DALTON—SOUTH AFRICA'S FIRST MILLING DIFFUSION SUGAR FACTORY

By W. R. BUCK

Introduction

Objection may be taken in some quarters to this title and therefore the author hastens to qualify it by pointing out that such title refers strictly to the first new sugar factory in South Africa, basically designed to operate the milling-diffusion process. In other words, it is not an existing factory to which a diffuser has been added to handle part of the throughput, or for experimental purposes.

General

The history of cane diffusion in Natal has been most ably covered in the current (December 1964) issue of *The Condenser*, the annual house magazine of The Tongaat Sugar Company. Therefore, it will be assumed that members of the Association have already read this extremely interesting account.

Mention is made of the Raabe continuous diffuser supplied by Duncan Stewart for Tinley Manor factory in 1927. The writer was able to glean a few details of this installation when visiting Duncan Stewart's works many years ago.

The diffuser was of the cylindrical variety, divided into 22 equal chambers, the whole being inclined at 4° to the horizontal. The prepared cane entered at the lower end, meeting the draft water introduced at the other, higher end. Each compartment wall consisted of slotted brass screens which held the cane sufficiently long enough for the juice to penetrate through. It was then wiped off by the wiping arms carried on a central shaft and deposited into the succeeding compartment and so on. There were no fewer than 604 "lifting arms", arranged spirally, "comb-arms" and "wiper arms" in the diffuser, which was directly adapted from the ten Raabe units built and supplied to five beet sugar factories in Britain. One was still operating there quite recently. For that purpose they were quite satisfactory, but working with cane the apparatus did not receive a fair chance due to poor cane preparation and local prejudice and also other difficulties and the project was abandoned. The diffuser, of no mean size, 11 ft. diameter by 84 ft. long, ended its days as scrap.

This was unfortunate and little more or effective efforts were made until that South African champion of cane diffusion, Mr. R. Saville commenced his experiments many years ago, culminating in the forthcoming installation of an immersion type diffuser at his Entumeni factory. It will be extremely interesting to compare the performance of both the Dalton and the Entumeni installations once they are each working normally.

Location of Factory

The new factory is being erected at Dalton in the midlands of Natal, some 85 miles from Durban and 35 miles from Pietermaritzburg and will be operated by a co-operative concern, of which most of the members are either cane or wattle farmers, or both. Thus, it will become South Africa's second co-operative sugar factory and like Umfolozi, does not undertake the growing of cane for its own account.

Siting of Plant

The plant is unique in that it is believed to be the first sugar factory-cum-wattle extract plant. It adjoins the company's wattle extract factory and the terms of reference for its establishment stipulated that the maximum use be made of the existing wattle extract plant and machinery, where this was suitable.

In practice, it was decided very early in the project that it was not a proposition to utilise the autoclaves — corresponding to batch type diffuser cells — of the wattle plant, nor its evaporators and "finishers" or vacuum pans. Apart from handling difficulties, their capacity was small, so that further extraction plant, mills or milling-diffusion would have been necessary anyhow, in order to operate the factory at an economical crushing rate.

However, the factory water tube boilers and power house have been utilised, with suitable additions and although certain other adjuncts will serve both manufacturing purposes, the milling-diffusion house and the boiling house are completely new buildings.

Despite this, the part dual nature of the factory has resulted in the overall estimate of capital cost for the whole project not exceeding R2¼ million. No second-hand plant is installed with the exception of the two dewatering mills following the diffuser, described later.

Simultaneous operation of both plants is not envisaged at present, since most of the wattle extract production season lies conveniently outside of the normal cane crushing season.

Description of Factory and Process

Provision has been made in the yard, sidings and cane gantry layouts for receipt of cane by road and rail. All buildings and equipment have been sized or designed, so that the throughput can be readily doubled from the initial crushing rate of 60 tch to 120 tch. For example, the cane gantry is 205 ft. long by 80 ft. span and is equipped with a 10 ton cane grab crane, which outfit is easily capable of handling the cane from both road and rail vehicles in order to unload and store sufficient cane to ensure an eventual throughput of about 3,000 tons per 24 hours, with the addition of a Hilo unloading carrier.

Cane will be unloaded by grab on to a cross carrier or feeder of 20 ft. width by 40 ft. length, discharging directly into the 72 in. main cane carrier, which is 128 ft. long (centres).

