FELIXTON REVISITED

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Abstract

The Felixton mill was designed ten years ago and incorporated many innovations. The design is critically reviewed against a background approaching ten years of operating experience. Although very few of the design concepts have had to be changed, the cost-effectiveness of the plant can now be analysed. Conclusions are drawn on what design changes would be made if the mill were built again today in a developed, as well as in a developing country.

Introduction

It took ten years of investigation to justify the investment by Tongaat-Hulett Sugar into the new Felixton sugar mill. The mill design broke new ground in many areas with the objective of optimising the use of capital in the production of cane sugar. It is now ten years since those design decisions were made and, in the light of solid operating experience, it is possible to look back and review whether the right or wrong decisions were made. One can also look forward to consider what would be done differently if one were to start again with the operating experience gained at Felixton, and at the other more conventional factories, in the intervening period.

Felixton cost R158 million in 1983 Rands excluding finance charges, or R260 000 per ton cane/hour (tch) of capacity. Escalated to current terms of a mill being constructed now for completion in 1993 this would be about R1 million (US$ 0,36 million) per tch.

Translating this into a more popular mill sizing of say 8 000 ton cane per day (tcd), or 330 tch at 100% operating efficiency, the current cost would be about R330 million or about US$120 million. This is for a mill with quite a considerable investment in steam economy and depithing of all bagasse for fibre export, manufacturing VHP export sugar from very low quality cane, at overall recoveries commensurate with the normal high South African levels. Whether this level of performance is economically justified will be explored as well as how it may be possible to reduce this cost structure.

Design concepts

Felixton was designed to process 3,3 million tons of poor quality 17,5% fibre cane in a nine month season. It had to be able to export 100 000 bone dry tons per annum of depithed bagasse for paper manufacture at minimum cost. Its capital and operating cost structure had to be optimised to achieve an acceptable return on investment when compared with the option of continuing the operation of the two small existing mills at Felixton and Empangeni which it was to replace. It also needed to cater for future expansion in cane supplies. Plant layout and plant unit sizing took into account a future expansion to 900 tch.

Within this framework the plant design evolved using what were perceived to be the most cost effective solutions to each unit operation. The details of this design have been well documented elsewhere and will not be repeated here (Renton, 1985).

Outlined briefly they were

- Cane handling by road and mainline rail trucks with no on ground storage and minimum double handling.
- Cane preparation by billeting and one step heavy duty shredding.
- Extraction by cane diffusion, in the largest units ever constructed, to maximise extraction.
- Rapid low retention clarifiers followed by a syrup clarification step after evaporation.
- Quintuple evaporators with large scale bleeding of second effect vapour for process.
- Continuous A-, B- and C-pans feeding vertical crystallisers.
- Batch product centrifugals with continuous B- and C-centrifugals.
- Three 150 ton boilers each able to burn bagasse, bagasse pith and coal.
- A pneumatic screen separation of the intensively prepared diffusion bagasse into pith and fibre fractions.
- Extensive use of rubber belts for all cane and bagasse handling.

Operating experience

Cane handling and preparation

The cane handling system has proved to be economical and flexible. A swing away from mainline rail trucks necessitated the provision of a further spiller from road into millyard rail trucks, providing storage on wheels and maintaining the flexibility of having two cane preparation line feeders, i.e. road spiller and rail spiller. There is presently a swing back to rail cane deliveries which will reduce the necessity for double handling of surge capacity.

The mechanical reliability of the rail cane truck tipplers has been poor and it is likely that these units will have to be replaced with more robust and reliable plant if the swing to further rail cane continues.

Because the district had a reputation for delivering rocks included with cane consignments due to mechanical loading operations, the cane preparation plant was designed with sloping cane tables and a low intensity cane chopper or billeter chopping off the head of the cane table. The chopped or billeted cane could then be handled easily by belts under magnets and be fed to a surge bin feeding the shredder. The idea was that rocks could be detected in the billeter and removed before being fed into the intensive cane preparation stage.

Although the cane handling system has worked, it has not been possible to maintain continuously the efficient billeting of cane into cleanly cut short lengths. This has not been too serious as the practice of stopping to remove rocks after billeting has in any event not proved to be viable due to the downtime involved. Rocks are generally allowed to go through the cane shredders unless they are too large to pass the cane feeders, when they cause a choke and are then removed. The shredders have not been seriously damaged by rocks although maintenance costs are obviously increased.

