9TH MAY, 1901.

SMOKE PREVENTION AND ECONOMICAL STEAM RAISING, AS ATTAINED BY THE "MELDRUM PATENT FORCED DRAUGHT SYSTEM."

BY J. M. MELDRUM.

The question of smoke prevention was one of considerable interest, and was a subject which was receiving a large amount of attention at the present time, and he proposed this paper to very briefly discuss the subject of smoke—its cause and prevention—and at the same time to bring under your notice the system introduced by Messrs. Meldrum Bros., of Manchester, England, which they claimed successfully solved the question of the prevention of the smoke nuisance, and at the same time attained those very desirable conditions in steam-raising, greatly increased evaporation, and a substantial economy in the cost of fuel. The constant pollution of the atmosphere by the emission of dense black smoke from the chimneys of factories, power houses, and the numerous other places where steam-raising was a necessity, had been for decades past a subject of serious complaint and vexed discussion. From his point of view these complaints were most justifiable, and the necessity of some permanent abatement of the nuisance most pressing. So far, however, in this colony but little like a determined effort had been apparent when dealing with the question of smoke prevention. Municipal authorities had either been too weak to rigidly enforce the powers, amply sufficient as they were found to be, in which they were vested, or they had been deliberately neglectful, simply shutting thir eyes to the whole question and permitting matters to drift, entirely uncontrolled, till the existing stage of discomfort, inconvenience and danger to the public health had been reached. This neglect of a public necessity might possibly be overcome by simply throwing the whole responsibility of the due observance of the Public Health Act upon the various municipal bodies, and giving the individual a legal recourse against them. Under such a condition it was apparent stringent steps would assuredly be taken to compel the smoke producer to abate the nuisance he is the chief cause of.

He had no hesitation in stating that the time had passed when it could be said that it was impossible to burn coals or any other combustible matter without causing the production of dense black smoke. There were appliances on the market which long experience had proved to be not only perfect smoke consumers, but also capable of effecting a large economy in thn consumption of fuel. Under such conditions, therefore, could it be for one moment contended that the reckless production of large volumes of dense black smoke would be any saving to the manufacturer? He thought there could be no question that the deliberate waste of the large amount of unconsumed carbon present in smoke entails a serious loss upon the steam raiser Was it, therefore, in any way an unfair demand, that the public should require that the atmosphere of densely populated centres, like this city, should be freed from the pollution caused by the vomiting forth of dense black volumes of smoke, with its attendant dangers and discomforts.

One great, and possibly the chief cause of smoke production, was the carelessness of firemen when supplying fuel to their fires. Where coal was abundant, the stoker usually piled on an unnecessary quantity upon his fire; this had the effect of suddenly reducing the heat, and causing the production of a dense volume of smoke. There seemed to be no question but that careless stoking was the prime factor in causing smoke, and careful feeding of the fires would, to a very considerable extent, minimise the trouble. If the black smoke which escaped from a furnace when a quantity of cold coal was thrown upon an incandescent mass, could be made to pass over another portion of coal in active combustion, the floating particles of carbon were consumed, i.e., combined with atmospheric oxygen, and converted into carbonic oxide, which burnt producing carbonic acid gas, eventually escaping as a colourless vapour. In proof of this, a very simple method, which was sometimes adopted where coal was scarce and an expensive item, was to place a small quantity of coal in front of the furnace fire, where it was coked, the volatile carbon when released, passing over the heated coal was burnt, and but little visible smoke escaped. When the coal was sufficiently coked, it was shovelled on to the fire, and a fresh supply was placed in front of to undergo the same process. It seemed certain, therefore, that coke-firing, to a large extnet, prevented the creation of smoke. The best results had, however, undoubtedly been obtained by the adoption of effective mechanical apparatus. Numerous inventions had been patented for effecting this purpose, applied to steam boilers and other large furnaces, but very few had been found to be sufficiently economical and effective.

The first person, he believed, who attempted to investigate this subject in a scientific manner, was a Mr. C. W. Williams, at one time a managing director of the Dublin and Liverpool S.N. Co., and he also had the merit of constructing the first furnace which combined the prevention of smoke with increased energy of combustion, effecting also a more or less considerable saving of fuel, according to the care of the stoker. The invention for which he obtained a patent in 1840, consisted in the introduction of a sufficient quantity of atmospheric air to the bridges and flame-beds of the furnace through a number of small orifices connected with a common pipe or canal, whose area could be increased or diminished according as the combustion required by means of an external valve; the operation of the air thus passed in small jets into the half-burned carboretted hydrogen gases over the fire, and resulted in almost perfect combustion and the entire prevention of smoke.

He mentioned this system, believing it to be of interest, and also because, to some extent, it involved the principle of the arrangement he was about to describe, viz., "The Meldrum Patent Forced Draught Furnace."