The cane carrier follows modern practice in that no part of it is accommodated in any insanitary under-

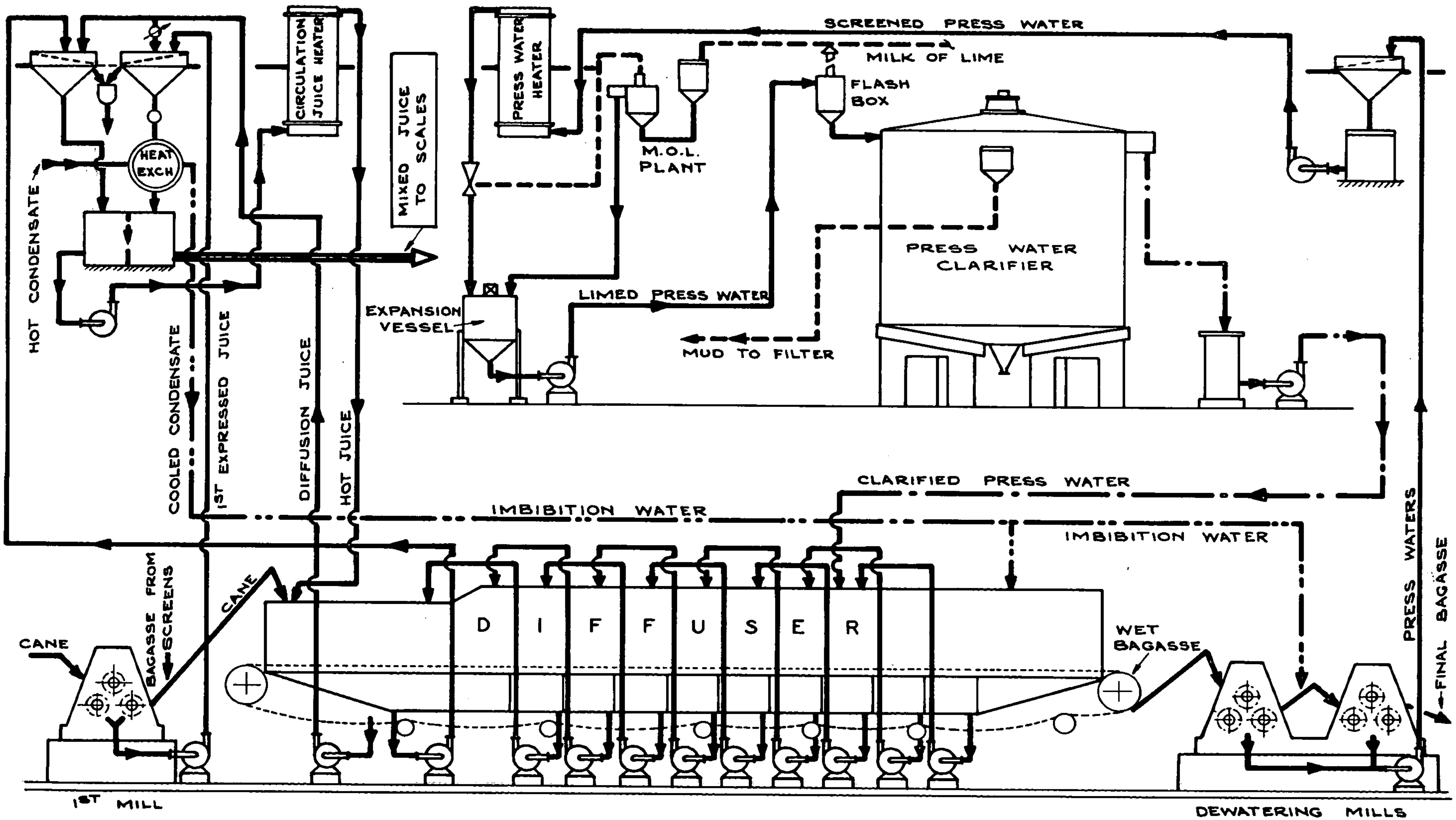

FIG. 1. FLOW DIAGRAM — MILLING DIFFUSION PLANT.

ground pit. These pits invariably become flooded at some stage apart from other objections to them. Where possible pits have been avoided throughout the factory as being sources of inversion due to flooding and fermentation of the trash which always finds its way into them.

Similarly, every effort has been made where possible, to avoid the underground installation of pipes, cables and other services.

There are two sets of cane knives, each close-pitched, the first being driven by a 275 h.p. motor.

The second knives are driven by a 350 h.p. motor. The knives are included in the diffuser supply so that cane preparation conforms to the makers' strict requirements.

The carrier feeds directly to the first or preparation mill, turbo-driven of 72 in. by 36 in. size, no shredder being employed.

