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NATIONAL CLEANER PRODUCTION CENTRE SA

NCPC
national cleaner production centre
South Africa

CONTRACT REPORT

IN-PLANT ASSESSMENT REPORT OF

HUDSON & KNIGHT(PTY) LTD

086DG / HY7AGRO

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IN-PLANT ASSESSMENT REPORT

OF

HUDSON & KNIGHT(PTY) LTD

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28 September 2007

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EXECUTIVE SUMMARY

Hudson & Knight (Pty) Ltd, which is a 100% subsidiary of the international Golden Hope Group of Malaysia, was selected as one of the case studies for the Cleaner Production Demonstration programme currently being hosted by the National Cleaner Production Centre (NCPC) of South Africa. The Hudson & Knight factory in Boksburg was the entity that was assessed.

The aim is to gather data on the production and waste generated in order to identify areas where cleaner production can be applied to improve profitability and enhance the environment. This report presents the outcome of detailed assessment findings on certain CP options chosen in the Quick-Scan phase.

The company produces refined vegetable oil from crude sunflower seed oil, crude linseed oil, crude bean oil, crude palm oil, and crude coconut oil. The refined oils are sold across the fence to Unilever Foods and small quantities to other food processors for the manufacture of margarines and edible fat products. The refinery operation which is owned by Hudson & Knight forms the scope for the Cleaner Production assessment. In the past Unilever owned the refinery operations. Therefore, there is a fair amount of synergy and infrastructure sharing between the two companies.

The CP Options of determination of material balance to identify areas where oil wastage can be decreased, and, reduction in steam consumption was investigated, and a number of cleaner production activities have been recommended in the action plan. The results of this can be benchmarked with the Best Available Techniques (BAT) as follows:

	BAT					
	Steam		Electricity		Total Energy	
	kWh/t product		kWh/t product		kWh/t product	
Range	low	high	low	high	low	high
Neutralisation	31	78	6	12	37	90
Soap Splitting	156	778	3	10	159	788
Bleaching					0	0
Winterisation					0	0
Hardening	-25	-125	111	278	86	153
Deodorisation	117	311	17	42	134	353
Total	279	1042	137	342	**416**	**1384**

	H & K
Utility	Total Energy
	kWh/t product
Steam	582
Gas	0.13
Electricity	25
	607.54

Total energy consumed of per ton of finished products is 607.54 kWh. This is in the lower quartile of the international range of operation from 416 kWh/t to 1384kWh/t.

The Hudson & Knight plant is operating at the top quartile of all seed oil refinery plants in the world. Acknowledgements to management on a well run operation is in order. However, TPM allows for continuous improvement and an opportunity to recover heat from hardening in the form of steam should be investigated. The recovery of wax slurry and the optimisation of steam usage with less steam leakage and waste will further enhance the company's competitiveness.

	Savings/month Rands	Savings/yr R Millions
Recovery of oil from wax slurry	288120	3.457

The recycling of wax slurry will generate revenues of R3.457 million per annum or discounted over ten years at 15% per annum, the present value of these cash flows is of the order of R17.3 million in savings.

The high steam bill can also be reduced as shown below, where steam leaks are eliminated with increased maintenance and monitoring of valves, steam traps, pipes etc. Savings in the form of raw water can also be achieved by recovering condensate that is not contaminated and sent to the boiler feed water.

	Savings/month	Savings/yr
Steam Leaks	R126666	R1.52m
Condensate Recovery	R19253	R231033
Total	R145919	R1.75m

Assuming an inflation rate of 5% per annum and a discount rate of 15%, the present value of the cash flows over a ten year period is R10.45 million.

Total potential savings that can be realised from Cleaner Production initiatives is of the order of R5.21 million per annum or R31.1 million over a period of ten years.

CONTENTS

PREFACE

This Cleaner Production In-Plant Assessment Report was performed as part of an awareness and pilot NCPC project by the South African National Cleaner Production Centre (NCPC - SA). The NCPC was established in 2002 within the framework of UNIDO/UNEP[1] Cleaner Production Centres

The programme has been designed for the needs of companies ready to analyze and optimize their internal business processes with a view to developing Cleaner Production (CP) techniques and to implement Environmentally Sound Technologies. This will allow the companies to reduce both their operating costs and the environmental performance, thus increasing their productivity and competitiveness. The project provides opportunities for staff training and technical consulting. It is targeted at executives and technically skilled employees (such as managers with a special brief for environmental affairs).

Further information can be found on the internet www.ncpc.co.za. Before a company is analyzed in detail, a *Quick-Scan* is usually conducted. The Quick-Scan is a short analysis which assesses the quality of the crucial processes, material- and energy flows in order to identify the *potentials* for CP. I.e. with the Quick-Scan the process areas with good optimising potentials are found and a possible focus for further analysis can be defined. On the basis of the Quick Scan, the company will decide whether or not and in which process areas an in-depth analysis (the CP Assessment) shall be conducted.

1. PROCEDURE

The company Hudson & Knight (Pty) Ltd, represented through its Manager, Mr Noel Alleaume, declared an interest in conducting an in-depth In-Plant Assessment, for the CP Option of material balance to decrease oil wastage and reduction in steam consumption, performed at its premises as indicated by communication with the CSIR.

The IPA was initiated on 17 November 2006, at the company's plant in Boksburg. The following persons have been involved at different stages of the process:

From Hudson & Knight (Pty) Ltd.:

Mr Noel Alleaume – Factory Manager
Mr Shailen Toolsi – TPM Manager/ Process Engineer
Mrs Rabelani Ngobeli – Process Technician

[1] UNIDO – United Nations Industrial Development Organisation
UNEP – United Nations Environment Programme

From the NCPC:

Mr Mano Ramreddi	- Project Manager
Dr Johannes Fresner	- FHBB Basel/Stenum
Dr Thomas Burki	- FHBB Basel

Consultant Team Members:

Mr Woody Naicker	- team leader
Mr Bongani Mudau	
Mr Tshinanne Mutshatshi	

2. COMPANY INFORMATION

2.1 The Enterprise

The company Hudson & Knight (Pty) Ltd which is a subsidiary in the Golden Hope Group based in Malaysia. The plant was started some thirty years ago. The company is domiciled at 511 Commissioner Street, Boksburg, South Africa. The company produces refined vegetable oil from crude sunflower seed oil, crude linseed oil, crude bean oil, crude palm oil, and crude coconut oil. The refined oils are sold across the fence to Unilever Foods and small quantities to other food processors for the manufacture of margarines and edible fat products. The refinery operation which is owned by Hudson & Knight forms the scope for the Cleaner Production assessment. The refinery operation was acquired from Unilever Best foods Robertson's (UBR) in 2004. Therefore, there is a fair amount of synergy, infrastructure sharing and management between the two companies.

The factory at Boksburg processes approximately 13,374 tonnes of crude vegetable oil per month and produces 12,036 tunes/month of refined oil products, 36 tones'/month of spent earth, 54 tones/month of wax slurry, 300 tones/month of soap stock, and 21 tones/month of waste or drain fat. The factory employs a total of 53 people at the site, including 39 operators and 14 staff members. The plant operates on a two shift basis, 24 hours per day, seven days per week. Maintenance and cleaning is carried out on an ad-hoc or at breakdowns. Hudson & Knight (Pty) Ltd has a turnover of R550 million per annum.

The suppliers are Nola for sunflower oil, Unilever for palm oil, palm kernel, & coconut oils, and NCP for caustic soda. Utilities are supplied by Eskom for electricity and Rand Water for potable water usage in the plant.

The customers include Unilever Foods, Felda Bridge, Nestlé, Simba, and a number of small companies.

The company has an environmental philosophy that allows it to comply with most environmental standards. The company is HAACP compliant and has GMP, ISO 9001, ISO 14000 certification, and NOSCAR. The company is will have ISO 22000 by August 2007. There is also a health and safety management system implemented.

