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DESCRIPTION OF A MOLASSES BURNING FURNACE.

(By W. H. GERMAN.)

Molasses, from which no more sugar is obtainable, is a residual product of sugar mills and refineries, and in many cases can be profitably placed upon the market for direct consumption. In other cases it is used in distilleries for producing white spirit or rum, and in some instances is mixed with vegetable fibre, meal, or such like, and sold as cattle fodder, while it is also used on some plantations as manure, being applied to the land in its semi-fluid state.

The price obtainable for molasses fluctuates considerably and varies with the seasons; and although there is a steadily increasing demand for it for food purposes during periods of drought, its sale rapidly diminishes so soon as herbage is plentiful. An approximate average value in such centres as Sydney, Brisbane and Melbourne may be roughly stated at £4 per ton. It will, therefore, readily be recognised, when considering the difficulties and expense of storing it at the mills, the cost of casking and transport to steamers, the freight to the cities, and the further expense in handling until distributed to consumers, that there is no margin of profit left to the producer unless his mill be most advantageously situated; consequently, only a very small proportion of the quantity produced in Australia is put to good use. A small quantity is burned in the furnaces of the steam-generating boilers after sprinkling upon or otherwise mixing with the megass, but generally with very indifferent results. At many mills the accumulation of molasses is simply run into neighbouring rivers or estuaries, often resulting in a nuisance and the destruction of fish.

The average production of molasses may be roughly stated at $2\frac{1}{2}$ per cent. of the weight of sugar cane crushed, so for a medium-sized mill dealing with 40,000 tons of cane per season 1,000 tons of molasses will result—no small quantity to dispose of unless suitable means are at hand; so it is not surprising that mill owners should appreciate a convenient means of burning it. In Java and Hawaii molasses is largely used as fuel, either by allowing it to fall in fine streams on the megass on its way to the furnaces or else in specially constructed furnaces in which the molasses is atomised by means of a jet of high-pressure steam. Several instances of the former method of application have come under the author's notice, but none of them were satisfactory; while, as regards the latter system, a device known as Anderson's Patent Molasses Burner is advertised and well spoken of in Hawaii, but the author has otherwise no knowledge of its behaviour.

A typical West Indian molasses will have a composition, say, of sugar 35 per cent., glucose 25 per cent., organic non-sugar 13 per cent., water 20 per cent., ash 7 per cent.; but the extraction of total sugar products at the C.S.R. Co.'s mills has been carried much further, the average figures being: Sugar 36 per cent., glucose 14 per cent., organic non-sugar 14 per cent., water 25 per cent., ash 11 per cent.

The thermal value depends upon the amount of sugar and organic matter present; hence the thermal value of the Company's molasses is considerably reduced, although the percentage of potash per ton is higher. The gross thermal value of an average sample of C.S.R. Co.'s molasses is 3,700 B.T.U.'s; the net value is nearer 3,000 B.T.U.'s—say, one-fourth the value of coal.

Apart from the calorific value of molasses, every ton should by combustion yield about 96lb. of potash worth, say, £1; so, again assuming a mill to produce 1,000 tons of molasses, and reckoning the cost of coal at £1 per ton delivered at the boilers, the amount returned by combustion should work out as follows:—

By Fuel	$\frac{1{,}000 \times 20/-}{4}$	=	£250 0 0
By Potash	1,000 x 20/-	=	£1,000 0 0
	Total	=	£1,250 0 0

In practice, however, it is found that as the potash is very volatile, a considerable portion passes up the chimney with the waste gases. This cannot, however, be said to be lost, for, under ordinary circumstances, it settles from the atmosphere on to the cane fields in the neighbourhood, so is thus distributed as a potash for manurial purposes.

Ash of C.S.R. Co.'s Molasses.

Potash	39 per cent.
Soda	4 ,, ,,
Lime	16 ,, ,,
Magnesia	8 ,, ,,
Sulphuric Acid	11 ,, ,,
Phosphorus	5 ,, ,,
Chlorine	10 ,, ,,
Silicon	7 ,, ,,
	100 ,, ,,

At one of the Colonial Sugar Refining Co.'s mills, viz., Childers, near Bundaberg (Q.), where more than 2,000 tons of molasses is annually produced, there is no large river or estuary into which this residual product can be discharged; so, for a time, a large area of land was especially set apart and ploughed so as to absorb it, but objectionable results soon followed, surface water after heavy rainfalls conveying a portion of the molasses into and poluting an adjacent creek.

As transport charges upon molasses from this mill are prohibitive, it was decided to install a special furnace to burn it so some experiments were carried out, which clearly demonstrated the fact tnat if the material be first charred it will readily burn ilself to a white ash upon an ordinary firegrate.

