

# SOME NOTES ON MACHINERY MAINTENANCE IN A CANE SUGAR FACTORY

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The modern cane sugar factory contains a varied collection of plant and machinery, ranging from the heavy and slow-moving type as exemplified in the crushing mills, to the lighter fast-moving machinery at the dry-sugar end, comprising the centrifugals, conveyors and so forth down to the weighing scales and sewing machines for closing the bags. The writer presents the following few notes as taken from the point of view of the engineer-in-charge—the man directly responsible for the efficient running and maintenance of this very diverse plant. It is not intended to discuss the general principles which are more or less common to all prime-movers and power driven machinery, but simply to bring to notice a few facts which arise out of the peculiar conditions under which the machinery in the various parts of the factory has to be operated.

Under the term "plant and machinery" the writer includes buildings, tanks, piping for steam and other fluids, and practically everything which constitutes the material part of the factory. At the outset it must be noted that in all sugar factories the conditions under which the greater part of the plant operates are generally very severe. Cleanliness may always be an object of pursuit but it is certainly one which is most difficult of achievement. In the mill-yard, at the very entrance to the factory, we have brought in to us from the fields all the dust, grit, fine char and half-burnt trash adhering to the cane. From the boiler-house we get the finely-ground bagasse particles and the charred smuts discharged with the flue gases from the chimney, both of which combine to form a penetrating and all-pervading dust. To this must be added, although in lesser quantities, clouds of finely-powdered lime together with the vapours rising from the hot juice and syrup tanks. It will be realised from this how difficult it is to keep the average appearance of a sugar factory clean and tidy, and to what an extent the structural metal-work of the building is liable to suffer from the corrosive action of the hot vapours produced inside the factory together with the normal effects of weather conditions outside. The preservation of steelwork in sugar factories ought surely to give paint manufacturers a field for research and experiment quite as wide as that presented by the problem of protection of the steel bridges of our coastal railways. The writer notices that the Railway Administration is solving their trouble very ingeniously by constructing their new bridges wherever possible in reinforced concrete.

Turning to the consideration of the mechanical equipment of the factory we have to bear in mind that the working season lasts an average of only seven months of the year, and this period is tending, for economic reasons to become shorter. As a result the mechanical equipment, as regards spares and stand-by machinery, is cut down to very meagre limits. During the four or five months' off-season the machinery has to be overhauled, re-conditioned and put into a state of efficiency so that it will run at least the length of the working season without breaking down or otherwise causing trouble. These conditions, although very logical and necessary from an economic point of view, increase the responsibilities of and demand a high degree of experience and foresight from the engineering staff. The seriousness of any hitch or delay in the running of the factory during a busy season is only too well known to those in charge of its management, and the primary concern of the engineering staff lies not so much in the repairing of breakdowns as in the prevention of their occurrence. Owing to the high mechanical efficiency, robust construction and the use of ample safety factors in its design, capricious breakdown of modern machinery is rare, but accidents will happen. A reasonably equipped repair shop is a very necessary adjunct to every factory. Although the engineering resources of a large town may be close at hand, yet time is such an important factor that even the few yards journey within the factory itself between the place of breakdown and the repair shop seems uncomfortably long to those anxious to avoid delay in getting things "going" again. There are of course varying opinions on the question of the extent of machine-tool and other equipment which a factory repair shop should carry, but on the whole the furnishing of the repair departments of factories in this country does not display much extravagance. Good machine tools cost money, but their life of usefulness is long, and in the event of extreme necessity such tools can usually command a ready and profitable sale. As much can hardly be said of the main plant and equipment of the factory.

Before leaving the subject of the factory repair shop, mention must be made of the great boon placed in the hands of the maintenance engineer by the recent development of welding processes, both of the electric arc and the oxy-acetylene blowpipe. These wonderful aids to maintenance engineering have now got beyond the stage when our enthusiasm outran our discretion and the wrongful or mistaken use of these welding processes led sometimes to disastrous failure. It is sometime now

however since we saw attempts to use the electric arc for sealing cast iron roller shells to steel roller shafts with the idea of preventing the ingress of juice; or of "building up" worn and torn roller journals so that after machining they would be "as good as new." Everything has its limits of usefulness, and if these welding processes are intelligently employed it is surprising how long a list can be compiled of repair jobs, neatly and cheaply done, which not so many years ago would have been regarded as impossible.