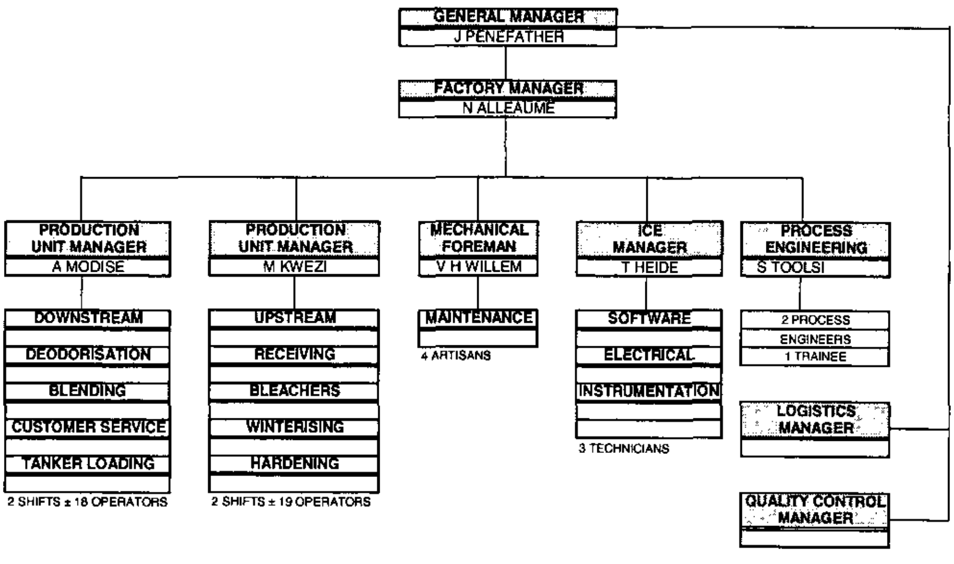
Hudson & Knight is implementing a Total Productivity Manufacturing (TPM) programme at it plant which will drive continuous improvement in process and manufacturing. Mr S Toolsi is the TPM champion.

2.2 Manufacturing Processes

2.2.1 Overview

The departments or sections at the Hudson and Knight refinery are represented in figure 1.

Figure 1: Overview of the various departments at Hudson & Knight Factory



The factory consists of two production sections; the upstream section consisting of crude oil receiving, bleaching, winterising and hardening processes, and the downstream section consisting of the deodorisation, blending, customer service, and tanker loading services.

The company is continuously improving plant and processes. It is in the process of implementing the Total Productivity Manufacturing (TPM) philosophy which is a continuous improvement programme at its plant. The vision of TPM is to focus on improvement in productivity, quality, cost, delivery, safety, and staff morale. There are eight pillars of TPM each with a champion to drive indicators which are communicated to staff continuously. The eight pillars are focussed improvement, autonomous maintenance, planned maintenance, quality, SHE, training & education, TPM in administration, and early management. The full implementation of TPM will generate significant rewards and cost savings for the company into the future.

2.2.2 Vegetable Oil Refining Material Flow

The process of edible oil refining, in general, comprises of Degumming, neutralization, bleaching, deodorization, and winterisation. Chemical refining is the traditional method whereby the free fatty acid of the crude oils is neutralized with caustic soda. The resultant sodium soaps are removed by batch settling or by means of centrifugal separators. The neutral oils are subsequently bleached and deodorized.

MATERIAL FLOW ANALYSIS

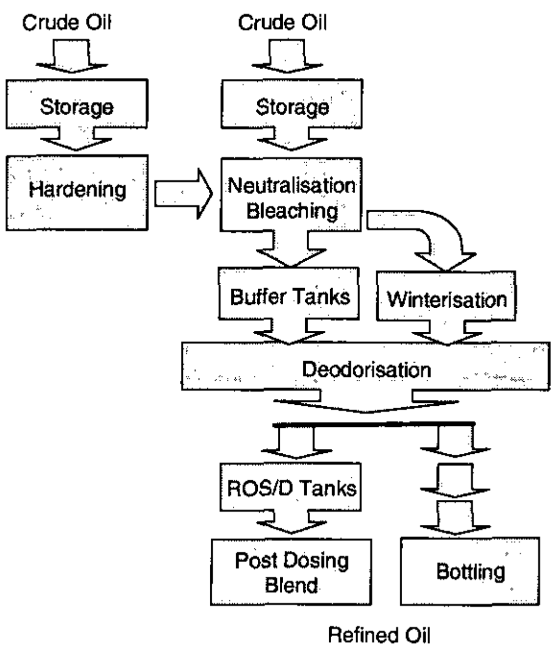


Figure 2: Material Flow Analysis

2.2.3 Degumming

Degumming is the removal of gums in vegetable oil to avoid colour and taste reversion during subsequent refining steps. Degumming is effected by the addition of hot water and centrifugation. The edible oil refining process depending on types of phosphatised either water Degumming, acid degumming, or superdegumming is carried out so as to yield phosphorous contents of less than 10ppm. At Hudson & Knight the degummed oil is stored in storage tanks.

2.2.4 Neutralisation

Sunflower, linseed, and bean oils are commonly neutralised by addition and mixing of caustic soda (0.8 Normality) under controlled conditions, which neutralises the free fatty acids. Here the degummed oils or oils with very low phosphatide contents are saponified with caustic soda and the sodium soap is separated. The oil is initially heated to the optimum process temperature. In order to condition the non-hydratable phosphatides, a small quantity of concentrated phosphoric acid is added and intensively mixed with oil. Following a brief reaction time, diluted caustic soda is added in order to neutralize the free fatty acid and the phosphoric acid. After mixing with the oil, the mixture is either conveyed directly to the first separator or it passes through a further reaction tank. The latter is recommended only for oils with relatively high phosphatide content. Hot water is added to the oil, intensively mixed and the soapy wash water is removed in a further separator. In general, one wash stage is adequate. A second washing is only necessary if very low residual soap contents are required.

Recently to reduce the water consumption in edible oil refineries, the use of silica adsorbents for the removal of residual soaps after neutralization have been implemented. Up to 1000 ppm soaps are removed by sequential addition of silica adsorbent under presence of moisture at 65 C. The dosage of the silica adsorbents may vary from 0.1 to 0.2%.The silica adsorbents further also pick up polar impurities in oil and also gums to give better edible oil in subsequent processes.

2.2.5 Bleaching

Bleaching involves the removal of colour and purification of the oil which is usually achieved with neutral clay or bentonite (acid-activated earth), while deodorisation consists of a steam-stripping of the oil at high temperature and under high vacuum. The bleaching system gently removes residual phosphatides, metals, soaps and oxidation products in addition to coloured matter. The two step bleaching process consists of a caustic wash followed by bleaching with bleaching earth under 5 mBar to 10 mBar absolute vacuums.

The washed and neutralized oil is preheated to 80^{0}C and fed to the bleacher which is a series of three 40 ton vessels namely; TSB 1 (two step bleaching), TSB 2 (two step bleaching), and MPV 3 (multipurpose vessel). Bleaching earth is added to the oil through the dosing unit which is controlled by a programmable controller. The oil is mixed under vacuum conditions with 0.03 to 0.07% of bleaching earth. The bleacher, designed with internal partitions and high efficiency turbine agitators to avoid short cycling and provide the necessary retention time from 30 to 90 minutes before filtration. Steam is used to increase temperature to 115 ^{0}C to dry out water. The conjunction of vacuum dryer with a bleacher allows the oil going to the bleacher to be thoroughly dried and deaerated removing fugitive particles from the bleacher sucked under vacuum and scrubbed by the down coming oil. The bleached oil from the three pressure leaf filters are transferred to the bleached oil tank for intermediate storage. Filters are operated at 400 kPa pressure. The spent earth has up to 30% oil content and a high calorific value. The customer who purchases the spent earth uses it as fuel in its furnaces/boilers.

2.2.6 Deodorisation

Deodorisation is the final treatment step in the refining process that converts crude oil to finished refined oil. The passage of steam through layers of oil held in trays under vacuum at temperatures of about 230-240℃ strips the oil of traces of free fatty acids, volatile fat oxidation breakdown products and other odoriferous compounds. To prevent oxidation of oil, the column is operated between 3 to 5 mBar absolute vacuum. The given temperature and vacuum conditions provide the driving force and carrier for stripping steam to remove volatile components from the feed material. The process is a semi-continuous process with steam heating up the contents of trays, and live steam being sparged on each tray.

Fatty acid removal occurs instantaneously and hydrolysis is avoided. Lower temperature and lower residence times result in lower trans-fatty acid formation. The volatile components of the steam from the vacuum condensers are scrubbed in a scrubber and released as acid oil. A high quantity of oil is carried by entrainment in the steam and ends up in the wastewater system.

