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GAS POWER IN TEXTILE MILLS.

By T. ROLAND WOLLASTON.

I WISH in the first place to thank you for this, your second invitation to me, to address you upon the subject of "Gas Power in Textile Mills," and sincerely hope I may attribute it to my Bradford paper having been of some interest and value. I have tried on this occasion to avoid repetition, but if in what I say hereafter there be some small amount of overlapping I beg your indulgence.

One thing I claim to-day, namely, that I give you safe figures of gas power performances. All results recorded and foreshadowed are substantiated by many examples in every-day work, and like results would be readily guaranteed under penalty by numerous British makers of repute.

So far as this subject of mill driving is concerned, I prefer to regard a "Textile Institute" audience as composed of practical men, desiring practical results rather than notes on record breaking, and I deprecate the use of "testplate figures" on such an occasion.

May I disclaim personal obsession with gas power? My duty to-day is to point out to you its advantages as I know them, and to endeavour to clear away prejudices which certainly exist in some quarters, but I am as sure as anyone here that the steam engine, steam turbine, and Diesel engine must in many cases show advantages. We must all recognise that the fuel bill is far from being the only or even the most important item in mill driving economy.

The criticisms generally advanced to oppose the installation of gas engines in textile mills are set forth below. To each one is appended a short reply:—

(1) "They are sometimes stated to be uncertain in starting."

This criticism unquestionably arises out of early experience with engines fitted with so-called self-starters, and generally when used in conjunction with suction gas plants. The self-starter has given way in plants of any size and class to the independent compressed air starting plant, which renders the gas engine as easy to start or easier than, any steam engine. Reference will be made to suction gas plants and their bearing upon this point hereafter.

Ignition troubles, perhaps formerly the most serious, are now almost universally and satisfactorily overcome by duplicating the ignition gear.

(2) "There is said to be difficulty in maintaining a steady quality of gas both as regards composition and cleanliness."

This criticism, again, is largely founded upon experience with suction plants. Good plants of the positive type (the word positive is used to differentiate them from those depending wholly upon engine suction) present no difficulties, if worked with reasonable intelligence, in maintaining the composition of the gas constant. Clean gas is admittedly essential. It is quite easy to obtain if the plant be properly designed and controlled, and engines turning 500 H.P. to 3,000 H.P. are running to-day without having had cylinder or valve cover removed for cleaning for six months. I venture to refer you to the paper read before the Manchester Society of Engineers by my able colleague, Mr. Weil, on this point.*

(3) "Gas power plants are said to be more costly in the first instance than steam power plants."

Comparing the bare cost of gas engines and gas plants with the cost of steam engines and steam boilers, this may be correct. There are, however, so many adjuncts to the steam set; for example, the chimney or forced draught plant, sometimes the automatic stoker, the boiler setting, special pipes and fittings for high pressure and high superheat, feed pumps, lagging, and so on, which almost invariably bring the price up to, or near, that of the gas set. Mr. A. E. L. Chorlton, for his paper† recently read before the Manchester Society of Engineers, went to great pains to obtain check estimates, and his conclusions, substantially confirmed by my own experience, were to the effect that for plant as required for a modern textile mill there is little difference in first cost between gas and steam when all apparatus is taken into account. It must be remembered that we are considering high-class steam plant, involving high-pressure steam, superheat, and condensing.

Recent improvements, moreover, in gas engine and plant design combined with ever-increasing output of the leading makers are tending to lower prices.

(4) "There is said to be liability of breakdown due to high internal temperatures and cylinder cracks."

That there have been several such failures is admitted. That the number of these is a steadily decreasing quantity must be also admitted. The problem of designing cast-iron cylinders to stand these temperature conditions has been among the most difficult which makers of large gas engines have had to face, and has called forth much ingenuity. The problem appears still more difficult of solution in Diesel engine design, while it is by no means unknown in superheat steam engine and turbine work. Modern designs and care in the foundry render the percentage of such accidents lower year by year.

