AN ALTERNATE USE OF SUGARCANE - THE OPEN PAN SUGAR PROCESS AND ITS DUAL ROLES OF RURAL DEVELOPMENT AND CANE SUPPLY REGULATION

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Abstract

All of South Africa's sugar mills use Vacuum Pan (VP) Technology. As a result its cane supply base is more suited to Large-Scale Growers (LSGs). The Open Pan (OP) sugar processes are as a general rule, found throughout the developing world, particularly in countries with a large third world sector farming sugarcane in Less Developed Areas (LDAs)

The Open Pan, in addition to its role as a more suitable milling process for Small Scale Growers (SSGs), has the capacity to benefit (LSGs) by regulating the oversupply of sugarcane in a given cane supply area.

This paper is about sustainable development, but is not an attempt to shorten the length of milling season by diverting cane supply away from the existing VP mills, apart from cane that falls outside the local area agreements.

Introduction

The South African sugar industry has long been regarded as a developed sugar producing country, both grower and milling technology placing it amongst the best producers of centrifugal sugar in the world. Notwithstanding, South Africa has a large third world population with a sizeable sector farming sugar cane in Less Developed Areas (LDAs). Small-Scale Growers (SSGs) are thus required to operate under the structures and pressures of a clearly defined 'developed' industry making exclusive use of Vacuum Pan (VP) Technology.

VP mills require significantly larger volumes of cane supply, than Open Pan (OP) mills (Tribe 1987). The amalgamation of larger cane supply volumes means greater transport distances; which in turn sees pressure being brought on the infrastructure (zones, roads, bridges etc.) supporting the command areas of these mills. LDAs in the sugar industry occur as a general rule on the periphery of Large Scale Growers (LSGs), areas increasing transport costs for SSGs supplying existing VP mills.

In contrast to the technology employed in the South African industry, OP mills are found in a number of 'developing' countries (Table 1). Traditionally operating in LDAs they produce a number of different types of amorphous sugars, classified by the FAO and the ISO as non-centrifugal sugars. (including Gur, Jaggery, Panela, piloncillo, chancaha, papelon, rapadura, muscovada, panocha).

Table 1. Non-centrifugal sugar production estimates ('000 tons, product weight).

Country	Average 1969-71	Average 1979-81	Average 1985	Average 1971-75	1971-75	1986
India	7,395	8,107	9,660	6,295	6,320	8,000
Pakistan	1,423	1,766	1,400	1,313	1,449	1,300
Thailand	210	733	950	312	614	
Colombia	457	925	850	672	818	900
Bangladesh	526	427	496	700		
China	208	351	443	790	863	
Indonesia	207	301	243	171	210	
Brazil	217	200	200	271	200	
Burma	145	139	141	140	139	
Haiti	68	80	84			
Mexico	155	68	73	105	61	
Ecuador	40	53	60	40	46	
Africa	49	77	85			
Other C. America	130	106	112	117	111	
Other S. America	36	29	29	42	42	
Other Asia	85	58	65	84	83	
World	**11,350**	**13,419**	**14,889**	**10,372**	**10,968**	

a. The time reference of FAO data is the year in which the entire harvest or the bulk of it took place. USDA data relate to crop years which ended in the year shown. Figures may not add up to totals due to rounding.

b. FAO figures include khandsari: USDA figures do not.

c. Including Taiwan province.

Sources: Food and Agriculture Organisation, 1981-; US Department of Agriculture,1980-.

While not suggesting that the SA industry should re-focus its objectives, away from excellence in the production of the best exportable sugar produced at the lowest possible cost, this paper seeks to highlight the benefits of appropriate technologies suited to SGs in LDAs in the South African industry.

The open-pan milling process

Basically, all sugar mills need to render sugarcane juice down to the desired consistency, or brix, prior to crystallisation, by applying heat in order to boil off the excess water. This can be achieved by two methods; the first is the vacuum pan (VP) method, currently used in the SA sugar industry. This is a very efficient system capable of processing large volumes of sugar juice, to produce very high quality sugars. The second, much older method, is the open (OP) pan method. This technology requires constant ladling and a certain finesse, limiting it to smaller volumes to allow for closer attention.

A review of Hindu literature (Pearson, 1987) suggested that the basic (OP) process has remained largely unchanged over time, except for the evolution of minor techniques. OP technology makes use of two very important components largely absent in the VP process - the first is oxygen and the other is caramelisation.