The current configuration of the deodorisation column is as follows:

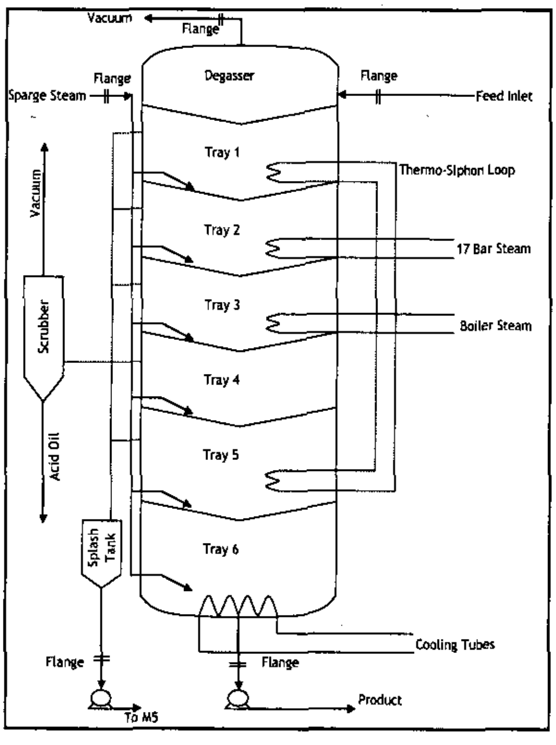


Figure 3: Existing Configuration of Deodorising Column

The deodoriser technology is that of a Lurgi design for batches of up to 7.5 tons. The capacity of the deodorizer is between 10000 and 11000 tons/month.

The feed at 60 ^{0}C enters the degasser section of the column and then sent to tray 1 which is maintained at 190 ^{0}C. The material on tray 2 is heated to 220 ^{0}C. Tray 3 is heated to 250 ^{0}C with external steam from a Sasol-gas fired boiler which is operated at 50 Bar. The temperature on tray 4 is maintained between 240 ^{0}C and 270 ^{0}C. On tray 5 cooling begins and the temperature is between 190 ^{0}C and 200 ^{0}C. Further cooling on tray 6 is administered to reach a temperature 60 ^{0}C. All along the column steam is sparged onto each tray to release volatile gas molecules. A small quantity of Citric acid is sprayed onto the oil as a preservative.

The proposed installation of demisters to decrease oil entrainment is illustrated below:

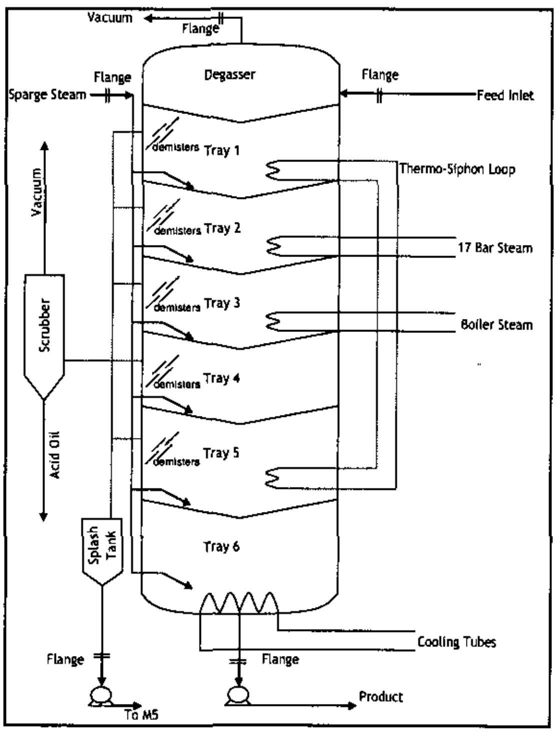


Figure 4: Proposed Configuration Changes to Deodorising Column

The strategically placed de-misters ensure minimal carry-over of the fatty acid to the hot well. This ensures an extremely high steam to oil interfacial surface without the build-ups or stagnant zones. Energy consumption for this process is in the form of electricity and steam.

2.2.7 Winterisation

Dewaxing is the removal of high-melting-point "waxes" extracted from certain oilseeds, such as corn, sunflower, and canola. Dewaxing is made by a winterisation process which cools the oil to crystallise the wax and removes the wax crystals by filtration. If the oil is not dewaxed, the oil may appear cloudy and wax may settle out. For consumer-grade cooking and the manufacture of food products oil must be fully refined and winterised.

The process is continuous until the leaf filters block-up. Oil at 60 ^{0}C is cooled by water in an exchanger to 30 ^{0}C. The oil is sent to first-step crystallisers where it is cooled to 17 ^{0}C, and second step-crystallisers where it is cooled to 6 ^{0}C further removing higher melting point components. The oil is filtered in leaf filters and stored.

2.2.8 Hardening or Hydrogenation

Hydrogenation involves the actual transformation of characteristics and properties of the oil through chemical reaction in the presence of a catalyst. Hydrogenation allows for the tailoring of the fat system for very specific applications and functions and is one of the key functions of a value-added operation. Hydrogenation was developed to allow vegetable oils as margarine to substitute for butter and ghee. Hydrogenation is generally performed for one of two specific purposes. The first is to provide taste and smell stability and to enhance the shelf life for unsaturated products. The second is to change the functional characteristics of the naturally occurring fats to those required for a specific application. Hydrogenation is designed to saturate double bonds in the fatty ester of the triglyceride molecule.

Two tanks of 25 tons are used to heat oil to 200 ^{0}C where Ni catalyst and hydrogen is added for saturation of double bonds.

2.2.8.1 Interesterification

Interesterification is one of the lesser practiced unit operations which modifies the characteristics of the fat without chemically modifying the individual fatty acid composition. The process of Interesterification may be applied to a variety of interchange reactions of fats with other components. The various types of reactions are (1) alcoholysis (with monohydric alcohols to produce methyl esters or with polyhydric alcohols to form monoacylglycerols), (2) acidolysis (acid interchange), or (3) transesterification rearrangement. Oil is heated after being neutralized and dried to around 90–120^{0}C and is blended in the reactor with a catalyst. During reaction, the reactants become orange-brown in color (the first quality check of reaction process). Once the color develops, the reaction is normally completed within 30 min, where an equilibrium exists of the random distribution of fatty acids on the glycerol molecule. When completed, water is introduced to stop the reaction, vacuum is released, and the oil discharged to a holding tank. As a soap residue is normally present in the oil, the mixture may be washed and centrifuged from the oil. The oil is dried and bleached and deodorized in the normal manner.

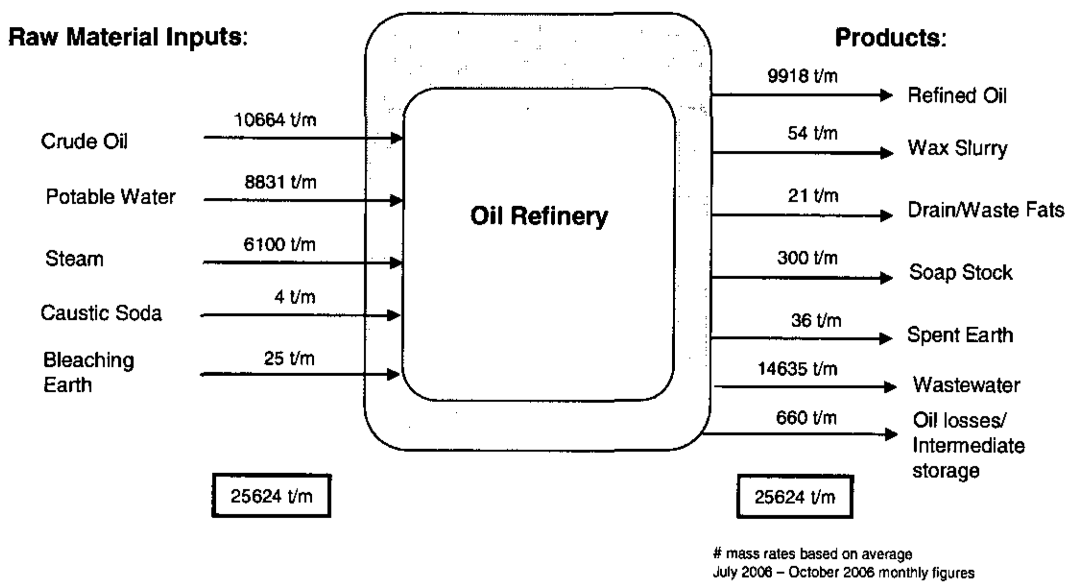
3. CP OPTIONS OF DETERMINATION OF MATERIAL BALANCE TO DECREASE OIL WASTAGE AND REDUCTION OF STEAM CONSUMPTION

3.1 Determination of Material Balance to Decrease Oil Wastage

In order to determine the wastage of oil product, it was necessary to establish a material balance and an oil balance. The majority of the factory processes are batch operated except for the deodoriser, which is semi-continuous. This makes the material balance more challenging and dependent on a substantial historical database. The information that was available to the NCPC team was data collected from July 2005 till October 2005.

