

SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 2403.)

“Experiments on a Steam-Engine, the Cylinder of which was heated externally by Gas-flames.”

By BRYAN DONKIN, Jun., M. Inst. C.E.

In the following experiments an attempt has been made to determine how far cylinder-condensation can be prevented, and an economy of steam realized by heating an engine cylinder externally by gas-flames, so as to raise its temperature considerably.

The engine was of the horizontal single-cylinder type. Diameter of cylinder, $8\frac{7}{8}$ inches; stroke, 14 inches. It was coupled direct to a rotary gas exhauster used merely to pump air so as to absorb the power. One set of experiments were made non-condensing, and one set condensing. In the latter case communication was made with the condenser of a factory engine, so that the air-pump discharge of the experimental engine could not be measured. The feed-water was carefully measured in all the trials, and indicator diagrams were taken frequently from both ends of the cylinder.

The arrangement of the gas-jets was necessarily somewhat imperfect; but every care was taken to ensure accuracy in recording the results. Several experiments were made both with and without the condenser, and with and without the gas-flames. When using the gas-flames the quantity of gas burned was varied. The Bunsen burners were placed quite close to the cylinder externally, and the flames reached about halfway round the cylinder. External radiation was prevented, as far as possible, by sheets of asbestos, the products of combustion passing away through holes left in these sheets. The expansion was constant in all the experiments, as there was no separate expansion-valve.

Results of the Experiments.—These are given in the Tables below. It will be seen that the temperature of the cylinder wall when the gas-flames were used was generally much above that of the steam admitted.

There is a decided economy of steam when the gas-flame jacket is used, but against this must be set the cost of the gas used. This

will vary in different localities, and the commercial gain will be the difference of cost of the fuel saved and the gas used.

Since these experiments were made a better mode of burning the gas has been adopted.

Professor Dwelshauvers Dery, of the University of Liège, was much interested in this novel way of heating the cylinder, and, at his request, copies of the results were sent to him. He has carefully analyzed these results and compared them with experiments in which two other ways of reducing cylinder-condensation were used. In Mr. Willans' experiments the amount of cylinder-condensation, reckoned per indicated HP., is reduced by increasing the speed of the engine. In Mr. Hirn's experiments the condensation is diminished by superheating the steam. The comparison of the economy obtained by these three methods is instructive.

TABLE I.—SUMMARY OF EXPERIMENTS ON A 6-HP. NON-CONDENSING STEAM-ENGINE, WITH AND WITHOUT GAS-FLAME JACKET, AT BERMONDSEY, 1888.

		Without Gas-Jacket.	With Gas-Jacket.		
	Experiment . . .	No. 3	No. 6	No. 9	No. 8
	Date, 1888 . . .	July 26	July 28	July 31	July 31
	Duration . . . hours	4	4	3	3
Feed-water . . .	{ Feed-water per I.H.P. per hour . . . } lbs.	44.4	34.1	33.8	34.8
I.H.P. . . .	I.H.P. by diagrams . . .	6.26	6.17	6.33	6.31
Ordinary London gas }	{ Gas burnt in Bunsen burner per hour } cub. feet	0	49	40	35
Temperature	{ External temperature of cyl. walls at top . . . } ° Fah.	248	414	..	336
Steam - pressure above atmosphere	{ Boiler-pressure . lbs. Initial pressure in cylinder } "	35.5 31.7	35.0 34.7	35.5 34.7	34.5 33.8
Speed . . .	{ Revolutions per min. (by counter) . . . } Total revolutions . . .	90.73 21,776	90.79 21,790	89.7 16,147	90.1 16,218
Steam from diagram . . .	{ Steam per I.H.P. per hour calculated from diagrams at $\frac{7}{10}$ ths stroke . . . } lbs.	35.87	34.42	34.37	..
	{ Percentage of steam used shown on diagrams at $\frac{8}{10}$ ths stroke }	80	101	101 $\frac{1}{2}$..

CHIEF RESULTS OF THE EXPERIMENTS.

TABLE I, *with and without gas, non-condensing*.—Comparing experiments No. 3 with No. 9, there is an economy of 24 per cent. in feed-water per indicated HP. per hour, and this with practically the same pressure of steam, power, speed, and expansion. It will be noticed that the external temperature of the cylinder-walls was much greater with the gas burning than without. The initial pressure of steam of the indicator diagrams was also about 3 lbs. greater, say 10 per cent. with the gas than without. As to the steam calculated from the diagrams at $\frac{8}{10}$ of the stroke, 80 per cent. only of the total steam supplied appeared in experiments without the gas-flame jackets, and 20 per cent. was missing; while on the other hand, with gas-jackets on, the diagrams showed that at $\frac{8}{10}$ of the stroke, all the feed-water was present as steam, there being no missing quantity.

TABLE II.—SUMMARY OF EXPERIMENTS ON SAME 6-HP. STEAM-ENGINE, but CONDENSING, WITH AND WITHOUT GAS-FLAME JACKET, 1888.

—		No Gas-Jacket.	With Gas-Jacket.	
	Experiment	No. 4	No. 3.	No. 2
	Date, 1888	August 9	August 9	August 8
	Duration hours	3	3	3
Feed-water	{ Feed-water per HP. per } lbs.	38·5	30·7	30·3
I.H.P.	{ I.H.P. by diagrams	5·61	6·05	5·47
Ordinary	{ Gas burnt per hour in } cub.	0	35	28
London gas	{ Bunsen burners . . . } feet			
Temperature	{ External temperature } { of cyl. walls taken } ° Fah.	213	239	240
	{ at top }			
Steam - pres- sure above atmosphere	{ Boiler-pressure	35·0	34·5	34·5
	{ Initial pressure in cylindr. lbs.	14·8	15·3	13·2
Speed	{ Revolutions per minute (by } { counter) }	92·27	92·66	90·16
	{ Total revolutions }	16,610	16,680	16,230
Steam from diagram	{ Steam per I.H.P. per } { hour calculated from } lbs. { diagram at $\frac{8}{10}$ ths stroke }	28·3	27·3	27·3
	{ Percentage of steam used } { shown on diagrams at } { $\frac{8}{10}$ ths stroke }	73½	89	90

TABLE II, *with and without gas, condensing*.—Comparing experiment No. 4 with No. 2 there is an economy due to the gas-flame jacket of 21 per cent. in feed-water per indicated HP. per hour,

with about the same pressure of steam, power, speed, and expansion.

The temperature of the external cylinder-walls was greater with the gas.

The initial pressure of steam was also greater with the gas. In the steam calculated from the diagrams at $\frac{8}{10}$ of the stroke, 73 per cent. only was shown on the diagrams in the experiments without the gas-flame jacket.

In the experiments with the gas-flame jacket 90 per cent. of the total steam used was shown on the diagrams, or a diminution of condensation of 17 per cent.

Comparing the two sets of experiments, Table I and Table II, the jacket gives a rather greater effect in the non-condensing set than in the condensing. The experiments made with increased quantities of gas, show that after the cylinder metal had been raised to a certain temperature, the extra quantity of heat seemed to have no beneficial effect whatever. Probably the extra heat was partly radiated externally, and partly passed away with the exhaust.

A few trials were made at 45 revolutions, and there was still an economy due to the gas-flame jacket, but not nearly so marked as at 90 revolutions.