The Felixton system of cane preparation is shown in Figure 1 where the chute feeding the shredder stand is clearly shown. Because of the poor cane billeting it has not been possible to use the full capacity of this chute. The tangled mat of cane, although able to be handled by the belt conveyors, does not flow freely as properly billeted cane would.

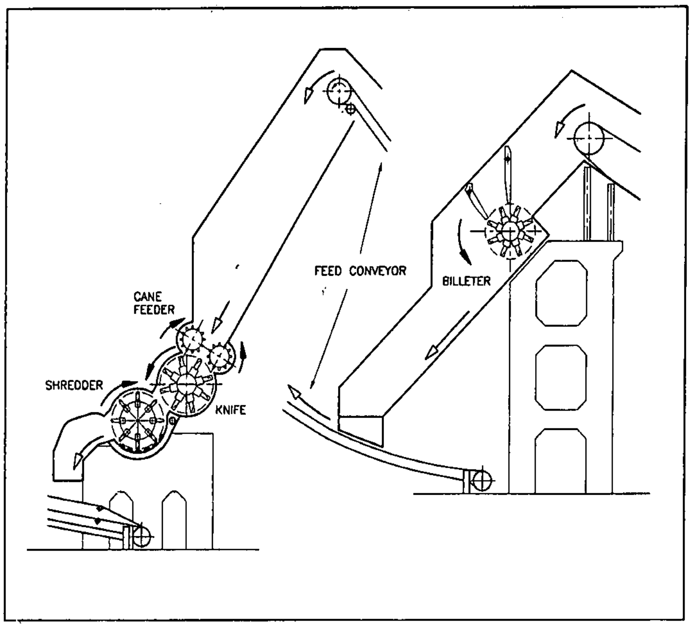

FIGURE 1 Felixton cane preparation line

Figure 2 shows the layout of cane preparation which would be used currently. This features a slow speed coarse knifing followed by a vertical surge feed chute feeding the shredder. As shredding is the most power intensive operation in milling, the importance of feeding a steady stream of cane into the mouth of the shredder is emphasised. The kicker feeding the shredder has been effective in steadily feeding cane with very variable trash contents.

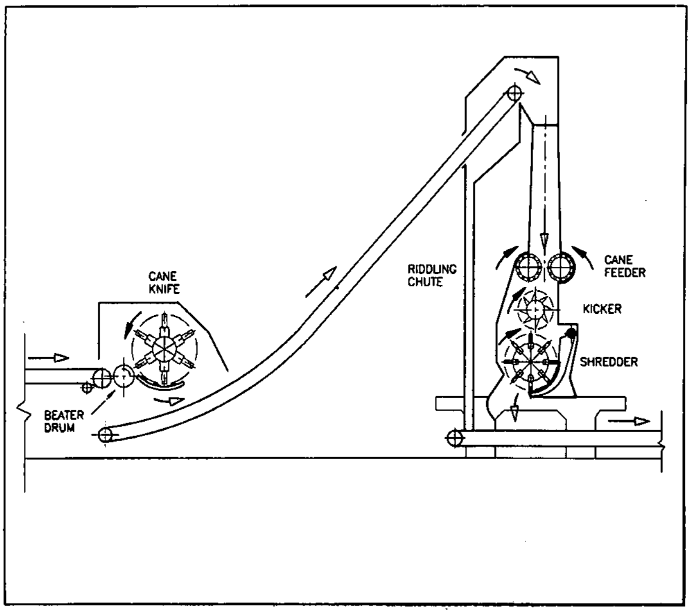

FIGURE 2 Preferred layout for a cane preparation line

Extraction

With South Africa's long operating seasons (over 40 weeks was considered normal before the advent of eldana borer) and relatively poor quality due to a variable natural rainfall, the economic advantages of cane diffusion over milling extraction plants have been well established. Tongaat-Hulett Sugar has pioneered the design and operation of large cane diffusion plants, the first 400 tch or 65 tons fibre per hour (tfh) diffuser having been installed at Amatikulu in 1974. There was no hesitation in deciding on cane diffusion for Felixton. However the design 600 tch at 17,5% fibre gave 105 tfh throughput, which was considered too much through a single extraction line aiming for high extraction. Two extraction lines each handling a comfortable 53 tfh was the conservative option chosen.