The overall material balance is as follows:

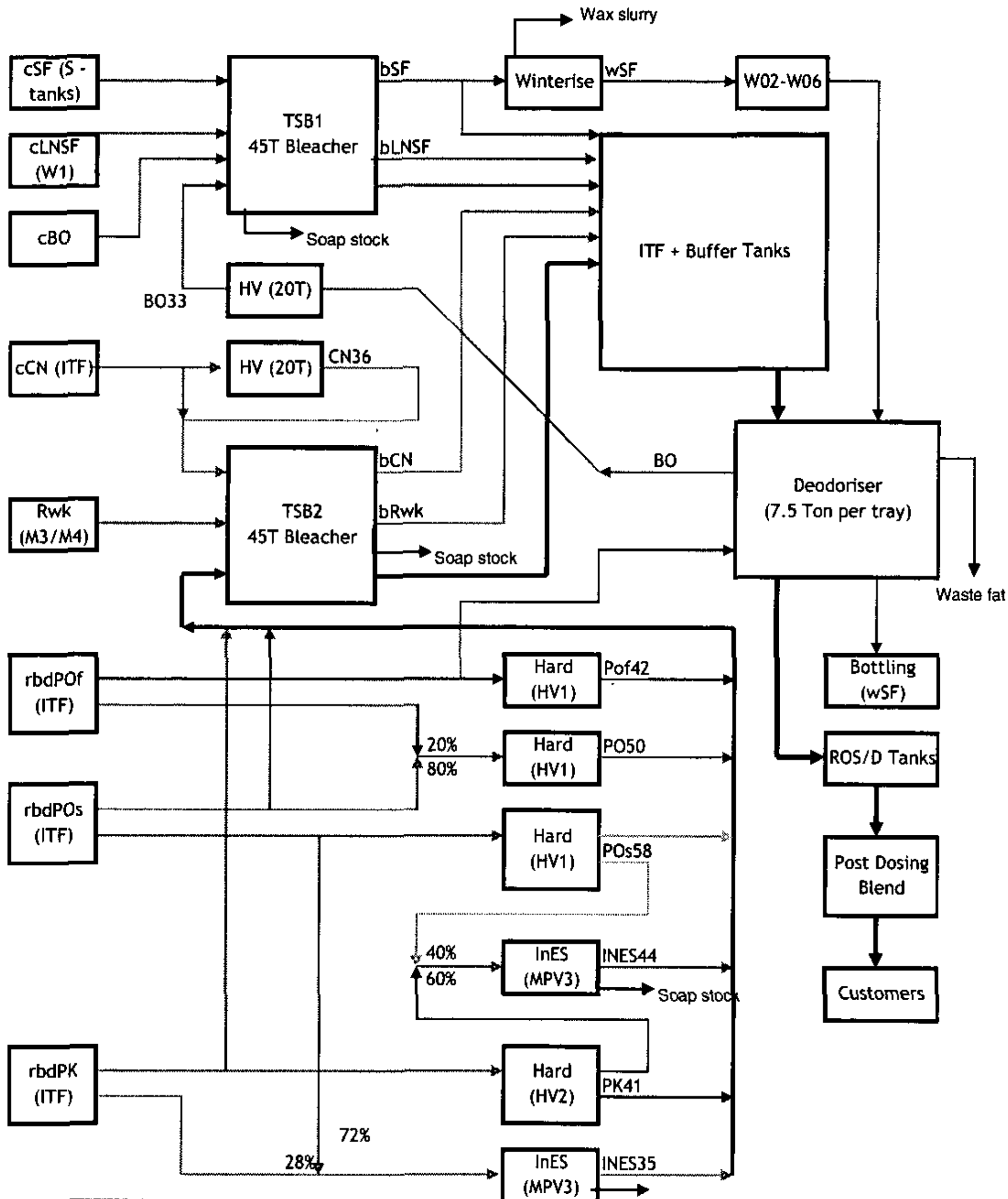
Figure 5: Overall Material Balance of Refinery



The plant operates on a batch process with large intermediate storage facilities after each process. As some of the material from intermediate storage is processed, the material balance is subjected to any accumulation of product which is reflected as oil losses/ intermediate storage in the above figure.

The process flow sheet for the Hudson & Knight operation is as follows:

Figure 6: Process Flow sheet for Hudson & Knight Refinery



Oils		Equipment
cSF = crude Sunflower	wSF = Winterised sunflower	TSB = 2 step bleachers
cLNSF = crude Linseed/sunflower	bSF = bleached sunflower	MPV3 = MultiPurpose Vessel
cBO = crude Bean Oil	BO33 = hardened bean oil	HV = Hardening Vessel
cCN = crude Coconut	CN36 = hardened coconut	ITF = Intermediate Tank Farm
Rwk = Rework	POf42 = Hardened Pof	
rbdPOf = Palm Olein	PO50 = hardened product	
rbdPOs = Palm Stearine	POs58 = Hardened POs	
rbdPK = Palm Kernel	INES44, INES35 = Interesterified Product	

Source: Hudson & Knight

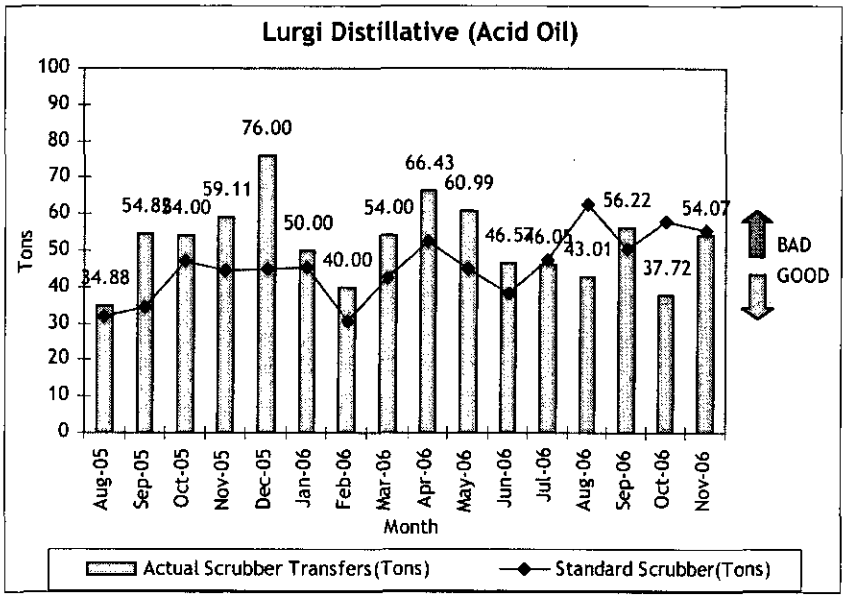
The material balance is determined from crude oil storage to the refined oil storage (ROS) tanks. The oil balance reflects a 93% recovery of oil product from crude oil or an oil loss of 7%. The target for Hudson & Knight is 95% recovery.

The area of significant oil loss is in the deodorising column, wax slurry, and spent earth. Oil losses in the deodoriser are via the steam vacuum system, in terms of acid oil and splash oils which are characterised as waste fats. The wax slurry loses about 3.6% of oil feedstock and spent earth about 0.1% of oil feedstock.

