

THE DORR CLARIFIERS AND THE PETREE SYSTEM.

By W. T. LATHAM, of Gledhow Sugar Estates, Ltd.

Mr. W. T. Latham also read the above paper:—

Before proceeding, I would like to say a few words in connection with this paper on Dorr Clarifiers and the Petree System. The report was not intended originally as an individual paper, but merely as a concise description of some of the methods employed in this very important phase of the manufacture, and that it would be embodied in the general report of the Committee on Clarification and Filtration. I feel that standing alone it is not nearly complete enough, and I have taken the liberty of supplementing it with further details in relation to compound clarification, which, with the permission of the Chairman, I shall read to you afterwards.

Dorr Clarifiers were first introduced to the Sugar Industry in Cuba, where the development in replacing the old type of open clarifier has been most rapid. The clarifier is a mild steel cylindrical tank with an almost flat conical bottom and a low conical top. The main body is divided into compartments by steel trays parallel to one another and to the top and bottom. Through its entire centre is an opening or central mud passage, which is common to all compartments. Riveted to the top is a small cylindrical tank or feed-well, and above this again, carried by steel trusses riveted to the main body itself, is the worm gearing for driving the mud thickening mechanism, and to one side, the diaphragm pumps for drawing off the mud from the bottom of the clarifier. The mud thickening mechanism consists of a steel shaft passing through the entire centre of the clarifier, and keyed to the shaft are spiders, which carry steel arms extending to the periphery of the tank. These steel arms carry flexible palettes of brass, which rest lightly upon the bottom of each compartment or tray; also, at the top of the feed-well and attached to the central shaft are paddles for removing the scum, which flows into a gutter connected to the mud trough at the side of the tank. At the top of each compartment are internal pipes leading into a header, which passes through the side of the main tank, and upwards into the clear juice overflow box. There are therefore as many clear juice overflow pipes as there are compartments. The overflow pipes are fitted with adjustable sleeves, which control the level of the juice in the main body, besides the rate of flow from each compartment.

When once full, the operation of the clarifier may be continued indefinitely. Hot tempered juice (210°—215° F.) enters the feed-well, the scum rises and is removed, while the heavy solids settle to the bottom of each compartment. The revolving arms

with their brass palettes pull this mud to the opening at the centre; it falls to the bottom of the main body, where it is removed by the diaphragm pumps.

In the Petree Process, usually two such clarifiers are used, termed the Primary and the Secondary, and the juice from the mills is divided in such a way that the richer juice, namely, that from the crushers and 1st Mill, after treatment flows into the one, while the poorer juice with dilution water after treatment flows into the other respectively. The primary or richer clear juice is sent direct to the evaporator, while the secondary or poorer clear juice is returned to the primary raw juice to be further treated along with that juice. Similarly, the primary mud is sent to the secondary raw juice for further treatment, while the secondary mud is returned to the bagasse, usually between the 2nd and 3rd Mills in a fourteen roller plant. Imbibition water is applied after the 3rd Mill, and the usual system of compound imbibition employed.

The final reaction of the primary tempered juice is usually slightly alkaline, while that of the secondary is made slightly acid, owing to the larger quantities of colloid impurities and bagacillo contained in the latter.

The great advantage claimed for the Petree Process is the total elimination of the filter press station. A saving is effected by eliminating the cost of and repairs to filter cloths, the general maintenance of presses, pumps, washing machines and auxiliary equipment, the expenditure on plate and frame renewals, the cost of disposing of the cake and the labour used in operating the station.

The substitution of Dorr's in place of the open type of clarifiers constitutes a saving in space and part of the labour required to operate the latter.

It is also claimed that the added fuel value of the bagasse contributed by the return of the mud to the mills is worth a consideration, but against this must be considered the value of press cake as a fertilizer.

The process is essentially one for cheapening the production costs of sugar, and as such was given a fair trial by at least one factory in this country before being partly discarded. Here, it was realised that, although certain advantages mentioned above were to be gained, losses of sucrose and mechanical difficulties in other directions were continually to be met with, which made the whole process a somewhat doubtful proposition under the conditions existing at the time.