* Proceedings Manchester Society of Engineers, 1911-12, page 489

† " " " " " 1910-11, page 1.

(5) "Regularity of turning with gas engines is sometimes said to be insufficiently good for spinning mills."

This is another statement based wholly upon what may now be regarded as the ancient history of single and double-cylinder single-acting four-cycle horizontal engines. During thirty years' experience with cotton mill engines, the best turning I have ever seen was by a gas engine, and as the point seems of great importance I have been able, through the courtesy of makers to add a few diagrams of turning effort and cyclic variation from actual data of high power gas engines manufactured in this country, fairly representative of all the types now available.

(6) "Gas power plants are said to require more room."

For small powers this is not true. Of course, more space is required than for Diesel or other oil engines, but less than for steam engines with their boilers and adjuncts. For large powers, with pressure bituminous gas plant, a somewhat larger area may be sometimes required. The gas plant, however, is composed of parts which may be coupled together in so many ways that it is frequently possible to arrange it on space impossible of utilisation for boilers of any kind, and it requires practically no housing and the simplest and cheapest of foundations. An important point is that distance apart of gas plant and engine is of no consequence. There is no condensation loss to consider, and gas mains are cheap. With so many reliable designs now available the engine-house dimensions need not exceed those required for steam or Diesel engines.

(7) *General Reliability*.—One can do no better than quote the published report of the performance of the Westinghouse engine and Mond gas plant at Hollins Mill, Marple, which is, I believe, word for word as supplied by Mr. Hodgkinson, the chairman, to whom, incidentally, all manufacturers of gas power plant and all textile economists are indebted for pioneer work in this important subject. His plant is upwards of six years old, and much important work has since been done in the direction of improving and cheapening gas plant and engines. I could quote plenty of examples as good or better, but choose this one, as the figures have been recently published and are common property, and I respectfully submit that what has been done in this case can now be excelled in any spinning mill or weaving shed of like size. Mr. Hodgkinson was not encouraged by his advisers to adopt by-product recovery on his comparatively low load and load factor, but, persisting, he has clearly demonstrated that it pays, and pays handsomely.

The extract (from "Gas and Oil Power," dated June 6th, 1912) runs:—

"The operatives' opinion is unanimously to the effect that the drive is steadier with the gas engine and rope drive now installed

than it was with the steam engines and geared shafting which were displaced. The gas engine, which is supplied with gas by a 1,000 H.P. Mond pressure producer, which will be dealt with later, is regularly started up at 6, 8-30, and 1-30 o'clock. The starting is accomplished by compressed air at 300 lbs. per square inch pressure, which is admitted to the lower cylinders. The compressed air is stored in six tanks, and is furnished by a direct steam-driven Reavell quadruplex compressor, which averages only 20 minutes running per diem. Turning the air starting valve, getting up to speed, and throwing full load on the engine is regularly accomplished in the remarkably short space of time of 20 seconds. During the past 21 months the engine has only twice failed to start up at the first attempt, both times owing to bad gas. Freedom from promiscuous shut-downs is probably of more importance in the textile trades than in any other manufacturing business, since the employees are practically one and all machine tenters, and a stoppage is, therefore, an important consideration from the view-point of lost wages alone. The reliability of the prime mover under review is unsurpassed by the great majority of steam-driven installations, since during the same period of 21 months the almost incredible record of but one running stop has been put up. This stoppage was due to a faulty ignition plug, and its duration was only a matter of minutes."

There are given in Appendix No. 1 the actual figures of running cost for the year 1911, as supplied by Mr. Hodgkinson, and in Appendix No. 2 figures adjusting these in accordance with the coal cost agreed upon in our introduction, together with what may be considered a safer basis for sale of ammonium sulphate, and taking into account of capital charges.

One might give even more favourable figures from flour mills, chemical and steel works, where the power plant runs night and day, without spare sets, and where stoppages due to engine and gas plant mishaps are practically unknown.

