ENERGY MANAGEMENT PROJECT AT MALELANE SUGAR MILL: RESULTS AND COMMENTS AFTER ONE SEASON OF ITS INTRODUCTION

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Abstract

Transvaalse Suikerkorporasie Beperk (TSB) refines all but a small portion of its raw sugar production and this, coupled with the export of both bagasse and electricity results in Malelane normally having to use external supplies of fuel to augment its energy requirements.

During the 1985/86 crushing season a concerted effort was made to measure and where possible reduce energy usage. The parameters developed and used to monitor and appraise energy usage, the problems encountered and the success achieved at Malelane during this period are discussed. Details of energy control documentation and graphs showing the improvements attained are included.

Introduction

Due to the need to cut down on the operating costs of the factory it was decided that amongst other major expenditures the coal budget at TSB was an area where, with time and effort, significant savings could be possible especially in light of the success being achieved internationally with regard to energy management.

With the broad objective being to reduce the annual coal consumption, a long term Fuel Control Project was initiated and in order to cover the entire factory operations an Energy Management Committee was formed with the following members:–

Factory Manager (Chairman)
Manager Engineering Development
Manager Technical Development
Process Manager
Factory Engineer
Powerhouse Engineer
Projects Technologist

During the 1985/86 crushing season this committee met fortnightly.

The committee's objective for the first year was to look mainly at the operational aspects and to suggest and implement changes. Major modifications such as the installation of a vapour compressor or the change over to quintuple effect evaporation, would be considered when problem areas had been identified.

In addition to the actions of the Committee, the Sugar Milling Research Institute (SMRI) was consulted and several of their recommendations were implemented.

It is pleasing to report that although energy management and control has only just started, the little that has been done during this first year of the Fuel Control Project has already resulted in a noteworthy reduction in coal usage and there is great optimism for the future.

Energy Measurement

Steam and Power Generation

The TSB steam generating plant consists of three combustion engineering boilers of 45 tph, one Yarrow boiler of 100 tph and one John Thompson boiler of 200 tph.

The power generation plant consists of the three AEG type C.3 6,6MW and one AEG 8,0MW Alternating Sets. One of the 6,6MW Turbines is fitted with an AEG type K.63 condensing unit.

Energy Flow

To gauge the effects of actions taken to improve the energy utilisation it was soon obvious to the Committee that simply looking at coal usage would not give an indication of how the factory was responding to the various changes that were being made and that it would be essential to look at total fuel burnt. Thus it was decided that a daily energy balance would be needed.

TSB imports and exports energy. Energy is imported as electrical power from Electricity Supply Commission (ESCOM) and as coal. Energy is exported as electrical power for irrigation and as bagasse to a neighbouring particle board manufacturer and to a recently commissioned cattle feed plant. ESCOM power is imported mainly for starting the factory. KWH meters provide the electrical units of energy imported and exported. The various quantities of bagasse exported are calculated from the production figures of the particle board and the cattle feed plants.

Knowing the mass of bagasse made from the mill balance and knowing the amount of bagasse exported it is then possible to calculate the mass of bagasse burnt and its corresponding energy value calculated from the SMRI calorific value formula. It is necessary to take into account the daily change in bagasse store levels and for this purpose graduated level indicators were fixed to the walls of the two bagasse stores and readings were taken daily.

The amount of coal burnt is determined from a Servo Balans belt weigher situated between the coal bunker and the boilers. This Servo is checked regularly. A standard calorific value for the coal was obtained and used.

Knowing the coal and bagasse details it is possible to determine the amount of energy in the total fuel burnt on a daily basis and it is this figure in relation to factory throughput which is being used for assessing daily performances for energy usage. Ideally, to assess the usage of energy by Production, the energy in the steam produced would be a more useful figure as this would eliminate the variable energy loss across the boilers, but as is the case at Malelane, the accurate measurement of steam and the calculation of boiler efficiency is proving difficult.

This is mainly due to the number of small boilers being operated and the physical layout of the steam piping. Although all the boilers have measuring devices in the form of orifice plates in the steam outlets, their inherent inaccuracy especially at low flow rates appears to be the main stumbling block.

Limited success has been achieved with the recent installation of a Vortex Meter in the high pressure feedwater line to the boilers but trying to compensate for the feedwater that is not turned into steam, such as blowdown water, is not as easy as first thought. Impossibly high boiler efficiencies are frequently recorded due to what is believed to be an over estimation of steam production.

