

THE NEW DARNALL MILLING PLANT

By J. B. GRANT

Historical

In 1950 the Darnall milling plant comprised two tandems of two roller crushers and four mills 32 ins. diameter by 60 ins. long, and the throughput of these totalled 120 tons per hour. However, the increase in cane production necessitated an increase in milling capacity and it was decided to instal one tandem to replace the existing units and to be capable of handling 160 tons per hour. This was subsequently increased to 180 tons.

It had been originally intended to instal two large mills behind the existing tandems as a nucleus of the new set-up and an order was placed for these two units. However, in order to improve the mill yard facilities to cope with the increased tonnage of cane, it was finally decided to instal the new tandem on a completely new site. At the same time it was decided to order three more mills and a Searby shredder, and provision was made for the installation of an additional mill at a later date. Owing to the inability of the machinery manufacturers to supply the complete plant, only two mills were installed for the start of the 1952-53 crop and the cane was fed through them and then passed on to the two existing tandems. These two mills had 1 inch grooving throughout and were driven by two 400 h.p. high-speed engines which we had on hand. Three months later the shredder was installed and put into service. The shredder preceded the mills and the cane carrier fed directly into it. This was an innovation in milling in this country, and as there was a slight doubt that it might not be satisfactory, the shredder foundation was designed so that it could be replaced by a mill at a later stage. By the twenty-first week of the crushing season two further mills were ready and put into service, and the two old tandems were closed down. Four weeks later the fifth mill was complete and the new tandem was running as a complete unit. Finally for the start of the present season, a three-roller crusher was installed. The complete plant now comprises a three-roller crusher 44½ ins. by 84 ins., a Searby shredder and five mills 42½ ins by 84 ins.

Cane Offloading and Cane Carriers

Cane is supplied in 3-ton capacity basket trucks over our tramway system and in S.A. Railways trucks, approximately 50 per cent. of the total in each case. Cane is offloaded from the S.A. Railways trucks by two electrically-driven 7½-ton capacity cranes using "American Hoist and Derrick" type 8-tyne grabs. These were fitted with oil-cushioning cylinders so that they could be tripped in the air and these cylinders were attached to the framework

of the grab head and the plunger rods to the grab main shaft. Although knuckle joints were provided where the rods were attached to the shaft to allow for any misalignment during operation, the rods were continually being bent at the bottom. However, turning the cylinder upside down, i.e. attaching the cylinder to the shaft and the plunger rod to the head, and of course correcting the valve mechanism, obviated this fault and they now operate with a minimum of trouble.

During the first year of operation an out-of-balance tipper was used for tipping the basket trucks directly on to the auxilliary carrier which is in line with the main cane carrier. With straight cane a means of dividing the load into two sections whilst being tipped, was devised and was quite satisfactory.

However, with twisted cane, which interlocked during loading and transporting, no simple method was found whereby the loads could be halved and so ensure a satisfactory feed. Later a hydraulically-operated tipper was installed which tips two trucks at a time on to a subsidiary carrier which feeds at a right angle on to the auxilliary carrier, and this arrangement has been entirely satisfactory. The cane from the S.A. Railways trucks is also offloaded on to a subsidiary carrier which feeds at a right angle on to the auxilliary carrier.

The installation of the three-roller crusher necessitated the steepening of the main cane carrier and some doubt was expressed that the steep angle might cause slippage. The angle from the horizontal is 23°, but with the excellent preparation at the knives and with a blanket of prepared cane not exceeding 18 ins. when crushing at the rate of 180 short tons per hour, we have had no trouble whatsoever.

