Use of Petroleum or Mineral Oil as Steam Fuel in place of Coal.

By B. H. PAUL.

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This subject continues to excite so much interest among those connected with steam navigation, and the statements which have been made by those who propose by means of petroleum or coal oil to effect a reorganization of our naval and mercantile marine, are so totally irreconcilable with all known principles relating to the application of fuel, that it will not be superfluous to illustrate this fact by reference to the opinions expressed and to the arguments used by several of the speakers in a recent discussion of the subject at the United Service Institution. Such a course is the more admissible since many who appreciate the importance of any mode of improving or economizing the use of fuel, confess their inability to judge as to the merits of this project, and express themselves desirous of information.

The data which I have already referred to in this journal,* for the purpose of showing that the substitution of petroleum for coal as fuel is impracticable, are not disputed. On the contrary, they are adopted by those who advocate this change. But, at the same time, they urge that those data relate only to a theoretical consideration of the subject, and are therefore not to be taken as deciding the practical question as to the relative fuel value of petroleum and of coal. In this opinion I quite concur, but it must be remembered that no means of arriving at a practical solution of this question have yet been afforded. It was only from the want of such positive data, expressing results obtained with petroleum and with coal, as would enable an engineer, or any one else, to form an opinion as to the comparative values of these materials as fuel for steam vessels, that I was constrained to have recourse to the only accessible criterion by which an opinion could be formed as to the representations which have been made. The comparison of the utmost effects capable of being produced by petroleum and by coal under the most favorable conditions, is perfectly valid so far as it applies; but I must admit that it would have been far more satisfactory to have been able to base my opinion on the results of trustworthy experiments made with the object of ascertaining the actual duty obtained with the two materials, and I cannot refrain from expressing my surprise that statements so extraordinary as those I have referred to, should have been put forward ostensibly as the result of experiments made in the government dockyard, with the apparent authority they thus acquire, and without a vestige of practical evidence in support of them. Mr. Richardson has publicly declared that forty-two gallons of oil equal one ton of coal in steam-producing power. He admits that this requires proof, and he has promised that it shall be proved;† but as yet the proof has not been furnished, nor was any approach made towards it in the papers read at the United Service Institution, on the 16th inst. It rests, therefore, with the advocates for the use

* *Chemical News*, December 17, 1864, page 292.† *Mining Journal*, December 24, 1864, page 890.

of petroleum to remove the cause of the objection they made to the comparison between that material and coal upon theoretical grounds.

But their chief argument in favor of petroleum is, that this material can be used as fuel so that its capability may be rendered effective to a much greater proportion than is possible in the case of coal. Here again we are without any evidence of a practical nature in support of this proposition. No doubt it is a well established fact that different kinds of fuel do not always admit of equal effects being produced in generating steam, although their heating capability or calorific power may be the same. It is upon this ground that the advocates of petroleum take their stand, and Mr. Richardson states that, while one-half of the coal consumed in a marine boiler furnace disappears and is lost as soot and smoke, the heating capability of petroleum is fully utilized.* If this were admitted, we should still be far from attaining that advantage from the use of petroleum in place of coal which Mr. Richardson represents by stating that one ton of petroleum equal five tons of coal; for, since the calorific power of petroleum is to that of coal as 1·5 : 1, it follows that by fully realizing the calorific power of petroleum and realizing only half that of coal, the practical effects of these materials would be in the ratio of 3 : 1, not as 5 : 1, which, upon the same supposition, would require the calorific power of petroleum to be 2·5 as compared with that of coal = 1·0. There is, therefore, some error in this; but without attempting to ascertain in what it consists, it will be more useful to inquire how far there may be—in the absence of those special data which are so much needed—any means of instituting a practical comparison between coal and petroleum in regard to the possibility of using the latter more advantageously than coal as fuel in a marine boiler furnace.

It is well known that no kind of fuel is burnt under ordinary circumstances, so as to realize the whole of the heating effect it may be capable of producing. Therefore the true practicable comparison between different kinds of fuel as regards their value, consists in ascertaining not only what they respectively can do, but more especially what they really do. The actual work done by fuel depends partly upon its nature, partly also upon the kind of effect to be produced. When an intense degree of heat or very high temperature is required, as in smelting iron, the heating capability really utilized is not a tithe of that which is utilized when fuel is burnt for generating steam, and still less than that utilized when fuel is burnt in a common domestic grate.