A brick furnace, as shewn in Fig. 1, Plate XII., was then built; this proved to have a burning capacity of about 80 to 100 gallons per hour. After being started by a wood fire, the molasses falls in a number of fine streams upon the inclined hearth (A), over which the products of combustion pass; so it is soon heated to an incandescent state. Here the liquid molasses is partially charred, this process being continued on the successive steps (B, C, and D). It is then allowed to burn right out on the firegrate (E), and the ash is collected from the pit (F) below.

This form of furnace proved fairly successful, so it was adopted at two other mills where difficulties in disposing of the molasses existed, and in each case the hot gases were led to a separate boiler in which steam was generated for supplementing the ordinary steam supply to the factory; and from one of the mills (Labasa, Fiji) the following results of evaporative trials were obtained :—

MOLASSES BOILER TRIALS. L BASA MILLS.

Date of Trials.	Lbs. Burned.	Lbs. Water Evaporated.	Temp. of Feed Water ° Fahr.	Steam Pressure on Gauge.	Llbs. Burned per Hour.	Lbs. per sq. ft. fire grate per Hour.	Lbs. per sq. ft. H.S. per Hour.	Lbs. water evaporated per lb. at Feed Pump.	Lbs. water from and at 212 ° F.	Lbs. water evaporated per sq. ft. H.S. per Hour.	Weight per Gallon.	Temp. of Waste Gases.	Duration of Trials. Hours.
1899 Nov 6	8479	21950	185	73	1060	48	·68	2·57	2·92	1·8	13·9	430	8
,, 7	8208	21890	185	78	1026	47	·67	2·68	3·03	1·77	13·5	405	8
,, 8	8329	22650	176	73	1111	50·5	·72	2·72	3·08	1·86	13 5	385	7·5
,, 9	8829	23930	185	70	1174	53·5	·76	2·71	3·66	2·0	13·5	406	7.5

In this form of furnace rather much hand labour is required to work the partially charred materials from the sloping hearth to the grate below, and, unless close attention is given to this duty, pyramids of partially charred matter form below each vertical stream, and, when these pyramids unite, a dam is thus formed behind which the fluid gathers and then, breaking away, is apt to smother the fire and run through the grate, resulting in an ash of inferior value for mixing with other chemical manures.

The primary object of this paper is to describe the construction of a furnace designed to overcome the objections alluded to, and upon which lines a furnace was, in 1906, erected at Hambledon (near Cairns), another of the C.S.R. Co.'s mills from which the transport charges upon molasses would be too heavy.

Plate XIII., Fig. 3, shows the main features of the furnace, while Figs. 4 to 13, Plate XIV., illustrate the driving mechanism, the accessories, and an ordinary tubular boiler arranged in conjunction with the furnace.

Returning to Fig 3, Plate XIV., it will be seen that a slowly revolving cast iron drum (A) is substituted for the fixed inclined hearth (A) in Plate XII., Fig. 2, and that it is supported in a position partly over the firegrate, from which it receives the necessary heat. The principle thus aimed at is the constant provision of a clean and red-hot iron surface for the streams of molasses to fall upon and become charred in a regular and continuous manner prior to being automatically fed to the firegrate underneath, where the burning is completed and the ash removed from the pit below.

This furnace is also started with a wood fire, as a coal fire would spoil the first yield of potash; and, when the drum gets to a dull red heat, the feed of molasses commences and should continue night and day, because, as the heat is very intense (estimated at 2,000deg. F.), it is obvious that frequent heating and cooling off tends to early destruction and must increase the cost of repairs. To maintain the drum at a suitable temperature, a door (B) is arranged at the back for the admission of cold air; this door also serves for ready inspection. C is a water-cooled scraper suitably balanced to bear against and keep the drum clean. The fire bars (D) are of square section, and are revolved at intervals by hand to let the ash fall through. E and F are doors for working the fire, if necessary. The drum is composed of five separate cylinders bolted together for easy renewal of any part; but its life has exceded anticipations, having worked for nearly two years without need of replacements. It is connected to a heavy C.I. hollow shaft by arms specially angled, and pin-jointed to allow for excessive expansion and contraction, and the shaft is supported on roller bearings and revolved by means of worm gear. The walls of the furnace are heavy and lined with fire bricks and bound together by means of buck staves, but, at the back, part of the wall is omitted to allow of the drum and shaft being readily inserted or withdrawn.

As regards capacity, this furnace has dealt with 100 gallons per hour of specially good burning molasses, but it cannot average more than 80 gallons per hour. It requires the attention of one intelligent man and a boy to regulate the molasses feed and bag the potash.

