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## THE EFFICIENCY OF THE STEAM TURBINE.

The communication from the Hon. Charles A. Parsons, which we publish in our correspondence columns, will be read with great interest by every one that is interested in the development of the steam turbine, whose performance in the closing years of the nineteenth century affords reason to believe that it is to be the steam motor of the twentieth. We would draw particular attention to the economy shown in the two 1,000-kilowatt turbine plants at Elberfeld, Germany, where the trial tests revealed a steam consumption of 11.9 pounds per indicated horse power per hour. In this connection mention may be made of the comparative test carried out recently of the Parsons turbines installed in the works of the Westinghouse Air-Brake Company, where the old reciprocating steam engine plant and the new turbine plant were each run for a week, careful measurements being made of fuel and water. During the day the saving in coal shown by the turbines averaged 35.7 per cent, and the saving in feed water 29.8 per cent, the economy being in great measure due to the turbines, and in part to the electrical transmission.

The paper read by Prof. Thurston, at the recent annual meeting of the American Society of Mechanical Engineers, on the steam turbine, is at once an emphatic tribute to the excellent work which has already been accomplished by the steam turbine, and a prediction of its future triumph. The author's opinion of this form of motor, considered as a prime mover, is evidently summed up in the title of the paper: "The Steam Engine of Maximum Simplicity and of Highest Thermal Efficiency."

It is not possible to give here any extended review of this valuable article, which is published in the current issue of the SUPPLEMENT, and it will be sufficient to summarize the results of the tests and give the final conclusions. In the test of a Parsons compound turbine made by Prof. Ewing in August, 1892, the consumption when making use of superheated steam and a jet condenser fell to about 16 pounds per indicated horse power per hour. Recent trials with the Parsons turbine constructed by the Westinghouse Machine Company, of this country, give the following economy of steam, the steam being practically dry during the trials. At full load, 16.4 pounds of steam were consumed per electric horse power per hour; at  $\frac{3}{4}$  load, 17 pounds; at  $\frac{1}{2}$  load, 18.2 pounds; and at  $\frac{1}{4}$  load, 22 pounds of steam per electrical horse power per hour. Regarding these remarkable results, Prof. Thurston says: "It will be particularly interesting to observe that the loss of efficiency with decreasing loads is less marked than with the common forms of engine." From a table published by the Continental European representatives of the De Laval Steam Turbine Society, showing the consumption of dry steam, we gather that the consumption in a condensing De Laval turbine varied from 34.8 pounds in a 3-horse power engine to 15.8 pounds per horse power per hour in a 300-horse power engine. In tests of the De Laval turbine reported by Prof. Goss, the lowest result obtained with 10.33 brake horse power was 47.8 pounds of steam per brake horse power per hour. The tests of a 50 horse power De Laval turbine by Prof. Cederblom at Stockholm showed a consumption of 19.7 pounds of steam per horse power per hour at the brake. In this connection Prof. Thurston draws attention to the fact that the gain in economy progresses in the steam turbine with increasing loads up to the limit of the power of the machine, in which respect it departs markedly from the case of the common forms of engine. The Curtis steam turbine is reported as having given a performance with 130 pounds steam pressure, and 28 inches of vacuum, of 24 to 27 pounds of steam per brake horse power per hour.

The conclusions of the paper are:

First: The steam turbine thermodynamically approximates in its real form more closely to the ideal than does any other type of heat motor. Its cycle lacks only the introduction of the Carnot compression.

Second: It is entirely free from that waste which, in the real steam engine of common type, constitutes

usually, if not invariably, the most important of its extra thermodynamic losses.

Third: It is peculiarly well fitted for use with those very high steam pressures as we now regard them, which must ultimately be resorted to by the engineer in his endeavor to improve the efficiency of heat engines.

Fourth: It is limited in speed of rotation only by the strength of its materials of construction.

Fifth: It is especially suitable for use with superheated steam, it having no rubbing parts on which lubrication may be difficult, and the limit of superheating being found only at that point at which increased temperature of metal produces an objectionable amount of reduction of tenacity. The limit of superheat is fixed with this machine at the boiler itself.

Sixth: Friction is peculiarly active for evil in this motor, and it must be guarded against by using small diameters of journal, by freedom from contact of part with part, by the minimizing of fluid friction by the use of superheated steam, and by the removal, as far as practicable, of the atmosphere, air, or vapor from about the revolving wheel.

Seventh: The wastes of the steam turbine are all extra thermodynamic, with the exception of the loss due to the absence of adiabatic recompression. They consist of (a), journal friction, which is made a minimum by the use of flooded bearings and a light unguent; (b) fluid friction between the disk and the leakage of steam or suspended moisture in the jet, which may be made a minimum by superheating; and fluid friction between the disk and its inclosing atmosphere of vapor, which may be minimized by the employment of a good condenser; (c) loss of heat and of steam by leakage which may be reduced to a minimum by durable material, fine workmanship and close fits; (d) waste by incomplete expansion; and finally (e) thermodynamic waste by failure to secure complete adiabatic recompression of the fluid—a peculiarly difficult matter in steam turbines, since it probably involves the employment of a separate vapor-compression pump, and an amount of added work and cost which may introduce losses more than compensating its gains.

## THE SHIP-SUBSIDY BILL.

There are some questions of great national importance which, because of their complexity and the many side issues which attach to them, are peculiarly liable both to misunderstanding and misrepresentation. To this class belongs the ship-subsidy bill, a measure which has been defined and explained by its friends with a clearness of definition, and an honesty of purpose, that are only equaled by the misrepresentation (much of which we are willing to believe is quite unintentional) with which it has been clouded by its enemies.