The subject of the maintenance of the Milling plant alone is one large enough to be discussed in a paper by itself and we may here mention only a few points of special interest. Of all parts of the factory, the milling machinery has to stand up to the heaviest mechanical wear and tear, as well as the corrosive and erosive effects of the cane juice. In its ability to withstand shock, the cane crushing mill has to stand second only to steel rolling mills, whose duties they are indeed at times forced to perform when dealing with what our Trans-Atlantic friends picturesquely term "tramp iron." Unfortunately, for the maintenance engineer, the effects of the passage of a railway coupling-link or pin through the mills is not always evident until even years later, when they mysteriously show up in the form of broken bed-plates and trash-turner beams and seatings, which failures have had their origin in cracks originally too small to be visible produced by the excessive strains set up by the previous accident. In this connection the operating engineer would be greatly assisted by mill designers if the later would see to it that all reasonable facilities are provided for the quick removal and replacement of rollers—especially side rollers, the taking out and putting in of which often involves the tearing down of the intermediate carrier and other accessories.

The trash-turner is undoubtedly the most troublesome part of the ordinary three-roller mill both in regard to its maintenance and to its proper setting. The greatest wear and tear is concentrated on the trashturner plate, especially when working with deep circumferential roller grooving and the usual "Messchaert" juice-drainage grooving. It is very noticeable, even after only a few months' work, how large gaps occur in the edges of the trashturner plate opposite the Messchaert grooves. These are quite evidently caused by the bagasse which packs hard into the drainage grooves, and in being carried past the edge of the trashturner plate gradually cuts out these cavities. This process like all other similar abrasive processes in a sugar mill, is hastened by the corrosive action of the natural acids in the cane juice. To offset this trouble, all trashturner plates working with Messchaert-grooved rollers should have scraper teeth welded on to the edge of the plate and extended (following of course the proper curvature of the trash-plate surface) to reach to the bottom of the

drainage grooves. If these can be successfully welded to the edge of the plate and made to stay in position for the season, this damage would in a great measure be avoided and owing to the reduction of bagasse droppings much cleaner conditions under the mills would result. The ordinary scraper-knives used for cleaning the grooves could also be dispensed with.

The grooving of the top surface of the trash-turner plate is also a source of wastage. It is one of the many troubles of the maintenance engineer which have been brought about by the heavy, deep intermeshing V-grooving of the rollers, of which this is a natural consequence. There have recently been attempts to "assist nature" in this respect by artificially grooving the surface of the plates before installing them, and considerable argument and controversy has arisen as to whether this practice is worth while. The writer's own opinion is that it does not justify the extra expense and that it is better to let the natural grooving find its own form. This form will take its own way according to the depth and angle of the roller grooves and their pitch, the hydraulic pressure applied to the top roller, the loading of the mill, hardness of cane, speed of rollers and so forth. All these variable factors make it practically impossible to determine the form which the artificial grooving should take, and it is therefore better to start off with a plain smooth surface.

The proper setting of the position of the trash-plate is of the greatest importance, and once the best setting has been arrived at to suit local conditions, the best course is to leave it alone as far as possible. Nothing more readily upsets the working of a mill than the continual fiddling about with the setting of the plate, the trashturner has originally to be set higher than its normal working position, the extra height being about half the expected wear. Towards the middle of the season it will approximate to its normal position and by the end it will be slightly lower. This compromise is necessary, because it must be remembered that the trashturner cannot be raised vertically from the position it has been working in without either raising the feed roller with it or else re-shaping the edge of the plate to suit the new raised position. Either of these operations is troublesome and cannot very well be done during the season except at the sacrifice of crushing time. Plates of special hardwearing metal have been introduced in the past few years, which, barring accidents, have a much longer life than that of the ordinary cast steel plate. But they are more costly and are just as liable to accidental damage, which is usually the determining factor in the life of a trashturner plate. It is indeed exceptional for an ordinary cast steel plate to survive more than two average crushing seasons.

The difficulties of properly maintaining the milling plant through the course of the season has been made increasingly difficult in this country by the tendency to progressively overload the mills. That the average extraction had been maintained, and even improved in recent years is all the credit of the factory engineering staffs, but the writer feels that greater improvement could be made if the mills were run nearer to their normal capacity.