Reference has been made above to gas plants known as the "suction" type. We have to recognise that the suction gas plant has been largely instrumental in bringing gas power to its present position of popularity, due to its cheapness, compactness, and simplicity. With eyes fully open to the criticism likely to fall upon me, let me confess that I do not like them, and I believe them to be responsible for at least one-half of the gas power installations pronounced unsatisfactory in textile mills.

The process of producer-gas generation is believed to be as follows:—

Air drawn through the grate and lower hot-fuel zone is decomposed, the oxygen combining with carbon of the fuel to form first CO_2 (carbonic acid gas) and inert nitrogen.

Water admitted as steam or vapour is split up by the high temperature into its component gases, oxygen and hydrogen.

The CO_2 and O thus freed in the lower zone assimilate more

carbon from the higher zones in the producer and become converted into CO (carbonic oxide), the most useful constituent of producer gas.

The hydrogen remains in the mixture as a useful gas.

The nitrogen of the air with some amount of carbonic acid gas remain in the mixture as non-productive diluents. A good producer gas will have something like the following constitution:—

Hydrogen.....	18.7	per cent	} 44.4 per cent combustible and useful for power
Marsh Gas, &c. . .	.6	„	
Carbonic oxide . .	25.1	„	
Nitrogen.....	49.0	„	} 55.6 per cent in-operative.
Carbonic acid . . .	6.6	„	
<hr/>			
100.0			

It will be seen that the chemical reactions are somewhat delicate and intricate, and, as anyone at all familiar with chemical processes can gather, good results must depend upon the maintenance of the fuel bed in proper state of incandescence, and upon correct regulation of the proportions of air and steam or vapour. I submit that in the suction plants so generally used no proper provision is made for such regulation. To me it is remarkable that, under any variation of load, they work as well as they do. Some inventors have attempted to improve matters by regulating automatically the water supply to the vaporiser, but the effect of this must be altogether too sluggish and dilatory.

Further dependence upon the intermittent suction strokes of the engine does not appeal to one. That the results chemically are unsatisfactory may be confirmed by anyone who will take several snap samples of gas from such plant for analysis.

I do not criticise the suction principle *per se*, but I would prefer to supplement the engine suction by fan suction in the first place, thus keeping the rate of blast through the fuel bed steady, if not constant. Such procedure has two further recommendations: the fan assists in cleaning the gas, and the added "pressure" permits the interposition of more adequate gas cleaning and drying plant. Then I would generate the steam in a closed vessel or coil, which might still operate through the agency of the hot gas issuing from the producer, but which would discharge under slight pressure to the blast inlet, and under valve control, automatic or otherwise.

These are simple refinements, not of a costly nature, which in my view would obviate the majority of troubles one hears of with suction plants. They are not novel, and are, I am persuaded, only omitted by the majority of makers due to the foolish craze for low first cost.

Let us now turn to the features in which gas power appears to excel every other power in regard to textile mill driving. May I say at first that I do not think electricity enters into the question as a competitor? Electricity as we have it at present is not a source

of power, but a *means of transmission*. I believe it to have a great future in the textile industries. What I do claim is that everything I may say in favour of gas power for mechanical driving in textile mills applies with added import in regard to the generation of electrical energy, whether at the mill or at the central station supplying the mill.

(1) As I attempted to show in my Bradford paper, the fuel cost per brake horse power for the gas engine as compared with that for a high-class steam engine is about in the ratio 5:9.

Comparing the gas engine fuel cost with that of the Diesel engine, rating the former at $1\frac{1}{4}$ lbs. of coal and the latter at $\frac{1}{2}$ lb. of oil per B.H.P., prices respectively 11s. and 50s. per ton, we get:—

Gas Engine.		Diesel Engine.
1.25×11	:	$\times .5 \times 50$
Say 14	:	25

Steam is always required for one purpose or another in textile mills, however driven. There may be obtained at least 2 lbs. of steam, per horse power driven, from boilers coupled to the exhaust pipe of the gas engines and receiving their heat from the waste products of combustion. That is to say, if in the steam-driven mill 20 per cent of steam is required for heating, additional to the power steam, in the gas-driven mill about 11 per cent of this or more than half would be provided without extra coal and substantially without attention.