Owing to some extent to the uneven feed of cane to the crusher and subsequently the unevenness of

the blanket of bagasse, a condition existing in many mills in this country at that time, it was found that re-expression of the mud from the bagasse and its subsequent return to the process was a factor very difficult to control, which led finally to the accumulation of mud in the clarifiers and to its further intensive circulation in the endeavour to keep the levels down. High mud levels led to decomposition of the mud, the evolution of obnoxious gases and presumably to the solution of decomposition products with its attendant loss of sucrose. Had these conditions been a prevalent feature, the process would have been at once discontinued, but they were existent chiefly after rains and after crushing cane of an inferior quality.

Another feature of the process was the abrasive action of the mud against roll surfaces which tended to wear them smooth, causing slippage, while the subsequent choking of mills caused a further circulation of mud due to the interrupted feed.

Heavy imbibition was found to be undesirable, as it tended to increase the re-expression and circulation of mud, a decrease in the quantity of applied water led to a further drop in extraction, apart from the apparent drop through the transference of the losses in filter press cake to the mills.

It was realised that, owing evidently in the main to the large volumes of mud which had to be contained in this country, that part of the process which dealt with the application of the mud to the mills, was not altogether feasible, and this practice was discontinued. The process of double clarification with Doors in conjunction with a filter press station is still practised and has worked successfully for a number of years.

The advantages of this method may be said to be, in the main, threefold. Firstly, the division of the juices into a primary and a secondary permits of separate treatment of each with regard to the quantity and nature of their impurities. Secondly, the secondary clarified being returned for double treatment, the poorer juice obtains more energetic chemical treatment, which is a distinct advantage, and more impurities are thrown down. Thirdly, the primary mud being high in sucrose is returned to the secondary and more dilute juice, containing, as this does, all the dilution water from the mills. By this means every advantage is taken of this water for diluting the mud and lowering its sucrose within reasonable limits before filtering. It is also claimed that the return of this mud, through adding further to the bulk of the precipitate in the secondary, assists in entrapping the many small particles of suspended matter contained in that juice.

It has been stated by some in this country that inversion losses, through the use of this system and Dorrs, are very heavy. This is partly true, but again is governed by the reaction of the juice. A

few years ago, before the present improved methods in clarification became generally adopted, it was the custom to work the final reaction of the juice on the acid side for white sugar manufacture (clear juice 6.7 to 6.8 pH.), and under these conditions I feel sure that losses through inversion were rather high, especially where the system of compound clarification was employed. At present, the final reaction of the clear juice is from 7.0 to 7.1 pH when making white sugar, resulting no doubt in a decreased loss through inversion. In the first instance, the rise in purity between mixed juice and syrup, as far as I remember, was about 0.5; it is now about 1.5, this seeming to indicate that inversion losses are not very much heavier than those experienced with open clarifiers, as it compares favourably with many mills on the coast to-day employing this type of clarifier. These losses, I dare say, could be diminished by operating single defecation with Dorrs, but I am of the opinion that the advantages to be gained by the double system warrant its continuance, where the final reaction of the juice is not lower than 7.0 pH.

The process of compound clarification is definitely claimed by many authorities in other countries as one whereby colloidal substances are efficiently eliminated. It is claimed that these colloids are more soluble in an alkaline juice than in an acid one, hence the practice of keeping the secondary juice, which contains the bulk of colloidal matter slightly on the acid side. In quoting from "Spencer" (1929 edition), we find that the colloids eliminated have been shown by Paine and his colleagues to be largely of the irreversible type. (Those high in ash.) Reversible colloids (gums, pectins and those low in ash) pass through the process almost untouched. An increase in lime salts, above the excess required for efficient clarification, causes the amount of the reversible colloids to increase in almost direct linear relation, the assumption being that excess lime either converts irreversible into reversible, or that it has a peptizing effect on pectinous materials, or that it enters into chemical combination with reversible colloids.

Whether the effect of reboiling part of the mud and the prolonged high temperatures which obtain cause part of the colloidal matter to go into solution, thus giving easy filtration of Dorrs Clarifier mud, I am not prepared to say beyond the fact that pan boiling and curing of sugars seem to present no great difficulties, while just the reverse would be expected, if this were so. I feel, however, that decomposition of mud at the bottom of Dorrs through too prolonged standing or other causes may cause an increase in the percentage of soluble solids through the re-introduction of impurities. This is a condition which rarely occurs even over the weekend, if the mud levels are kept reasonably low.