But even in the generation of steam, different kinds of fuel give different results, and under the very unfavorable conditions which obtain in a marine boiler furnace, experience has shown that there is a great difference in the duty or effects produced by equal quantities of different coal possessing equal heating capabilities. Hence the recognised practical superiority of Welsh steam coal over the more bituminous kinds of coal represented by the North country coal.

Now, what is the difference between these two kinds of coal to which

* See *Times*, December 14, 1864, page 7.

their different value as steam fuel is referable? It is simply this, the Welsh coal is almost entirely fixed, approximating, in this respect, to pure carbon; it does not give out much combustible gas when heated, but it burns almost entirely within the furnace, and, unless the rate of combustion be very rapid, it burns completely, generating its full equivalent of heat, which is transferred through the medium of the combustion products to the water in the boilers. The amount of heat generated by the combustion of the best Welsh coal is equivalent to the production of nearly 15 lbs. of steam from water at 212° F. for each pound of the coal completely burnt. Of course, this duty is never realized in practice, because the water has to be heated to the boiling point, and because the whole of the heat generated cannot be transferred to the water in the boiler, great part of it escaping in the combustion products. But the approximation to that theoretical duty will be greater in proportion to the perfect combustion of the coal, and to the absence of soot or smoke production. For every pound of soot or smoke produced, the possibility of generating at least seven pounds of steam will be lost, and the duty of the coal will be proportionately reduced.

The calorific power of the best bituminous coal is not appreciably less than that of Welsh steam coal, but it contains from 30 to 40 per cent. of volatilizable substance, and consequently when heated combustible gas or vapor is evolved to that extent. This gas or vapor, amounting to something like 300 times the volume of the coal from which it is produced, mixes with the combustion products, and is thereby rendered less readily combustible. Under the influence of the draught, and by reason of its great bulk and mobility, it is drawn out of the furnace before it can be burnt, and, passing into the tubes of the boiler, the combustion is stopped partly by the cooling of the gas, and partly by the want of air, so that instead of generating its equivalent of heat it produces soot and smoke.

This action takes place to some extent with all coals, especially when it is burnt under the unfavorable conditions obtaining in a marine boiler furnace, and it was the disregard of this circumstance which vitiated the results of the long and costly experiments made some years ago by Dr. Lyon Playfair, with the view of ascertaining the relative value of different kinds of coal as fuel. But in regard to steam navigation, the relative values of different coals are determined by the degree to which this action takes place. The more a coal is capable of being burnt within the furnace, the better it is for that purpose. The greater the amount of volatilizable substance it contains, the less suitable it is, and the greater the extent to which production of soot and smoke is substituted for the production of heat. These being correlative results, it follows that the fitness of coal for steam navigation is inversely proportionate to the amount of volatilizable substance it contains. It is for this reason that while the duty obtained with Welsh coal sometimes exceeds 10 lbs. of steam per pound of coal burnt, that obtained with Newcastle coal is often as low as 6 or 7 lbs.

Applying this result of long experience to the case of petroleum as

compared with coal, the conclusion to which it leads is even more disadvantageous for the former than the comparison already made on the ground of calorific power and cost.* For petroleum is altogether volatilisable, and is, consequently, peculiarly liable to produce soot and smoke when burnt even slowly, and without any of those disadvantages to which it would be subject in the furnace of a marine boiler. Indeed, it appears to me that nothing can be more incompatible with the use of petroleum as fuel than the conditions which obtain in that case. No doubt it may be urged in answer to this that the introduction of a peculiar boiler is contemplated; but nothing need be said as to that contingency until the superiority of petroleum over coal shall have been satisfactorily made out.

The objection I have urged to the use of petroleum on the score of cost, has been answered by Capt. Selwyn, who suggests that the price of petroleum ought to be reduced if it came to be used as fuel, and that if it were not he believes a material almost identical with it may be obtained from coal at a lower cost, 9*l.* or 10*l.* per ton. So far as the price of petroleum is concerned, I am disposed to consider any anticipation of a reduction as being extremely delusive, and the lower cost of coal oil would still leave it at a great disadvantage as compared with coal.