The Meldrum Furnace was specially designed to efficiently meet the following conditions:—

1. Perfect Combustion.
2. Economy in Steam-raising.
3. The Perfect Prevention of Smoke.

Taking the first-named condition: To effect the perfect combusiton of fuel for steam-raising purposes, it was evident some means for producing draught must be resorted to. This leaves a choice of two methods: 1st, Whether it is better to erect a high chimney stack, and keep a column of gas-air in it at a high temperature; or, 2nd, to provide some mechanical means of either inducing or forcing the requisite air through the fire. Of course, it is admitted that a chimney of some kind is necessary to carry off the carbon dioxide CO_2 and other products of combustion, at a sufficient elevation from the ground.

Chimney, or natural draught, depends upon the difference in the specific gravity due to the difference in temperature between the column of hot gases in the shaft and a corresponding column of the external air, and, consequently, must vary to some extent with the prevailing conditions of the atmosphere, humid or bright weather altering the condition considerably. Anyone who has had to do with steam generation knows how materially the direction and velocity of the wind affect the fire when natural draught is relied upon. A strong wind blowing from the ash-pit will often necessitate the continual rousing of the fire to the discomfort of the stoker and the entailed loss of fuel.

There is also the question of heat-power to attain the desired result. Practically each degree F of heat imparted to air increases its bulk $\frac{1}{523}$ part, so that by heating it 523° F, its bulk will be doubled and its density reduced by one-half. At this temperature, or say about 600° F, a chimney about 100 feet high will be required to give a pull or head of 3/4" inch water column, a proportion of about 1 to 2 between the hot chimney gases and the external air (or say a temperature of about 600°

F) will, according to Morris, give the best results for a natural draught. "This shows," says Wilson, "that the loss of heat is very considerable, and it may be approximately calculated as follows: Taking the quantity of air used as about 21 lbs. per lb. of fuel, we have the weight of the products of combustion of 1 lb. of coal multiplied by the specific heat of the mixed gases = 3.053, and the remaining 9 lbs. of air multiplied by its specific heat 0.238 = 2.142; adding these two products together we have 5.195, and multiplying 2938, or the elevation of the temperature of the gases above the boiler at 60 lbs. pressure, we have 1.532 units of heat, equivalent to 1.5 lb. of water evaporated per lb. of fuel, or taking the temperature of combustion at 2.7508, the loss is equal to 10 per cent. compared with the result that would be obtained if the hot gases escaped at the temperature of the boiler.

In ordinary practice is was generally found this loss is much greater, according to the temperature of the chimney gases, in some cases amounting to 25 per cent. or even more. Further, there was the difficulty of making the brickwork quite sound in chimney and flues. The air would enter by any orifice there might be, and the draught would be impaired. Again, fires would not burn without attention, and every time the furnace doors were opened, either for cleaning, rousing, or feeding, a great rush of cold air entered through the fire-door, cooling down the heating surface and flues, retarding combustion, and impairing the draught.

Now, suppose, instead of relying upon the chimney for draught, the ash-pit was closed and the required air forced in, either by means of a fan or a steam-jet apparatus, the same effect would be produced so far, namely, a greater pressure of air under the bars than over the fire, the difference being that instead of atmospheric pressure under the grate, and something less than that over the fire we had approximately atmospheric pressure over the fire and something more than that under the grate. Several advantages would follow—

1st. We should be entirely independent of both wind and weather.

2nd. The whole heat of combustion would be available down to the temperature of the entering fluid, or even much lower, minus the power required to produce the draught.

3rd. There would be no loss of draught nor cooling gases through leaky brickwork.

4th. The blast could be so regulated that no cold air need be drawn through the fire-doors when they were opened for cleaning, or otherwise attending to the fire, so that the heating surfaces could be kept at a more uniform temperature, greatly to the advantage of both boiler and setting.

5th. The fire grate could be considerably reduced in area, and the fire, therefore, concentrated, by which means the large excess of air over the theoretical quantity required for combustion could be very materially reduced; with a resultant much higher temperature and a consequent greater proportionate evaporation, the transference of heat being in proportion to the difference in temperature between the heating and the heated bodies.

6th. As a much greater force could be readily obtained than would be the case with natural draught, except by means of an enormous and very costly edifice, greater power could be developed from a given size of boiler; or, on the other hand, much that would otherwise be considered refuse could be used as fuel with considerable advantage.

Mechanical draught could be produced in various ways, a fan could be placed in a chimney, or the exhaust pipe could be somewhat confined at the outlet and introduced into it, thus inducing a current of air through the fire, as in the case of the familiar locomotive blast-pipe. The latter system, however, was wasteful, as well by its intermittent action as by the unavoidable back pressure thrown upon the pistons, whilst, moreover, the blast was regulated, not according to the necessities of the fire, but by the requirements of the engine. But until some practical means of utilising the exhaust in locomotives (either by condensation or otherwise) had been devised, not much improvement could be looked for in this direction.

With stationary boilers no such waste of the exhaust steam would be possible, and consequently more economical means had been adopted.