In sizing the diffusers the marginal costing of a 97,0 or 98,0% extraction clearly indicated that even with low export prices, the additional diffuser screen area to get to 98% extraction was worthwhile. The screen area required, 720 m^2, gave 12 m wide x 60 m long diffusers which are the biggest cane diffusers built to date. The Tongaat-Hulett diffuser is illustrated in Figure 3. It is interesting to note that with 12,5% fibre good quality cane they would achieve the same 98% extraction at a cane throughput of 420 tch, or at 96,5% extraction would each process some 650 tch of 12,5% fibre cane. Recent developments in juice flow control could increase these throughputs by a further 10% (Rein and Ingham, 1992).

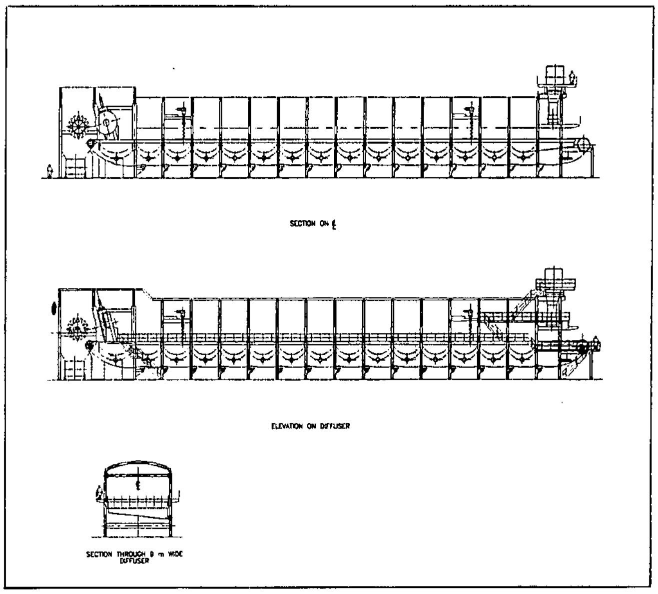

FIGURE 3 The Tongaat-Hulett diffuser

The performance and mechanical reliability of the diffusers have more than met expectations. Chain wear, a major maintenance cost in most diffusers, has been minimal after nine years, and a 15 to 20 year chain life is predicted. Virtually the same design would be chosen again with some refinements to lower construction costs and to limit corrosion but with less screen area due to improved juice flow control within the cane bed.

Drying diffuser bagasse is always slightly more difficult than straight milling, and diffuser bagasse moisture has always tended to be on the high side. It seems that under the conditions at Felixton drying more than about 35 tfh through a 2 134 mm mill will not give adequate drying in one pressure fed mill, and certainly not in a conventional three or four roller mill. There is an option to place two mills in series, the first of which can be a lightly loaded mill, or to place two pressure fed mills in parallel. At fibre throughputs in the 50-60 tfh range, two pressure fed mills in parallel were chosen. The possibility of using one wider mill was considered but there seemed to be considerable sacrifice in terms of total pressure loading onto the bagasse blanket with wider mills, as well as a cost penalty for larger gearing. The double mill in parallel configuration gives some advantage in terms of maintenance of one unit without stopping the extraction line.

There is a dearth of published research data on drying diffuser bagasse, but with information currently available the same drying arrangement would probably be chosen today. However there is always the option of using mills which are available, rather than purchasing new units which are very costly. A drying mill layout to suit existing or second hand mills is a definite possibility if costs are to be minimised in a new installation.

Boilers and power generation

Felixton II was designed to start operations with a full cane supply all supplied by private growers, so it was important that operating time efficiency was good from the start. A philosophy developed that when plant units may be subject to periodic maintenance or breakdown, three units was a good compromise with any two being able to maintain throughput at about 80% of design. This philosophy was applied to boilers and power generation, and during the first few seasons when boiler grates and feeders gave teething problems, it greatly helped maintain continuity of production. However the importance of continuity of production has to be weighed against the additional capital cost of smaller units. There is no doubt that a single large boiler and single turbo-alternator have the cheapest first cost for any sugar mill. The capital cost savings are quite material and must be balanced against the cost of interrupted crushing programmes in the event of breakdowns.

Sizing of units in this case was also affected by planning for a future 50% increase in throughput. Often units were sized so that at 900 tch, four process units would suffice.

The Felixton boilers were designed to burn whole bagasse, bagasse pith or coal, and, after initial problems, have performed extremely well. They are fitted with wet scrubbers and cold induced draft fans on the basis that once the mill settled down very little coal, if any, would be burnt. Unfortunately throughput has not been maintained at design capacity, although the designed 100 000 bone dry tons of fibre per year have been exported. The resultant shortfall in fuel is made up with coal burning which has led to a corrosion problem in the wet scrubbers due to SO^2 absorption. Steps are being taken to solve this but the best solution would be an increase in cane supply to limit the additional fuel requirement.