Briefly, the process is as follows: juice is introduced to a single open pan over a naked flame, boiling off excess water to render a sweet solid substance. The addition of ash to the warm juice, accidentally or deliberately, improves the procedure. Caramelisation is an important requirement for the unique taste of the different products. There must, however, be control to ensure that excessive foaming does not trap heat so causing a burnt taste, although the use of anti-foaming agents does prove effective (Shrigoankar 1974) and Pandit and Singh (1984).

A number of problems exist with the process, when compared with modern VP technologies, and therefore it is often viewed as a regression in technology. First, the process is thermally inefficient. In addition to the residual stalks, large amounts of firewood are required to supplement the heat requirements. Secondly given the nature of an OP over a naked flame, there were continuing problems of the juice overheating and losses through inversion and excessive caramelisation. Storage of the final product can also be problematic due to poor separation of molasses and crystal.

Jaggery manufacture

Jaggery, Panela, Pilon, Piloncillo or Gur are basic amorphous sweeteners. These products are derived from the small scale or cottage type industry, processing sugarcane into traditional sweeteners in the rural areas of many countries.

Cane juice is reduced by boiling using traditional methods, including the use of vegetable clarificants, most commonly a mucilage of various shrubs, most notably '*Hibiscus esculentis* and *Hibiscus ficuluous*. These form a coagulant or gummy albumen, which collects colloidal impurities, which are then skimmed off the surface of the boiling pan. Lime is introduced to the juice but this is found to darken the colour of the Jaggery.

A form of crude carbon (paddy husk) is also used in the making of Cream Jaggery.

The juice is boiled in a single pan over a naked flame, continuing until the correct brix is obtained. There is no set period and success is directly proportional to the experience of the pan operator. Flavourants (ginger roots, coconut slices, cardamoms, and cloves) were observed being added to the boiling pan just before strike temperature was reached (between 105^o and 136^o dependant upon the purity of the juice [Dangre, 1958]).

No attempted separation takes place and before solidification, the syrup is poured into moulds for setting, the size of which is controlled by the market requirement e.g. consumption for rural households saw moulds of 300 to 500g. Rural or cottage based sweet makers require about 2.5 kg sized blocks. Industrial factories (sweet and alcohol) require 10 kg to 20 kg blocks.

Capacities of the different units were found to be:

Animal drawn crusher with a single pan:	2-4 TCD
Power driven crusher with three pans:	15-24 TCD

Khandsari manufacture

Khandsari is a highly flavoured crystalline sugar made in small scale or cottage industries. Technically the process remains almost the same as for Jaggery production, with a final stage of crystal separation which was originally undertaken by gravity, then rubbing, followed later by hand and pedal centrifugal, then finally power centrifugal.

The manufacture of Khandsari gives us a crystal rendiment of only 5-7%. This sugar has a higher nutrient content (Baboo and Solomon, 1995) and its by-product of high quality yellow/orange molasses can be made into a lower quality solid Jaggery or gur product called Raskat.

This process cannot compete with the large scale VP mills because of losses incurred by inversion that lead to excessively low levels of recovery. Problems are also incurred in crystal separation with large amounts of caramelised molasses remaining coated to small crystals, which gives these sugars their highly sought after taste.

The open pan sulphitation process (OPS)

Developments in the 1960s resulted in the birth of the 'New Open Pan', primarily attributed to Garg (1979) and the Appropriate Technology Development Association (ATDA) in Lucknow, UP Province, India, who took the basic OP and developed the open pan sulphitation process (OPS).

The process:

Crushing: With rural electrification three roller horizontal mills (16" x 24") normally in sets of three, some in tandem, are common. Cane preparation is generally performed by two sets of cane knives. Milling efficiencies of approximately 75% extraction are achieved, without imbibition (first roller 65%, second roller 16%, third roller 4%).

Clarification: Chemical clarification replaces the traditional vegetable process in the form of a single cold lime sulphitation (in essence it copies traditional large-scale mills). During this process other impurities are formed and are removed by a settling process and then decanting.

Evaporation: Larger round multi-pan furnaces are built to cope with the greater juice quantities. They are more or less continuous with juice cascading from the sulphitation tank down the various pans until the last and hottest pan where a point of saturation is reached. From here the product (with a consistency of syrup) is transferred into cooling tubs where cooling causes the formation of fine crystals.

Crystallisation: Crystallisation is achieved by cooling and manual agitation. The fine crystals serve as the nuclei that grow in the tanks over a period of 4-7 days. Manipulation of crystal size is possible, resulting in the producing of 'Rock Candy' (with crystal size of up to 2 mm). Crystal separation takes place by low cost centrifuges (electrically driven). Boiling house recoveries of 50% of plantation white equivalent and a further 20-25% of lower grade sugars are achieved by sequential boiling. Total boiling house recovery is approximately 75%. The overall sugar recovery is equal to 56% giving a rendiment of 7% on cane with a sugar content of 12.5% (McChesney 1987).