Cane Knives

As the intention in the first instance was to feed directly into the shredder it was necessary that any arrangement of knives should satisfactorily prepare the cane for this purpose. Only one set of high-speed knives was installed. This comprised a set of 48 knives, 5 ft. 6 ins. diameter over the tips, and driven by a 450 h.p. motor running at 550 r.p.m. The number of knives were specified to give the maximum coverage across the carrier and to avoid gaps between the blades. To keep the h.p. consumption of the motor at a minimum, to keep the tips of the knives as close as possible to the carrier and to ensure the best possible even feed to the shredder, the knives were set to cut on the end of the auxilliary carrier and the knives shaft was set about 45° in front of and above the carrier shaft. The tips of the knives

were set 1 inch from the carrier slats. Two difficulties arose from this arrangement. If separate bundles of cane on the auxiliary carrier were not tightly interlaced and so making virtually an unbroken mass of cane, and although while the greater part of the bundle was broken up into small chips, the end of the bundle was dragged through almost untouched and deposited on the main carrier in a heap, which, when it entered the shredder, caused overloading, tripping the driving motor and choking the shredder, with consequent loss of time. Secondly, hard straight cane such as Co.331 was dragged through in lengths up to six feet, and these fell on the main carrier and were covered over with chips from the next bundle. These long pieces bridged the shredder mouth and stopped the flow of cane into it, also causing further delays.

To overcome the first difficulty, a second set of knives (levelling) was put in on the slope of the carrier and was a big improvement, but was not completely successful as we still had choking which we wished to eliminate entirely. The second difficulty could possibly have been overcome by altering the mouth of the shredder, and probably both faults could have been overcome by installing the second set of knives at the point of the main carrier where the cane enters the shredder. However, as we had had considerable trouble with the installation as it was and there was a doubt that any new arrangement may have created further difficulties, it was decided to revert to the conventional arrangement in this country and instal a three-roller crusher before the shredder.

Whether this was the correct procedure to adopt is debatable, for although we have eliminated delays from the causes already mentioned, it is found that the best extraction that we can obtain from the three-roller crusher is about 50 per cent., whereas when the cane passed through the shredder first, the extraction by the first unit was as high as 63 per cent.

Mills

The mills are of the conventional king-boltless type with "Munson" air-oil hydraulic system. Having had bearing trouble at another of our factories with the type top brasses supplied originally with the "Munson" accumulators, i.e. brasses with one long and one short leg, we decided to revert to the conventional type brass with each side being similar lengths. Other large mills which had been put into commission just before Darnall, experienced bearing trouble.

With their misfortunes to guide us we were particularly careful on the positioning of the oil groove and oil feed inlets and have been fortunate in having no bearing troubles. The journal diameters are 21" x 30" long and the oil groove is 2" wide by 24" long.

The back edge of the groove on the top brass is 7½" from the butts of the brass. The back edge of the oil groove of the side brasses is 7½", 3½" from the edge, and oil is fed into the groove through four holes equidistant along the groove. The first two mills were supplied with the side brasses water jackets between the brasses and the housings but we have latterly reverted to the water jacket being cast in the housing itself.

Trashplates are cast iron fastened to the dumbturner bar with long studs, the studs projecting below the bar. The studs originally supplied were of muntz metal and we had innumerable breakages. After trying various mild and stainless steels we are now using a vibration-resisting steel, which is standing up very well, although we do have an occasional broken stud. The dumbturner bar has a specially long footing to reduce the tension on the draw bolt and we find that even with a loose draw bolt the trashplate remains snug against the feed roller. Independent self-discharging bed plates are fitted to each mill, discharging tangentially into a round tank 2 ft. 7 ins. deep and 4 ft. 9 ins. diameter. The velocity of the juice entering the tank causes a swirl, which prevents the cush-cush settling. The juice is drawn from the side of the tank by a centrifugal unchokable pump. This arrangement has been completely trouble free.

Roller grooving is 3 in. pitch on the crushers, 2 in. throughout on the first and second mills and 2 in. feed with 1 in. top and discharge on the third, fourth and fifth mills. We are this off-season putting 2 in. grooving throughout the third and fourth mills and hope that this will improve the efficiency of these two units. Messchaert grooving is used in all the feed rollers.

Owing to limitations of space it was only possible to instal the mills at 21-ft. centres, and while it is a neat, compact arrangement, some may claim that it does not give sufficient time for the necessary penetration of the imbibition water and return juices.