The prototype of the diffuser installed, operated successfully on high tonnages in Egypt for three complete seasons, producing excellent results and with the minimum of down time due to breakdowns or processing difficulties. There, over 60% of the juice was expressed by this first mill but, the nature of Natal cane varying so much from that of Egypt, it may well be that this figure will not be much over 50%. Accordingly and as a prudent measure, it was decided to extend the diffuser by adding two compartments so that there are now nine.

Diffuser

The basic construction and operation of this unit are clearly illustrated in the diagram, Fig. 1.

The overall length of the diffuser is 93 ft. 6 in. It is 7 ft. 3 in. in width and 19 ft. 9 in. high.

The length of the complete milling diffusion plant from cane carrier tail shaft to centre line of bagasse conveyor below the second dewatering mill is 305 ft. 6 in., which necessitated a mill house of 275 ft. in length. This was unavoidable because, due to the limitations of the site, the mill house width could not exceed 60 ft. so that the diffuser could not be located parallel to the mills.

The initial quantity of juice removed by the first mill is not treated in the diffuser, but is pumped to the juice scales in the normal manner, via a heat exchanger. It is the remainder of the juice content of the cane which is subject to extraction by milling-diffusion or "coffee-pot extraction" to quote the term most aptly applied in the article referred to, "Diffusion", in *The Condenser*, December, 1964.

Reference to Fig. 1 makes the action within the diffuser quite clear. The diffusion time is about 24 minutes, but the retention time of the cane within the diffuser is about 40 minutes on average. The draft water — corresponding to the imbibition water of the normal milling tandem — amounts to 250% on fibre on an assumed basis of 14% fibre content on cane (or 35% on cane).

Critics of cane diffusion often aver that the amount of draft water employed is excessive, involving heavy steam consumption at the evaporators. It is difficult to appreciate this common criticism because, in the home of the diffusion process, the beet sugar industry, the average draft water can hardly be described as excessive, although it was generally higher than our corresponding imbibition rates.

To refute this constantly repeated criticism, it is pertinent to point out that in Natal, as in many other sugar producing countries, i.e. Australia, the imbibition water % fibre in cane, is often considerably higher than the amount of draft water % fibre, applied in the milling-diffusion process under review. For example, the Natal average imbibition rate, % fibre in cane was 258, for the season 1963/4, one factory averaging 372%. To date, week ended 23rd January, 1965, the average is 255%, the highest figure being 371% without, it may be said, undue use of additional fuel because of the increased amount of water to be evaporated from the juice. Therefore, the alleged excessive use of water by the cane diffusion process can be dismissed as having no foundation in fact, at least, in those processes in successful use at the present time.

All the calculations, including the heat balances produced, used a presumed average fibre content of cane of 14%. Although it is known that much of the cane grown in this area contains somewhat more fibre, it was considered prudent to use this figure, particularly as no regular analyses of fibre content of cane from the Dalton area are carried out, or need be by the factories at present handling this cane.

Hence, employing this figure, the amount of mixed juice to the scale will be 132,000 lb./hr. at 60 tch, equivalent to only 110% on cane weight.

The design and construction of the diffuser are relatively simple and are not based upon that of some contemporary sugar beet diffuser. It is clearly brought out in Fig. 1. Mild steel is used entirely for the body of the diffuser and for the screens, there being no necessity to employ stainless steel or brass, unlike some contemporary designs.

The screens are perforated with conical holes of a mean diameter of 9 mm. These screens do not become clogged in use and chokeless pumps are used throughout.

Various guarantees are embodied in the diffuser supply contract, involving penalties for their nonfulfilment. Subject to certain contingencies, the extraction will be such that not more than 1.8% sucrose will remain in the residual bagasse, which may vary from 50% to 53% moisture content, depending upon fibre content and milling-diffusion performance.

There is every reasonable expectation of achieving the 1.8% (or less) sucrose in bagasse and, under the conditions of sale of sugar and purchase of cane in this country, any increase in extraction which can be obtained over and above the present average % sucrose in bagasse for Natal, is of direct financial advantage to the miller.

Particularly is this advantage attractive if it can be attained by avoiding the tremendous expense entailed nowadays in the purchase of a milling tandem com prising, at least, a shredder and six mills. True, one factory in Natal does manage to obtain a very creditable extraction of 95.2%, and only 1.9% sucrose in bagasse. However, this target is only achieved by an expensive installation, all requiring some 4,750 total h.p. in the form of steam turbines for the drives aided by the application of 371% on fibre imbibition water.

There are instances of other factories achieving over 94% extraction, some of which also burn additional fuel, which of course could be purely coincidental.

Many other factories find that they are burning additional fuel in order to justify high imbibition water and extraction rates and obviously, in many of these cases a balance must be struck, a point arrived at where it is no longer justifiable to obtain a few decimal points of extra extraction at the cost of an additional fuel bill and no surplus bagasse on hand for emergencies.