Capacity: Until the 1950s, OP systems in India were by and large limited to crushing 100 TCD (production could be pushed up to 150 TCD). Crush rates of up to 200 TCDs have been recorded but these cannot be maintained (Jones 1987) due to the intense attention required by the final pan operators. Recent research into OPS technology should increase sugar yield from 7 to 8.1 tons of sugar per day from a crush of 100 TCD. Positive results from a liquid sugar/molasses trial indicate a potential further increase in sugar yield of 1.3 tons of sugar per 100 TCD, to give a total sugar recovery of 9.4 tons from a 100 tons of cane (Mallory 1987; Kaplinsky, 1987).

The open pan industry in India

Prior to the 1930s, OP production was limited to Jaggery and Khandsari manufacture. A re-emergence of the OP system started in 1950-60, and was directly attributed to the surge in the building of large sugar mills in the 1930s (Garg, 1979).

These large sugar mills sought to guarantee cane supplies and were thus over-specifying the command area of a mill (AUC), with the result that there was too much cane in good seasons. The OP mills provided a solution to the problem of surplus cane supplies by providing a low value outlet for cane in good seasons; farmers could either supply large-scale mills with their cane for which a higher price could be obtained (but often this was negated by the increase in transport costs), or they could accept a lower price from the small OPS mills situated close by. The OP system thus operates as a shock absorber, smoothing the peaks and the troughs of cane supply.

By the 1980s, some 8500 OPS mills were added to the 8-million Jaggery mills in existence in India, and the technology had attracted the attention of the ITDG and the FAO of the UN. In 1956 India crushed 33 million tons of cane in small OP sugar mills, which had increased to 100 million tons by 1998 (Singh, 1999). During the same period the number of VP mills increased from 160 in 1956 to 465 in 1998, with a further 240 licensed for erection, indicating that these technologies can co-exist, and there could well be a mutual benefaction supporting growth.

Open pan technology in South Africa

The South African sugar industry encompasses characteristics of both a developed and developing industry. This has been recognised through the efforts of the contractor support programme and the payment of additional revenue for RV deliveries from SSGs due to their transport and logistical difficulties. Furthermore, the South African industry is characterised by a long milling season, with the potential for further lengthening, as increased cane supplies are not matched by milling capacity. When cane supply exceeds VP milling capacity, there are only five realistic disposal options.

1) Increase the length of milling season
2) Carry over the crop to the next season
3) Engage restrictive forces, Quotas, Permits, Pools etc,
4) Alter the cane payment method, by paying for only a por tion of the stalk
5) An alternate crop disposal, through the OP process

The ability of the OP process to absorb surplus cane supplies and resolve transport and logistical difficulties has been illustrated by the Indian sugar industry. The suitability of this technology to South Africa is assessed below. A summary of the advantages and disadvantages of VP mills and OP mills is presented in Table 2.

Costing and viability

High capital costs associated with the establishment of the VP mills prohibits individual entrepreneurs establishing such mills to absorb surplus cane supplies. By contrast, OP technology requires significantly less capital investment. A summary of costing for two Jaggery units is presented in Table 3. The turnkey cost of the various OP mills fluctuated between R6 000 and R15 500 per ton an hour capacity. By comparison a vacuum pan mill will cost about R1 500 000 per ton an hour capacity.

The price of Jaggery in India seemed to be twice the cost of cane equivalent. Thus, if the price of cane was R100 per ton then the miller would sell his Jaggery at the equivalent cane price of R200 per ton cane (R2).

Beneficiaries

There would be a number of beneficiaries from the introduction of OP technologies which can be identified. These include:

- The primary beneficiaries would be the SSGs in the LDAs, as well as small LSGs farming some distance from their mill. A further advantage for these growers would be enhanced cash flows from the sale of these products. In addition, it is likely that significant social benefits would accrue to the LDAs.

Table 2. Advantages and comparisons.

OPS	VP
Decentralised industry	Centralised industry
Higher nutritive value	A source of sucrose only
Processing in area of consumption	Consumption away from production area
Lower transport costs	Higher transport costs
Farmer can harvest climatically	Harvest dependent on mill requirement
Lower cost of production	Higher cost of production
Recovery 10-12% jaggery	Recovery 10% sugar
5-8% khandsari + 5-3% solid molasses	
High export potential	Overseas market well competed
Self funding	Funding from external source
Multi level marketing	
Production easily shifted	Production static

- A secondary beneficiary would be the remaining LSGs and the government. Remaining LSGs would benefit by virtue of less variable length of season, while the government would benefit as the process would bring competition and initiate the sustained development of a micro industry where it is needed most.

