SUGGESTED IMPROVEMENTS TO CLARIFIER DESIGNS

By J. R. GUNN

Summary

The author has produced this paper to promote discussion on clarifier design which he believes can be improved.

The suggestions include the replacement of the conventional mud pump with a screw type pump to be positioned at the bottom of the clarifier and the alteration of the feeding and decanting arrangements.

Introduction

Basically there are two types of clarifier design used in the cane sugar industry although there are more than two manufacturers of this type of plant. These are classified as either upward pointing cones or downward pointing cones by reason of the direction of the cones, as they draw off clarified liquid either at the centre of each tray or at the circumference of the tray. Manufacturers have their own refinements such as the type and speed of scraper gear, the type of mud extraction pump employed and various other features such as skirts on the trays and varying diameters of trays, but as stated above basically there are only two main differences in design.

Suggested Improvement Common to All Clarifiers

The stability of all clarifiers is a steady convection-less slow passage of liquid through the clarifier with the least possible disturbance of mud formed in the mud thickening compartments. It is usual for the mud filtration station which is used in conjunction with the clarifier station, to be on a lower level than the top of the clarifier. Thus any mud formed in the clarifier will actually gravitate to the filtration station and consequently it is unnecessary to use a mud pump to extract the mud. Yet every clarifier manufacture supplies a pump of either diaphragm or plunger design and the pump is always sited at the top of the clarifier. The pump is acting merely as a flow rate controller for without the pump the mud would simply gush out at an uncontrolled rate. Both designs of pumps, i.e. diaphragm and plunger, cause pulsations in the suction line and consequently these pulsations must react on the mud in the thickening compartments and cause a small disturbance of flow—an undesirable feature. The suction lines to these pumps are usually of large bore with ultra-slow velocities. Thus with a long heavy column of mud subjected to pulsations, the author suggests that the heavier portion of the mud will tend to stay at the bottom of the pipe and only the lighter fractions will actually reach the pump. One remedy is to reduce the bore of the pipe to increase the flow velocity and the other remedy is to place the pump at the bottom of the clarifier. However, a pump is unnecessary, as stated before; all that is required is a suitable valve that will not clog and that will pass the required amount of mud.

In Australia the author saw many installations where mechanical valves were used at the bottom of the clarifiers. These valves were operated by levers and cams driven by a variable speed motor and were either fully open or fully shut and there is not much danger of the valves becoming blocked. However this does not solve the problem because the intermittent operation of the valves is similar to the plunger pump and this must cause pulsations in the mud boot. Using a partially open valve or cock is undesirable because it will clog up or the mud will build up and only the thinner fraction will flow. The author suggests that the screw type pump driven by a variable speed drive and positioned on the very bottom of the clarifier is the only answer. If the variable speed drive is not available or too costly, running the screw pump for periods of not less than 15 minutes with stops of say 10 minutes will do no harm. Here the pump is merely acting as a flow controller and any thick mud which has passed the pump must be delivered to the mud receiver at the filter station.

Suggested Improvement to an Upward Pointing Cone Type Clarifier

One type of upward pointing cone type clarifiers has juice distribution pipes at the top feeding into four rectangular downtake situated at 90° to each other around the circumference of the clarifier. This forces the dirty juice down to the level of the lowest tray before it can rise again for that portion of the juice to reach the upper trays. At the bottom of these four intakes there must be considerable turbulence and also the upward rising juice may tend to prevent the lighter mud fractions from settling. The author suggests that an improvement in design would be to have a ring feed of only about one foot deep right around the whole circumference of the clarifier. Here all the dirty (and incidently the hottest) juice will be at the top of the clarifier and the mud and juice will have a downward movement when proceeding to the trays and mud boot. The author believes that the lighter fractions will now have a better chance of settling. The suggested design is shown here diagramatically compared with the existing design. It is worthy of note that removal of the four downtakes will increase the area between the downtake and trays and radically reduce the velocity in that region.

Suggested Improvement to a Downward Pointing Cone Type Clarifier

One of the latest types of design of downward pointing cone type clarifiers has two clarified juice outlets per compartment, these being diametrically opposite. The dirty juice is fed through a centre distribution pipe and it has to work its way to the two outlets. There is reasonable evidence that this juice travels directly to the outlets in a channel and that the full advantage of the low velocity at the circumference is lost. The author has been told by a member of the West Indies Sugar Company that in

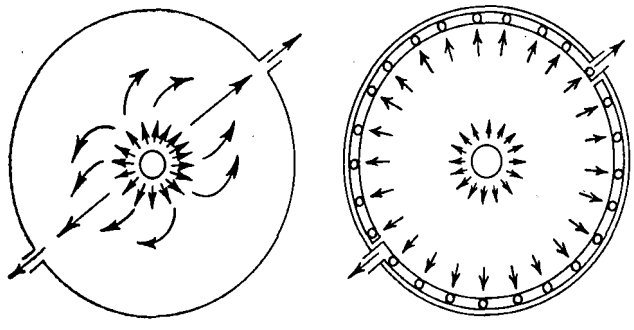
one installation a ring main was fitted inside the clarifier and that the clear juice was decanted through a number of small bore stand pipes fitted to the ring main. It was claimed that this increased the throughput by no less than 143 per cent. Whilst the author cannot substantiate this figure, it is well to mention that the informant was one of the very top executives.