I might add here that regularity of temperature of the ingoing juice is necessary for the good working of the clarifier, while the constancy of the final

reaction of the tempered juice seems to play an important part so far as the clarity of the final juice is concerned.

The whole question of the colloidal properties of Uba juices seems somewhat involved, especially under chemical treatment, while the lack of information and comparative figures in this country, make it more so. Clarification methods need more thorough investigation, and some method needs introduction to this phase of the manufacture, whereby these impurities could be determined more or less as a routine, thereby permitting comparative results to be drawn with a view to still better clarification methods for the future.

Mr. FOSTER: I think Mr. Latham is to be congratulated on producing this paper, also Mr. Patrick Murray for preparing the report of the Clarification and Filtration Committee which he has done practically by himself. At the preliminary meeting of the Filtration and Clarification Committee we thought this was so much one of engineering that it would be interesting to get the views of engineers on the subject, hence the call for description of the various apparatus used in this department. I notice Mr. Murray has referred to the continuous clarifier used at Mount Edgecombe. I should like to ask Mr. Rault if he would give us a description of it and how it is working.

Mr. RAULT: Although I may not describe it mechanically, still it would be interesting for everybody to know what made us go back, because as you all know carbonatation is essentially a process in which all the juice is filtered, and when one hears that Mount Edgecombe has put a settling tank in one begins to wonder what is the matter. It is a long story to tell, but it was with the idea of cheapening our processes. We are trying little by little to discard the filter presses, which as you know have many disadvantages, principally that they are cumbersome, require a lot of cloth and labour, and are also very dirty, and we are trying to get more modern means of filtration, such as by rotary vacuum filters. We find these rotary filters, although quite good for the filtration of sludge, are rather weak, when a lot of juice has to be filtered, and therefore the juice filtration itself has to be tackled by some other system, and naturally if you want to work by volume filtration there is a corollary to it; there is what is called a thickener, being another filter in which is removed the greatest part of the clear juice and settling the mud to a greater thickness, and that is how we came to use settling. We thought of the Dorr thickener, and we thought of other modern thickeners—the Oliver thickeners—but after having studied our local conditions we ourselves made a very simple settler—which is patented by the way—it is an oblong tank; there is only one moving part at the bottom to extract the

mud. It is an open tank, and the bottom part is conical. The idea is that it is continuous; the juice from the carbonatation tank enters, is settled in a certain length of time, and at the bottom a mud, which contains about 30 per cent. solids, is drawn off, and this smaller quantity of mud is easily tackled then by the volume filters, and we hope next season to do away completely with the filter presses. For long periods at the end of the past season we closed down our filter presses and have been able to work with the Mauss filters, which are very economical in cloth and require very little labour. We are perhaps able to do what defecation mills may not be able to do. In that way a good part of our juices are settled clear. There is a very small amount of solids passing over, but this small amount is filtered again at the second carbonatation.

Mr. DYMOND: I have a suspicion that Mr. Latham has been rather "pulling our legs" over his paper on Dorr Clarifiers. I am wondering if he has taken the case of the Opposition? If he has I must congratulate him on his paper, because he has told us quite a lot of good things about the Dorr Clarifier. If I had been asked to do the same I am afraid I could not have written a line, but I might have written a book on the reverse side of the question! I don't want to enter into rather a contentious subject—the work of the Dorr Clarifiers. I would merely like to say that we used Dorr Clarifiers for a year. We did have definite information of extensive inversion; certainly the filter press worked extraordinarily well, because the colloids were emulsified to such an extent that where our boiling time was very much increased, our recovery was much lower, and generally we only worked the system for a year. Other factories in the country followed us and they discontinued using the Dorr Clarifiers. I believe in other parts of the world this system has been more or less thrown out.

