8 2-phase	4×1.6 4×1.8 3-phase	4×1.6 4×1.8 3-phase	8×1.6 3-phase	8×1.8 2-phase	8×1.6 3-phase	8×1.6 3-phase	–	–	–
Light phase ex-decanter	VM (%)	4.25	1.85	3.64	3.87	4.09	–	–	3.54	0.97	27.47
	Dirt (%)	2.08	0.83	0.81	1.37	2.99	–	–	1.62	0.93	57.31
Solids ex-decanter	VM (%)	78.44	78.95	80.05	80.49	78.28	–	–	79.24	0.89	1.24

(e) System with static clarifier/3-phase decanter operation (System E)

Run number	1	2	3	4	5	6	7	8	9	Overall		
										$\bar{x}$	γ	CV
Orifice plate setting LP/HP	8/14	8/14	8/14	10/14	10/14	10/14	10/14	10/14	10/14	–	–	–
Temperature of feed (°C)	92	95	95	96	97	97	97	96	97	96	2	1.71
Dilution rate (% HW/DCO)	24.8	20.7	22.6	18.5	15.5	19.6	16.5	21.2	23.2	20.29	3.08	15.20
Throughput (tonne FFB/h)	19.6	21.4	21.1	22.6	20.8	22.7	22.5	24.2	21.4	21.81	1.34	6.14
Oil content in feed (%)	6.58	5.33	5.23	5.56	6.10	–	–	–	–	5.76	0.57	9.87
Oil loss in solids ex-decanter (kg/tonne FFB)	1.08	0.97	1.05	1.09	0.82	0.94	1.03	0.75	0.76	0.94	0.14	14.32
Oil loss in heavy phase decanter (kg/tonne FFB)	3.28	2.50	2.85	2.72	2.22	1.93	2.21	2.66	2.07	2.49	0.43	17.23
Total oil losses ex-system (kg/tonne FFB)	4.36	3.47	3.90	3.81	3.04	2.87	3.24	3.41	2.83	3.44	0.51	14.89

ECONOMIC CONSIDERATIONS

a. The capital expenditure required is as follows:

Decanter cost (1985)	$185 000
Installation cost	$ 25 000
Evaluation cost	$ 14 000
	$224 000

b. The operating expenditure required is as follows: The scroll life of the decanter is guaranteed for 6000 hours of operation. The re-conditioning cost for a scroll is $10 000 per unit. Hence the operating cost of the decanter per annum based on 3000 running hours (BPOM – 60 000 tonnes FFB/annum) is

$$\frac{3000}{6000} \times \$10\,000$$

= $5 000/annum.

c. The savings for decanter operation are as follows:

System D

i. Improved oil loss ex-system based conservatively on 4.5 kg/tonne FFB for conventional system achieved by established plantation agencies.

$$\text{Saving per annum} = \frac{60\,000 \times (4.5 - 3.16) \times 700}{1\,000}$$

$$= \$56\,300$$

(based on CPO price at $700/tonne)

ii. The estimated cost of water per cubic metre for Brooklands Palm Oil Mills is $0.40/ m^3. With decanter operation it would be possible to reduce water consumption by 0.1 m^3/tonne FFB.

$$\text{Saving per annum} = 60\,000 \times 0.1 \times \$0.40$$

$$= \$2\,400$$

iii. Reduced operating cost of major parts for Alfa Laval PASX 410T sludge separators.

Savings per annum are as follows:

Nozzles	$ 6 700
Erosion guards (top and bottom)	$ 1 600
Distributor inserts	$ 800
Bushings	$ 6 600
	$15 700

Summary

Yearly expenditure	
Reconditioning the scroll	$ 5 000
Yearly revenue	
Improved oil recovery	$56 300
Reduced water consumption	$ 2 400
Maintenance cost reduction	$15 700
	$79 400

$$\text{Payback time} \quad \frac{224\,900}{79\,400} = 2.83 \text{ yrs}$$

System E

i. Improved oil loss ex-system based conservatively on 4.5 kg/tonne FFB for conventional system achieved by established agencies.

$$\text{Saving per annum} = \frac{60\,000 \times (4.5 - 3.44) \times 700}{1\,000}$$

$$= \$44\,500$$

(Based on CPO price at $700/tonne)

ii. The estimated cost of water per m^3 for Brooklands Palm Oil is $0.40/$m^3$. With decanter operating it would be possible to reduce water consumption by 0.2 m^3/tonne FFB.

$$\text{Saving per annum} = \frac{60\,000 \times 0.2 \times \$0.40}{1\,000}$$

$$= \$4\,800$$

iii. No operating cost for sludge separators (Alfa Laval PASX 410T)

Savings per annum are as follows:

Nozzles	$10 100
Erosion guards (top and bottom)	$ 2 500
Distributor inserts	$ 1 200
Bushings	$ 7 200
Total	$21 000

Summary

Yearly expenditure:	
Reconditioning the scroll	$ 5 000
Yearly revenue:	
Improved oil recovery	$44 500
Reduced water consumption	$ 4 800
No maintenance cost for PASX 410T	$21 000
	$70 300

$$\text{Payback time} = \frac{224\,900}{70\,300}$$

$$= 3.20 \text{ yr.}$$