This fact was realised long ago in Cuba and the West Indies generally, where there was no cheap coal available and the price of fuel oil (other than in Trinidad) soared to R18 per ton shortly after the last war, so that although scores of factories employed a shredder and seven mills, none attempted to improve extraction by various means to the extent that they were compelled to burn additional fuel to justify this achievement. Consequently, their extraction rarely exceeds 94% with average sucrose at 6.29% bagasse (Cuba excepted), see B.W.I.S. Association, 1963/64 season.

The diffuser manufacturers carried out experiments with a tower type diffuser at one of the Caroni Ltd. (Tate & Lyle Group) factories in Trinidad in recent years, in order to improve upon this position, but the results were not encouraging. Caroni, having spent a good deal of money on abortive batch-type diffusion systems in the past were not deterred, but there is no record of any recent development there. However, the method of milling-diffusion to be employed at Dalton has already been well proved elsewhere and is being installed with every confidence in its performance.

The unit is arranged to commence operations by being fed with cane at 60 tch. Subsequently, it can be readily increased to the optimum rate of 120 tch and it is of interest as to how this is achieved. Within the diffuser proper, the conveyor chains are speeded up, the thick blanket of bagasse naturally increases in depth and quantity and the amount of juice circulated by the pumps (see Fig. 1) is correspondingly increased.

This is attained by employing a diffuser, eventually capable of the desired 120 tch. It is not possible to design this type of diffuser for 60 tch fixed capacity and subsequently to double this figure to 120 tch, without installing a second such diffuser. Hence an efficient compromise was evolved whereby, although the diffuser has the final size and capacity for 120 tch, it arrives on the site equipped to handle 75 + tch and commencing — with no disadvantage — at 60 tch.

Steady feed is of the utmost importance so that the whole cane feeding and milling-diffusion stations are controlled from one platform using remote controls. Carrier speed and the speed of the diffuser are controlled by fluid drive torque converter.

The chokeless juice circulating pumps are fitted with impellers sized for their initial duty and these can be replaced by larger ones as the need arises, in two stages, if necessary.

Regarding the juice and recirculation heaters, the suppliers' proposal was that the optimum size heaters be installed with certain of the tubes removed or blanked off, for the earlier stages. This suggestion was firmly resisted and the heaters will be replaced or duplicated as necessary.

The cane is rather coarsely prepared, or would appear to be so to most of us, accustomed as we are to finely shredded cane. However, because of the close pitched cane knives, very few long pieces of cane appear to pass the first mill.

After the initial juice extraction at the first mill, the cane is carried along horizontally in the form of a continuous thick mat, averaging 5 ft. deep at 60 tch, over the perforated steel screens previously mentioned.

Each of the nine compartments is so screened, with juice collecting hoppers below. The juice, containing a considerable proportion of fine particles of cane in suspension, is removed by means of chokeless pumps and passed through the recirculation juice heater.

It is recirculated by being discharged on to the top of the thick mat of bagasse above the chamber prior to that from which it was collected. The recirculated juice percolates down through the cane mat again, removing more sucrose on the way, largely by the process of lixiviation, but partly and only where the cells of the cane are not ruptured, by true diffusion, that is by osmosis and dialysis. Although this last process only yields a very small proportion of the available sucrose, it is contended that, nevertheless, this proportion is higher than when the cane is subjected to shredding in addition to the usual preparation.

The thick mat (it would be considerably thicker at 120 tch) is carried slowly through the length of the diffuser by the chain and slat conveyor and it will be readily seen that the process is both simple and continuous.

No elaborate thrower or bagasse extraction device is necessary where the bagasse leaves the diffuser, since the lower run of the conveyor chain passes beneath the diffuser shell where, in its slow passage, it is visible and accessible for inspection and repair or adjustment. One set of chains operated for three seasons in Egypt with only very minor replacements and no down time whatsoever due to chain failure or repair.

A most important part of the process, properly realised by the makers, is the function of the two dewatering mills following the diffuser. A drag conveyor hauls the wet bagasse up to a vertical, deep feed chute supplying the first dewatering mill. The second such mill is similarly fed.

Various terms are applied to the waters so expressed. "Les eaux de Moulinage" is perhaps the most picturesque, as used by M. Naudet in Egypt, where the dewatering mills followed their highly successful batch-process of milling diffusion (now superseded). "Milt waters", "press-water", "wash-water" and "sweel water" are among other terms employed. Press-water is perhaps the most suitable and is the one which we employ.