The bagasse system is entirely on belts without any chain or slat carriers, with ploughs feeding the boiler feeders. The control of bagasse flow from drying mills and storage has been a problem and ploughs that could cope with differing quantities of bagasse on the belt took some time to perfect. However the cost effectiveness of bagasse belts is unquestionable.

Clarification

The use of rapid clarifiers has advantages in short retention but most importantly in first cost. In order to ensure high quality VHP sugar from relatively low quality cane, a syrup clarifier was also installed. This combination has proved to be effective in allowing Felixton to maintain export quality raw sugar under almost all operating conditions. This is the course which would be taken again if a mill were to be built today.

Evaporation

The Felixton evaporators with very large (5 500 m^2) first and second effects, to provide a Vapour II bleed for process steam, were designed when mechanical cleaning had a very clear cost advantage over chemical cleaning. The large rising film Kestner vessels were provided with easily removable tops to facilitate regular mechanical cleaning.

The arrangement of the evaporator station is the heart of a factory heat balance and it is not intended to discuss this here as it has been adequately covered already (Reid and Rein, 1983).

Due to the higher than normal second effect concentrations of 35-40 brix, a silicate scale normally found in later effects is deposited in the second effect vessels. Removal of this scale by mechanical cleaning proved a time consuming task. Felixton has therefore converted to chemical cleaning the first two effects. If chemical cleaning is to be used then longer tube falling film evaporators will give a more cost effective solution, and one which is likely to be pursued with new installations.

The acetic acid content of Vapour II has given some concern with steam side corrosion in process plant. This has highlighted the necessity for careful control of diffuser pH (Beckett and Graham, 1989).

Sugar recovery house

It was on the Felixton pan floor that the biggest departure from known technology was taken in the provision of continuous pans for product (A) as well as B- and C-strikes. Although a complete departure from previous practice, the decision was backed with considerable research and plant trials on existing mills. The saving in pan floor capital costs by going continuous was estimated at R1 million and this escalates to almost R4 million currently. Because of the possibility of using Vapour II on continuous pans, additional fuel economies were also achieved. A typical pan floor layout with continuous pans is shown in Figure 4.

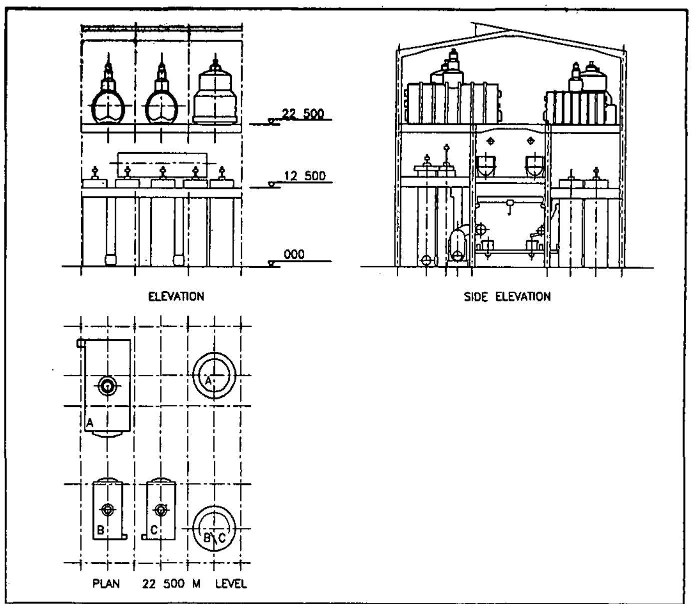

FIGURE 4 Typical pan floor layout with continuous pans

Although the decision was considered risky by some, there was confidence that it was the right one. In retrospect the right thing was done. The only regret was in not being sufficiently far advanced in seed production to be able to eliminate batch seed pans altogether, where a further saving could have been realised.

Steps now being taken to work towards the ultimate elimination of seed production in batch pans makes the design of a totally continuous pan floor a future possibility.

The remaining sugar house equipment was fairly conventional. The centralised control and instrumentation has been a success and would definitely be repeated.

Summary

As can be seen from the foregoing discussion, few of the original design concepts have had to be changed. Changes that would be made in a new mill are mainly to reduce the initial capital structure by reducing the standby capacities, at the risk of more intermittent operations.