The effect of the ring main would be to ensure that the dirty juice radiates outwards in all directions instead of in two directions diametrically opposite. It may be argued that as the centre downtake rotates that at least the juice starts off radiating in all directions but, if what hapened in the West Indies is true, it obviously settles down to a flow in the direction of the two outlets.

The author, during a tour of the British Sugar Corporation, found a five tray clarifier of the type under discussion being used in the bottom two compartments only. The factory manager would not say what modification he had done but he had managed to get the output of the two trays increased by 150 per cent, i.e., he used only 2/5ths of the clarifier which, prior to modification required the whole unit. This figure balances well with the 143 per cent stated above.

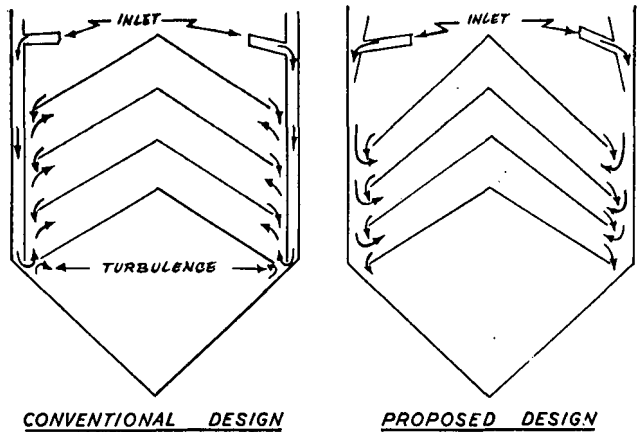
The author suggests that if the above modification is so effective, inversion losses can be cut down by either using less clarifiers, as most factories have more than one clarifier, or by using less trays or compartments. This necessitates the installation of decanting boxes at different levels in the clarifier but the shorter retention time may well justify the additional expenditure.

A sketch of the proposed installation of stand pipes is included.



ANTICIPATED FLOW PATTERN

CONVENTIONAL IMPROVED



CONVENTIONAL DESIGN PROPOSED DESIGN

Mr. Rault (in the Chair) said that one point emerging from this very practical paper was the importance of not disturbing the floc. At Natal Estates, when using the double carbonatation juice process, when trouble was experienced with clarification, it was difficult to know if this was due to the clarifiers or to the filters. Most often however, the trouble was clearly ascribable to the filters. The filters now used were not really filters but rather sieves.

Mr. Robertson asked if the several stand-pipes fitted to the ring of outlets mentioned by the author had the same capacity as the original outlets. If the volume of these pipes was too big poor settling would result, but in any case the flow could not be increased beyond a certain rate without poor results.

Mr. Gunn agreed there was nothing one could do to increase settling rate other than the use of some polyelectrolyte, but the claim made in the West Indies was that if there were only two outlets for clarified juice there was short-circuiting, some juice going straight through while much of the rest was unduly delayed. The clarifiers were improved there by the installation of a ring main in which were fitted small-bore stand pipes for decanting the clear juice, as mentioned in the paper.

Mr. Perk said that it was usual to have only two outlets with clarifiers up to 24 feet in diameter but with a 36 foot clarifier there was usually provided a three-fold outlet. He agreed that the annular ring would be a great improvement.

Dr. Douwes Dekker said that the continuous clarifier was a piece of plant such that one could not look inside to see what was happening. He considered that the multiple outlet for the "Dorr" was an excellent idea. With the other type of clarifier, the "Bach", he was not sure that to change the present inlets would be an improvement. At Amatikulu also they had tried to raise the level of the inlets of the "Bach" clarifiers but apparently this was not successful. Taking away the present inlets might cause turbulence at each of the cones.

Mr. Turner related that at Amatikulu the inlet pipes had originally been lengthened and sloped further downward because previously the tendency was for these pipes to clog with mud readily.

Mr. Gunn said it was usual to have the filter station at a lower level than the clarifier so there was therefore no necessity to pump the mud from a clarifier. He thought that to pump mud at the top of the clarifier was wrong and that the pumps should be at the bottom. However he did not consider that using valves instead of pumps was a good idea.

Dr. van der Pol said that at Doornlop the mud pump was not usually used and the mud was allowed to gravitate to the filters. He did not however advocate doing away with the pump altogether because after a week-end stop the mud became so heavy that it had to be pumped. He could not see that any difference would result from discharging the clear juice from the outside or from the centre of the clarifier. The mud would settle out where the flow was slowest and it did not matter where this discharge point was.

