BOILERS AND FURNACES FOR CANE SUGAR FACTORIES

(Paper by PATRICK MURRAY, Durban.)

The boiler house is a very important station in the factory and one in which great variation exists as regards type of boiler, capacity and setting.

In this country most factories have ample fuel during the ordinary crushing period but sometimes there is difficulty in keeping up steam when crushing is continued too late in the season, when the plant works intermittently and when the plant is not working up to its rated capacity as the radiation losses in the factory are constant no matter how much cane is being crushed.

In other countries with cane having about 11 per cent fibre most factories are able to keep going without extra fuel except in the cast of temporary shutdowns and for boiling off. Here with the fibre in the cane averaging about 15.5 per cent giving roughly 40 per cent more fuel, there should be ample fuel for all purposes even though it is reckoned that 15 per cent more fuel is required to manufacture white sugar than 96 polarisation sugar. With this large amount of fuel available, it should be possible to apply a very large maceration to the mills and greatly improve the extraction. It might also be possible to briquette the surplus bagasse for firing the locomotives and in pumping plants for irrigation purposes.

There are two main types of boilers in use here—the horizontal multitubular boiler and the watertube boiler. They both serve their purpose well and there is practically no difference in them as regards economy. Multitubular boilers are in more general use and are much cheaper to instal, but the watertube boiler is considered safer and with its small water capacity steam can be raised more quickly but the feed takes greater care as it is liable to fluctuate greatly owing to the small water capacity. The circulation is much better in the watertube boiler but some of the multitubular boilers have been fitted with circulators which greatly increase the circulation, prevent mud settling on the bottom of the boiler and remove a large amount of impurities in the water and tend to greater safety.

It is usual to state the boiler power of a factory in boiler horse power per ton of cane ground per hour. One boiler horse power is the evaporation of 30 pounds of water per hour from an initial temperature of 100 degrees Fahr to steam at 70 pounds per square inch pressure. It is usually taken that one boiler horse power can be got from 10 square feet in a watertube boiler and from 12 square feet in a multitubular boiler. That is a watertube boiler evaporates three pounds per square foot per hour and a multitubular boiler 2½ pounds. In all future figures watertube boiler heating surface is taken as smoketube boilers by adding 20 per cent to the heating surface to give them one basis.

The usual figure allowed for boiler horse power per ton of cane ground per hour is 37.5 per cent. This figure is for cane having about 12 per cent fibre; here with cane having about 15.5 per cent. fibre, to burn the bagasse with the same economy this figure would require to be increased by at least 25 per cent, making it roughly 46 horse power per ton of cane ground per hour. I have collected a few of the figures in actual use here and you will see these vary between 29 and 44.6 per cent. As is well known boilers can be greatly overloaded as regards capacity with a slight drop in efficiency and this accounts for the variation. An evaporation of 3 pounds per square foot is considered an economical figure. Taking the average bagasse as 32 per cent on the weight of the cane and that one pound of bagasse with 47 to 48 per cent moisture evaporates 2½ pounds of water, it is then possible to calculate the evaporation per square foot of boiler surface. This varies here from 2.98 to 4.7 pounds per square foot.

The usual type of fire grate in use is the stepgrate but there are some flat grates and also a combination of both. The area of the grate should be about 1/100 of the boiler surface. This ratio varies here from 38.5 to 80.9 to one. Taking one pound of bagasse to evaporate 2½ pounds of water and a boiler with a grate area of 1/100 of the heating surface, the boiler will burn 100 pounds of bagasse per square foot of grate area per hour and 120 lbs. when it evaporates 3 lbs per square foot. Basing on bagasse being 32 per cent on the cane, this gives the pounds of bagasse burned per square foot as varying between 63 and 125 pounds per square foot of grate area, in the factories here.

High combustion rates give the best results; also, better results can be obtained where large quantities are burned. This is obtained in Cuba by making one furnace serve two boilers. In Mark's Mechanical Engineer's Handbook it is stated that with a draught of 0.3 in. water column a combustion rate of 250 to 300 pounds per square foot of grate area per hour can be obtained and with a blast of 0.5

"IDEAL" STOVES, The Most Popular Range in the Country—at Henwoods, Box 3, Durban.