In regard to the surface of rollers, the maintenance engineer may look forward with some consolation to the fact that the day of the extra-deep V-grooving seems to be passing. The value of these deep intermeshing grooves is not a matter within the intended scope of this short paper, except in-so-far as it effects the question of maintenance. Experience has shown that the maintenance costs of deep-grooved rollers, that is grooving from lin. pitch upwards, is much higher than those having comparatively small-pitched grooving. There seems to be a definite tendency in every cane sugar country to return as far as possible to the smaller type of grooving, especially in the rollers of the last two mills of the train. This is not being done merely with the object of saving maintenance costs, but of improving extraction by bringing down the moisture content of the bagasse. The main object of the deep-meshing grooves was to enable the roller surfaces to get a better grip of the cane and so increase the capacity of the train of mills. The idea probably appealed to the sugar machinery manufacturers, as it saved them the trouble in searching for what they ought really to provide us with—a roller metal of such texture that it will keep rough as it wears and provide a proper gripping surface without the aid of intermeshing grooves. The gradual reversion to grooving of smaller pitch will also reduce the costs and maintenance troubles inseparable from such fittings as scraper plates. The deterioration of roller shells due to the gradual widening of the Messchaert drainage grooves, due mostly to the corrosive effect of the stream of juice running down the groove, cannot very well be avoided, and as these grooves are of prime importance, especially in the feed rollers, there is no way of getting round this maintenance trouble.

Whilst on the subject of the corrosive effect of raw cane-juice, it may here be observed that cold raw juice has a much more destructive action on cast iron and mild steel than have the tempered and heated juices or the syrups and molasses. This is particularly noticeable on the juice trays under the mills on which the juice splashes in contact with the open air, which probably accentuates the oxydising effect in this instance. But even when flowing in closed pipes the corrosion is considerable, even on hard cast iron, as evidenced in the deterioration of sluice-valve casings and other fittings. An ultimate saving in maintenance costs is made by the use of copper piping, gunmetal or bronze valve casings, pump bodies and other fittings which come

in contact with the flow of the juice. Stainless steel for pump rods and spindles has superseded bronze and monel metal, being both cheaper and more lasting. In using these metals in place of mild steel and cast iron the heavier first cost is soon offset by the much longer life and freedom from maintenance costs, not to mention the great improvement in cleanliness and general outward appearance. The first cost of lining a mill bed with copper sheeting is inconsiderable compared with the advantages gained in these other respects. The writer knows of several large gunmetal pumps which have been pumping raw juice from the mills for the past twenty-three crushing seasons without showing any signs of deterioration beyond slight abrasion due to the fine grit in the juice. This statement of course refers to the casings and not to liners and parts in rubbing contact: these require the usual frequent replacement due to the unavoidable presence of the same fine grit. The natural acids in the juice, however, which so quickly destroy mild steel have very little effect on copper and its alloys. In the case of intermediate carrier chains, also, the destruction of the chain links and pins is due mainly to juice-corrosion and it is to be noted with satisfaction that the chain-makers are now bringing out chains of metal alloys more resistant than the ordinary malleable cast iron with steel pins.

Passing on to the boiler-house, the major maintenance costs are here incurred mainly in furnace repairs which vary greatly according to the design of the furnace, the quality of the firebrick lining and, last but not least, the efficiency of the workmanship put into its building. There are many different makes of firebrick and other refractory materials in use throughout our sugar factories, and the writer has pleasure in stating that he has found some of the materials produced in South Africa quite as good as any imported from overseas. Many of the excellent furnace cements now available on the market are also a great help to the maintenance engineer, and serve efficiently to patch up a damaged furnace lining to a servicable condition and so save the expense of complete rebuilding.