Time span and target areas

OP industries exist in Africa, from Sudan to Kenya and Tanzania (Iaisas, 1980). It is thought that entry into Northern Mozambique is imminent, and from Mozambique they are likely to spread into South Africa. There are specific conditions that are ideally suited to the erection of OP mills. These are:

1) Where cane supply in a mill area is in excess of milling capacity. The OPS system would benefit those growers furthest from the mill by giving them a further disposal option. The test would be one of accepting a slightly lower price due to lower recoveries of the OPS at the peak RV period or a lower RV price by supplying cane to the VP mills in the months of April or January.

2) Where the land is climatically suitable for the growing of sugarcane, but the total land area is not large enough to supply cane at the minimum requirement level needed to feed a large-scale VP mill.

3) As a stop gap in areas that have the potential to accommodate a large scale VP mill in the future. Here an OPS mill would develop in the area until economic viability for a VP mill is achieved.

Economic impact

The government has long identified the need for the creation of sustainable employment and economic empowerment in our extreme rural areas. A 100 TCD OPS mill (Kenyan) together with its transport would employ 220 people directly, of which 188 would be unskilled (Mallory 1987).

The benefits of sugar cultivation would also be spread evenly amongst the growing community. A 100 TCD, OP mill supplied by SSGs would take about 22 000 tons of cane annually. At an average annual SSG production of 100 tons, the mill would empower and sustain some 222 small-scale farmers.

Impact on sugar consumption

Based on research from other sugar industries, it is unlikely that there would be any erosion of existing local markets. In Colombia, for example, research by Cock and Luna (1995) showed that although one would expect to find panela and sugar competing, the two products existed side by side with no competition to speak of.

Funding

It is estimated that an increase in the length of milling season by one week, will cost on average R800 000 to the growers supplying a South African VP mill (Hackman 1999). Based on this analysis, the development of OP mills could become by and large self funding from an oversupplied cane area, as R800 000 would pay directly for the establishment of about six Jaggery units with a total capacity of 140 tons cane per day, or 31 920 tons cane over the crushing season.

Conclusion

The South African sugar industry has a significant SSG sector farming sugarcane in lesser developed areas. Given the nature of vacuum pan technology, current milling capacity is more suited to LSGs with their increased volumes. By contrast, the OP sugar mills would allow for increased flexibility, more suited to SSGs from less developed and more remote areas. Experience from India has shown that the development of an OP industry, in conjunction with the existing vacuum pan technology, can be beneficial to all parties when there is more cane than the VP mills can handle.

Table 3. Costing and viability (estimates).

JAGGERY UNIT, OX POWERED 3-4 TCD CAPACITY

Capital Requirements	
Animal powered vertical crusher	1 500
Ladles tools, moulds etc.	500
1 x 1.6m furnace pans	2 000
1 furnace with clay bricks	10 000
Total	27 500
Input costs	
Sugar cane purchase 3tons x 24days	
@R85.00 per ton cane	6 100
Yield 72tons cane x 10% recovery	
= 7200kgs Jaggery @R2.00kg	14 400
Gross margin	8 300
Less loan	2 500
Less Sundries	1 000
Net Total before wages	R4 800
Labour requirements, (family units)	
Furnace stoker	
Pan operator	
Bagasse drier	
Cane feeder	

JAGGERY UNIT - 24 TCD CAPACITY
(Situated rural areas- access to Eskom)

Capital requirements	
Horizontal three roller crusher complete	15 000
10hp electric motor	3 800
Ladles tools, moulds etc	800
5 x 1.6m furnace pans	20 000
1 x multiple pan concrete furnace	
with heat bricks & insulation	80 000
Total	R107 600
Input costs	
Sugar cane purchase 480tons can pm	40 800
@R85.00 per ton cane	
Yield 480tons cane x 10% recovery	84 000
= 48000kgs Jaggery @R1.75kg	
Gross margin	**43 200**
Less loan	5 000
Less Sundries	5 000
Less Electricity	3 000
Less Transport	6 000
Net Total before wages	R24 200
Labour requirements, (normally extended family units)	
1 Furnace stoker	1 Cane feeder
1Pan operator/foreman	1 Chak agitator
1 Bagasse drier	1 Mould filler
2 Bagasse carrier	2 Cane carrier

The success of the South African industry is linked to the survival of all growers, including the SSG's. The investigation of appropriate technologies suited to all sectors of the industry is thus important, and based on experience from other lesser-developed countries, it is hoped that the South African Sugar Association will nurture both processes (VP & OP).

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