The Meldrum Furnace, as would be seen by reference to the Plate was an adaptation of the forced draught closed ash-pit system, the air being supplied by two steam jet blowers to each furnace. These blowers were the outcome of long and careful experimenting, some thousands of tests having been made with blowers of all shapes and nozzles of all kinds; and it was now confidently affirmed that the proportion of the blowers could not be materially departed from without great loss of efficiency. Many people imagined that so long as a steam jet was inserted into a pipe the end is accomplished; but this was only true, if economy of steam and pressure of air were no objects, and steam jet blowers had been generaly condemned through the wastefulness of badly designed apparatus; whereas tests made by the Admiralty and several large firms in England and on the Continent had verified the fact that, under ordinary working conditions, the quantity of steam used by the Meldrum blowers was only equal to about 2 per cent. of the total evaporation.

In one case, where the Meldrum blowers were tested by a large firm in the North of England against blowers of the annular nozzle type, it was found that to move a given quantity of air, only 780 lbs. weight of steam was required by the Meldrum, as against 5000 lbs. weight by the annular nozzle blowers, the condition of work being the same in each case.

The fire bars employed with forced draught should be made with very narrow air spaces—those used with the Meldrum Furnace have only about 1-16th of an inch clearance, so that nothing of value could fall through, and the saving in fuel from this cause alone was generally sufficient to provide all the steam required by the blowers. The bars were made inter-locking, so that it was impossible to accidentally displace or lift a bar when cleaning the fire, as was often the case. The action of the steam upon the bars kept them perfectly cool, so that the clinker did not stick, and the bars lasted a very long time; in fact, with care, the bars would last for years, most of the bars originally fitted with the furnaces were still in use.

The steam for the blowers was super-heated by being passed into the furnace round the doors, and means were provided to ensure the re-evaporation of any condensed water that might enter the super-heater. Another special feature of the Meldrum Furnace was the valvular dead plate, by the careful maniplation of which the primary and secondary air supply could be so proportioned that, even with bituminous coal, practically no smoke was made. From the design it would be seen that with the valve open a thin stream of air was admitted over the fire; an intimate mixture of air and gas took place before they came in contact with the cool plates of the flue, and the smoke was thoroughly consumed. This arrangement had practically the effect of multiplying the points of contact ad infinitum, thereby causing instantaneous combination of the air and gases, making the combustion as perfect as possible, and obtaining all the heat that the combination of oxygen with the hydrogen and carbon could give. The smoke was never allowed to pass the bridge of the furnace—in fact, its formation was prevented. Having no moving parts, and positively nothing to get out of order, this system was practically applicable in a boiler-house where the greatest care was not generally available, and in actual practice it had been demonstrated that the upkeep of the apparatus costs practically nothing. The economy to be obtained depended largely upon the kind and cost of the fuel obtainable. In many large collieries, gas-works, and ironworks the whole cost of the fuel was saved, refuse formerly carried away at considerable expense being the only fuel used.

In the tables appended would be found results of savings actually realised (calculated in cost of evaporating 1000 gallons of water) at various works where working tests have been made for the purpose.

No. 1.—

Place.	Type of Furnace.	Kind of Fuel.	Cost of Fuel per ton, delivered.	Water evaporated per lb. of Fuel.	Cost of Fuel for evaporating 1000 gallons.
Manchester	Ordinary	Steam Coal	10/-	8	5/6
,,	Meldrum	Coke Dust	4/-	6½	2/9
,,	,,	Pan Breeze	Nil	3	Nil
Blaydon on Tyne	Ordinary	Steam Coal	10/-	8.9	5/0
,, ,,	Meldrum	Coke Dust	1/8	5.5	1/4
Birmingham	Ordinary	Steam Coal	5/6	7.5	3/3
,,	Meldrum	Coke Dust	4d.	4	5d.
Leicester	Ordinary	Steam Coal	9/-	6.8	5/11
,,	Meldrum	Slack	5/-	7	3/2

No. 2.—Result of working of "Meldrum" Furnaces on two Lancashire Boilers—30' 0" x 7' 0"—at Kathleen Pumping Station, Roanhead Hematite Mines, Ulverston, showing annual saving made by adoption of these furnaces.

Kind of Furnace	Kind of Fuel Used.	Pump Strokes per minute.	Weight of Fuel burnt in seven days.	Percentage of loss in clinker and ash.	Cost of working seven days.
Natural Draught	Whitehaven Coal at 12/- per ton	5.61	T. C. QR. LBS. 36 3 1 16	10%	£21 14 0¼
Meldrum Furnace	Wigan Slack at 8/- per ton	5.61	T. C. QR. LBS. 44 1 0 17	9.06%	£17 12 5½
				Saving per week	£4 1 6¾

This shows a saving of £212 2s. 11d. per annum on the two Boilers.

The following extract from the "Sheffield Telegraph," of June the 27th, 1900, showed a saving in fuel of £18 per week, caused by the adoption of the Meldrum Furnace, and also established its claim of being an efficient smoke consumer:—

"A couple of months ago, when coal which formerly cost us 8s. per ton rose to 12s. 6d., we read a lecture on the cost of steam production by John Holliday, in which the following paragraph appeared:—