It may be thought that undue importance is attached to this press water, since it is only of an average 2° Brix. Although the next point is debatable, it is the writer's opinion that the proper use of this press-water ensures that the total amount of imbibition water employed is kept within reasonable limits and at no time approaches that used in some factories already referred to which have conventional milling trains.

This water (representing 65% on cane) is pumped through the press water heater, thence to an automatic liming plant and then to a clarifier (approximately 20 ft. diameter), of conventional design, at 95 to 97° C. For convenience this clarifier has been located alongside the usual clarifier and not in the milling diffusion house. Its effluent mud will not exceed 2% on cane or 1.2 t/hr. The clarified press-water is returned to the diffuser in front of the point at which part of the imbibition water is added.

The diffusion juice is extracted at the head of the diffuser, passed through the juice heater and then directly on to the prepared cane as it enters. This is essentially a scalding treatment and maintains the temperature of the cane in process at a minimum of 70° C. (158°F.). This can hardly render the vicinity of the diffuser a "comfort zone" and it may be necessary to insulate it.

It was mentioned earlier that only part of the imbibition water enters the diffuser. The remainder is applied between the two dewatering mills. The designers are insistent that its temperature does not exceed 30° C. (86° F.), so that it cools the bagasse to some extent, to prevent slip at the dewatering mills.

The available condensate, being considerably hotter than this permissible figure is accordingly pumped through a heat exchanger in the quantity required, the heat exchanger being supplied with raw juice from the first mill (only). This will result in a heat saving on juice heating and will produce imbibition water of the desired temperature.

At this stage, it is not proposed to go into long technicalities of the design and operation of the diffusers, but it is hoped that its general features and operating principle are now fairly clear.

Instead, it is hoped to produce a paper, comparing the results and collected data of the operation of both the Dalton and Entumeni diffusers after they have been in use for one season.

Steam Consumption. No steam is injected into the diffuser and no steam jackets are employed. The total steam consumption of the diffuser (at 60 tch) is 14,700 lb./hr. of vapour at 4 psig which is supplied from the vapour cell first effect, to the two heaters involved.

Final Bagasse. The bagasse is not expected to exceed 52% moisture content and 1.8% sucrose content when its L.C.V. will be 3,140 btu/lb. The two dewatering mills will require replacement when the throughput exceeds about 65 tch so that, until this figure is imminent, two secondhand, turbine-driven mills of modern design and 30 in. by 60 in. size have been purchased, the foundations for which are arranged so that two 36 in. by 72 in. mills can be subsequently readily installed.

Steam raising plant. It was only necessary to add one w/t boiler to the existing range. The new unit is 60,000 lb./hr. mcr, the steam conditions being 250 psig at 538° F. A de-aerator and feed water treatment plant are included, all in an extension of the existing boiler house. The position of this boiler house largely determined the siting of the factory buildings, already referred to.

Power Plant. A 1,500 kW back pressure turbo-alternator, taking steam at 235 psig and 535° F. has been added, in the existing power station building. Generating voltage is 380 at 3 phase 50 cycles, to suit the existing power supply, no long runs of cable being involved and no transformers therefore employed.

Arrangements have been made to synchronise the present turbo-alternator in case the throughput of cane increases before a second set can be installed, but normally the load will not exceed 1,100 kW at 60 tch crushing rate so that the existing set will not be required. The back pressure is 10 psig, that being the limit of the turbines driving the dewatering mills. It can be readily increased to 15 psig if desired, when the larger mills and turbines are installed.

Factory Details. The process house is located parallel to and alongside the mill house, between it and the existing wattle extract factory buildings. It is 84 ft. wide by 165 ft. long. 60 ft. of this length comprises the clarification and evaporation house which is 70 ft. high to the eaves, the pan house section accounting for the other 105 ft. which is 90 ft. high to the eaves. There is one common ground floor level to all sugar factory buildings.

The buildings are of the normal steel-framed type, sized and designed so that the whole of the process plant can be readily duplicated or expanded in capacity. Ventilation is assisted by extractor fans in the roofs.

The cladding, both for roofs and walls, if of fluted sheeting. Dalton is in a hail area and it was decided to dispense with ordinary windows, fitting instead continuous strip translucent sheeting, thus achieving considerably more daylight than the legal minimum laid down. Below this a continuous range of vertically hinged, louvre type glazing is fitted.

Process. The diffuser juice passes over vibratory screens before joining the first mill juice from its heat exchanger, both then being pumped to the usual automatic juice scale. Automatic liming is employed, using temper lime supplied in pockets, in preference to preparing it at the factory. Although technically "cold" liming is intended, in practice, the juice leaving the scales will be at 135°-140° F., i.e. similar to that in some factories, which lime after the primary heating.