Mr. LATHAM: I note what Mr. Dymond says with regard to the Dorr. I may say that I think that when first we started the Dorr we had more or less the same trouble. We were working with a very acid juice and, as he says, inversion losses were fairly high. But afterwards when we gained more experience with them, we found that through increasing the pH value of the juice, making it pH 7.0 instead of 6.7 or 6.8, these inversion losses were cut down considerably. If we were to take the rise in purity from mixed juice to syrup as any criterion, taking it as a measure of the efficiency of clarification, I have shown in my report that that has increased from roughly 0.5 to 1.5 last year, thus proving that these inversion losses have been decreased considerably by the steps we have taken. To start off with in earlier years decomposition of the mud at the bottom of the Dorr seemed very prevalent, especially with that part of the process which returns the water to the mill. We found that in the application of the water to the mills re-expression was rather great, the water mounted

to a high level and decomposition was liable to take place. On decomposition you may get any amount of impurities re-introduced into the juice. All I can say is that I seem to uphold the Dorr to a certain extent. I can't altogether agree with Mr. Dymond in condemning it even on his grounds. I think that with more experience of the Dorr Clarifier there would be more people going in for it. I have here, with the permission of the Chairman, extracts from "Facts about Sugar." There is an article written by E. M. Copp, A.S.M.E., which appeared in "Facts about Sugar" of April 5th, 1930.

(Mr. Latham then read extracts under the headings of "Filterability," "Clarity" and "Colloids in Cane Juice," from the paper referred to.)

Filterability.

Sugar refiners are paying more and more attention to the filterability of the sugar they buy, as it is this property of the raw sugar which affects refining costs and refinery output more than any other. The raw manufacturer must eventually produce a maximum amount of sugar with a maximum filterability at a minimum cost from a given clarified juice. A number of Porto Rican factories are testing their sugars for filterability with a view to improving the quality, but the lack of a standard method unfortunately precludes the use of such data as are available for comparisons. However, it is reasonable to expect that the filterability of the raw sugar will vary directly with some quality of the syrup or clarified juice, and if such be the case an important factor for measuring the quality of the clarification will doubtless be the filterability of the syrup.

Closely connected with the filterability is the boiling house efficiency number, since this factor is a measure of the sucrose retained throughout the evaporation and crystallization process, taking into consideration the initial purity. The value of this figure is being more and more appreciated among us as the one figure that gives a true picture of the quality of the boiling house work. Personally I prefer to base the boiling house efficiency number on the purity of the clarified juice and to measure the efficiency of the clarification up to this point by other means, such as the difference in purity between crusher and clarified juice.

Clarity.

We are now ready to consider clarity, for I have not discarded this factor as unimportant. Every effort must be put forth to eliminate the suspended impurities (or better, say, insoluble solids) from the clarified juice, and I am trying to differentiate between (a) a so-called cloudy juice, that contains impurities in a semi-soluble form; (b) a dirty juice that contains insoluble solids, such as bagacillo and cachaza, in suspension; and (c) a sparkling juice that has neither

impurities in suspension nor in the semi-soluble form. One therefore seeks a clarified juice absolutely free from insoluble impurities, that will produce a syrup with a maximum filterability and a maximum boiling house efficiency number. In order to produce these qualities one should not be unwilling to put up with a partially cloudy and dark coloured clarified juice, which makes juices under (a) and (c) not unacceptable. At any rate it seems logical that the liming of the juice should be governed by the filterability of the syrup and boiling house efficiency number, as well as the clarity of the clarified juice and one should determine the proper reaction (pH) of the clarified juice correspondingly.

Colloids in Cane Juice.

The amount of colloids that are introduced into the juice depends largely on the efficiency of milling and imbibition. The higher this efficiency, the larger the amount of colloids in the macerated juice and the greater the need of efficient clarification. These colloids are more soluble in an alkaline juice than in an acid one; hence the practice in compound clarification of keeping the secondary juice slightly acid to the hydrogen-ion test—i.e., below pH 7.0. In this way more of the colloids go off in the secondary mud to the presses or to the bagasse. But an alkaline or neutral juice for the boiling house tends towards a higher boiling house efficiency number and brings down a further quantity of impurities from the clarified secondary juice. This induces us to mix the clarified secondary juice with the raw primary juice, and to clarify the two together to an alkaline reaction that fits in with the quality of the cane juice to be treated.

The United States Bureau of Chemistry has been studying the effects of compound clarification on colloid elimination at Central Fajardo and has published the results of some of its very instructive findings in "Industrial and Engineering Chemistry," Vol. 20, No. 3, under the title "Influence of Phosphate and Colloid Contents of Cane Juice on Defecation."

Table 6 shows the trend of the boiling house efficiency numbers at the nine Porto Rican factories referred to before:

Table No. 6.
Boiling House Efficiency Numbers.

(Based on purity of clarified juice.)