19 Buick 24

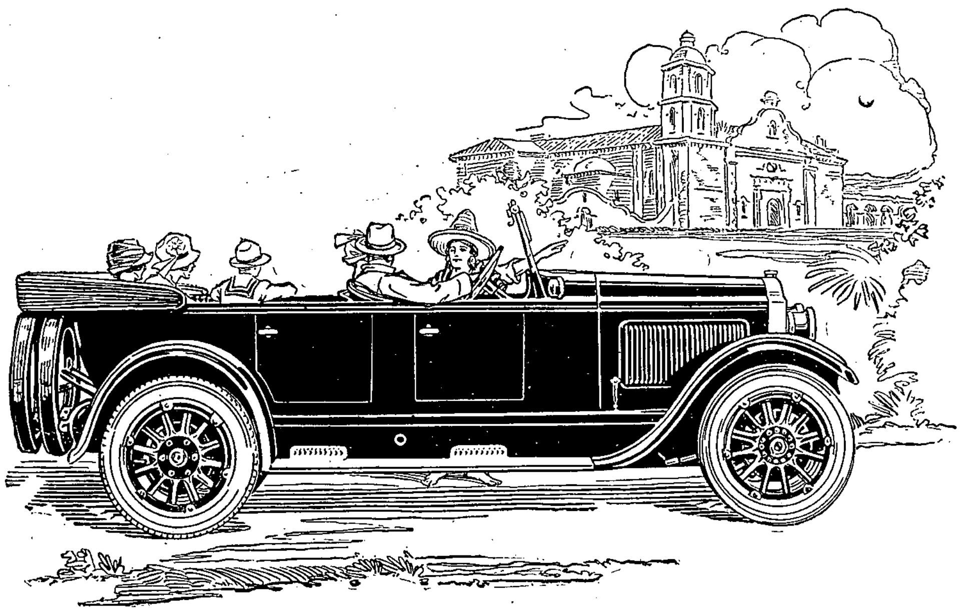
A Product of "General Motors."

Comfort :—

Newly-designed springs give the 1924 Buick exceptional riding qualities.

Seats are wider, lower, and tilted for comfort. The steering wheel has a new position, making for increased driving ease.

The staunch frame is strongly-braced, eliminating any tendency to distortion under shock. In every respect the new Buick four and six-cylinder models are planned for luxurious comfort under all road conditions.



We cordially invite your inspection and a demonstration will be arranged at any time to suit your own convenience.

Sole Distributors for Natal, Zululand, East Griqualand and Harrismith:

WICKINS & McNICOL,

184 SMITH STREET 'PHONE 1153 DURBAN

E

Boilers and Furnaces.

inches available 450 pounds may be burned. These rates are for bagasse containing 50 per cent moisture. It is also stated that 300 pounds is the most economical rate. These rates are much above the ones in actual use here and it would be worth while to reduce the grate area to improve this figure. Some of the engineers have actually blanked off a portion of their grates with improved results and it would be worth while to even go a bit further.

Combustion should be complete before the gases reach the comparatively cold boiler and taking the volume of the combustion chamber as up to the boiler Deerr gives this as 10 to 30 cubic feet per 100 square feet of heating surface. This is equal to 1.2 to 3.6 cubic feet per horse power. The volumes here vary between 1.08 and 3.3 cubic feet per horse power. Large volumes are necessary so that the brickwork may radiate heat to the bagasse and dry it. One factory had boilers with only 1.08 cubic feet per horse power and got a lot of charred bagasse in their flues, and when installing new boilers increased this to 1.7 cubic feet and then found only fine white ash in their flues. Some of the step grates appear to be too long and narrow, and better results should be obtained by making these shorter and broader and they should give a greater furnace volume.

For good combustion it is essential that the bagasse be distributed well over the grate and that it does not fall to the bottom in a step grate and leave a free passage for cold air to enter the furnace and reduce its efficiency. It is essential that the feeding hopper be fitted with a swing door to exclude air and that it be kept closed. In some factories the attendant to save effort has them propped open; this should not be allowed. One factory actually took tests with the door open and closed. When open the percentage of carbon-dioxide in the flue gases was 10 per cent and when closed rose to 15 per cent. Combustion was complete as there were only traces of carbon-mon-oxide. The closing of the hopper must have greatly increased the efficiency of the boilers. It would be worth while most factories fitting rotary bagasse hoppers to their furnaces to save labour, regulate the feed and prevent cold air entering the furnace in excess. A large number of factories have no ashpit doors and these should be fitted in every case to control the air.

For the combustion of bagasse 100 per cent excess of air is not considered excessive and for this Deerr gives the volume of gas per pound of bagasse as about 188 cubic feet at 523 degrees fahrenheit and allowing a velocity of 20 feet per second, this gives the area of the outlet flue from the boiler. This area works out at 4.51 square inches per boiler horse power. The usual area allowed is 10 square inches per boiler horse power where the gases leave the furnace to enter the heating surface down to 6 square inches where the gases leave the boiler to enter the main flue. In ordinary multitubular boilers this area is controlled by the area of the tubes, as all gases have to pass through them, and this area is a good guide to the area of flue necessary. In an 8 foot by 16 foot boiler this works out at 8.8 square inches per boiler horse power.