The power required for revolving the drum is almost negligible, and, during the slack season at Hambledon Mill, the steam from the boiler that the furnace supplies heat to is sufficient to drive the shop engine and other auxiliary engines about the mill, which formerly necessitated a consumption of 20 to 30 tons of firewood per week.

Considering that the furnace is the first built to this design, its working may be said to be satisfactory, though several desirable improvements are now apparent—for instance, a greater height between the top of the drum and the lower ends of the distributing pipes would lessen the charring upon and consequent clogging of these pipes, while the drum itself could with advantage be inserted further into the furnace. Then, the lining of the two side walls being quite flat, is inclined to cave in; so, in rebuilding, these should be cambered outwards to prevent falling in, for the outside baulkstaves will prevent bulging outwards. When the walls of the furnace are rebuilt it is also intended to make arrangements for more effectively collecting the potash that now passes up the chimney. For this purpose the boiler flues and tubes are to be so divided that one side can be worked while the other is being cleaned; and a Green's economiser will be interposed betwen the boiler and the chimney, so that the gases passing amongst the tubes through which the cold feed will be passed may condense thereon, and the potash deposited be removed by the continuous scraping mechanism, while a portion of the heat that now escapes to the chimney should also be thus utilised.

Although the author hopes that the description of the construction and method of working this furnace may be of interest to members, he wishes it to be clearly understood that he is not an advocate of burning so valuable a food commodity, except in special cases where there are no other profitable or reasonable means of disposing of it; in which connection it may be mentioned that, for the purpose of transporting to Sydney the molasses produced at their N.S.W. mills, the C.S.R. Co. have fitted special tanks in the holds of three of the coasting steamers, viz., the "Macleay," the "Duroby," and the "Friendship," which boats thus carry every trip south, river bars permitting, a molasses tonnage of about 90, 60, and 60 tons respectively, exclusive of a further quantity casked in the usual manner. The steamers mentioned berth at the Company's mill wharves on the Tweed, Richmond, and Clarence Rivers; the molasses gravitates from the reservoirs at the mills into the ships' tanks, from which, by means of special pumps in the engine rooms, it is elevated into large receiving tanks at the Company's Pyrmont refinery for distribution as molasses proper and for the distillation thereof of white spirit, rum, and methylated spirit, a further by-product resulting therefrom in the shape of carbonic acid gas, which is liquified by compression and sold.

Having referred to molasses tanks, it may not be out of place to describe a type of tank recently adopted by the C.S.R. Co. for storing this material in large bulk. It should be stated that the first condition to be generally observed is that the tank bottom should be some height above ground level to admit of drawing off the contents into casks or other receptacles, and it was customary some time ago to build foundation walls of concrete or brick-work to support the joists on which the tank bottom rested; but, if the joists were of timber, they were subject to decay, while, if of steel, they needed painting at intervals—and, in either case, the parts where actual contact occurs are somewhat inaccessible, so in the form of a tank (Plate XV., Fig. 14) the tank bottom proper is the concrete foundation or base, the use of metal being restricted to the sides only; and in order to provide a tight joint between the concrete bottom and the metal side, a deep groove is made in the former, as shown. Separate loose pieces of angle iron are laid in the bottom of the groove to act as bearing plates to take the weight of the tank side. This groove is filled with bitumen, for the double purpose of making a tight joint with a yielding material to allow for contraction and expansion. The whole area of the bottom is covered with a coating of val-de-travers asphalt, which is thickened at the edges to cover an angle iron gill close rivetted to the tank. It will thus be seen that before leakage can occur the liquid contents must find some channel round the inside surface of the angle gill, then down the tank side below the gill and upwards on the outside of the tank, while the greater the pressure inside the tighter will the asphalt (which should be impervious) be pressed against the metal of the tank; and although a number of these tanks have been installed, varying in depth from 20 to 25 feet (this latter depth of molasses being equal to a pressure of 15lb. per square inch), no instance of leakage or other trouble has come under the author's notice. The largest tanks so far built on this principle have a capacity of 100,000 gallons—30 feet diameter by 23 feet deep. The side plates are of steel of thickness varying from ⅜in. for the lower belts to ¼in. for the top belts. The vertical seams are butt-jointed and double-riveted, with a strength of joint=62 per cent.; so the factor of safety, taking steel of 56,000lb. per square inch tensile strength, works out at—

$$\frac{.375 \times 2 \times 56,000 \times .62}{13.8 \times 360} = 5.2$$

It may fairly be claimed that this type of tank in the circular form for holding molasses can be built at a minimum cost, and entails a minimum of maintenance charges.