As the boiler-feed (make-up) water in most factories is obtained direct from rivers or dams and is usually put into circulation without any previous treatment for the removal of impurities, a complicated set of maintenance troubles is usually met with in regard to scale formation and internal corrosion. The effects of bad feed water of course vary according to the nature and quantity of the impurities contained in it and in some factories preliminary treatment of the feedwater has been found necessary. As our crushing period coincides with the season of dry weather and almost stagnant streams our fresh water supply is usually contaminated with weak vegetable acids, which produce heavy internal corrosion on cast iron feed-pumps

casings and mild steel feedpipe ranges. In cases, however, where the corrosion of the feedpiping has been heavy, little or no corrosion has been traceable to this cause on the internal heating surfaces of the boilers themselves. It may be that these wear acids are most active at the temperature of the feed-water (say about 180°F.), but that they are broken up and rendered harmless at the higher temperatures obtaining in the boiler. Some support to this theory may be claimed from the fact that in a factory where corrosion of the feed piping was particularly bad feedwater heaters were installed some years ago. The temperature of the feedwater circulating in the pipe ranges was thereby raised to an average of about 208°F. and the amount of corrosion has since been found to have decreased very considerably. Under the circumstances feed ranges are now being made up in copper piping, and a quantity of scrap mild steel in the form of old bits of flat bar and pieces of plate (to present as large a surface as possible) is put into the feed tank so as to help in the breaking down of any acidity in the water before it reaches the inside of the boilers. In all probability this cheap and simple scheme has a good effect, in any case it can do no harm.

The excessive wetness of the steam in most factories where superheating is not employed causes trouble in the electric generating steam engines and all other reciprocating steam units. Not only does the accumulation of water in the steam mains—apart from the wasted heat energy which this water carries away—become an ever-present danger in the engine cylinders, but in wet weather when the water supply becomes contaminated with mud, fine particles of this mud are carried over in the steam and form a highly abrasive medium when mixed with the oil in the engine cylinders. The first indication of trouble from this cause usually appears in torn gland-packing of the piston and valve rod themselves. In vertical high-speed reciprocating sets this muddy sediment even finds its way down into the crank chamber oil forming a sludge which makes it necessary to change the oil much sooner than would otherwise be required. A very considerable safe-guard and a definite help towards the reduction of maintenance costs in this connection has been provided by the mechanical "steam purifiers" which have lately been brought into service. The "Tracy Purifier" in particular has been a proved success in eliminating the greater proportion of moisture and its muddy impurities from the steam, either as it leaves the boilers or just before it enters to engines.

Before leaving the boiler plant, it may be remarked that during the past half-dozen years or so the rate of evaporation in existing boilers has been considerably increased by the installation of improved design, giving both more efficient fuel consumption and also higher combustion chamber temperatures. It was feared at first that this so-

called "forcing" of the boilers might have a damaging mechanical effect on the heating surfaces, bringing local overheating and all its attendant troubles and dangers in its train. Such fears, so far as the writer knows, have not been realised. So long as the heating surfaces are kept reasonably free from scale and sediment no mechanical damage is likely to be suffered through the increased rate of working. Greater care must naturally be exercised in keeping these surfaces clean and for this the maintenance engineer can call to his aid the many efficient makes of mechanical scaling apparatus now on the market which make the process of cleaning much simpler than it used to be. There are besides several graphite coatings which can be applied by paint-brush after cleaning with a view to preventing as far as possible the scale re-forming on the surfaces, but is plain that for these preservatives to be effective the surfaces must first be clean.

The maintenance of the electrical equipment in the average sugar factory usually presents much more difficulty during the or-season than when the factory is at work. The factories are closed down during the summer months when the humidity of the atmosphere is at its highest and it is during this period that future electrical troubles are built up. Dampness creeps into the windings of motors and generators resulting in damage to the insulation which unfortunately shows up only when the time comes to start work at the beginning of the new season. The simple expedient of keeping a brazier of coke or charcoal burning near the machines for a few hours every day, shifting its position occasionally so as to distribute the radiated heat as evenly as possible, has been found fairly effective. Hot air fans or blowers, where a drying-out oven is not available, can also be used for getting rid of the moisture before applying a new coat of insulating varnish to the windings.

The part played by proper lubrication naturally has an important place in any well-organised scheme of maintenance, but as this subject has already been very fully discussed in previous papers before this Association, to say nothing of the vast amount of advertising literature broadcast in connection with the trade, we need only mention it in passing. What almost wholly concerns the maintenance engineer is to get efficient lubrication at the lowest cost, and he is best left to his own resources in working out ways and means of attaining this end.