Other problems such as boilers that are off-range and have to be occasionally drained due to slightly leaking feedwater valves has led the author to personally believe that trying to relate steam production to the feedwater usage will not prove successful at Malelane. It is quite probable that in order to obtain meaningful boiler efficiency figures, accurate steam flow measurement will be necessary and in order to achieve this, substantial changes will have to be made to the piping and instrumentation systems in the near future.

If steam flow could be accurately determined, the figure for energy in the steam produced would be available and this, corrected for the electrical energy exported, would provide a figure for the energy used solely by Production. This would be an extremely useful figure in our project.

Daily Report

A two page Energy Project Report is issued daily and a copy of page 1 of a typical report is shown in Figure 1.

Page 2 of the report deals mostly with the boilers and steam flow and has so far not been of very great benefit due to the misleading steam figures.

The format of the report is such that during the course of a week, the previous day's report is no longer needed as all the information is duplicated and updated daily. For example, when Thursday's report is received then Wednesday's report can be destroyed. This has helped in reducing the volume of reports being filed as well as facilitating day to day comparisons.

Initially the format and contents of the report changed regularly after every Energy Management meeting as ideas and suggestions came forward on how best to present the energy control data. The Committee believes that the present form of the report points out where the main control areas are.

In order to produce the report it has proved essential to computerise the data and for this purpose a micro computer and a commercial spreadsheet package is used. The software chosen was Lotus 1-2-3 which is proving to be extremely friendly and well suited for this sort of development work where changes are continuously being made both to the layout of the report and to the calculation methods.

Control Parameters used on the Daily Report.

In terms of energy measurement the term used is Tera Joules and the SI abbreviation as used in the Daily Report is TJ.

Instead of relating energy usage to the cane crushed it was decided to compare energy usage against the mass of brix processed as this appears to be more appropriate especially when dealing with frequent changes in cane quality as well as with the problem of diffusers being liquidated during stoppages and filled again during the start-ups etc.

The figure being used to evaluate the daily control is based on the amount of brix processed per TJ of energy in the fuel burnt.

Although this figure is independent of the bagasse export it is still influenced by the amount of electrical export, but because the energy in steam cannot be measured accurately this became the only figure in which there was any confidence. Fortunately the export load is reasonably constant on a day to day basis and any daily fluctuation is small enough to be insignificant when compared to the total energy usage.

Although there is provision for the figure of energy used by production on the Daily Energy Report it is recorded as not being available.

It was apparent, after the first few daily reports were compiled, that it was difficult to compare daily results because of the overriding effect that stoppages have on energy usage and hence some method had to be devised to overcome the daily differences in Overall Time Efficiency.

A target figure is set for Tons Brix Processed per TJ in Fuel. This is a moving target to take into account stoppages and consequently the Overall Time Efficiency was made a factor of the target.

Target Tons Brix per TJ in Fuel = (OTE * 0,75) + 10

This target formula, like most of the other various targets used in the report, is derived simply by looking at the best results already attained and by adopting the reasoning that if it has been achieved once, it should be possible to improve upon or at least repeat. Although this is not very scientific the targets set do give some idea of whether the changes that are being carried out are making an improvement or not.

What was also very obvious early in the project was the importance of the water loading attached to the brix being handled. The greatest user of energy in the plant is the evaporation processes both in the Quad and in the Pans and from an energy point of view this water loading is carefully monitored and reported. Originally all the process variables were compared to tons brix in mixed juice but when the mill is stopped and the back-end carries on boiling some of the ratios are meaningless. The Pan movement waters, centrifugal wash waters etc are now compared with the quantity of massecuite boiled and this is proving to be a more realistic approach.

Although the Daily Report is very useful in the project it is slightly disappointing in that it does not show quantitatively where the energy is being used which is what is really needed. For example, one may see on the report that a certain quantity of water has come in as clear juice make-up but the significance of this in terms of extra energy needed at the evaporator station, in the form of exhaust steam, is not readily visualised. Trying to produce a more meaningful report is a high priority task for the coming season.