But if Capt. Selwyn, before assuming the part of a protecting ægis to a deluded inventor, had applied to his own conceptions that simple axiom, that "a whole is greater than its part," he would probably have seen a little more clearly the value of the whole project of reorganization which it is proposed to carry out in relation to steam navigation. Thus, for instance, the very richest oil-yielding coal known—the Leeswood canal—yields about one-third its weight of oil. In producing a ton of oil from three tons of this coal, a considerable quantity of combustible gas, capable of generating a large quantity of heat, is lost, and there remains greater part of the carbon of the coal in the state of coke, amounting to more than one ton. Both the gas and the coke are of value as fuel, so that the real fuel value of the oil from three tons of coal is, in fact, equal to the total fuel value of that quantity of coal *minus* the fuel value of the coke and gas. But according to the representations made in favor of substituting coal oil for coal as fuel, one ton of oil is to do the work of five tons of coal; so that, according to this view, the fraction of the heating power belonging to the three tons of coal will be equal to the heating power of five tons of coal!! This is equivalent to the proposition that part of three is equal to five, an absurdity so glaring that it is truly wonderful that it should have escaped recognition even by an inventor.

The signal misconception which characterises the views of those who advocate the substitution of petroleum for coal in steam navigation, was illustrated in an almost equal degree during the discussion following the papers read by Captain Selwyn and Mr. Richardson at the United Service Institution. Thus, for example, Sir Edward Belcher referred to the oxyhydrogen flames as proving the fuel value of hydro-

* See *Chemical News*, December 17, 1864, page 292.

gen to be much greater than that of carbon or of coal. Nothing could possibly be more irrelevant, and it can only be inferred that Sir Edward Belcher is not aware that the thermal efficacy of the oxyhydrogen flame is solely due to the fact that oxygen gas is used in the place of air for the combustion. This circumstance alone places the oxyhydrogen flame beyond the range of a practical consideration of the subject; but so far as a comparison can be instituted between hydrogen and carbon when burnt with oxygen, the fact is, that the thermal effect or temperature produced by carbon under that condition is far greater than that produced by an equal weight of hydrogen, these effects being in the ratio of about 10:7. When those substances are burnt in air, the difference in thermal effect is inappreciable. So far as the possible evaporative effect is concerned, the difference between petroleum and coal, in the amount of hydrogen they contain, is not so great as to have a very great influence; and since an increase in the amount of hydrogen in fuel is accompanied by increased liability to produce smoke and soot, it would, under existing circumstances, be rather a disadvantage than otherwise. Captain Selwyn's reference to the common fishtail gas burner used for illuminating purposes, and to the Bunsen burner, used in laboratories for heatings, as being illustrative of the different effects obtainable by burning combustible substances under different conditions, was equally infelicitous, and indicated an equal ignorance of the most rudimentary principles affecting the use of fuel; for in the flame of the fishtail burner, and in that of the Bunsen burner, the heating effects produced are equal for equal quantities of gas burnt, and the thermal effects or temperatures produced are probably little if at all different. Both these gentlemen appear to be very much "at sea" in their notions respecting fuel and its applications.

The view of this subject which was put forward in the above remarks will doubtless appear to many extremely trite and self-evident; but the fact that it is not so to every one interested in the use of fuel may perhaps be a sufficient excuse for stating it so fully, and the still more remarkable fact that some who have held such a view have been induced to abandon it, and to express themselves satisfied with the astonishing statements made as to the effects of petroleum when used as fuel, will show what strange results may be produced by vigorous assertion even of the most palpable absurdities. In fact, the whole of the arguments brought forward by those who contemplate effecting the entire reorganization of our navy, and of steam navigation, indicate a woeful deficiency of acquaintance with the subject, and well illustrate the proverbial danger of a "little knowledge."

There is, however, still room to hope that, by having recourse to that practical mode of deciding any question there may be in their minds as to the relative values of coal and petroleum, which I fully agree with them in thinking the only satisfactory test, and which is, unfortunately, a great desideratum in the present case, they will arrive at such a state of disillusion as will permit them to make a more useful application of their ingenuity.