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THE SPLITTING OF THE MALELANE FACTORY INTO SEPARATE RAW-HOUSE AND REFINING OPERATIONS

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Abstract

The Malelane factory was built in 1967 as a raw sugar mill with a back-end refinery. During the 1993/94 season and off-crop, modifications were made to the factory, allowing the raw house and refinery to be run as semi-independent operations. This was necessitated by the building of the Komati raw sugar factory and the subsequent need to expand refining capabilities at Malelane. Modifications undertaken include the restriction of product flow between the Malelane raw house and refinery to massed and analysed streams, the isolation of the raw house during off-crop and stop-day refining periods, and the construction of raw sugar import systems. Different methods of mass balance calculations were investigated and implemented to accommodate the unique situation at Malelane. The reasons for the separation, the modifications made and the mass balances implemented, are discussed.

Introduction

Malelane, in line with the other sugar factories with back-end refineries, traditionally operated the raw-house and refinery as a single entity. Product flows between the departments were not measured, and no attempt was made to limit the products of the departments to the relevant department. In many cases, the flow of products between the departments was intentionally established; the use of sweet water from refinery press filters as movement water in raw vacuum pans is an example of this.

The refinery operated only whilst the raw mill crushed cane. The lack of raw sugar storage facilities did not allow for the operation of the refinery during either off-crops or stop-days.

The decision to build a second mill in the Eastern Transvaal was made in 1987, and in July 1991 it was announced that Transvaal Sugar would build the new mill. Work on the Komati mill began in November 1992. It was decided that the new mill would produce only raw sugar, and that the increase in refined sugar quota would be taken up by the Malelane refinery. It was felt that the increase in capacity of the Malelane refinery could be most economically obtained through the operation of the refinery after the Malelane raw-house shut down.

If the refinery at Malelane were to be operated for a refining period of 50 weeks, as compared to the 35-40 weeks that the raw-house operates, a theoretical increase in capacity of 33% with no further installed refining plant could take place. This results purely from increased utilisation of existing equipment.

Plant and structural changes implemented at the factory

In order to accommodate the change in operational philosophy, modifications to the plant and staff structures were made.

The installation of handling systems for imported raw sugar

These consisted of the following:

- The construction of a 65000 ton raw sugar warehouse to accommodate the import sugar from Komati for refining at later stages. Included in this are the raw sugar reclamation systems.
- The purchase and installation of further remelt systems.
- The purchase and installation of weighing systems, both into the warehouse, and between warehouse and refinery.

The isolation of the raw-house from the refinery; steam and water systems

All steam lines to the raw house had to be made safe for when refining outside of normal crushing hours occurs. Two modes of isolation exist:

- Off-crop isolation mode; all steam lines to the raw-house are isolated and locked out. Isolation occurs either by means of blank flanges, or "double block and bleed" systems. The latter consists of two isolation valves in series, with an open vent to atmosphere, or bleed valve, in between them. If the pressure side isolation valve were to leak, the escaping steam would be vented to atmosphere prior to building up any pressure on the secondary isolation valve, thereby reducing the danger of steam passing down the line.
- Stop-day isolation mode; exhaust steam lines to the evaporators, as well as other live steam lines, are isolated with double block and bleed valves and locked out. Exhaust steam lines to the shredder turbines and juice heaters are treated as live on stop-days when the refinery is operated.

All the isolation points in the plant are clearly marked by means of small boards indicating the normal (crushing) position of valves or spectacle flanges, as well as a brief (one sentence) description of the function of the isolation point. A procedure has been drawn up indicating each isolation point in the plant, as well as the required valve positions, product being isolated and reasons for the isolation.

The isolation of the raw-house from the refinery; product flows

No sugar products pass between the raw-house and refinery, or *vice versa*, without being massed and analysed. The only products allowed to pass between departments are raw sugar melt pumped from the raw house to the refinery, and return syrup (jet-4) sent from the refinery to the raw house.

- The refinery press-filter sweet-water is used only as refined pan movement water or in refined melters.
- No returned/rejected white sugar finds its way into the raw house. This is all remelted and kept within the refinery.
- The departments have been separated on the ground floor of the factory by means of a low wall. Floor washings are kept within each department, as are any inadvertent tank overflows. Each side of the wall has its own sump pumps and recovery systems.

- A raw melt scale was purchased and installed to allow for the determination of Malelane mill melt (*i.e.* raw sugar) masses passing to the refinery. A scale to mass the return syrup to the raw house was already in position.

Changes made to existing plant to allow for off-crop refining

Certain modifications to existing plant had to be effected to allow for off-crop refining.