Much of the balance of the heating steam can be raised by burning the tar produced under the boiler. Twenty-five tons of coal produce one ton of tar as an average, and a ton of tar will raise about the same amount of steam as a ton of coal.

I am not aware of the exhaust from Diesel engines having been used to raise steam, though this may be practicable.

(2) The stand-by losses in banking up over week-ends and at nights are in the gas plant about one-quarter those of the average boiler-house. The Diesel engine, of course, excels here.

(3) Incompetency or carelessness on the part of the boiler-house staff, even when boilers are fitted with mechanical stokers, frequently leads to considerable loss in steam plant. Very few steam plants work normally within 10 per cent of their supposed standard of economy. Like carelessness cannot well affect the gas plant in the same way. The stoking is a purely mechanical operation, performed as well by a novice as by an experienced man. The engineer in charge need only give very occasional supervision.

(4) The rate of gas production is in well-designed producer plants regulated automatically, and the efficiency falls away very little on low loads. When working under loads varying from 15 per cent to 100 per cent practically no extra care is required.

(5) The efficiency of the gas engine on low loads is considerably higher than that of the steam engine, and much higher than that of the steam turbine.

(6) There are with the gas plant no high pressures, no losses equivalent to pipe condensation, and no non-conducting coverings to provide and maintain.

(7) Quality of water supply is of no importance (except as regards the small amount for steam raising). If a water cooling tower be adopted the total amount of make-up water required is almost negligible, and no foul nor greasy effluent need be turned away to pollute streams or drains.

(8) The maintenance charges upon a well-managed gas plant are considerably lower than upon the equivalent steam plant. Maintenance charges upon gas engines seem to be very variable from records available, but they average little, if any, more than those of the steam engines.

(9) I now arrive at a point which seems to me of the utmost importance in considering gas power for textile mills other than spinning and weaving, for example, bleaching, dyeing, and print works. Taking an informal census among friends engaged in these trades, I gather that of the total steam raised as a rule only about one-third goes to drive engines, the balance being used for heating and boiling. There is surely no occasion to point out the enormous losses thus entailed in condensation during work and afterstoppage. We may take gas practically any distance to its work without measurable loss; we can apply it to dry, heat, or boil with far greater ease and facility for control than is possible with steam. We can maintain liquors at the boil or at any other temperature required without dilution due to condensation, and the apparatus necessary for all these processes is generally of a simpler and cheaper nature than for steam heating. Steam losses due to pipe and pan condensation are everywhere recognised, but their correct estimation in, for example, a large bleach works is a most difficult matter, and so far as I am aware no reliable data upon the subject has been published. Whatever it may be, and probably most here have views upon the subject, I submit it can be eliminated by substituting gas heating. That is to say, assuming that at the gas plant scrubber we get 75 per cent of the fuel heat units as cool clean gas, and that at the boiler junction valve we get 70 per cent of the fuel heat units in the form of steam, at the destination, be it a keir, calender, or drying machine, whatever distance away it may be, we get substantially the same value in gas; we get 10, 15, or 20 per cent less value in steam dependent upon the pipe line and quality and condition of its covering.

I should hesitate to give you these last paragraphs so emphatically were they based upon my personal knowledge of dye, bleach, and print works economy. I am, however, in touch with gentlemen of life-long experience in these trades who are as convinced

as I am of the economic possibilities, and experiments on a practical scale are at present in progress, details of which it may one day be my privilege to lay before you.

(10) Finally, a few words may be added upon an advantage peculiar to gas power alone, namely, by-product recovery.

The by-products referred to are sulphate of ammonia and tar. The former is probably the most valuable commercial nitrogenous manure in existence, and is year by year meeting with larger demand. One often hears it suggested that as the rate of manufacture increases the price will fall. Those connected with the trade are, however, unanimous in believing that for many years to come the demand will increase more rapidly than the supply. The present price, around £14 per ton, is considerably higher than the normal of the last ten years, and I have heard it suggested that an early rise, even to £18, would not be a surprise.