The primary heater uses vapour at 5 psig from the first effect exhaust steam being used for the secondary heater, each being of 1,000 sq. ft. h.s. The primary heater raises the juice temperature from about 145° F. to 205° F. The secondary to 215° F., while an evaporator pre-heater was found necessary using exhaust steam and heating the juice to 230° F.

Evaporator. This has been redesigned, following the decision to remelt certain sugars and to produce export quality final product. Hence the first vessel, which is also a vapour cell is now of 9,000 sq. ft. h.s. and takes the form of a semi-Kestner vessel. 76,000 lb./hr. exhaust steam will be required and 66,000 lb./hr. goes to this vessel, so that 49,500 lb./hr. vapour can be bled off to supply pans, diffuser heaters, primary heater, steaming out, etc.

The other three vessels of the evaporator effect are each of 3,000 sq. ft. h.s. giving a total of 18,000 sq. ft. h.s. an evaporation ratio of 0.764 or 76.4%, 5.68 lb./sq. ft. h.s. or 108,000 lb. water per hour from 141,200 lb. juice/hr. This will result in a syrup of 63.7 brix, which figure, for various reasons is considered satisfactory, although 70.0 would be possible. (The Natal average to date is 58.6 and for last season 58.06, the highest being 62.9).

Vacuum Filter. An 8 ft. diameter by 16 ft. rotary vacuum filter is installed with stainless steel screens, etc. Its capacity is sufficient to include the muds from the diffuser press-water clarifier. The filter occupies a 12 ft. high staging in the evaporator and clarifier house, sited for ease of mud disposal and subsequent duplication.

Boiling House. The vacuum pans are all at the 60 ft. level. Originally, it was hoped to market all sugar produced as "golden brown" (or equivalent) and two alternative heat balances with 3-boiling systems were produced. Each involved only 3 pans of 900 cu. ft. capacity. (Subsequently all the factory's production was switched to export quality sugar and a new heat balance and boiling system became necessary with increased use of vapour bleeding).

The "C" sugar and part of the "B" sugar are to be remelted, the remainder of the "B" sugar forming seed for the A pans of which there are now two. Hence four pans were required and they are all of 900 cu. ft. capacity, somewhat greater than was called for, but unavoidable in that the first three were already under construction. The pan ratio is 1.75 in order that all pans can be heated with vapour.

The pans are 12 ft. 6 in. in diameter by 23 ft. high and welded construction. Hydraulically operated discharge valves and electrically operated, rotatory massecuite discharge gutters, with selective push-button control for the respective crystallisers, are installed.

The crystallisers, numbering 10 in the first instance, are all of the familiar "U" type, of 900 cu. ft. capacity. Five are air-cooled, five are water-cooled, all located at the 30 ft. level.

The centrifugal station, immediately below, consists of five 42 in. by 30 in. semi-automatic machines for the A and B massecuites, selective as to speed of 1,000 or 1,500 r.p.m. and operating at 25 cycles per hour. All of the factory's commercial sugar output emanates from the "A" machines only.

For the "C" machines continuous centrifugals will be employed, arranged for double-curing, with the foreworkers located over the afterworkers, if the size of the machine permits.

Massecuite quantities are expected to average:

A	319.5 cu. ft./hr.	Total 515 cu. ft./hr.
B	123.8 cu. ft./hr.	or 8.6 cu. ft./tch
C	71.8 cu. ft./hr.	and 12,363 cu. ft./24 hrs.

Raw sugar will be shipped in bulk by rail to the Durban terminal for export.

Economics of the Milling-Diffusion Process

If due to a series of adverse circumstances the extraction and sucrose % bagasse of an installation of this type were not superior to those of a normal milling train, those results would still be achieved at considerably less capital cost.

For example the diffusion unit described, including imported cane preparation, mills, clarifier, heaters and all auxiliaries, costs about R646,700 delivered Durban. This total includes for 3 new 36 by 72 in. mills also imported. Obviously, the total could be somewhat less if most of these items were of local manufacture.

A 36 in. by 72 in. milling tandem, comprising 6 mills, shredder, all turbine driven, gearing and all accessories is quoted at R760,000 Durban and most of it is locally manufactured. The saving here is R113,300, using the most conservative figures.

However, with the saving thus achieved and the extra profits accruing from successful milling-diffusion, it has been calculated that an efficient factory would be able to write off the cost of the diffuser in about three years.

In addition, installation costs are considerably less as are the differences in maintenance costs and the value of the stock of spare parts required to be kept is less than for the mills and shredder, which the diffuser replaces.