- The V1 piping to the pan floor was separated into two feed systems, one for the raw pans and the second for the refined pans. This is to enable complete steam isolation of the raw pans during off-crop refining.
- Pipe work to one of the raw pans was altered to allow for the feed of jet to the pan for refined massecuite use.
- The pipe-work around the A-and B-molasses storage tanks was modified to allow for the storage and retrieval of "high jets" from these tanks. Jets from massecuites at a lower grade than usually boiled in the refinery, *i.e.* fifth through to ninth massecuites, are collectively referred to at Malelane as "high jets".

Items of plant that are normally used in the raw house but which are brought into service in the refinery during off-crop refining are completely isolated during the season to prevent the contamination of refinery product during normal crushing periods. Plant involved are a raw pan, certain strike receivers and the continuous A-centrifugal.

Staff changes

With the change in the operational philosophy, changes to staffing structures were implemented. It was believed that each department, *i.e.* the raw house and the refinery, should be operated as separate "business units" and therefore with separate staff structures. Each business unit would be responsible for the complete operation of the unit, with staff being more focused on the particular problems within each of the business units.

The responsibilities of the existing position of Process Manager were reduced to exclude the refining operation, and a Refinery Manager was employed to carry out these duties. Four further shift superintendents were recruited to run the shifts (a four shift system is operated at Malelane mill). No extra skilled or semi-skilled staff were employed. A Production Manager was appointed to oversee both operations, and to act in a co-ordinating role.

No changes were made to the engineering maintenance staff to accommodate the split of the operational philosophy.

The before and after production staff structures are depicted in Figure 1.

The positions of Refinery Manager and Process Manager were later merged into the single position of Production Manager, once the split had been successfully carried out and the relevant changes implemented.

Operational aspects of the abnormal refining modes

It was initially intended that the refinery would be operated for a further 15 weeks during the off-crop, without any attempt being made to refine on in-season stop-days. It was then realised that it would be advantageous to run the refinery through normal stop-days. The reasons for this were:

- Refining on stop-days would reduce the amount of off-crop refining that would have to take place. Refining during off-crop results in high energy costs in the form of coal and boiler feed water softening.
- It is well recognised that any boil-off process, whether in the raw house or refinery, should be avoided in order to reduce sugar losses. Continuous operation is always preferable to discontinuous operation.
- At Malelane, continuous refining at lower rates is better than intermittent refining at higher rates in terms of sugar quality. Lower refining rates put less pressure on plant with already marginal capacity, and the decolourisation plant at Malelane gives better results with longer retentions (carbonation/sulphitation).

Stop-day refining

During stop-day refining, the following are done:

- Raw sugar for refining is reclaimed from the raw sugar warehouse.
- The whole evaporator tail is isolated with regard to steam supply. This can be safely cleaned and worked on during stop-days.
- The boilers are fed with bagasse from the bagasse stores. Boiler feed water consists of raw pan and evaporator condensate held in boiler feed water tanks. CO_2 gas for carbonation is obtained from these bagasse fired boilers, as is normal during the season.
- Exhaust steam from the power generating turbines is let down to vapour one pressures and used in the refined pans. This same steam is used in the refinery evaporators.
- Any return syrup produced is held in the storage tank until the crushing commences. It is then returned to syrup.

The refining process is interrupted for a period of approximately 15 minutes on a stop-day whilst the steam isolation and valve change over are implemented. No boil-off takes place in the refinery.

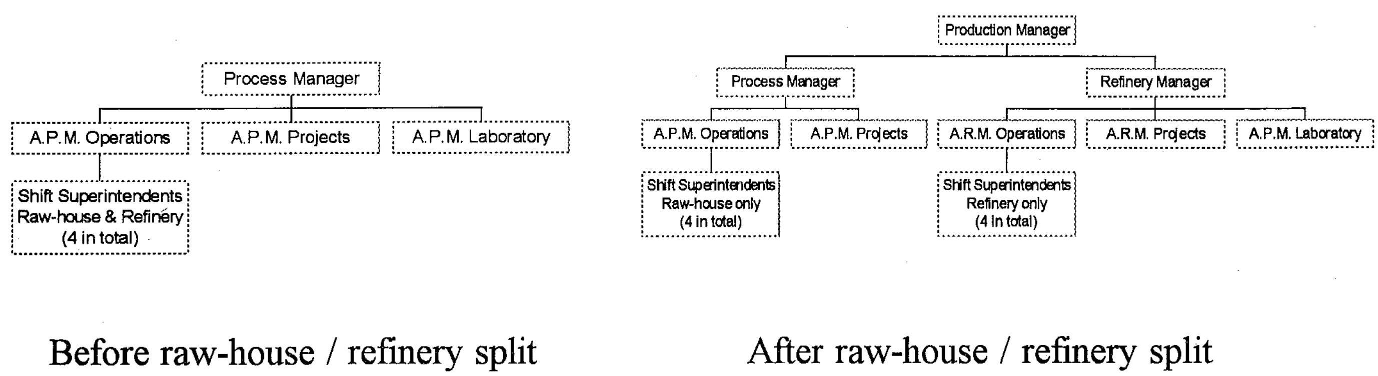

FIGURE 1 Staff structures at Malelane.