The other product, tar, is of less value. One must admit that the tar from producer gas is not of very good quality. Still it is marketable and useful, and may always, by means of a suitable jet burner, be used to supplement coal under the gas plant boiler.

I will not do more than refer you again to the Hollins Mill figures given in Appendix 1 to advocate ammonia recovery plants for small private installations. The short working day of cotton mills is not favourable to attainment of the best results, and there is something in the argument that spinners and weavers do not wish to start as chemical manufacturers. Certainly on powers lower than 700 H.P. and the ten-hour working day the addition of ammonia recovery plant can hardly be at present recommended.

But I suggest certain possibilities for the future of great interest to textile manufacturers.

Firstly, with the increasing popularity of electric driving from public supply, the substitution of gas recovery plant for steam plant at the power station may be looked to for decreasing the cost of current. No doubt many here will be aware of the enterprise of Accrington in this direction, and I, with others, am hoping and expecting that the results, when available, will lead to a large extension of the system.

Secondly, there is the case of the large firm having several mills near together, or, better still, of those who carry on spinning, weaving, bleaching, dyeing, and printing on the same ground. There are several such firms in this country, some of whom can provide a partial load through the night. Without further comment I give in Appendix 5 the estimate figures recently prepared for a firm of this kind.

The amount of sulphate of ammonia obtainable from a ton of average coal is about 90 lbs. This amount is to-day worth 11s., or, in other words, it is as valuable as the coal from which it is derived.

APPENDIX I.

Extract from "Gas and Oil Power," June 6th, 1912.

HOLLINS MILL, MARPLE.

The cost sheet for 1911 comes out as follows:—

	£	s.	d.
Coal: 1,100 tons at 10s. 3d. per ton ..	563	15	0
Oil for gas engine	110	2	10
Oil for gas plant auxiliaries	2	15	2
Scrubber materials	1	0	0
Packing for steam engines	0	19	6
Acid for recovery plant	55	0	0
Repairs, renewals, &c., to engine and plant	5	4	6
Wages.....	300	0	0
	<hr/>		
	£1,038	17	0

Of these items, the repair bill is extraordinarily favourable. The credit side is as follows:—

	£	s.	d.
Tar burned: 75 tons at 12s. 3d. per ton	45	18	9
Sulphate recovered: 32½ tons, £13 10s. per ton.....	438	15	0
Oil recovered by filtration	17	4	7
	<hr/>		
	£501	18	4

APPENDIX 2.

Adjustment of figures given in Appendix 1 to bring same in line with our introduction, and taking the selling price of sulphate of ammonia as £12 10s. per ton instead of £13 10s.

	£	s.	d.
Running Cost, as shown by Hollins Mill figures.....	1,038	17	0
Add for 9d. extra on 1,100 tons of coal...	41	5	0
10 per cent interest and depreciation on present cost of engine, auxiliaries, gas plant, and exhaust boiler, say £7,250	725	0	0
8 per cent on buildings and foundations, say £1,600	128	0	0
	<u>£1,933</u>	<u>2</u>	<u>0</u>

	£	s.	d.
Credit—As shown by Hollins Mill figures	£501	18	4
Less £1 per ton for sulphate, showing selling price as £12 10s. per ton.....	32	5	0
	<u>469</u>	<u>13</u>	<u>4</u>
	<u>£1,463</u>	<u>8</u>	<u>8</u>

Take B.H.P. as 670

B.H.P. hours = $55 \times 50 \times 670 = 1,842,500$

Cost per B.H.P. hour = '19 penny.

At 90 per cent generator efficiency this power equals 1,237,054 k.w. hours. Taking cost of generator as £720, 10 per cent on same increases net running cost to £1,535 8s. 8d.

∴ Cost per unit at terminals = '298 penny.

APPENDIX 3.