Steam Consumption. The three mills will require an average of 22,000 lb./hr. live steam and the diffuser, 14,700 lb./hr. of vapour, total, including radiation losses, of 36,700 lb./hr. The maker's information regarding the same size milling train of 6 mills and a shredder, crushing the same tons fibre/hr. is 52,000 lb./hr. live steam.

There is also a sizeable saving in weight. The milling train referred to weighs 732 tons complete, whereas the corresponding milling-diffusion installation weighs 542 tons complete.

Power required. The diffuser requires only a fraction of the power consumed to drive two or three mills.

Conclusions

It cannot yet be said that milling-diffusion has reached its peak of perfection and undoubtedly there will be startling innovations and improvements to the types of plant employed. It also has to be proved conclusively that the percolation type of diffuser is superior to the immersion type (or vice versa).

On the other hand it cannot be denied that there have been no major or significant changes and advances in mill design and construction over the last twenty years or so. Moreover, the most superior extraction figures are those achieved by milling tandems, consisting of a shredder and six mills, or quite often seven mills. They are expensive to purchase, instal and maintain and are heavy power consumers. Yet, in a seven mill tandem, four of the intermediate mills only achieve dilution — a poor return on the capital invested surely?

An obvious conclusion is that diffusers can efficiently replace two, three or even four mills in some cases, in a cheaper, more efficient and profitable manner than the conventional milling tandem.

Tremendous interest has been aroused by the fact that two full-sized milling-diffusion plants are being installed in our country, one of the companies concerned having sufficient confidence to design and build their factories around a diffusion plant — as it were.

The experience obtained by the diffuser suppliers over three seasons has a great deal to do with this important decision. It was obviously no coincidence which led them to investigate and to obtain the licence for the process perfected there.

Batch type diffusion had been successfully practised there, in large factories for many years — a refinement was employed following the extraction of the juice, whereby it was limed, recirculated under the Naudet system and clarified within the diffuser cells.

The limed juice, pumped upward through the tall column of bagasse, emerged perfectly bright and clear and required no further treatment other than a fine screening before going direct to the evaporators.

For further information on this interesting process, there is a full account in the *International Sugar Journal*, 1950, pages 369-370 and 397-399.

Although very rewarding, the process was messy and entailed far too much labour, apart from the complexity of valves and piping, so that considerable research was undertaken in the attempt to perfect a simple but efficient continuous process.

This has culminated in the type of diffuser selected for Dalton.

The road is obviously open not only for comparison of the results of both installations here, but for research and improvement.

The ultimate goal should be, I suggest, a continuous diffuser wherein the liming and clarification of the juice can be carried out, as it was in the batch type diffuser employed in Egypt.

It is known that others are engaged upon this type of research and, in this country, we surely have the brains and experience to make a substantial contribution to this research, which could easily result in a diffusion process capable of revolutionising the entire cane sugar industry.

Acknowledgments

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References

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Dr. Douwes Dekker (in the chair): South Africa is lucky in that in a year's time we shall have two factories with milling diffusion plants, each of a different type.

Diffusion is a process attracting much attention all over the world.

Mr. G. H. Walsh: In his paper Mr. Buck mentioned that the Dalton plant was unique in that it was believed to be the first sugar factory-cum-wattle extract plant. In fact, this is not the case, as for some years the Rhodesia Wattle Co. Ltd., in their Umtali factory, have been producing sugar by slicing the cane in a conventional wattle bark chopper, then using batch diffusion in a group of six autoclaves and evaporating the juice and boiling the syrup in their normal wattle extract evaporator and finishers. Admittedly this is only a very small plant but it is a sugar factory-cum-wattle extract plant and is using its basic equipment for both duties. During 1965 it will produce about 1,000 tons of sugar in a very short season.

Mr. Buck mentioned that an immersion type diffuser was about to be installed at Entumeni and it occurs to me that some comparison between these two plants may be of interest.

As regards the cane preparation, Mr. Buck mentioned that at Dalton the cane would be rather coarsely prepared. It has been suggested that as this plant employs a chain and slat conveyor to drag the thick mat of cane across a perforated plate, there is danger of the screens blinding whereas in the Entumeni installation the conveyor is in the form of a moving screen so that finer preparation can be tolerated as the fine particles do not tend to be forced into the perforations and, in any event, the screens are washed with high pressure jets from the underside on each revolution.

At Dalton the cane will be fed directly from the first mill by a scraper conveyor into the diffuser which is in line with the three mills, resulting in an enormously long mill house. At Entumeni the diffuser is being accommodated parallel to the mills in a mill house 150 feet long by only 60 feet wide, yet the dimensions of the Entumeni diffuser are in fact greater than those given by Mr. Buck for the Dalton plant.