Actions taken to Reduce Energy Usage

(1) Although it has always been a well-known fact that mill stoppages are not conducive to good thermal efficiency this project has highlighted the need to look at stoppages critically with a view to making the most of a bad situation. Management of the plant during stoppages has already been changed slightly and will be an important part of the project in future seasons.

(2) Lagging of the plant has been assessed and a plan is being implemented to lag new areas and to repair damaged lagging where necessary.

(3) Steam trap maintenance is being improved.

ENERGY PROJECT DAILY REPORT

GENERAL

W/ENDING :- 20/10/85 | T.S.B. WEEK No 26

	TARGET	CURRENT WEEK								PREVIOUS WEEKS			BEST
		MON.	TUE.	WED.	THU.	FRI.	SAT.	SUN.	WEEK TODATE	WEEK 25	WEEK 24	WEEK 23	WEEK 20
ESTATE RESULTS													
TONS CANE CRUSHED		4939	7602	6977	6001	7498	6906	5706	45630	46726	43757	49665	51687
TONS COAL BURNT		95	0	48	139	58	166	70	576	109	116	381	35
T.J's IN FUEL BURNT		12.6	16.5	15.5	16.1	16.0	16.8	15.0	108.3	101.7	94.0	106.8	100.0
TONS BRIX TO PROCESS		701	1171	1146	910	1143	985	924	6982	7349	7110	7931	8236
TONS BRIX / TJ IN FUEL													
TARGET		56	81	77	66	74	73	62	70	70	66	73	76
ACTUAL		56	71	74	56	72	59	62	64	72	76	74	82
H.P. STEAM % CANE		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FACTORY PERFORMANCE													
OVERALL TIME EFFIC.		61.6	94.2	88.8	74.9	85.6	83.5	69.4	79.7	80.6	74.9	84.3	88.5
T.J's USED IN PROD		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TONS BX IN MJ/TJ USED													
TARGET		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ACTUAL		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TONS BX/MWH GENERATED		3.3	4.6	4.5	3.7	4.0	3.9	3.9	4.0	4.3	4.2	NA	NA
MILLING DEPT.													
No 1 MILL MOIST. (ADJ)		50.0	50.3	50.3	50.7	50.0	52.8	51.0	50.7	50.8	52.2	51.8	50.5
No 2 MILL MOIST. (ADJ)		48.7	49.4	50.1	48.8	48.4	48.6	48.4	48.9	48.8	49.6	48.7	47.7
TOTAL MOISTURE (SICB)		49.3	49.2	49.7	48.5	48.0	50.0	49.0	49.1	49.0	49.3	50.1	48.3
PROCESS DEPT.													
IMBIBITION % FIBRE		258	309	368	272	281	295	415	314	327	302	306	337
PER TON BRIX IN M.J.:- KGS WATER IN...													
DIFFUSER JUICE	<6000	6289	6363	6449	6305	6351	6908	7063	6530	6222	5885	5896	6275
P/WATER MUD	<200	268	101	24	0	0	0	0	48	209	197	191	172
MIXED JUICE	<6200	6557	6464	6473	6305	6351	6908	7063	6578	6431	6081	6088	6447
EIMCO WASH	<70	181	149	248	256	243	285	159	218	235	96	90	92
SUMP RETURNS		24	32	62	35	29	26	44	37	36	NA	NA	NA
CLEAR JUICE	<6300	6354	6285	6422	6239	6286	6721	6469	6394	6277	5874	6003	6292
CLEAR JUICE MAKE-UP		941	60	105	945	219	233	65	322	177	148	154	86
TOTAL TO QUAD		7295	6344	6526	7185	6504	6955	6533	6717	6454	6022	6157	6378
EVAPORATOR SYRUP	470	630	455	458	506	455	544	423	488	439	480	455	470
HOT WATER MAKE-UP		439	26	0	0	0	0	0	48	105	89	76	87
SWEETWATER MAKE-UP		857	571	737	773	802	921	942	790	784	863	824	694
PER C.M RAW MASSECUITE KGS WATER IN....													
RAW PAN MOVEMENT		79	43	48	54	32	66	115	62	66	21	19	17
'A' C/FUGAL WASH		83	66	86	59	55	72	55	67	65	52	49	49
'B&C' C/FUGAL WASH		73	124	65	79	81	88	78	83	77	75	79	67
PER C.M REF MASSECUITE KGS WATER IN....													
REF EVAP MAKE-UP		8	11	1	8	1	6	30	9	1	6	5	6
REF PAN MOVEMENT		188	213	197	273	234	302	212	229	275	214	230	222
REF PAN WASH		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34
REF C/FUGALS WASH		45	51	55	64	48	57	55	53	52	48	51	50
SLUICING WATER		241	264	240	290	211	263	282	253	288	188	207	201
TONS REJECTS REMELTED		2	10	10	19	32	0	0	73	66	34	95	32