Most of the multitubular boilers have only two passes for the gases, along the sides and bottom and out the tubes, but some have three passes along the bottom, back and sides, and out the tubes; also sometimes along the bottom back through the tubes and out along the sides. The three pass system should give better results as the sides are not efficient in the two pass system, the gases tending to go along the easiest path, that is along the bottom.

The flues should be fitted with dampers to regulate the draught and have cleaning doors for the removal of the ashes and projecting walls to mix up the gases and ensure that the hotter gases come in contact with the shell of the boiler.

Every factory should have a CO_2 recorder to guide the engineer and it should be part of the chemist's regular duties to test the gases and ensure that too much air or too little air is not being supplied to the furnace. A pyrometer would also be useful to take the temperatures of the furnace and the flues.

Most factories depend entirely on the chimney for draught, but a few have in addition an induced draught fan and two depend entirely on the fan.

Mechanical draught gives the engineer complete control over the draught irrespective of the weather conditions. Its disadvantages are large steam consumption and upkeep. Where a chimney of sufficient size can be used to give the required draught and combustion rate, natural draught is to be preferred, but as a chimney has to be built to give large enough draught under all weather conditions, the flues must have proper regulators to give the right amount of air for the proper combustion of the bagasse as otherwise the draught will be too strong and therefore create too much steam or draw too much air into the furnace. A draught of about ¾ of an inch in the main flue will be found suitable. Too high a draught will carry charred pieces of bagasse into the flues and often out of the chimney. Charred bagasse in the flues will re-ignite if air leaks to it, with harmful results to the boiler.

Owing to the large number of factories entering into chimney design, no formula has yet been given that takes them all into account and the existing formula are purely empirical.

The following rule will give atisfactory results :—

$$\frac{C \times \text{Boiler Horse Power.}}{\text{Square root of H.}}$$

Area of chimney in square feet, equals square root of H. where C equals 0.51 and H equals height of chimney in feet.

The following table will give a few examples from actual factories in operation here.

Raybestos Brake Linings.—Agents **Associated Engineers Company, Limited.**

Boilers and Furnaces.

Particulars of Boilers in Natal Sugar Factories.

Factory	Boiler h.p. per ton of cane per hr.	Lbs. of steam per sq. ft. of boiler heating surface per hour.	Ratio: Heating surface to grate area.	Lbs of Bagasse burned per sq. ft. of grate area p. hr	Combustion chamber volume cubic ft. per boiler h. p.	Flue area entering heating surface in sq. ins. per boiler h. p.	Flue area leaving boiler in sq. ins., per boiler h. p.	Chimney Constant.
Column No.	1	2	3	4	5	6	7	8
A	36.2	3 67	70/1	102	1.08	7.83	9	0.4
B	29	4.6	38 5/1	71	—	—	—	.76
C	44.5	3	80.9/1	97	1.76	8	6	.44
D	42	3.15	69/1	87.3	1.89	14.4	6	.53
					3.3	11.5	6.8	—
E	40	3.32	46/1	63	1.75	8.9	13	.503
F	30 4	4.38	55.8/1	98	1.34	8 76	8.1	
G	33.2	4.0	71.2/1	125	1.66	10.6	10.6	.457
H	42 7	3 12	68.7/1	83	—	7 9	12.3	.403
I	36.6	3.64	71 7/1	120	2.85	7	5.77	—
			68.5/1		1.7	10.7		.551
J	31.6	4.22	70/1	111	1.08	7.83	9	.4
					1.61	12.6		
K	44.6	2 98	67/1	80	2	10.4	—	—
As paper	46	3	100/1	120		10	6	.51

I have to thank the various factory managements and engineers for giving me facilities to get these particulars.

DISCUSSION ON THE PAPER.

Mr. M. McMaster thanked Mr. Murray for the very interesting paper that he had put before them. There was a mass of figures and formulae given which would be very useful to engineers when it was printed in the report of the Congress later. It was a very difficult matter and a very big question, and he felt that no discussion would be really worth while at present.

Mr. A. Townsend asked Mr. Murray which would be the most economical system to work with, to have high or low pressure boilers. Mr. Murray replied that in the modern factories they were putting in boilers of high pressure. The most efficient was to have high and low pressures, the high pressure for driving the whole of the engines in the factory.

Mr. Tresize asked whether Mr. Murray favoured a very low furnace with a very sharp angle ramp as compared to a higher furnace with the angle not so great. He also asked whether the fire would impinge on the shell of the bottom of the boiler or whether the combustion which takes place did all its work eventually in the tubes.

Mr. Murray replied that the combustion should be complete before the gasses reached the boiler. Immediately the gasses touched the relatively cold boiler heat was lost unnecessarily. Combustion should be complete before the gasses reached the boiler. By bringing down the roof the volume of the furnace would be reduced.