It occurs to me that the reason why the Entumeni plant can be accommodated in the minimum of space is that the cane is "flumed" from the first mill into the diffuser using recirculated heated juice to pipe the cane from a hopper, into which it is delivered by a conveyor from the mill. This means that the diffuser can be located in any position convenient to the mills, even outside the mill house. The Dalton plant, being fed directly from a wide conveyor, would take up much more space as cross conveyors and elevators would be required if it is to be located parallel to the mills. This is an important point in considering relative costs and particularly so in the case where the diffusion system is being applied to an existing milling plant.

It is interesting to note that the juice and cane retention times are much the same for the two plants although the designers of the Entumeni plant have guaranteed, also subject to penalties, a much higher extraction equal to a residual sucrose in the bagasse of 1.25 to 1.5 per cent with imbibition water corresponding to only 100 per cent mixed juice on cane.

In the Dalton plant I see that imbibition water is being applied before the last mill and also into the end of the diffuser which is most interesting. Can Mr. Buck tell us what proportion of the total imbibition is applied before the last mill?

One last point I would like to mention is that the milling/diffusion system or the pure diffusion systems are particularly suited to factories which have a large outside electrical load for irrigation and/or drainage. Having a considerably lower power consumption and with less mixed juice on cane, the factory requires much less live steam and a good deal less exhaust so that considerable excess generating capacity is available from the bagasse by careful selection of back pressure and condensing power plant.

Mr. Buck: I was quite aware of the wattle-cum-sugar factory in Rhodesia, I have in fact visited it, but this paper refers to South Africa only, as its title implies.

Regarding cane preparation, the manufacturers have tried many different methods, even to chopping up the cane like hay. They insist that a coarse form of preparation is to be preferred. The experience of three seasons in Egypt with this type of diffuser showed that no screen blinding difficulties were encountered.

If the type of diffuser to be used by Entumeni had been purchased for Dalton it would have been possible to install it alongside the milling train. But only 62 feet width was available and also it would have meant a complicated arrangement of carriers so that it was decided to place it in line with the mills.

The operation of the Dalton and Entumeni diffusers is fairly similar, but you say that the makers of the Entumeni unit guarantee a lower sucrose figure in final bagasse for somewhat less imbibition. The results are awaited with interest.

A cautious but firm guarantee has been given for the Dalton plant, including a penalty clause which I hope will never have to be invoked.

The reason for applying imbibition water on the carrier between the dewatering mills is the extreme heat of the bagasse at that point and it is applied for cooling purposes and to prevent slip at the mills. It is possible that water will also be applied to two points in the diffuser, to two compartments, but this has not yet been finally decided.

Dr. Douwes Dekker: Dr. Tantawi in Egypt is adamant that cane preparation should not be too fine and he does not favour a shredder.

But in Hawaii, where a percolation diffuser of circular type is being installed there is special equipment for cane preparation and it is so fine that the pith is nearly completely separated from the fibre.

The one in Hawaii takes less space than either the Dalton or Entumeni type.

We do not know to what extent inversion will take place. From evidence available, where lime is used for clarification of the press water and a pH well over 6 is maintained in the diffuser, inversion apparently is negligible.

A diffuser in Tanganyika does not use lime and it is claimed that there is no inversion, but the pH is so much lower that, particularly with acid juices, one would expect inversion to take place.

The drop in purity between the first expressed juice of the first mill and the last expressed juice is probably a little less than in a conventional milling tandem. This also indicates that inversion is possibly smaller than in the normal mill.

Mr. Saunders: What will be done with excess bagasse?

Mr. Buck: The factory has been designed so that at least half a ton an hour of bagasse will be surplus and will be used during breakdowns and at week-ends. If a huge surplus did accumulate, it would be baled and used during the off-crop in the processing of wattle.

Mr. Covas: Would not the guarantee figure of 1.8 per cent sucrose have been better given in respect of mill extraction, as 1.8 per cent sucrose in bagasse is misleading. With cane at 10 per cent sucrose it might be acceptable, but at 17 per cent a figure of 2.2 per cent would also be acceptable.

Mr. Buck: I agree, but I am not at liberty to give further details about the guarantee.

Mr. Dent: The diffusion operation appears to incorporate the starch removal process, so that good sugar should be produced. The temperature is controlled at a minimum of 158° F.

Dr. Douwes Dekker: We have considered the point but we will have to wait for an answer until the machine is operating. For starch destruction by enzymes the granules must be dissolved, so that temperatures should be high enough to accomplish this.

If the temperatures are too high the enzyme is made inactive.

The granules might even be retained by the bagasse in the filtration.