REVIEW ON DESIGN AND OPERATION OF CLARIFIERS IN THE SOUTH AFRICAN SUGAR INDUSTRY FOR THE PERIOD 1975 TO 1995

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Abstract

The major trends in clarifier design and operation over the past 20 years are reviewed. No important breakthrough has been achieved despite changes in juice quality due to diffusion and deterioration in cane quality. The main change has been the advent of the trayless SRI-type clarifier which now represents sixty per cent of the installed units.

Keywords: clarifying, diffusers, design, SRI

Introduction

At the outset it is worth noting that there has been no major breakthrough in the industrial process used for clarifying cane juice in the last twenty years. Clarification is still carried out by liming and settling in subsiders at boiling point and the operating technique is basically the same. It is remarkable that this static situation was maintained despite of three major changes to the local conditions, namely, the advance of diffusion, the decline in cane quality and the many drought years. Of the three, the drastic reduction in the amount of suspended solids in mixed juice due to the progressive replacement of milling trains by diffusers is certainly the most striking. On a quantitative basis the diffuser does more of the clarification duty than the clarifier itself. For example, in the 1995 season, the average solids content of diffuser mixed juice was 0,2% against 1,0% for the mills, equivalent to a 80% removal of solids in the diffuser (Anon., 1996).

It is arguably a poor reflection on the local technologists that this particular set of conditions has not led to a clarifier of entire South African design. All the clarifiers presently installed are of foreign design, albeit with certain modifications to suit the local conditions.

Clarifier design

Trends in clarifier types and numbers

Over the many decades since juice clarification by settling has been carried out on a continuous mode, the main evolution in clarifier design has been in the direction of a decrease in the number of compartments for settling, relative to mud thickening (Hugot, 1986) as shown in Table 1. This trend has culminated in the SRI design with only one settling compartment and one mud boot.

The trend in the types of clarifier installed in the industry over the years has followed the same pattern with very few Dorr, Graver, Bach and RapiDorr clarifiers still being in operation. Of these, most, if not all, have been modified to multi-point juice off-takes for more uniform flow pattern and some have been baffled to reduce turbulence at the juice inlet to each compartment. The modifications have generally led to much reduced retention times as reported by Scott (1988) and van Duyker and Tosio (1986). Scott (1988) also reports on improvements due to additional gas venting at each compartment.

Table 1

Number of compartments in clarifiers

Type	Number of compartments		Ratio settling/thickening
	Juice	Mud	
Dorr/Graver/Bach	4	1	4
RapiDorr	4	2	2
Dorr 444/BMA	4	4	1
SRI	1	1	1

In the clarifiers with one mud boot per settling tray, the SRI-type unit has received overwhelming preference over the Dorr444. For example, the last 17 clarifiers installed locally since the early 1980s, except one at Komati Mill, have all been of the SRI type which now represents 60% of the total number in use. It must be noted that, in the more recent installations, the conventional SRI model has been slightly modified by reducing the size of the underflow region and mud boot ([1]personal communication) to accommodate the very low mud volumes encountered locally and reduce the retention time of the muds, which is otherwise excessive.

One of the latest additions to the local clarifier population is at Komati and was installed in 1994. It is a new design in the sugar industry although its concept has been used for many years in water and effluent treatment. It is trayless, with a central feedwell and eight radial launders fitted with identical diameter holes through which the clarified juice exits. It is felt that there are not enough performance data available, at this stage, to express an opinion on its performance. As with the SRI model the mud region of this clarifier is being reduced presently to accommodate the very low mud volume.

The almost universal adoption of the SRI-type clarifier by the industry is based on many reasons, not the least of which are the markedly cheaper cost of equipment, installation and maintenance, and the simplicity of operation. In general its clarification performance is considered equal to the multi-tray units except that it is known to be sensitive to juice flow variations and it has been found almost essential to have automated control of the juice flow into the clarifier for optimum operation. Although it has the reputation of using more flocculant this is not reflected in the industry figures for the 1995 season, with 3,3 ppm on mixed juice for both the SRI-type and multi-tray clarifiers (Anon., 1996).

The change in the number and type of clarifiers operating in South Africa (Allan, 1973; Reid 1992) over the past 20 years is shown in Table 2.

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Table 2

Type and number of clarifiers in the sugar industry

	1975	1995
Ratio 4 Clarifiers (Dorr/Graver/Bach)	21	1
Ratio 2 Clarifiers (RapiDorr)	25	7
Ratio 1 Clarifiers		
Dorr 444	2	1
SRI-type	0	16
BMA	1	1
Envirotech	0	1
Total	49	27

In 1975 there were 20 mills and 49 clarifiers in the industry, corresponding to an average of 2,5 units per mill, which has reduced to 1,7 in 1995 (27 clarifiers in 16 mills). In this connection it is interesting to note that in the last three new installations, two (Komati and Eston) installed only one unit each whereas Felixton installed three units. Within the industry eight mills (50%) operate with only one clarifier, the other half having two or three units.

With the mills running more than one unit, the proper splitting of the juice out of the flash tank into the clarifiers, often of different capacity, is an important operational aspect. The most commonly used system consists of a distribution box with weirs.

Capacity of clarifiers

In the past the capacity of a subsider was usually expressed in terms of the settling area of the trays. However, it is considered more practical to compare capacity trends based on subsider volumes, for the simple reason that the most widely used SRI-type clarifiers are trayless. As can be expected, with the progressive replacement of old units with the short retention SRI-type, the installed volume of clarifiers in the industry has decreased considerably in spite of a marked increase in crush rate, as shown in Table 3.