Off-crop refining

At the end of the crushing season, both the raw house and the refinery are boiled off. The refinery stocks are also liquidated as no provision exists for the holding of return syrup generated over a period longer than 24 hours. Some of the raw house plant is also required to run the refinery in off-crop mode, and in order to effect these as well as the steam system changes, a few days are required for the change over. The raw house steam/water/product isolation programme is implemented, and once the change over is complete, the refinery is restarted.

- Steam is obtained from the coal fired boilers, as is the CO_2 required in the carbonation process. Because of the high sulphur content in the gas produced from coal, the flue gases are scrubbed prior to use in the refinery.
- The off-crop refining cycle is briefly described. The first four refined boilings are carried out in the same way as is done during the crushing season. Jet-4 is then pumped to the syrup tank and is used to boil a fifth massecuite in a raw pan modified for the purpose. The fifth massecuite is struck into an A-strike receiver, and cured through the A-continuous centrifugals. The melt obtained is returned to raw melt. The fifth jet is sent to the B-molasses tank. This is boiled up into a sixth, in the same raw pan, and handled in the same way as the fifth massecuite, except that the sixth jet, as well as all higher jets, are returned to the A-molasses tank.
- Five distinct and identifiable massecuites are boiled, with the sixth and higher massecuites being contaminated to a greater or lesser extent by other "high jets". These higher jets are not kept separate due to a lack of storage tankage. Up to nine identifiable massecuites have, however, been boiled.
- With the above procedure, the impurities are cycled up in the refinery, and at some stage these impurities must be removed from the system. The high jets in the A-molasses tank are regularly analysed, and it has been empirically determined that when the colour of the jets is greater than 50 000, then the handling of these jets in the pans becomes problematical. Boiling times are long (up to ten hours), and the grain is deformed and dark. At this point, the jets are pumped from the factory to final molasses.

Raw house sucrose balances and recoveries

It was initially stated as an objective of the raw house and refinery split that separate recoveries would be calculated for the two departments. It was envisaged that the weekly and monthly recoveries published by the Sugar Milling Research Institute (SMRI) would reflect only the raw house's performance.

The Malelane factory is in a unique situation. No other Southern African mill with a back-end refinery calculates a full recovery balance for the raw house only, and the method whereby this recovery balance was to be calculated had to be determined. The problem arose with the way in which the return syrup should be handled in the recovery calculations.

A simplified flow of the products around the two departments is presented in Figure 2.

Initial calculation methods

If recovery is regarded as the ratio of output over input, and the inputs into the raw house take the form of cane and

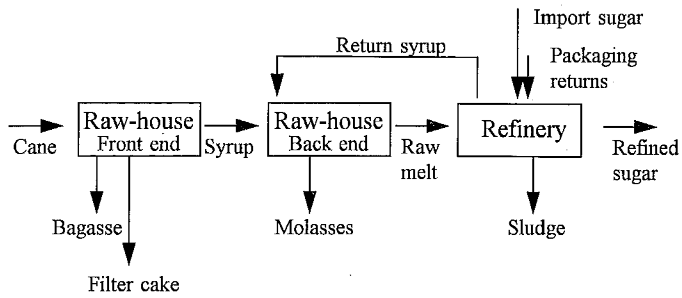

FIGURE 2 Product flow between raw-house and refinery.

return syrup, then the sucrose balance can be calculated as follows:

Overall recovery	=	tons pol raw sugar m&e/(tons sucrose cane + tons sucrose return syrup) * 100
Boiling house recovery	=	tons pol raw sugar m&e/(tons sucrose mixed juice + tons sucrose return syrup) * 100
Molasses loss	=	tons sucrose final molasses m&e/(tons sucrose cane + tons sucrose return syrup) * 100

Incorporating the sucrose in return syrup into the boiling house recovery and molasses loss is reasonable, as the constituents of the return syrup will have an effect on performance within the boiling house. The addition of return syrup into raw syrup, however, will have no effect on the loss of sucrose in filter cake or bagasse. These losses will therefore take the form of:

Filter cake loss	=	tons pol filter cake/ton sucrose cane * 100
Bagasse loss	=	ton pol bagasse/ton sucrose cane * 100
Extraction	=	tons sucrose mixed juice/ton sucrose cane * 100
Undetermined loss	=	((tons sucrose return syrup + tons sucrose cane) - (tons pol bagasse + tons pol filter cake + tons sucrose molasses m&e + tons pol sugar m&e))/(tons sucrose return syrup + tons sucrose cane) * 100

Because the denominator in the above indices is not always the same, the summation of the percentage losses in molasses, filter cake, bagasse and undetermined loss with boiling house recovery will not necessarily yield 100. The relationship

Overall recovery = boiling house recovery * extraction/100 does not hold either.