Technically the design has been a success and Felixton is vying for top spot in performance with a number of other older and well established South African mills. Last season it achieved 98,3% sucrose extraction, 89,1 Boiling House Recovery and 87,6 Overall Sucrose Recovery while processing some of the worst cane in the industry. Financially, although Felixton paid for itself in less than six years, it has not proved to be as profitable as predicted because the cane supply, instead of increasing to the designed 3,3 million tons per annum or more, has remained at 2,5 million tons despite expansion by small growers, due to the inroads of the timber industry. This depletion of cane supplies has abated for the present due to over-production in the pulp market. It can hopefully be made up again by additional expansion into irrigated cane and by small grower expansion. But this is a lengthy and costly process and Felixton cane supply remains almost 1 million tons below its cane crushing ability.

Throughput tests conducted at Felixton have proved that given the cane supplies, the crushing rate could be increased to 700 tch or 16 800 tons per day without significant loss in performance. This is partly due to a reduction in fibre content of cane to present values of about 16%. From this point of view then, the plant has more than adequate reserve capacity which one hopes increasing cane supplies will eventually allow to be utilised.

The future

It can be seen that there has been little need for change in the Felixton design and that it has met its technical objectives. With more cane it would have met its financial objectives. What can be learnt from this experience and where would future mill design go?

In the introduction the cost of building a 330 tch, 8 000 tcd, mill in South Africa conforming to present performance norms was estimated at R330 million (US$120 million). The problem in a developing cane industry is that mills costing this amount are not a viable investment at current and projected world sugar prices.

Is it possible to build cheaper mills? The answer can be found in many developing countries, where mills are being built at approximately half this cost. This is achieved in two ways, firstly by the benefit of cheap construction labour, and secondly by accepting lower performance standards. For example, the average overall recovery achieved in Thailand, a rapidly expanding industry, is 77% compared to the South African average of 87%. If a hypothetical mill was crushing for 36 weeks, this recovery difference would amount to some 23 000 tons of sugar, worth as export, say R20 million (US$7 million) per annum. It may be worth spending some R100 million (US$35 million) to achieve this additional sugar production, depending on how proceeds are shared with growers.

A recent exercise was done to cost a mill with a minimum capital expenditure, but maintaining present normal performance. This envisaged dispensing with all standby equipment and providing single large units for all plant items, i.e. one diffuser, one boiler, one turbo-alternator, one clarifier, one each continuous A-, B- and C-pans etc. This would cut the overall cost of the envisaged 8 000 tcd mill to R240 million (US$85 million), which could be further cut by judicious use of some secondhand equipment, if it was available.

At current world sugar prices such a mill would probably still not make a viable return unless soft loans or preferential markets were available. However, with good management, such a mill design should give adequate performance, particularly if the cane supply, as is often the case, had to be built up over a few years. The mechanical reliability of the plant could then also be improved to acceptable standards over this initial period.

It is what happens over the first few years that makes a material impact on the viability of new capital intensive projects, and there may be some further strategies which can help to reduce the hiatus between capital outflow and revenue inflow from full production. If cane is grown by the same organisation then performance standards can be allowed to slip on the premise that it may be cheaper to develop additional land than to invest in capital intensive plant. However, increased operating costs, harvesting and transport, quickly reduce the effect of the capital saving. This may be an approach on a temporary basis, so that capital expenditure is delayed into the period after revenue is being earned by producing sugar. There are a number of options for doing this, e.g. A- and B-crystallisers could be completely left out in the initial stages. Diffusers have the advantage of having no limitations on throughput, only on performance. They can also be easily expanded when either money is available or improved performance is justifiable. The Amatikulu diffuser was expanded by 30% five years after installation. Continuous pans also have the ability to be expanded by adding stages when this becomes necessary.

These strategies, although messy in terms of construction, could easily make the difference between having a profitable project or none at all.

REFERENCES

Beckett, J and Graham, WS (1989). Acetate extraction in a cane diffuser. *Proc S Afr Sug Technol Ass* 63: 28-32.

Reid, MJ and Rein, PW (1983). Steam balance for the new Felixton mill. *Proc S Afr Sug Technol Ass* 58: 85-91.

Rein, PW and Ingham, P (1992). Diffuser performance optimisation through control of liquid flow patterns. *Proc int Soc Sug Cane Technol* 21: (in press).

Renton, RH (1985). Felixton - a new sugar mill in Zululand. *Proc S Afr Sug Technol Ass* 59: 1-4.

Wagner, DB and Schumann, GT (1988). Improvements in the operation of smuts and scrubber water system at Felixton. *Proc S Afr Sug Technol Ass* 62: 94-98.