Table 3

Installed volume of clarifiers and crush rate

	1975	1995
Industry overall TCH	3500	4640
Total clarifier volume (m^3)	11700	7200
Capacity in m^3 per TCH	3,3	1,6

For the six mills using only SRI-type units the average installed capacity is 1,1 m^3/TCH (range 0,9 to 1,2 m^3/TCH) while it is 2,0 (range of 1,4 to 2,3) for the eight mills operating multi-tray units only.

Based on the above figures for installed capacities the average nominal retention times in the clarifiers are 1,5 h for multi-tray clarifiers and 0,8 h for SRI-type clarifiers. The largest units installed in the industry are three multi-tray clarifiers of 11,0 m diameter at Malelane mill (RapiDorr), Darnall mill (BMA) and Umzimkulu mill (Dorr444) and an SRI-type of 10,7 m diameter at Eston mill.

Clarifier operation

As already mentioned there has been little change over the past 20 years in the way the clarifiers are operated. The only noteworthy industrial trends are the running of clarifiers with muds at lower levels and thinner concentrations than in the past and the shift from mechanically stirred tanks to in-line static mixers for lime mixing.

Liming

All the mills, except one, use a straight hot liming system for their clarification. The exception is Gledhow mill which, at times of high turbidity and colour, practices saccharate liming. Saccharate liming has been tried at different places (North Coombes *et al.*, 1981 and Scott, 1988) but has never been adopted, the opinion being that the process difficulties associated with it outweigh the marginal benefits. The quantity of lime used is about 0,6 kg CaO per ton cane and does not vary much between mills and seasons. The addition of lime is automated by a pH controller and the pH of the limed juice (range of 7,3 – 8,1 measured at room temperature) is set to obtain a clear juice at 6,9 – 7,1.

Liming is generally effected in-line, upstream of a static mixer and before flashing. Five mills are still liming after the flash tank using a stirred tank.

The concentration of the lime slurry varies between 4 and 16 degrees Beaume, the average being around 10. In general, the milk of lime is prepared with hot condensate.

Phosphate addition

About half the mills monitor the phosphate content of their mixed juice regularly and add phosphoric acid when the P_2O_5 level drops below 150 ppm in order to bring the concentration back to about 200 ppm.

Flocculant usage

The consumption of flocculant in the industry has not changed much over the past 20 years, considering the advent of the short retention time clarifiers during that period. The industry average was 2,7 and 3,4 ppm on mixed juice in 1975 and 1995 respectively. Contrary to 1975 when the popular flocculants were Separan 273 and Talosep A3, those most widely used now are Magnofloc D and LT 27, Floccotan R300, Primco A115 and Rheofloc 430.

A few years ago there was a shift in the industry to liquid flocculants which, for various reasons, was discontinued and all the mills are now back to powder form.

Under normal conditions these flocculants are used on their own although most mills prefer a cocktail of two or even three flocculants when handling refractory juices. Two thirds of the mills use cold potable water for flocculant preparation, the remainder using condensate cooled to about 50°C. Most installations allow four to six hours retention time for hydrolysis and the dosing concentration is normally 0,05%. The point of application of the flocculant to the juice is invariably at a spot of turbulence just before entering the clarifier.

Juice quality and monitoring

With the availability of two distinct types of clarifiers in the industry it is interesting to make a comparison of the trend in purity and pH of the juice from the multi-tray and short retention time clarifiers. Based on the reported data for 1995 (Anon., 1996 and [1]personal communication), there is no marked difference in both parameters between the two types, as shown in Table 4.

Table 4

Purity and pH changes in clarifiers – 1995 season

Purity drop	Type	
	Short retention	Multi-tray
Clear – mixed juice	–0,40	–0,61
Clear J – filtrate	1,44	1,58
pH drop		
Limed – clear juice	0,6	0,7
Clear juice – filtrate	0,3	0,3

Despite of the recent development of a juice turbidity meter by the Sugar Milling Research Institute (Stone, 1994) which is reported to be working successfully on trial at two mills, the clear juice clarity is still assessed visually in the industry by means of the clarity wedge (Allied Colloid Patent), with readings in the range 8-14 being normally achieved.

Fifty per cent of the mills measure the clear juice colour by spectrophotometer. The normal values in 1995 were in the range of 20 000 to 26 000 ICUMSA units.

It is worth noting that the filtration of clear juice is practised, albeit crudely, at only one of the sixteen mills, by means of static screens.

Mud handling

Since the mid-1980s the trend in the industry has been to operate the clarifiers at much lower mud levels and at a solids content below 4%. This change in practice followed the recommendations of the Sugar Milling Research Institute (Lionnet, 1984) whose objectives were to reduce the retention time of the clarifier mud and improve its filterability. In most of the mills the mud extraction from clarifiers is done by gravity while the others use pumps, mainly of the diaphragm type. In general the rate of mud extraction is controlled by an on-off automatic system based on the mud level in the mud mixer feeding the filters.

Precautionary measures for long stoppages

Of the 16 mills in the industry, 10 increase the limed juice pH to 8,0 – 8,5 for about two hours before the stoppage. Four of the 10 will also reduce the juice temperature to just below boiling point. Six mills dose biocide at rates of 40-150 ppm half an hour before stopping. Three mills empty all the mud from their clarifier/s over the stoppage and one mill liquidates its clarifier every week.

Conclusions

In conclusion, the main trends in clarifier design and operation in the past 20 years can be summarised as follows:

- the marked reduction in the solids content of mixed juice due to diffusion.
- the advent and popularity of the trayless SRI-type rapid clarifier and the progressive elimination of the multi-tray units.
- the lower installed volume of clarifiers and shorter nominal retention times.
- the mixing of lime by means of in-line static mixers rather than mechanically stirred tanks.
- the operation of clarifiers at low mud levels and the production of thin muds.

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