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

By M. DAMMS

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,OMW 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 particleboard 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 Jowatts 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 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 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.

**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**

<table>
<thead>
<tr>
<th>Week Ending: 20/10/85</th>
<th>T.S.B. Week No 26</th>
</tr>
</thead>
</table>

#### Estate Results

<table>
<thead>
<tr>
<th>Target</th>
<th>Current Week</th>
<th>Previous Week</th>
<th>Best</th>
</tr>
</thead>
</table>

- **Estate Cane Crusher**: 4939 7692 6777 6001 7498 6506 5706 45630 146726 47577 49665 151687
- **Tons Coal Burnt**: 93 0 48 139 58 166 70 575 109 116 381
- **Tons in Fuel Burnt**: 126 16 84 15 16 16 15 1088 1001 940 1106 81100
- **Tons Brix to Process**: 701 171 1146 910 1143 485 924 7882 7349 7110 7931 8236
- **Tons Brix in Fuel**: Target
- **M.P. Steam % Cane**: NA NA NA NA NA NA NA NA NA NA NA

#### Factory Performance

**Overall Time Efficiency**: 61.6 94.2 28.8 74.9 85.8 85.5 69.4 79.7 80.6 74.9 84.3 88.9

**Tons by M.P. Used**

- **Target**: NA NA NA NA NA NA NA NA NA NA NA
- **Actual**: NA NA NA NA NA NA NA NA NA NA NA

**Process Dept.**

- **Imbibition % Fibre**: 250 300 368 272 281 295 415 314 327 302 306 337

### Per Ton Brix in M.J:-

- **Kgs Water In**:
  - **Diffuse Juice % (600)**: 6289 6363 6449 6305 6351 6908 7063 6530 6222 5885 5986 6275
  - **P.H. Water Add**: 200 48 191 24 0 0 0 0 0 0 0 0
  - **Wet Juice % (600)**: 6557 6494 6478 6305 6351 6908 7063 6530 6222 5885 6086 6089 6447
  - **Sum Returns**: 93 105 159 241 248 285 159 239 230 197 211 191
  - **Clear Juice % (600)**: 6534 6282 6229 6226 6721 6469 6396 6277 5874 6003 5986 6292
  - **Clear Juice Make-Up**: 914 80 105 943 239 233 232 65 177 148 154 86
  - **Total & Sugar**: 7293 634 612 618 6504 6555 6333 6177 6454 6022 6157 6578
  - **Evaporator Syrup**: 479 639 469 482 506 485 444 423 423 439 480 453 470
  - **Hot Water Make-Up**: 743 26 0 0 0 0 0 0 0 0 0 0
  - **Sweetwater Make-Up**: 857 571 677 773 802 921 942 790 784 863 824 698

**Per C.M. Raw Massceuite**

- **Kgs Water In**
  - **Raw Panama Movement**: 1 4 18 21 21 0 0 1 1 1 1 1
  - **A' C/Fugal Wash**: 4 6 3 1 3 1 1 1 1 1 1 1
  - **B & C/Fugal Wash**: 73 124 65 79 81 88 78 83 77 75 79 67

**Per C.M. Ref Masceuite**

- **Kgs Water In**
  - **Ref Evap Make-Up**: 9 11 1 9 6 30 9 1 6 5 5 6
  - **Ref Pan Movement**: 186 213 197 273 234 392 212 229 275 214 230 222
  - **Ref Pan Wash**: NA NA NA NA NA NA NA NA NA NA NA
  - **Ref C/Fugal Wash**: 43 35 35 84 48 57 35 35 52 48 51 50
  - **Sluicing Water**: 241 264 240 290 211 263 282 253 288 188 107 201

**Tons Rejects Remelted**: 2 10 10 19 32 0 0 71 66 34 95 32

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**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 junction 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 growing 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 operation 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 was used 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 1000 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 1000 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.

<table>
<thead>
<tr>
<th>Season</th>
<th>OTE</th>
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<tbody>
<tr>
<td>78</td>
<td>72,6</td>
</tr>
<tr>
<td>79</td>
<td>73,8</td>
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<td>84</td>
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<tr>
<td>85</td>
<td>76,7</td>
</tr>
<tr>
<td>Average</td>
<td>75,5</td>
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</tbody>
</table>

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.
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.

Acknowledgements

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