The above method of performance calculation was discussed with the SMRI (Lionnet, personal communication), and implemented at Malelane at the beginning of the 1994/95 season. All weekly and monthly figures reported to the industry were in the above form.

Final calculation methods

Concern was expressed, however, that the performance results reported by Malelane were not directly comparable to other mills in the industry. It was felt that the effect of the addition of return syrup on boiling house performance was not being accommodated in the calculation, and that recoveries reported were inflated.

Mr Ken Koster of Illovo Sugar suggested an alternate method of recovery calculation. With this method, an attempt was made to remove from the calculation the effects of the addition of return syrup. Basically the method consists of the calculation of the recoverable sugar in the return syrup, as well as the amount of final molasses obtained from the return syrup in the boiling house. These amounts of sugar and molasses (termed "deemed" sugar and molasses) are deducted from the actual masses obtained to yield nett sugar and molasses tonnages. Recoveries and performance factors are then calculated in the normal way using the nett tonnages.

Deemed sugar in return syrup is calculated using standard SJM techniques.

SJM recovery = (S * (J - M))/(J * (S - M)) * 100
where

S: actual raw sugar purity
J: return syrup purity
M: final molasses gravity purity

No account is made for undetermined loss in the conversion.

Tons pol in deemed sugar	=	tons sucrose in return syrup * SJM recovery
Tons sucrose in deemed molasses	=	tons sucrose return syrup - tons pol in deemed sugar
Tons pol in nett sugar	=	tons pol sugar m&e - tons pol deemed sugar
Tons pol in nett molasses	=	tons pol molasses m&e - tons pol deemed molasses

The balance and recoveries then become:

Overall recovery	=	(tons pol raw sugar m&e - tons pol deemed sugar)/tons sucrose cane * 100
Boiling house recovery	=	(tons pol raw sugar m&e - tons pol deemed sugar)/tons sucrose mixed juice * 100
Molasses loss	=	(tons sucrose final molasses m&e - tons sucrose deemed molasses)/tons sucrose cane * 100
Filter cake loss	=	tons pol filter cake/tons sucrose cane * 100
Bagasse loss	=	tons pol bagasse/tons sucrose cane * 100
Extraction	=	tons sucrose mixed juice/tons sucrose cane * 100
Undetermined loss	=	(tons sucrose cane - (tons pol bagasse + tons pol filter cake + tons sucrose molasses m&e + tons pol sugar m&e))/tons sucrose cane * 100

After further consultation with the SMRI, the 'Koster Method' was adopted at Malelane for the final calculation of the 1994/95 season's results, as well as the weekly/monthly calculations of the 1995/96 seasonss performance. The Cane Testing Service MILL LAB system was changed to accommodate the required calculations.

One of the advantages of this method is that other indices such as corrected reduced boiling housing recovery (CRB) and cane to sugar ratios can be calculated, and yield results which are directly comparable to other raw sugar mills in the country.

In certain of the performance indices, such as m^3 massecuite/tons brix in mixed juice, the effect of the return syrup is still accommodated. In this example, the ratio m^3 massecuite/(tons brix mixed juice + tons brix return syrup) is actually calculated. If this were not done, the ratio would not represent the actual performance of the pans and the boiling house.

A comparison of the results of the two methods is given in Table 1.

Table 1
Comparison of the results obtained from different mass balance calculation methods.

	Original method	Koster method
Overall recovery	87,4	86,5
Boiling house recovery	89,3	88,5
Bagasse loss	2,2	2,2
Filter cake loss	0,1	0,1
Molasses loss	9,2	9,8
Undetermined loss	1,2	1,3

Cost control

Each of the departments (raw-house and refinery) are treated as individual business units within the plant. Each has separate budgets and profit and loss statements. Decisions in respect of plant operation and capital expenditure are made with regard to the economic value added (EVA) by the department. This results in the more effective control of resources within the plant.

Conclusions

The split of the Malelane factory into separate raw house and refinery departments was necessitated by the change in operational philosophy of the plant. Certain of the consequences of the change, such as the mass balance modifications, were not foreseen, and working towards solutions for the problems was extremely challenging and interesting. Advantages of the split are:

- Increased focus by departmental staff on the problems particular to the department.
- Increased control over product losses due to the extra weighing systems.
- Improved cost control within the plant by the creation of departmental business units.
- Increased refining capacity by the extension of the refining season.

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