3.1.1 Acid Oil

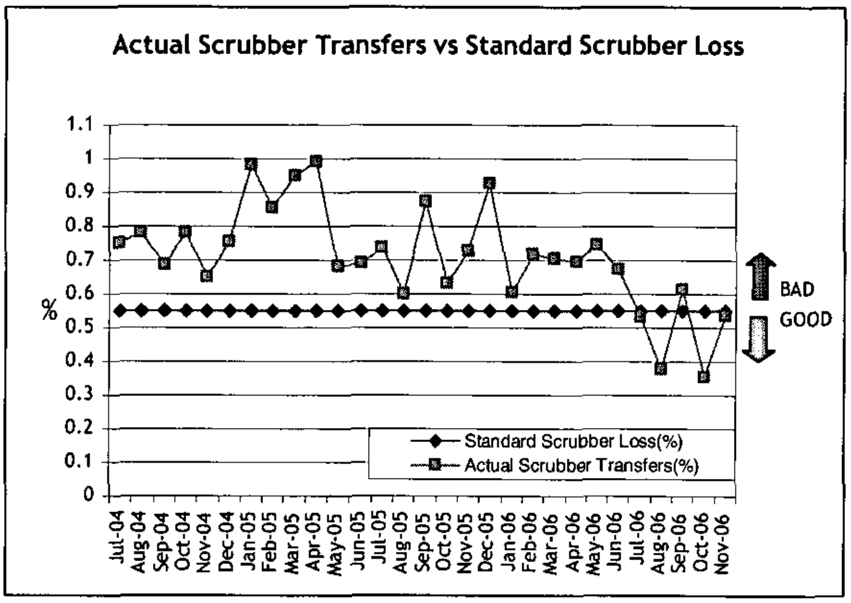
The following diagram illustrates the production of acid oil from the scrubbers.

Figure 7: Lurgi Distillate (Acid Oil)



The actual scrubber transfers have been much higher than the standard except from July 2006. The standard scrubber loss of 0.55% has been exceeded consistently prior to this date as shown in the following figure.

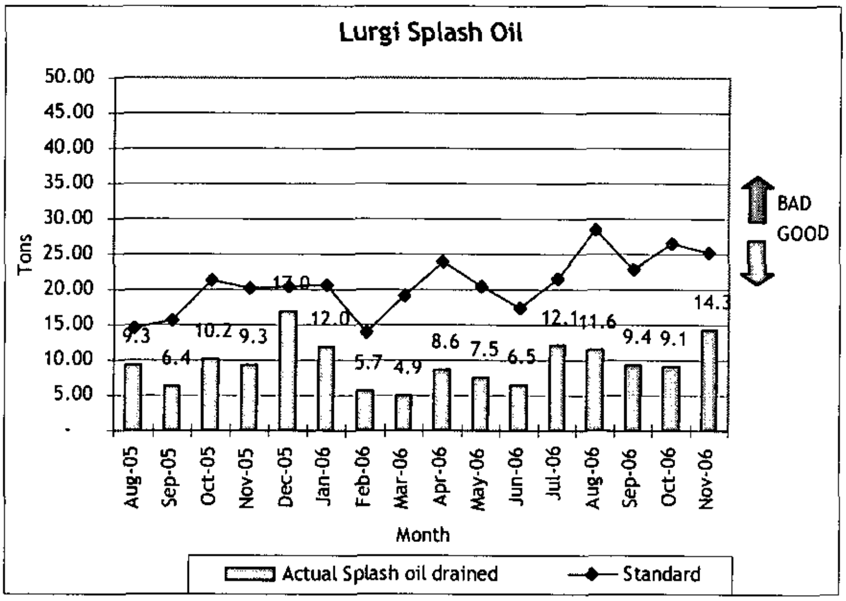
Figure 8: Actual Scrubber Transfers versus Standard Scrubber Transfers



There appears to be better control of scrubber transfers as from July 2006.

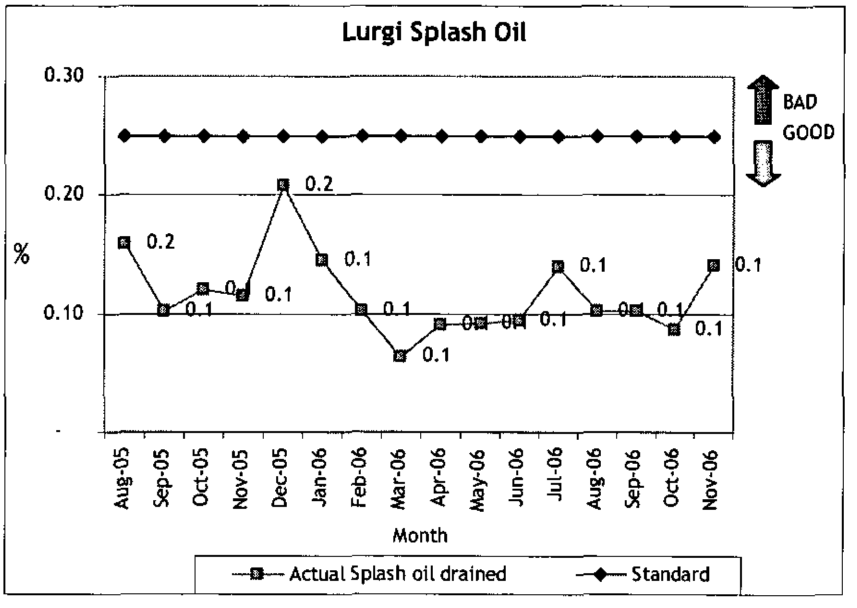
3.1.2 Splash Oil

Figure 9A: Graph of Lurgi Splash Oil versus Standard



The splash oil appears to be well controlled with losses significantly below the control limits.

Figure 9B: Graph of Lurgi Splash Oil versus Standard



The control limit is 0.25% and the average splash oil drained is 0.11% which represents a 54% saving in splash oil. The company should consider lowering the standard limit to 0.2% in its quest for Total Productivity Manufacturing (TPM).

3.1.3 Recovery of Oil from Wax Slurry

The wax slurry from the winterisation process is sold as waste. This oil on average is about 60 tonnes/month which can be recovered. The oil content in the wax slurry is 80% and a valuable resource. The cost of wax slurry is given below:

Table 1: Cost of Wax Slurry

	Per Tonne of Product
Cost of wbSF	R 6128
Oil content in Wax Slurry	80%
Value of Wax Slurry	R 4902
Revenue Loss from Sales of Wax Slurry	R 100
Cost of Wax Slurry	R 4802

The equipment to implement this oil recovery exists in the plant. There is a 10 ton mild steel tank in the winterising plant that is not being utilised which can store this wax. The process of implementation should be to introduce this slurry at 5% - 6% in a recycle stream to the bleaching units with POf and PK oils as the slurry has higher melting point oils.

3.2 Reduction in Steam Consumption

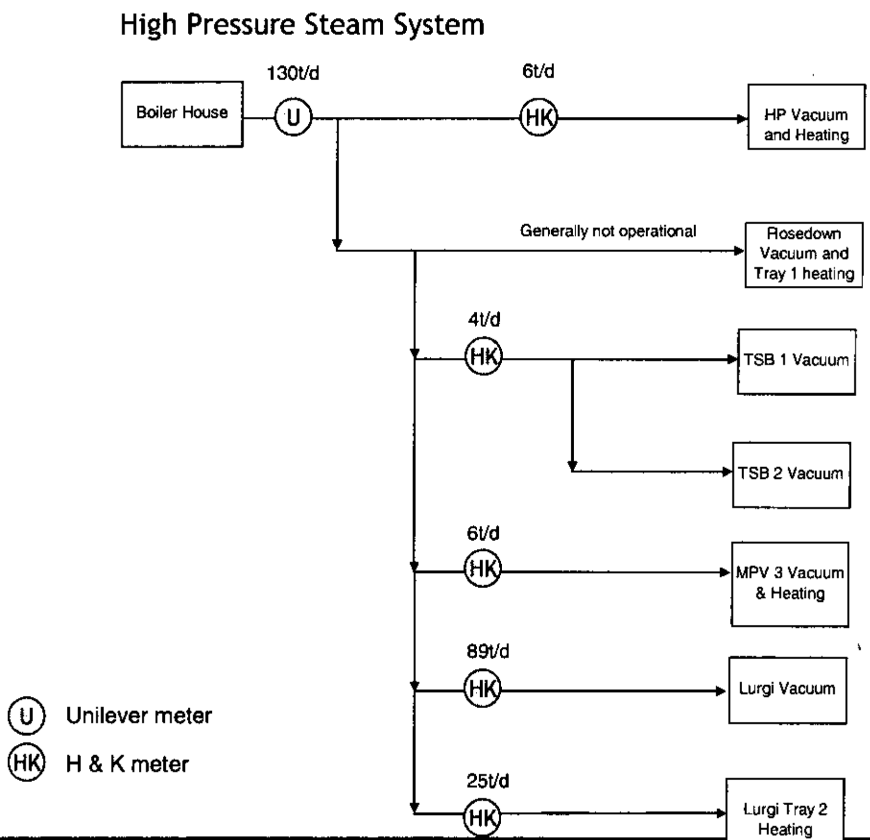
The annual cost of steam of some R6.5 million is the highest utility cost by value and comprises 69.6% of the total utility bill for the plant. Therefore saving steam is a CP focus area as it would reduce costs and improve plant efficiency.