With regard to the clarification, boiling-house and curing machinery, maintenance is not so expensive in these departments as in the heavier milling machinery, and the cost can greatly be reduced by the use wherever practicable of metals which resist corrosion. Cast iron tanks for instance, in spite of their high initial cost, are far more resistant to the attack of acid juice and mud than tanks

constructed of mild steel and are also much more easily kept clean. Centrifugal machines with the perforated sides of the baskets made in hard-rolled copper sheet will last indefinitely as compared with the usual mild steel baskets, and many more instances can be quoted where the application of corrosion-resisting metals more than repays their extra first cost both in length of service rendered and their freedom from heavy maintenance charges.

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The PRESIDENT: In opening the paper for discussion pointed out that it was by one of the experienced engineers of the Industry, and he hoped that the many engineers present would take part in the discussion.

Mr. BECHARD: Thanked Mr. Camden Smith for a long overdue paper, which opened a new field of enquiry. With respect to the conditions inside a factory, could be noted (1) The loss of heat units from non-insulated tanks and heating units, (2) The damp conditions, reflecting on the health of workers (3) The deterioration of the roof. The last was very important and was a very heavy item of cost. Arising from this subject also was the undesirable feature of roof sweating which could be very serious. This not only lead to deterioration of the metal itself by the acid formed by the gases from the sulphur dioxide plant, but also lead to deterioration of stored sugar upon which this acid might drip. Mr. Bechard then spoke about the grooving of trash plates, which he thought should be done previously to installing in the Mill train. In his factory malattention of the trash plate had been thought responsible for lowering the efficiency of juice extraction. With regard to grooving of rollers they had found that deep grooving (1½ in.) was the best. Lastly on the point of view of maintenance of efficiency he said that centrifugal baskets, referred to by Mr. Camden Smith, were often designed to last longer when not subjected to steam, which causes corrosion and even erosion. As it was often necessary in low grade production to use steam the problem might well deserve further investigation.

Mr. MACBETH: Associated himself with Mr. Bechard in congratulating the writer on a very interesting paper. He said that a welding plant in a factory could replace six or seven workmen and save much time. Electric welding of mill rollers held much promise as the heating was purely local, unlike the acetylene plant. Tips of grooves on crusher rollers of cast steel and those that have a 10% steel mixture (10% steel and 90% cast iron) had been very successfully welded on using a mild steel electrode for the first layer and thereafter a manganese steel electrode. Referring also to the grooving of trash plates he preferred to have these grooved before installation as there would be less wear and tear on both the roller and the trash plate.

This he had found to be the case at Mount Edgecombe, and better feeding had resulted. Installing large V grooves on mills was merely a matter of capacity. Capacity could not be obtained with small grooves, and to increase tonnage per hour he had found it essential to resort to larger grooving. Larger grooving, of course, would result in higher moisture—but you could not have it both ways. Mr. Macbeth mentioned that the corrosive action of juice on cast iron could be reduced either by heating the juice or by pretreating with lime. He could not say which was actually the better. He went on to say that one or two firms were supplying non-corrosive metals for the intermediate carrier chains. He had some on test this year. Referring to furnace cement he said that some local products were standing up very well indeed. Mount Edgecombe intended using locally made bricks in their kiln this year, as they had already proved their worth. In conclusion he wished to refer to the "simple expedient" used to rid moisture from electrical equipment, namely a charcoal burner. The sulphur dioxide fumes coming from the charcoal he said would tarnish copper and brass parts.

Mr. W. A. CAMPBELL: Again raised the question of roller grooving. He said he had persuaded his engineer to increase the grooving of the last mill, which resulted in a bigger tonnage and practically no increase in moisture. He even went as far as to recommend 2 in. grooving, which he believed would not affect the moisture content. He hoped that the engineers would consider very big grooving in future.

Mr. J. Murray: In complimenting Mr. Camden Smith made reference to the "magnificent work" of the Experiment Station in introducing new canes and helping planters generally in field work. The chemical side of factory work was receiving all the attention, and except for the really excellent work of Dr. Hedley, the mechanical side had received hardly any attention. Mr. Murray suggested that Dr. Hedley should be given an engineering assistant whose whole time job should be to study such problems as mill extractions and heat balance. Problems such as mill grooving could thus be studied. He thought a great deal of good would result to the Industry generally from the establishment of an engineering section at the Experiment Station under the supervision of Dr. Hedley.