FIGURE 1 Energy project daily report

(4) Both operating and maintenance staff have attended in-house lectures on basic energy management.
(5) Towards the end of the season there were short periods when the exhaust balance was such that the condensing turbine had to be used to keep the exhaust from blowing off. Attempts will be made to overcome this type of situation in the future.
(6) A literature survey is being conducted in matters relating to energy management.

Diffusion

- Several operational aspects have been changed slightly. Tighter imbibition water metering and control, modified warming up procedures after the maintenance shutdown and checking of temperature drops across tanks and juice lines are among the items receiving attention.

Dewatering Mills

- The individual performance of the two dewatering mills is being checked with more frequent bagasse moisture tests being carried out. Operational changes have resulted in lower moisture figures being recorded and major changes are planned for the off-crop in relation to the size of grooving etc.
- More attention is being paid to the hydraulic loading on the mills.

Front End

- High quality turbine water meters have been installed on the various juice heater condensate systems. This is assisting in the compiling of steam and water balances.
- A magnetic flowmeter has been installed in the sump return lines from the back-end and refinery. This is helping both in the control of floor washings and spillages as well as in determining the total water load going to the evaporators.
- A water meter has been installed in the spray water system to the mud filters. Although the brix of filtrate would have also indicated dilution rates, it was decided that a direct measurement of wash water was preferable.
- Water added to the evaporator supply tank in the form of clear juice make-up is also being metered. This is helping in the determination of evaporator balances.
- The operation of the evaporator has been changed slightly. Changes include the use of a variable VI blow off point instead of a fixed point. During stoppages and shutdowns the tail end of the quad is now isolated as soon as practical. Continuous juice samplers for brix determination have been installed after the first and second vessels to help in determining the evaporation rates across the vessels used for vapour bleeding.

Backend and Refinery

(1) Turbine water meters have been installed to measure:-
    Pan Movement Water
    Refined Pan Wash Water
    Centrifugal Wash Water
    Refinery Evaporator Make-up Water
    Sluicing Water to Refinery
    Sweetwater make-up
    These meters have been an aid in the control of water going into the backend products.
(2) Exhaust Steam usage has been replaced by VI in the following areas:-
    Refinery Saturators
    Sugar Driers
    Steaming out of Pans
    C Massecuite reheater water system

Steam Production

(1) Individual steaming rates are now being monitored by the use of a system which records the length of time the boiler is either under-steaming or over-steaming. These readings indicate what percentage of time the boilers are in their most efficient range.
(2) Investigations are currently under way into the feasibility of recovering energy from the boiler blowdown system.
(3) A water meter was fitted to the condensate return from the combination passout and condensing turbine in the powerhouse. This meter indicates the amount of exhaust that has been condensed. The opertion of this turbine is being carefully monitored as it is crucial to good thermal efficiency.
(4) The exhaust steam desuperheating system has been slightly modified as it was discovered by measuring the water flow that the spray system was not functioning properly and excess water being used was picking up sensible heat and flowing out through the steam traps in the exhaust line.
(5) The design and operation of the air-heaters on three small boilers is receiving attention. These air-heaters use saturated high pressure steam and the condensate is flashed to exhaust.
(6) The operation of the high pressure steam to exhaust let down station is also being monitored as large variations in letdown quantities have been experienced, even under steady crushing conditions.

Results

Not having any comparable industrial standards by which to judge the performance of this first year of the fuel control project, the annual results of TSB since 1978 have been used as a comparison. The last of the major expansions occurred in 1977. The drought year of 1983/84 has been excluded because TSB imported raw sugar from Swaziland for refining and a large amount of coal was burnt, especially when compared to tons cane crushed or tons brix in mixed juice.

Figure 2 shows the results in the basic terms of tons coal per 1 000 tons cane and as can be seen the 1985/86 season was notably better than the previous seasons.