The variable cost of steam is 40% of the total steam bill and fixed costs 60% of the total steam bill.

3.2.1 Steam System

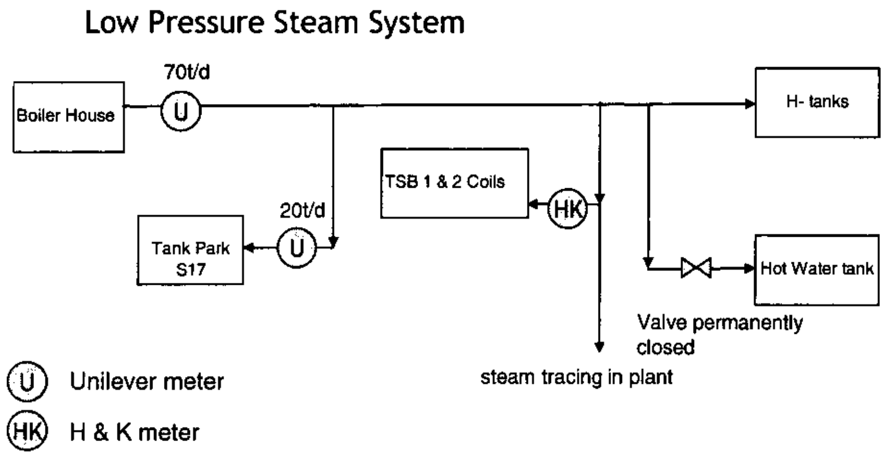
Steam is purchased across the fence from Unilever who manages the boiler and steam system. The steam levels are high pressure steam at 17 bar and 260^{0}C and low pressure steam at 3 bar and 180^{0}C.

Figure 10: Configuration of High Pressure Steam System (17 Bar)



No condensate is recovered. All the steam ends up as hot water and wastewater.

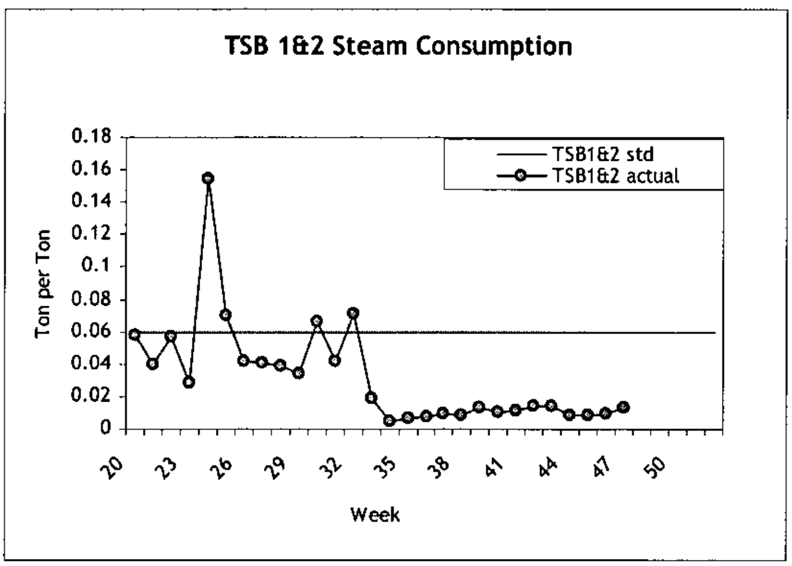
Figure 11: Configuration of Low Pressure Steam System (3 Bar)



The total steam purchased is 200 t/d at R35.93/t variable cost and R53.17/t fixed cost. The total variable cost per annum is R2.59 million (2006) and the total fixed cost per annum is R3.88 million (2006) resulting in total annual steam costs of R6.47 million. The fully absorbed cost of steam is R89.10/t.

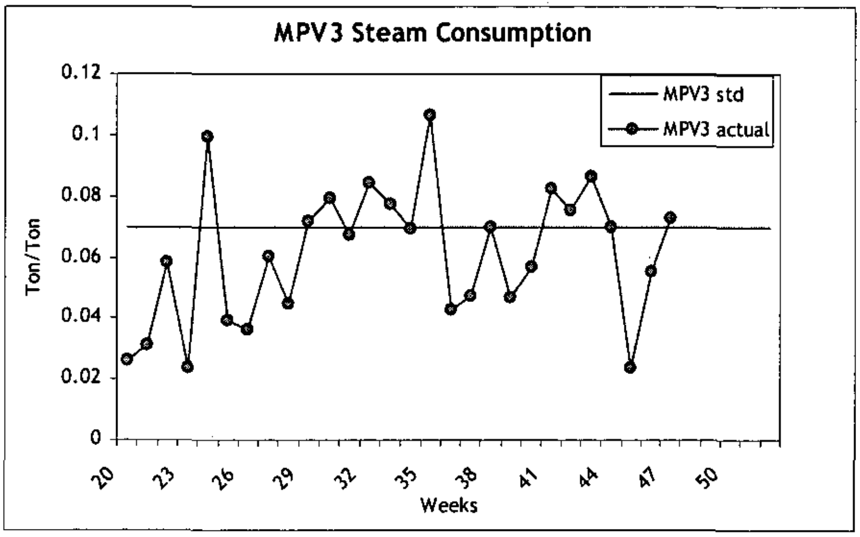
3.2.2 Process Steam Utilisation

Figure 12: TSB 1&2 Steam Consumption



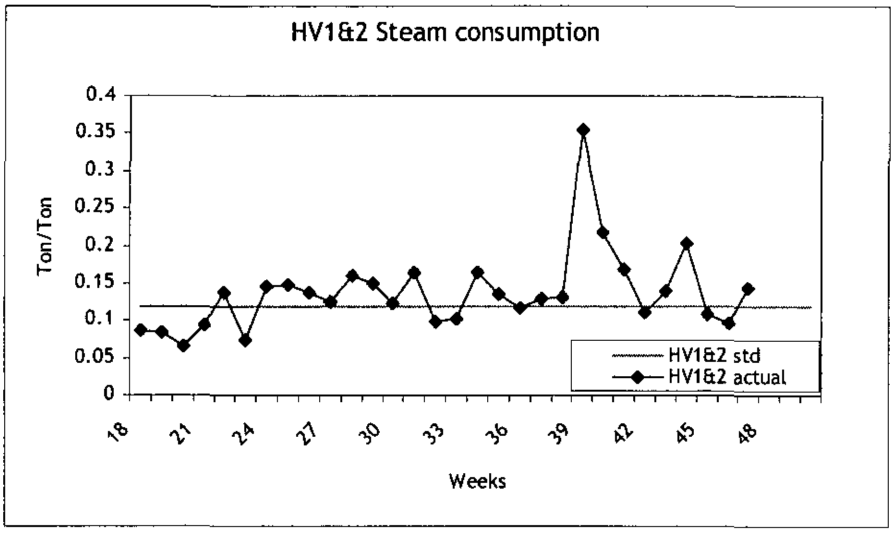
The steam consumption for vacuum generation only in the two step bleaching(TSB) units appears to be well under the control standard of 0.6 ton steam per ton of product from about week 33. This is due to the meters being recalibrated. In fact this process could probably have always been under control.