In Fiji a considerable quantity of the molasses produced at the mills is fed direct to the working horses and mules; and at two of the Company's mills in Queensland special plant has been installed for the manufacture of cattle fodder composed of about four parts by weight of molasses to one of megass. This form of product from one of the mills in question is expected to reach, during the coming season, the respectable figure of 2,000 tons.

Another rather curious but interesting use of molasses is that of preserving timber; and it may be news to some members that several works are being installed in Australia and New Zealand for this purpose. One factory in Sydney, trading under the name of the N.S.W. Powell Wood Process Company, is just about complete and ready to thus operate on timber to an amount of a quarter of a million feet per week.

On the table are shown eight samples of the different products referred to, viz.:—

Molasses, prior to treatment in the furnace.

Molasses, charred on the furnace drum.

Three grades of potash from different parts of the fur nace.

Molasses fodder (C.S.R. Co.'s make).

Two grades of sifted megass from which the fodder is made.

Inspection of these may be of interest to members.

The author is not aware of any other refuse destructor having been constructed on the principle described, but thinks it may be applicable to semi-fluid waste product resulting from other industries, for instance, distillery refuse, known as dunder or spent wash, is in some cases burned in a special kind of furnace; but, in this material, as the sugar contents have entirely disappeared during fermentation and distillation only the organic matter is available for thermal effect, so a considerable amount of coal is required to complete its combustion, unless the wash be thickened up by evaporation before burning. The potash is recovered from the fire grate and flues in a similar manner to that already described.

In conclusion the author recognises that he has wandered rather far from the subject of the title of this Paper, and has departed from the strict engineering aspect of the question, but offers as excuse "exceeding short notice for preparation," also the fact that the apparatus illustrated "being very simple," requires but little description; but, perhaps, the subject dealt with possesses some little merit through being original matter.

The President (Mr. J. Shirra), said that he considered the Paper a most interesting one, and felt that they were much indebted to the author for having prepared it at such very short notice. The subject had been very clearly put before them, and is quite a specialty and interesting to engineers. It proved that if an engineer wished to advance in his profession, he should make a study of chemistry. He would like the author to explain the source from which the molasses used was obtained. He presumed it was from the centrifugals.

Mr. R. Sinclair, in moving a hearty vote of thanks to the author, said he would like to know whether it had been found necessary to use water cooled bearings, also in reference to the storage tanks, had it been noticed that internal rusting occurred or that any leakage of molasses had taken place at the joints.

Mr. A. J. Arnot said it gave him great pleasure to second the vote of thanks, as he felt sure we were all very much indebted to the author for having supplied this very interesting Paper at a few days' notice. The subject was new to most of them, it certainly was to him, and he was sure that they would all agree that the author was to be congratulated on the able and lucid manner in which he had placed the information before them. He would like to be permitted to ask a few questions. In the Paper it was stated that one pound of molasses would evaporate three pounds of water, and further stated that its value was equal to a quarter of that of coal. This would bring the evaporative efficiency to twelve pounds of water per pound of coal, which certainly could not be obtained from any coal in Australia. He had only to-day heard that at the lower Burdekin, a Diesel Oil Engine of 120 h.p. had been installed, which was to use spirit distilled from molasses. This appeared to him to be a new departure, and he would like to know if such a proposal had come under the notice of the author, and whether such was likely to prove a success. It had also occurred to him to ask what draught was necessary in these furnaces; was any special draught required such as is obtained by induced draught fans?

Mr. W. H. German, in acknowledging the vote of thanks, said in reply to the President's question regarding the source of the molasses supply that this product was the last syrup from the sugar crystals in the centrifugal machines. With reference to Mr. Sinclair's questions he desired to say that water cooled bearings had not been found necessary, because the heavy cast iron shaft which revolved with the drum was supported on roller bearings fixed entirely outside the furnace; the speed of the drum was about two revolutions per minute.

Regarding the inside surface of the storage tanks, no corrosion had so far been reported, and no trouble with the joints had taken place either in regard to leakage or in other respects. In reply to Mr. Arnot, he wished to point out that the particular sample of molasses which showed such a high calorific value was West Indian, and was equal to about one third of that of coal. That of the Colonial Sugar Refining Company was only equal to about one fourth, and they prided themselves in so very thoroughly exhausting it of the crystalized sugar. With regard to Mr. Arnot's remarks on the use of spirit in oil engines, the Colonial Sugar Refining Company manufactured alcohol at their works at Pyrmont, and had experimented with it on a "Hornsby Ackroyd" Engine. He considered that the point that turned against its application in England and other centres was due to the excise duty which made it too expensive. Regarding the draught required in the furnaces described, an ordinary funnel was all that was needed.