Annual Power Estimate for a Gas Power Set, suitable for an average Weaving Shed, comprising 250 normal B.H.P. Gas Engine, capable of taking at least 10 per cent overload, Coke Suction-pressure Gas Plant, with all usual and necessary auxiliaries and connections, foundations and buildings.

Capital Costs.

Gas Plant.....	£450
Engines and Auxiliaries	1,700
Exhaust Boiler	200
	<hr/>
	£2,350
Buildings and Foundations	£700

Dr. Running Cost Account.

To 385 tons of coke at 13s.	£250
„ Oil and stores	35
„ Mechanic (part time).....	75
„ Labourer	65
„ 10 per cent interest and depreciation on £2,350	235
„ 8 per cent „ „ „ £700	56
„ Maintenance and repairs.....	25
	<hr/>
	£741

Cr.

By 900,000 lbs. of steam raised for mill heating by exhaust boiler = say 60 tons of coal at 11s.	33
	<hr/>
Net running cost	£708

687,500 B.H.P. hours for £708 = .248 penny per B.H.P. hour.

APPENDIX 4.

Annual Power Estimate for a Gas Power Set suitable for an average Spinning Mill, comprising 600 normal B.H.P. Gas Engine, capable of taking at least 10 per cent overload, Mond water-cooled gas plant, with all usual and necessary auxiliaries, foundations and buildings.

Capital Costs.

Gas Plant	£1,200
Engine and Auxiliaries.....	3,700
Exhaust Boiler	310
	<hr/>
	£5,210
Engine house and foundations	£1,100

Dr. Running Costs.

To 920 tons of coal at 11s.	£506
„ Oil and stores	80
„ One mechanic	100
„ Two labourers	130
„ 10 per cent interest and depreciation on £5,210	521
„ 8 „ „ „ £1,100	88
„ Maintenance and repairs.....	52
	<hr/>
	£1,477

Cr.

By 2,000,000 lbs. of steam = 300,000 lbs. of coal, raised by exhaust gases, available for mill heating, &c., say.....	75
	<hr/>

Net running cost £1,402

1,650,000 B.H.P. hours for £1,402 = 2 penny per B.H.P. hour.

APPENDIX. 5.

Cost Scheme for large Textile Works, doing Spinning, Weaving, Dyeing, and Bleaching.

Electric Transmission.

Day load averages 3,500 B.H.P. } Total annual B.H.P.
Night load averages 500 B.H.P. } hours, say 12,000,000.

Capital Outlay.

One Mond Recovery Gas Plant and Auxiliaries for 4,000 B.H.P.....	£13,000
Three Gas Generators of 1,200 B.H.P. each ..	25,000
One Gas Generator of 600 B.H.P.....	4,000
Four Exhaust Boilers, fittings and connections	1,300
Auxiliaries, starting plant, pumps, engine house crane, switchboard, pipes, &c.....	2,000
	<hr/>
	£45,300
Engine House, Foundations, and Buildings ..	£3,700

Running Costs.

7,500 tons of coal at 11s.	£4,125
Oil and stores	400
300 tons of acid at 35s.	525
Bags for and packing sulphate.....	100
One chief engineer	150
Three driver-mechanics	300
Seven labourers	455
Maintenance and repairs of engines and plant..	500
10 per cent interest and depreciation on £45,300, machinery	4,530
8 per cent interest and depreciation on £3,700, buildings, &c.	296
	<hr/>
Gross running costs	£11,381

Credit—

By 300 tons of sulphate of ammonia at £12 10s.	£3,750
By 300 tons of tar at 12s. 6d.	187
	<hr/>
	3,937
	<hr/>
Net running cost	£7,444

Cost per unit power.

12,000,000 B.H.P. hours for £7,184 = '149 penny,
or 8,056,800 k.w. hours for £7,184 = '222 penny per k.w.
hour.

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BHP ENGINE

$\frac{1}{200}$

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" VERTICAL GASENGINE. LOAD = 250KW
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0° DEGREES 90° OF 180° MAIN 270° CRANK 360°

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