Figure 13: MPV 3 Steam Consumption



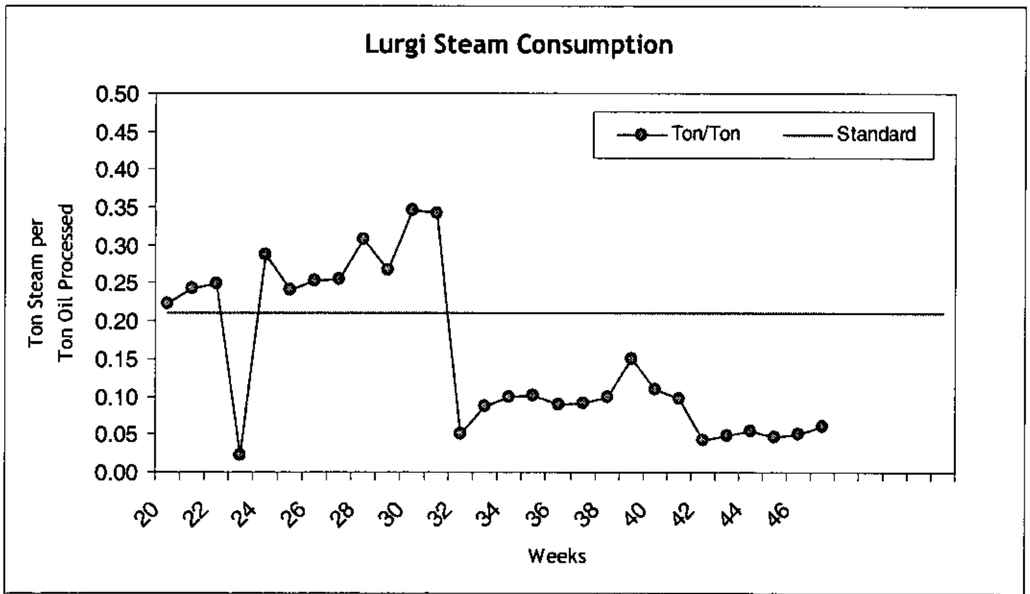
The total steam consumption (vacuum plus coils) for the multi-purpose vessel(MPV) appears to be varying around the control limit of 0.07 ton steam per ton product with a higher percentage being within control. The variation is due to the range of materials being bleached at different times.

Figure 14: HV 1&2 Steam Consumption



The hardening vessels (HV) operate just above the control limit of 0.12 ton steam per ton product. The possible recovery of heat from hydrogen of unsaturated to produce steam should be able to offset the high consumption of steam.

Figure 15: Lurgi Steam Consumption



The steam consumption for vacuum generation only for the Lurgi Deodoriser appears to be under the control limit of 0.21 ton steam per ton product from week 32. At week 33 the meters were recalibrated and illustrates that the steam consumption is under control.

3.2.3 Steam Leaks

Many steam leaks have been noticed in the plant at valves, fittings, from pipes, and steam traps. The biggest leak was at the hot water tank where the inlet steam valve is shut. Steam from elsewhere in the plant is fed via the hot water and released to atmosphere. The size of the two pipes venting steam to the atmosphere is 150 mm in diameter. This steam is from the low pressure line as shown below:

Figure 16: Hot Water Tank with LP Steam Leaks

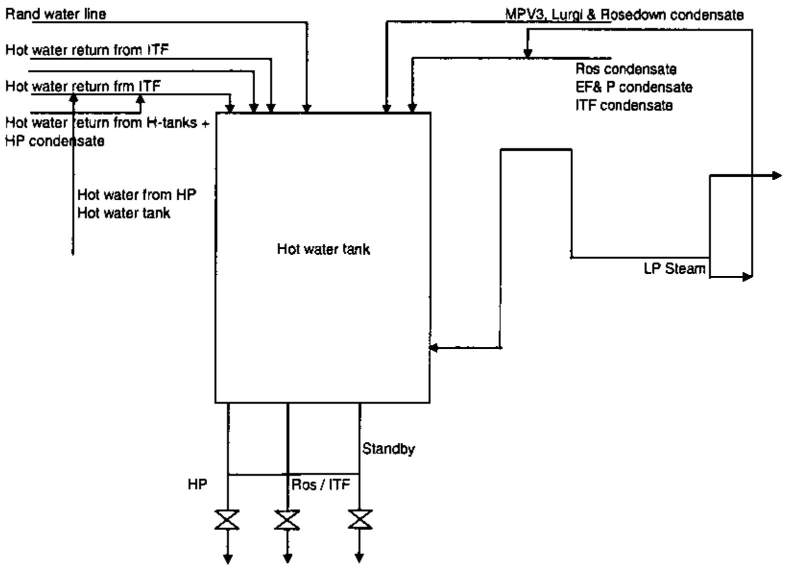


Table 2: Quantification of Steam Leaks

#	Position of Leak	Size of Leak	Size of Pipe	Pressure	Steam Loss		
		mm	mm		MJ/yr	tpa	tpd
1	Flange	1	10	LP	105510	48.76	0.14
2	Flange	1.5	50	LP	163541	75.57	0.21
3	Flange	1.5	50	LP	163541	75.57	0.21
4	Flange	1.5	50	LP	163541	75.57	0.21
5	Flange	1	10	LP	105510	48.76	0.14
6	Flange	1	10	LP	105510	48.76	0.14
7	Flange	1	10	LP	105510	48.76	0.14
8	Flange	1	10	LP	105510	48.76	0.14
9	Flange	1	10	LP	105510	48.76	0.14
10	Flange	1	10	LP	105510	48.76	0.14
11	Flange	1	10	LP	105510	48.76	0.14
12	Flange	1	10	LP	105510	48.76	0.14
13	Flange	1	10	LP	105510	48.76	0.14
14	Flange	1	10	LP	105510	48.76	0.14
15	Flange	1	10	LP	105510	48.76	0.14
16	Flange	1	10	LP	105510	48.76	0.14
17	Flange	1	10	LP	105510	48.76	0.14
18	Flange	1	10	LP	105510	48.76	0.14
19	Flange	1	10	LP	105510	48.76	0.14
20	Flange	1	10	LP	105510	48.76	0.14
21	Flange	1	10	LP	105510	48.76	0.14
22	Flange	1	10	LP	105510	48.76	0.14
23	Flange	1	10	LP	105510	48.76	0.14
24	Flange	1	10	LP	105510	48.76	0.14
25	Flange	1	10	LP	105510	48.76	0.14
1	Valve	1.5	50	LP	163541	75.57	0.21
2	Valve	1.5	50	LP	163541	75.57	0.21
3	Valve	1.5	50	LP	163541	75.57	0.21
4	Valve	1	50	LP	105510	48.76	0.14
5	Valve	1	50	LP	105510	48.76	0.14
6	Valve	1	50	LP	105510	48.76	0.14
7	Valve	1	50	LP	105510	48.76	0.14
8	Valve	1	50	LP	105510	48.76	0.14
1	Online	1	50	LP	105510	48.76	0.14
2	Online	1	10	LP	105510	48.76	0.14
3	Online	1	10	LP	105510	48.76	0.14
1	Pipes to atm	1	150	LP	105510	48.76	0.14
2	Pipes to atm	1	150	LP	105510	48.76	0.14
3	Pipes to atm	150	150	LP	16354050	7557.32	20.99
4	Pipes to atm	150	150	LP	16354050	7557.32	20.99
	Total				**37065663**	**17128.31**	**47.58**

The total steam loss from leaks at flanges, valves, and pipes are 47.58 t/d. The two open 150 mm pipes bleeding steam to atmosphere account for 88% of the steam leak volume. Based on R89/t cost, the annual steam loss is R1.52 million per annum.

Reduce system leaks:

Repair leaks in steam piping, condensate lines and fittings. Leaks cause both higher fuel use and increased make-up water consumption. The energy savings potential, especially in higher pressure systems, increases proportionally with steam loss. Implementing a proactive steam leak management program can reduce a facility's energy usage by one percent.

Condensate and steam loss could occur if the coils are leaking. High energy usage could result from fouling in coils.

3.2.4 Condensate Recovery

When steam transfers its heat in a manufacturing process, heat exchanger, or heating coil, it reverts to a liquid phase called condensate. An attractive method of improving power plant's energy efficiency is to increase the condensate return to the boiler. Returning hot condensate to the boiler makes sense for several reasons. As more condensate is returned, less make-up water is required, saving fuel, make-up water, and chemicals and treatment costs. Less condensate discharged into a sewer system reduces disposal costs. Return of high purity condensate also reduces energy losses due to boiler blow down. Significant fuel savings occur as most returned condensate is relatively hot (60℃ to 110℃), reducing the amount of cold make-up water (25℃) that must be he ated.

At Hudson & Knight, no condensate is recovered to the boiler system. Therefore there is a CP opportunity. The condensate from the factory, except that which is used by the deodoriser, can be recovered as it is in sealed coils and no contamination from organics could occur. Out of the 200t/d steam purchased, 89 t/d to the deodoriser is not recoverable. Condensate return should be at least 80% of the remaining steam of 111t/d. Therefore 88.9 t/d is the possible savings in condensate return, and eventually in potable water purchased from Rand Water. The value of this water is R7.12 per ton. Possible savings of R231033 can be achieved per annum thereby reducing operating costs.