Intermediate Carriers

With the exception of the intermediate carrier following the shredder, all of these are the scraper type. Here we had considerable trouble as the chains and slats were too light for the work. There were four chains arranged in pairs and each pair conveying slats at about 16 in. centres. The chain was 4 in. pitch and had a breaking strain of 5,500 lb. and the slats were very light galvanized serrated angles. Chain of 7,000 lb. breaking strain was obtainable locally and slats were made of heavy 3 in. angle with 1 in. square spikes welded on and projecting about 3 ins. below the slat. This was an improvement but not sufficiently so and we had to go on to a 6 in. pitch chain with a breaking strain of 8,500 lb. and

the 3 in. angle slat before they were satisfactory. The carriers are driven by a $2\frac{1}{2}$ in. pitch Reynolds chain from the top roller of the preceding mill, and the speed of the carrier is slightly in excess of the peripheral speed of the rollers which is 37 ft. per minute when the engines are running at normal speed. There is a phenomenon to which we have not yet found the answer. From some mills the bagasse is discharged and flows away smoothly in a layer about six inches thick and the carrier slats convey it with the maximum of ease. In others the bagasse swells as it leaves the discharge roller and consequently the tail shaft of the carrier is rising and falling as the slats alternately slip and then bite into the bagasse. With the original chains and slats they would ride over the bagasse and give us endless trouble and several major breakdowns. However, the problem now is, why does the bagasse discharge differently from different mills? We can find no mechanical reason which could cause this, but mill efficiency results lead us to consider that it may be due to faulty mill or trashplate settings, and although we have made major alterations to these, it has not made any improvement.

We hope ultimately to find the answer to this peculiarity and a thorough investigations of the mills when they are opened up in the off-season may put us on the right track.

With the installation of scraper type intermediate carriers it was realized that some feeding apparatus was necessary and feeding rollers were fitted at each mill. These consisted of mild steel rollers 24 inches in diameter with longitudinal strips welded on, and facilities were provided that these could be adjusted so that the opening between the feeding roller and the top mill roller could be between 7 ins. and 14 ins. Experimentation showed that the closer setting was necessary, and as the adjusting gear was not sufficiently strong, these were made a permanent fixture at that setting for the five mills. As the crusher was handling unshredded cane, the opening here was set between nine and ten inches. In all cases this caused excessive strain on the driving chains and feeding roller shafts and these had to be increased in size to take the load. In the light of experience I consider that we could even have a closer setting, say four to five inches with equipment designed to take the heavier load. This would tend to bring us nearer to the "pressure feeder" idea which has been such a success in Australia. In stating this point, I take into consideration that the uncompressed blanket of bagasse on the intermediate carrier is only about six inches thick.

Prime Movers

All the milling units are to be driven by 600 h.p. compound engines, the steam pressure being 180 lb. per square inch and about 50°F superheat. Con-

sideration was given initially to turbine drives but owing to the protracted deliveries of any type of driving unit and considering that we had on hand three 450 h.p. high-speed engines which we had to use to start up the plant, it was decided to accept the reciprocating engine drive. These drive through a double-reduction co-axial gearbox to a final enclosed spur gear on to the conventional box coupling and tail shaft. To allow for lift of the top roller the final gear shaft is set $\frac{1}{4}$ in. above the top roller shaft. In conjunction with two other milling plants of similar design installed within the last few years, we have experienced a certain amount of engine bearing failures, but possible on account of our higher horsepower engines, not to the same extent as the other factories. These failures consisted of the white metal bearings of the big and small ends and main bearings cracking and coming loose from the shells. On investigation, these failures at the three factories by engineers of the suppliers, indicated that the faults were caused by excessive oil temperatures in the crankcase. It has been decided by this factory and I believe by the other factories, to instal independent oil coolers on each engine, and while it is anticipated that this must be an improvement, it remains to be seen whether this is the complete answer to the trouble. Unfortunately, owing to a misunderstanding we will not be able to instal the coolers for next crushing season but we hope that the other two factories will be so equipped, and as they experienced more trouble than we did at Darnall, it will be interesting to see the effects on their engines during the next crushing season.