Mr. W. C. LINDEMANN: Congratulated Mr. Camden Smith on his paper and remarked that one point had been overlooked, namely the incorporation of fine beach sand in machinery. As an example he quoted the elevators on the beach front, where the terrific wear and tear was evident. Sezela was a mill exposed to the beach, and he suggested the growing of trees to serve as a break. Referring to the workshops, Mr. Lindemann said these were far from satisfactory in the sugar mills. This was illustrated by a case in which a fatal accident had occurred through the

wearing of a thread. This wearing out he could trace to the workmen using pieces of sack which they picked up from dirty floors and the silicious matter collected by the oil and grease on the cloth had found its way into the thread. He appealed to the Industry to get the engineer a better workshop—especially the floor and machine tools. A first class workshop automatically decreases costs of maintenance. It was an unchallenged fact that where a first class well equipped workshop was found and the machine tools operated by experienced workmen, maintenance costs came down. Referring lastly to the cleanliness of boilers he thought Mr. Camden Smith must have had some experience with graphite paints. He quoted an instance where he had entered a boiler and discovered certain nodules, which marked areas of excessive corrosion taking place in spite of preservatives. The preservative had been painted over the scale, showing how essential it was to thoroughly clean the plate first. Such corrosion incidentally reduced the pressure permitted in the boiler.

Mr. P. MURRAY: In expressing his pleasure on reading the paper, wished to say that grooving had nothing to do with increased extraction. It was just a matter of capacity and every factory was running practically over capacity. The size of the grooves did not matter. Referring to the idea of deep grooves being merely a substitute for a smooth roller with a proper gripping surface, he said this was not the case. The sugar manufacturers encouraged the machinery manufacturers to produce deep groove rollers as they expected to get greater capacity. Furthermore the widening of Messchaert grooves was due more to the movement of the side rollers (i.e. due to the top roller lifting the flanges on the side rollers) than to juice corrosion. As regards new metals for chains on carriers, he thought it was just a matter of installing stronger chains. Mr. Murray said that the mud which came in with cane had a wearing effect throughout the whole mill, and some attempt should be made to settle out the mud in the first stages. Referring lastly to electric and acetylene welding he said that acetylene welding had made a tremendous difference to the repairs in a sugar factory. He thought in fact it had been the most important thing in sugar factory upkeep for a great many years.

Mr. CAMDEN SMITH: In replying to the

various questions said he was gratified there had been so little destructive criticism. He appreciated the remarks of the speakers, and stated that his paper had been written purely from the point of view of maintenance. He preferred smooth rollers because they overcome the endless task of repairs. Further to this, heavy grooving did increase capacity as Mr. Campbell said, but he still thought smooth rollers with gripping surfaces should be used. He emphasised this point and said that much of the capacity of the mill as well as the extraction was lost by smooth surfaced slipping rollers. This had been proved also by the introduction of new variety canes. Co.281 for example went through the mills with very little effort as compared with brittle, hard Uba. The fluctuations in mill extraction with the different varieties was really traceable to this objectionable feature.

Dealing with Mr. Macbeth's remarks about electrical welding, he thought electric welding had its limitations also. Each type of welding had to be considered in relation to the particular job for which it was being used. He at Sezela had electrically welded a damaged roller, but had found difficulty in maintaining the grooving of the roller by this method, owing chiefly to the repaired patch being too hard to finish off with a machine tool.

With respect to Mr. Lindemann's remarks about beach sand he said he was only too well aware of the damage thus caused, especially in the mill yard. Mr. Camden Smith said he was glad to have the necessity of a good workshop emphasised. At the same time the equipment of a workshop could be overdone, and could even verge to the point of extravagance if we let our enthusiasm go too far.

There are certain jobs in a sugar factory which can always be tackled more economically by an engineering firm. After all the sugar factory engineers' job was to keep the machinery running and do everything possible towards the economic production of sugar.

With regard to Mr. P. Murray's statements on capacity he also thought we could wisely reduce the capacity and expect rather less from our milling plant than we do. This would no doubt result in an all-round improvement.

Mr. Camden Smith concluded by thanking the audience for their patient hearing and for the kind criticism received.