The principle of upward floc filtration had definitely been established in water clarification where the floc was finer and lighter than in juice clarification, but it might be that with juice such upward floc filtration was unnecessary, and only experiment could establish this.

As far as the size of the discharge pipes was concerned, he considered that if they were too large in diameter this might interfere with the control of the clarifier, as a very small change in the static head might seriously interfere with the settlement.

Mr. Gunn said that if one led the hot incoming juice down to a point three-quarters of the depth of the clarifier its tendency would be to rise. If the hot juice were led into the top of the clarifier there would be no convection currents.

As the tendency was to overload plant, he could not see that the benefit of upward floc filtration would be obtained in practice.

Leading the hot juice in halfway down the clarifier would not be much better than leading it in lower down, and besides this, the intake pipes reduced the volume of the clarifier, thus reducing the settling time.

it was interesting to note that one clarifier manufacturer had already installed a screw-type mud pump.

Mr. Thumann said he had had experience with a "Bach" clarifier in India which had a "V" gutter and a ring feed, and had 24 pipes about one inch in diameter going down to the cone. At distances of about one foot from top to bottom $\frac{1}{4}$ inch holes were located, but these became clogged with bagacillo.

Taking the pipes out and making the $\frac{1}{4}$ inch holes of all of them into narrow slots and removing the plugs at the bottom of the pipes, made the clarifier then work very well but whether similar results would be obtained in other countries was difficult to forecast.

He thought the continuous clarifiers were originally designed for water clarification and on being applied to juice the capacity was increased, but with competition between various makers the capacities were over-estimated and one could only attain these capacities with very good juices. One of the drawbacks suffered by the clarifiers was the necessity of returning the poor juice from the filters, and he suggested therefore that the Industry should make a study of positive filtration instead of our present so-called filters.

Dr. Douwes Dekker agreed with Mr. Gunn that if the juice was fed into the top of the clarifier there would be no convection currents but this hot juice had to eventually go to the bottom of the compartments and the question was, should the juice be guided down or be allowed to go down freely as had been suggested? The only way to determine this was to try it out.

The point brought up by Mr. Thumann about the inter-relation between clarifiers and filters was extremely important. Determination of mud retention should be regularly carried out in all factories. The maximum amount of retention one could expect was

about 80 per cent, but it frequently fell to about 40 to 50 per cent, thus overloading the clarifiers. Rotary cloth filters were now being tried out by clarifier manufacturers while another idea was to filter the juice from the filters again, after adding "Separan" and lime.

Mr. Boyes felt that claims made by overseas sugar factories could be commented upon. Basically, settling depended upon Stokes' Law, the factors involved being the difference in density between juice and floc, the viscosity of the medium, the shape of the vessel and so on. When changes were made to clarifiers these had in view the elimination of hindrance effects.

In the West Indies the claim was made that through-put was increased 140 per cent and he wondered if this increase was due to some effect apart from the improvement in the clarifiers themselves. He thought this might also apply in the case where the number of trays was reduced from five to two, perhaps through the use of polyelectrolytes.

Mr. W. H. Walsh said he also agreed with Mr. Thumann who had brought out a most important point. In the older designs there was a lot of capacity in hand for a good reason. Many clarifiers operated in regions where there was frosted cane, wet conditions, and soil introduced by mechanical harvesting. Competition had resulted in attempts to obtain greater through-put than before. One way to increase through-put was to improve the free settlement of the first heavy muds and then leave the rest of the clarifier to deal with the lighter suspended solids. As far as a screw-type pump for removing muds was concerned, a continuous clarifier fitted with a helical screw for removing the muds had been in use at Natal Estates for many years and it had worked very well.

Mr. Gunn said, regarding the size of the hole in the ring, in the West Indies the total area of the holes was equal to the size of the original outlets so the control of the clarifier was not changed. In answer to Dr. Douwes Dekker he said that one clarifier, in which the feed was as he had now suggested, worked very well.

Regarding Mr. Thumann's statement, he was informed that the gutter round the top of the clarifier he had mentioned was a sloping gutter and this did tend to choke up. The modification he now suggested did not employ a gutter, it had merely a ring round the top with a restriction about two inches in diameter to ensure even distribution from the four pipes supplying to the ring.

He considered that mud re-circulation would be reduced if clarifiers worked better. There was nothing one could do to improve settling other than the addition of a settling accelerator, but there was much one could do to improve the efficiency of the clarifier. One reason some manufacturers gave for not installing a ring type of feed was that this would increase the price.

Mr. Rault said that one of our visitors from Mocambique had stated that settling troubles were also experienced there.

In this country in 1934, settling time was considered to be ample at 1½ hours, but now with continuous settlers, it was much more like two to three hours.