To overcome the effects that fibre % cane had on the quantity of bagasse available from season to season, the energy used in the total fuel burnt for the same periods has also been plotted. This is shown in Figure 3 entitled TJ in fuel per 1 000 tons cane.

It is interesting to note that the seasonal average fibre % cane for the 1985/86 season was the lowest ever experienced at Malelane and if the fibre had been higher an even lower coal usage would have been recorded.

The Overall Time Efficiencies for the same seasons are:

Season	OTE
78	72,6
79	73,8
80	76,9
81	75,5
82	78,9
84	73,9
85	76,7
Average	75,5

As can be seen, the OTE for the 1985/86 season although slightly higher than the average was not the best and certainly not the cause for the improvement in thermal efficiency.

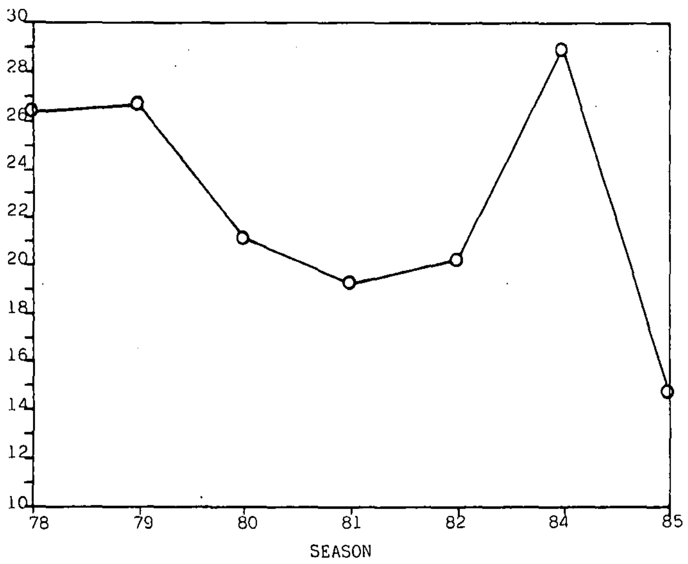

FIGURE 2 Tons coal per 1 000 tons cane

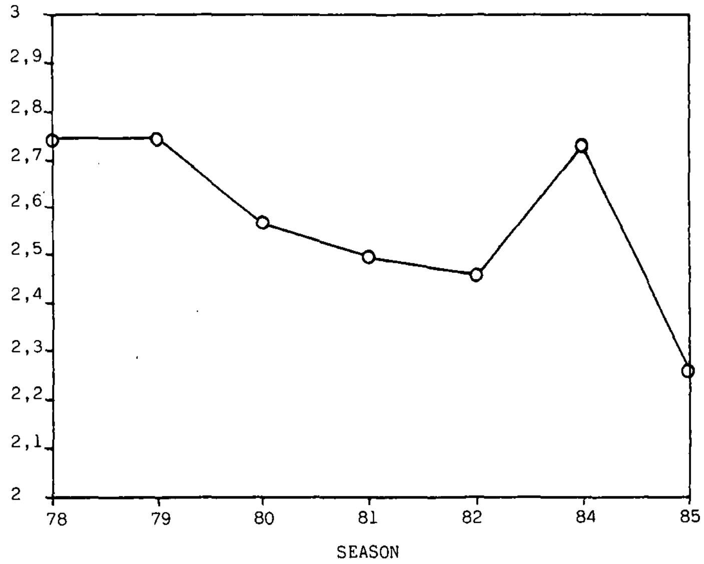

FIGURE 3 TJ in fuel per 1 000 tons cane

It is difficult to compensate for the differing Overall Time Efficiencies especially on a season to season basis. It is hoped that as the project progresses the amount of energy lost per unit of time stopped will be quantified, thus enabling better comparisons to be made.

Summary

The first year of the fuel control project at Malelane has resulted in a successful reduction in coal usage.

From the relatively little that has been learned, it is believed that the road to successful energy management will lie mainly in:

(1) Involvement of all staff.

(2) Accurate measurement and recording of energy in fuel, energy recovered in steam and energy imports and exports. This must be coupled with a comprehensive daily energy report.

(3) Achieving as a high a boiler efficiency as possible.

(4) Metering and control of the movement of water in the production streams.

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