Remote control for the speed of the engines has not yet been fitted and the intention is to have "push button" control placed on the mill platform independent for each engine, with a master control "stop" button which will immediately stop every engine preceding the switch operated.

Conclusion

The closing down of the old Darnall milling plant which has served us well since 1905 and in my personal experience since 1938, was like attending the funeral of an old and trusty friend. The starting up of the new plant was like the birth of a father's first offspring, full of hope, but tinged with a certain natural anxiety.

We doubt whether any young parent suffered the trials, the tribulations and the sleepless nights that our executive staff had in its first year of existence. Because of this I have been persuaded to describe some of our troubles and the means taken to overcome them, in the hope that it may be of assistance to our fellow technologists who may sometime be placed in similar circumstances. To complete the simile, we feel that we have a lusty young offspring

which in the not-too-distant future will take an honourable place among the milling plants in Natal.

In conclusion I feel that it is meet that I express my grateful thanks to the staff of Darnall factory who worked so willingly and well during the construction and the difficult period in bringing the plant into full operation.

Mr. Bouvet asked what kind of feed rollers were used.

Mr. Grant replied that they were set on top of the feed roller and compressed the bagasse against the top roller.

Mr. Bouvet stated that after a lot of trouble in Mauritius they came to the conclusion that the best thing would be the removal of the trash-plate which some manufacturers place between the feed rollers and the front rollers of a mill.

Dr. Dodds said that the staff at Darnall were to be congratulated upon not only in installing the new plant but attaining such a tremendous crushing rate in the first season. Although the extraction now left something to be desired he thought that Darnall would one day be one of our most efficient factories.

Mr. Grant said that in endeavouring to find the reason for their low final extraction, he had taken some figures of individual mill extractions from three other Natal tandems of six milling units for comparison. In each of these cases, including Darnall, the extraction by the first three units equalled approximately 76.5 per cent. After that point Darnall fell away badly, and it was for this reason that they were now going to increase the grooving of the fourth and fifth mills to 2-inch pitch on the top and discharge rollers as well as the feed roller. He considered that this was necessary to obtain the maximum throughput of thirty tons of fibre per hour with a satisfactory extraction. He also considered that from the figures already quoted in the paper, from the point of view of extraction, it was advantageous to have the shredder preceding the first milling unit. He would, however, like an expression of views of engineers present, on these two points.

Mr. Hill stated that as they were considering installing a shredder at Renishaw he would also be pleased to learn other peoples' experiences and opinions on where the shredder should be placed. At the moment he was guided by Darnall's experience and he felt that a mill or crusher should precede the

shredder. He asked Mr. Grant what was the distance between the inter-carrier slats and how the carrier was driven. He found the settings at the bottom end of the carrier were most important.

Mr. Grant said that on the Darnall plant, the bottom plate of the intermediate carrier butted against the back edge of the scraper supporting plate and both of these were practically in line with each other.

The distance between the intermediate carrier slats was 18 inches.

Mr. Hill thought that more slats might be of value.

Mr. Gunn considered that the Darnall staff had done excellent work in accomplishing what they had to date. As far as grooving was concerned the feed roller grooving at Madistone had been increased.

He thought that by increasing to 2 inches far more throughput could be obtained. At Maidstone extractions at the first unit had been as high as 64 per cent. This last year when something happened to the trash-plate it had decreased to 62 per cent. He had a large labour staff chipping the back rollers, during the week-ends. If the bagasse did not expand on leaving the mill they then decided to chip the top rollers.

Mr. Rault stated that the reasonable moisture content of bagasse and sucrose extraction obtained at Natal Estates, in spite of a fibre throughput 115 per cent. over rated capacity, was in some measure the result of comparatively large groovings of the last mills, i.e. 1½"; the innovation of multiple groovings in the top and back roller of the last unit meant, nevertheless, that every second groove was made smaller.

A peculiar feature of their milling plant was the drop in moisture content between the last unit and the penultimate one, which was over 3 per cent., whilst every successive unit after the crusher could drop the moisture by only 1½ per cent.