	1923-24.	1929.
Factory A	95.08	100.44
Factory B	96.84	101.63
Factory C	98.81	100.96
Factory D	100.20	101.72
Factory E	100.23	101.79
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Average B.H.E.N.	98.23	101.31
Average increase		3.14%

	1923-24.	1929.
Factory F	97.20	99.79
Factory G	99.20	99.13
Factory H	97.46	98.18
Factory I	99.09	101.26
Average B.H.E.N.	98.24	99.59
Average increase		1.37%

Factories A to E employ, as stated before, compound clarification; the others have single clarification. In the last five years compound clarification has increased the boiling house efficiency numbers from an average of 98.23 to 101.31 = 3.14 per cent.; while general improvements alone, as is the case with Factories F to I, have increased the numbers from 98.24 to 99.59, an increase of 1.37 per cent.

This seems to point conclusively that if what Mr. Copp says is right there is quite a lot to be said for compound clarification with Dorr Clarifiers. We can't altogether overlook his remarks for the reason that I think countries overseas are very likely more advanced in this question than we are. Besides they have likely methods of comparison which we have not out here.

Mr. BRIAN PEARCE: At Illovo we have the Suchar process and our biggest trouble is filtration. We have tried half-a-dozen methods, and we find that the single clarification and cold sulphitation give the best filtration. We get more trouble at the filter presses and sugar house. We have taken the heating up to 140° F. sulphuring and liming and heating clarifiers to 200° F. We get a higher recovery that way in the raw house, but the filtration work in the refinery is very bad. For an experiment we got sugars down from Gledhow. Gledhow's sugar was the third boiling, and that sugar compared almost as well as our No. 1 sugars we filtered, taking the whole clarification and bringing it to boiling point. We went to the expense of getting a filtration testing plant. We found it was absolutely useless. We got Farnell to make a test and he found the same. I understand that the Refineries at Home suggest that 10/- should be taken off all South African sugars because of the difficult filtration. Another thing, we have tried to see if an iodine test has any effect on showing the filtration rate in the Refineries. There is no relation at all. We have tested Chakas Kraal sugar and Umzimkulu sugar. Umzimkulu sugar from the look of it appeared very nice, but we could do nothing with it. We took Chakas Kraal sugar, which was very good. It was rather dirty and

there was a lot of sediment in the settling tank, but that sugar gave us no trouble at all. We are making further experiments now.

Mr. CHRISTIANSON: While on the subject of filterability Mr. Latham has shown us that by using double clarification, particularly Dorr Clarifiers overseas, the filterability of the sugar and the syrup is improved. Mr. Dymond, on the other hand, maintains that filterability of mud was also improved by the emulsification of certain colloidal matters and impurities and more complete solution of other colloidal matters. I think that the solution of these impurities would make them more readily go into the molasses rather than crystallise in the sugars. At the same times these colloids going to more complete solution will increase the quantity of molasses and give a lower recovery.

CHAIRMAN: In the report of the Clarification and Filtration Committee mention is made of filter cloths and the desirability of using a standard type. That seems a very good suggestion. Of course it is not a thing you want to adopt in a hurry. You have to examine various types in use and find the most suitable. But not only that, but right away through where anything can be standardised I am sure there will be a saving in costs. Other industries have found it so, and it is one of the things which should be remembered now at a time when all efforts are being made to reduce costs to meet reduced prices. Mr. Pearce mentioned a proposal to penalise Natal sugars in the Home Refineries by a deduction. I have been informed that that proposition has happily been knocked on the head right away, and Sir Leonard Lyle has refused to consider it, and refused to make any deduction from Natal sugars. With regard to Dorr Clarifiers, I would like to mention a variation of that which I saw in use in America. Unfortunately I cannot remember the name of it.* It is made by Murphy's, of New Orleans, and is very similar in general to a Dorr Clarifier, but has no moving parts. It does not have that central settling apparatus, but in place of that it has very steep tiers so that the muds fall by gravitation over the tiers down the central shaft. There were two types, but from an examination of the drawings of the two I could never find the difference. I saw the apparatus in use at one of the Refineries there, and they were very pleased with it indeed. In these scrapers there are plenty of places for fermentation to take place, such as round the bolts, and various projections, whereas with these steep tiers the interior was kept very much cleaner.

*Rukstahl.