Mr. Tresize in referring to Mr. Murray's remarks concerning step grates and the passage of cold air into the furnace, asked whether it had been found that by blanking the top steps more efficiency was obtained. Mr. Murray replied that he had had no experience of blanking up the top steps, but he believed that some of the factories had done so. He, however, recommended a flat furnace in every case.

Mr. McMaster asked Mr. Murray if he could tell them how to get a perfect combustion chamber.

Mr. Murray replied that he had mentioned in his paper that the three way system was much more efficient than the two way.

Mr. Townsend referred to Mr. Murray's remarks in connection with combustion, and asked whether

PERFECTION OIL HEATERS—at **Henwoods, Box 3, Durban.**

Boilers and Furnaces.

it was not a fact that if a boiler was set so that the flames from the furnace struck on the boiler itself the furnace was too near the boiler. Should it not be set up to say 20 feet away to allow combustion to be perfect and prevent losses in the flue.

Mr. Murray replied that in the first place the combustion chamber should be big enough to give proper combustion. In Louisiana they were increasing the combustion chambers. The furnace should be far enough back to give enough volume in the combustion chamber so as to get proper combustion before the gases reached the boiler.

Mr. Camden Smith in referring to the question raised by Mr. Tresize regarding the blanking out of the top step in a grate, stated that in his experience the makers made them too large. There was quite sufficient cold air leaking in through the feed hopper itself and there was no necessity to have an open space at the top of the steps. With the particular set of boilers in his charge, they had experienced difficulty for two seasons until they discovered that their main difficulty was an excess of cold air. They had promptly blanked up the first quarter of the step grate area and there was a marked improvement immediately.

With the average bagasse furnace as designed by the makers, the grate was far too close to the boiler. The question raised as to whether they should be further away was, in his opinion, quite correct. They should certainly be further away than they were placed at present. At the factory he was connected with there were two sets. With the first one the boiler was only 10 feet away from the grate, and with the second the distance had been increased to 18 feet. It was only necessary to examine the resulting ash from underneath the furnaces to notice the difference. In the old set with the furnace so close to the boiler, the flames actually impinged on the boiler before combustion was started, and there was a huge accumulation of ash. In the other case there was really no ash except a white powdered ash consisting of more or less mineral matter. That proved that the combustion was far more efficient where the furnaces were set further away. Of course it went without saying that leakages of cold air must be guarded against.

Mr. W. E. R. Edwards stated that he believed the fibre content of cane in Cuba was about 10.5 per cent. Mr. Murray in his paper had compared factories here making white sugar, where the fibre content was about 15.5 per cent, with factories in Cuba making cargo sugar. There were some factories which had no difficulties with regard to steam, but taken all round he thought every factory in Natal and Zululand had difficulties. From a layman's point of view it seemed extraordinary that with such high fibre there should be steam difficulties. One would think that the steam difficulties would disappear entirely. He asked Mr. Murray for his opinion as to whether it was due to the setting of the boilers, faulty combustion, or some other cause.

Mr. Murray replied that Mr. Edwards had asked a very big question. One would need to go into the whole of the points raised as to the size of furnaces, flues, and everything else. There should not be any trouble in keeping up steam with 17 or 18 per cent fibre in cane. To give a reply would mean inspecting the whole of the boilers, furnaces, etc.

Mr. Loumeau stated that he had recently been in Cuba. He thought it was the rule rather than the exception to burn additional fuel there. There was no good reason why, with the conditions here, the supply of bagasse should not be sufficient in a well designed factory to supply all the steam necessary. He was rather struck to see that there were no measuring devices in use here to check the supply of steam. Very few factories used meters to measure the quantity of water going to the boilers, the taking of the temperature of the boilers, and other useful accessories of a like nature were absent. In a country like this it would be very useful to have such things.

Mr. H. S. Truscott considered they did not study steam economy sufficiently. The greatest trouble in regard to economy in steam started in the boiler room, and the manner of using steam was an important factor. The modern tendency in big factories was to strive for high initial pressures, and for the apparatus in the rest of the factory to go as far as possible on low pressures.

Mr. Truscott proceeded to describe the type of boilers in use in the Hawaiian Islands, and stated that if there was an excessive fuel consumption there was trouble for the engineers. There they were faced with the problem of buying coal at between £3 and £4 a ton, and fuel oil at 6/- a gallon. With regard to Mr. Camden Smith's comments about the blank steps, Mr. Truscott stated that that had been in use for the last fifteen years. No factory was complete without the blank sections.

He considered that a little more attention could be applied in giving more even distribution of the gasses, and a little more attention should be given to keeping out air. In some factories it was found that a huge volume of air got in.

There being no further discussion the Chairman thanked Mr. Murray for his paper.

HOUSEHOLD IRONMONGERY of Every Description—at **Henwoods, Box 3, Durban.**