This was tentatively explained by the nature of the imbibing liquid, which was dilute juice in every case except the last one, where water was used. Apparently this water could be more easily displaced than dilute juice.

Mr. Elysee said that at Amatikulu the moisture content often recorded figures which were not believed by the engineers. He had tried various new gadgets to check on moisture content. He thought that owing to the mills increasing their rate of crushing the moisture content increased. This high moisture content also led to steaming troubles. He wondered if using different settings and working their

mills slower, better results would be obtained. He was led to this conclusion by watching the figures over many years.

Mr. Mc. D. Dick said that he understood that the setting of the cane knives on the new plant had been in different positions in relation to the nose of the preliminary carrier and asked if figures on the horsepower required per ton of cane per hour could be provided when the knives were in the various positions referred to.

Concerning the position of the shredder, Darnall had been the first factory to instal this before the first mill but we have been informed that the shredder now follows a three-roller crusher. An indication of the horsepower required by the shredder in the two different positions would be most useful information to have available.

Mr. Grant said that now the knives were set almost directly above the auxilliary carrier drive shaft and the h.p. used differed little from that used when the knives were in the original position. In each case the knives were set about 1 inch from the carrier slats and the average h.p. recorded was about 250. The depth of the cane on the carrier entering the knives varied between three and six feet.

The shredder was now driven by a 450 h.p. motor running at 1,000 r.p.m. and in its original position preceding the crusher, the h.p. varied over a very wide range, from 300 to 450 under normal working conditions, but as metnioned earlier, although the trips were set up to 700 h.p. this was frequently insufficient, and stoppages occurred. Since the crusher was installed in front of the shredder, the average h.p. consumed was about 230 and this was reasonably constant.

Mr. Wilmot, replying to Mr. Hill's questions as to the situation of the shredder, said a lot depended upon the layout of the factory, and what room was available. At Sezela it was possible to place it only in front of the crusher. He agreed with Mr. Elysee that a larger setting and a slower crushing rate should give a lower moisture content of bagasse. Last year, running at a higher speed but with the same setting, the moisture content rose to 52 per cent.

Mr. Bax said in Mauritius, where intermeshing rollers in place of plain rollers had been used in the last mill of a tandem, the sucrose and moisture

content went up, although all other conditions of crushing rate, hydraulic load, etc., had remained the same. He added that the conclusion arrived at, was that with plain rollers the crushing pressure per unit area was much higher, and also the drainage was much better with a plain Maeschaert grooved bagasse roller.

Mr. Walsh said that it should be remembered that this was a modern plant and could not be compared with older plants. At such high capacities in the milling plant the feeding of the carrier became of utmost importance. As far as high roller speeds were concerned, it must be remembered that the cost of milling plant was very high and one could not afford to run it at other than the maximum capacity. Plants are now designed for these high speeds and milling companies would obtain the figures desired of them. It would take a little time for the Darnall plant to settle down and for the necessary adjustments to be made.

Mr. Gunn affirmed that at Tongaat they were crushing at the rate which allowed them to get a good extraction.

Mr. Grant commented on the short centres between mills here, whereas in Australia designers endeavour to get the maximum distance, even up to seventy-five feet, and he had heard it stated that some operators would like the bagasse to take a quarter of an hour between leaving one mill and entering the following. In the Darnall plant, it was only a matter of thirty seconds.

Mr. Rault said that as a result of his trips overseas and after studying various milling plants he had come to the conclusion that sugar milling was largely a matter of compromise.

Mr. Phipson asked if the higher sucrose and moisture content was due to poor drainage and if using Maeschaert grooves in the discharge roller as well as the feed roller would not be of benefit.

Mr. Bouvet pointed out that in Mauritius very low moisture per cent. bagasse in the neighbourhood of 46 to 47 per cent. obtained by using plain rollers was increased when the rollers were grooved.

Mr. Phipson said that at Empangeni the last roller put in one year had Maeschaert grooving, and in spite of no scrapers being fitted, gave a performance which was much better than in recent years.