3.2.5 Steam System Maintenance

Maintenance of steam traps:

Develop and implement a Steam Trap Management Program that incorporates the following activities:

- Personnel training – on entire boiler systems, not just for steam traps
- Identify and inventory steam traps

- Trap inspection and testing procedure – must have a written Standard Operating Procedure (SOP)
- Trap correction processes – included in the SOP
- Trap database and reporting tool. Malfunctioning steam traps waste steam and result in higher boiler fuel consumption. Potential savings for this practice range from five percent to ten percent of boiler fuel use. The simple payback for a steam trap maintenance program is often one year or less.

Recommendations:

- Check all steam traps for leaks
- Check all steam traps for vapour flashes
- Check all valves, flanges, and fitting for leaks
- Check steam coils.

3.2.6 Use of Mechanical Vacuum Pumps

Steam jet ejectors have long been used as a means of transporting gases, liquids or solids from one pressure level to a higher pressure level, particularly in sub-atmospheric applications. The ejector has no moving parts, making it easy to operate and durable. While the use of steam jet ejectors is an economical method of transporting product between pressure levels, to obtain optimum energy efficiency a design that reduces steam consumption should be considered. The spiraling increase of fuel costs for generating steam forces designers to consider vacuum system configurations that use a combination of steam and electricity. The use of liquid-ring pumps reduces steam consumption while maintaining reliable operation.

Mechanical vacuum boosters are dry pumps that meet most of the ideal vacuum pump requirements. They work on positive displacement principle and are used to boost the performance of water ring / oil ring / rotating vane / piston pumps and steam or water ejectors. They are used in combination with any one of the above mentioned pumps, to overcome their limitations. Vacuum boosters pumps offer very desirable characteristics, which make them the most cost effective and power efficient option.

The major advantages are:

- Can be integrated with any installed vacuum systems such as steam ejectors, water ring pumps, oil sealed pumps, and water ejectors etc.
- The vacuum booster is a dry pump as it does not use any pumping fluid. It pumps vapour or gases with equal ease. Small amounts of condensed fluid can also be pumped
- Vacuum boosters are power efficient. Very often a combination of vacuum booster and suitable backup pump result in reduced power consumption per unit of pumping speed. They provide high pumping speeds even at low pressures.

- Boosters increase the working vacuum of the process, in most cases very essential for process performance and efficiency. Vacuum booster can be used over a wide working pressure range, from 100 Torr down to 0.001 Torr (mm of mercury), with suitable arrangement of backup pumps.
- It has very low pump friction losses, hence requires relatively low power for high volumetric speeds. Typically, their speeds, at low vacuums are 20-30 times higher than corresponding vane pumps/ring pumps of equivalent power.
- Use of electronic control devices such as variable frequency control drive allows modifying vacuum boosters operating characteristics to conform to the operational requirements of the prime vacuum pumps. Hence they can be easily integrated into all existing pumping set up to boost their performance.
- Vacuum boosters don't have any valves, rings, stuffing box etc, therefore, do not demand regular maintenance.
- Due to vapour compression action by the booster, the pressure at the discharge of booster (or inlet of backup pump) is maintained high, resulting in advantages such as low back streaming of prime pump fluid, effective condensation even at higher condenser temperatures and improvement of the backup pump efficiency.

Mechanical vacuum boosters can effectively replace multistage steam ejectors, resulting in considerable steam savings and reduced loads on cooling towers. Mechanical vacuum boosters are versatile machines and their characteristics depend largely on backing pump.

Various types of backing pump can be used, depending upon the system requirement and ultimate vacuum needs. However, the final vacuum is governed by the suitable selection of the backing pump and booster arrangement.

For example, if a process is using water ring pump, the estimated working vacuums would be of the order of about 670-10 mm Hg gauge (90-50 mmHg abs), largely dependent on the water temperature and pump design. When a booster is installed backed by water ring pump, vacuum levels of the order of 5-10 Torr can easily be expected. For higher vacuums a series of boosters can be used to bring down vacuum down to 0.01 Torr. Mechanical boosters offer a completely dry pumping solution and do not add to any vapor load, unlike steam ejectors, and therefore, do not require large inter-stage condenser.
The operating costs for mechanical vacuum systems are low, resulting in extremely short pay back period. For example, when operating in the range of 5-10 Torr, the operating cost of the mechanical pumping system would be ***about one tenth*** of the equivalent steam ejector system.
The Lurgi deodorizer uses 89 t/d of hp steam from the Unilever boiler plant. If this is replaced with mechanical vacuum, the saving in steam costs will be R95 933 per month or R1.15 million per annum.

BENCHMARKING AGAINST BEST AVAILABLE TECHNIQUES

	BAT					
	Steam		Electricity		Total Energy	
	kWh/t product		kWh/t product		kWh/t product	
Range	low	high	low	high	low	high
Neutralisation	31	78	6	12	37	90
Soap Splitting	156	778	3	10	159	788
Bleaching					0	0
Winterisation					0	0
Hardening	-25	-125	111	278	86	153
Deodorisation	117	311	17	42	134	353
Total	279	1042	137	342	**416**	**1384**

	H & K
Utility	Total Energy
	kWh/t product
Steam	582
Gas	0.13
Electricity	25
	607.54

Total energy consumed of per ton of finished products is 607.54 kWh. This is in the lower quartile of the international range of operation from 416 kWh/t to 1384kWh/t.

The Hudson & Knight plant is operating at the top quartile of all seed oil refinery plants in the world. Acknowledgement to management on a well runs operation is in order. However, TPM allows for continuous improvement and an opportunity to recover heat from hardening in the form of steam should be investigated. The optimisation of steam usage with less steam leakage and waste will further enhance the company's competitiveness.

4. ECONOMIC BENEFITS OF CP OPTIONS

4.1 Decrease in Oil Wastage

	Savings/month Rands	Savings/yr R Millions
Recovery of oil from wax slurry	288120	3.457

The recycling of wax slurry will generate revenues of R3.457 million per annum or discounted over ten years at 15% per annum, the present value of these cash flows is of the order of R17.3 million in savings.

4.2 Reduction in Steam Consumption

The high steam bill can now be reduced as shown below, where steam leaks are eliminated with increased maintenance and monitoring of valves, steam traps, pipes etc. Savings in the form of raw water can also be achieved by recovering condensate that is not contaminated and sent to the boiler feed water.

	Savings/month	Savings/yr
Steam Leaks	R126666	R1.52m
Condensate Recovery	R19253	R231033
Total	R145919	R1.75m

Assuming an inflation rate of 5% per annum and a discount rate of 15%, the present value of the cash flows over a ten year period is R10.45 million.

The alternative is a loss of R1.75 million per year.

5. IMPLEMENTATION & CONTINUATION

5.1 Action Plan

The action plan identifies the tasks to accomplish the CP Option, identifying the resources needed the responsible person, due dates, and date completed.

Table 2: Action Plan for the implementation of CP Options

	Task	Resources Needed	Responsible Person	Due date	Date Accomplished
1.	Regularly calibrate and maintain all steam meters		Maintenance Team	Week 10	
2.	Regular maintenance of all steam traps		Maintenance Team	Week 10	
3.	Check steam coils for corrosion or damage		Maintenance Team	Week 10	
4.	Reuse wax slurry and feed to bleaching units		Production Foreman	Week 15	

	Task	Resources Needed	Responsible Person	Due date	Date Accomplished
5.	Evaluate the suitability and economics of mechanical vacuum generating units for the deodoriser		Production Foreman	Week 20	
6.	Research ways to improve oil loss to spent earth	Supplier	Plant Engineer	Week 12	
7.	Set up model to monitor mass balance continuously.		Plant Engineer	Week10	

5.2 Monitoring

The monitoring of CP Option is to illustrate the improvements as they occur. The before and after water steam consumption is recorded and the % savings is established. The environmental impact in terms of effluent discharged will also be impacted. This is done by the CP Team.

5.3 Possible Future Work Together with Unilever

Best Practices Steam Tips:

- Improve Boiler Combustion Efficiency
- Inspect Steam Traps
- Recover Heat from Boiler Blow down
- Minimize Boiler Blow down
- Removable Insulation on Valves & Fittings
- Waste Steam for Absorption Chillers
- Flash Condensate to Low-Pressure Steam
- Minimize Boiler Short-Cycling Losses
- Insulate Distribution an d Condensate Lines
- Economizers for Waste Heat Recovery
- Clear Boiler Water-side Heat Transfer Services
- Return Condensate to the Boiler
- Deareators in Industrial Steam Systems
- Vapor Recompression to Recover Waste Steam
- Use Vent Condenser to Recover Flash Steam
- Benchmark the Fuel Cost of Steam Generation