The confusion of ideas regarding the present state of our shipping interests is due largely to the fact that, in much of the written and spoken discussion of the subject, there has been no distinction made between those shipping interests which are protected and those which are not. To avoid such confusion, we will ask our readers to omit from the present consideration that portion of our shipping which is included under the term "lake and coastwise," and to bear in mind, also, that in excluding this we exclude by far the largest portion of the tonnage that carries the flag of the United States. Our lake and coastwise shipping must be omitted for the reason that it is secured against foreign competition by a sweeping law which forbids any foreign ships from engaging in this particular trade; the fostering effect of which law is seen in the fact that our lake and coastwise traffic is both healthy and highly remunerative, and is increasing by leaps and bounds.

When we come to consider our merchant marine, however, we find that it is exposed to the direct competition of maritime nations, who are able to build and operate their ships at a cost so much lower than ourselves, that any hope of successful competition is out of the question. The ship-subsidy bill has been drafted with the idea of affording such assistance to the merchant marine as shall place it on equal terms of competition with the rest of the world.

It is a matter of fact, as we shall show, that under existing conditions the United States cannot compete successfully with other nations either in the first cost, the cost of maintenance, or the cost of operation, of ocean-going steamers. It is a matter of opinion, whether, as a question of broad, far-seeing policy, the Treasury of the United States should render to the shipowners such temporary financial assistance, in the early years of a serious and determined effort to move up to our proper position among the maritime nations of the world, as will place us on equal terms, and give us a reasonable hope of being ultimately able to maintain and improve our position without such national aid. It is a matter of fact that although the cost of the crude material for shipbuilding is not materially greater in this country than abroad, the cost of labor is so considerably greater that there is an ultimate dif-

ference in cost per ton of the ship at the date of her launching in favor of the foreign builder of at least 20 per cent. It is a fact that whereas the "Pleiades," a 3,750-ton cargo steamer, of 9 $\frac{1}{2}$  knots speed, which has the distinction of being considerably the cheapest cargo steamer ever built in this country, cost \$275,000, the British steamer "Masconomo," of 4,200 tons, and 10 knots speed, cost only \$217,000. It is a fact, moreover, that while the annual charges on the "Pleiades," based on the cost of construction, amount to \$44,000, the annual charges on the "Masconomo" amount to only \$34,240. It is a matter of fact that while the total annual wages paid to the crew of the "Pleiades" amounts to \$14,580, the total annual wages paid out on the "Masconomo" amounts to only \$11,751, while the total wages paid out in one year to the British ship "Pinedene," of about the same size and type as the others named, amounts to only \$9,505. It is a matter of fact that a mass of statistics, gathered and digested by the Commissioner of Navigation for the United States, shows that in the cost of construction of cargo steamers there is an average difference in favor of Great Britain of 20 per cent, and in cost of operation of 33.1-3 per cent. It is a matter of fact that the possibility of carrying on a profitable competition under such unequal conditions has discouraged the investment of capital in our merchant marine, and has diverted it into the more promising channel offered by our protected and flourishing lake and coastwise trade. It is a matter of fact that owing to the stagnation of our merchant marine we are now paying out annually, at a conservative estimate, \$240,000,000 to foreign shipowners for carrying our rapidly increasing exports across the seas.

In the presence of these facts we are confronted by the question as to whether it is consistent with the commercial interests of the nation, to say nothing of its proud traditions, that we should be beholden to a foreign flag for the transport to foreign markets of the multiplied products of our fields and factories. The ship-subsidy bill has been drawn up under the conviction that, contemporaneously with the present enormous increase in our manufactured exports, there should be a determined national effort to resuscitate our merchant marine, and place ourselves in a position where we can act as the carriers of our own products and thus secure the rich returns upon our industries, in their entirety, where now so much of it is diverted elsewhere. On the other hand, the opponents of the bill profess to be perfectly satisfied with the existing situation, and quite willing to allow the foreigner, as long as he can carry our goods more cheaply than ourselves, to do so.

Without making any obvious comment upon the unprogressive spirit which lies behind such an attitude, we offer the following considerations: First, that such an attitude means the practical abandonment of any considerable development of deep sea shipping in America. Secondly, that this involves that the United States must be destitute of any numerous or adequate auxiliary merchant marine. Just what this implies may be best understood by reference to the deplorable muddle into which our transportation was thrown, when we put our little army into Cuba, and endeavored at the close of the war to bring the disease-stricken victims home again. A numerous auxiliary merchant marine is an indispensable accessory to distant foreign possessions; and it is a fact that, although we disdain to designate our little affair in the Philippines by the name of "war," it has lately been necessary for our Quartermaster Department to charter, in addition to our considerable fleet of transports, no less than forty vessels to carry supplies to the Philippines alone. Lastly, we invite consideration of the fact that if Great Britain, which acts so largely as our carrier on the high seas, were to be at war with us, a contingency which, though unlikely and greatly to be deprecated, is yet a possibility that must never be lost sight of, we should be utterly unable to get our vast and rapidly increasing exports out of the country. Germany could carry but a part of it, and her commercial instincts are not so altruistic but that she would make haste, by an enormous increase in rates, to reap a rich harvest. The loss from this source alone would amount to more than the annual amount of subsidy asked by the present bill for many years to come.

The question before us, then, may be stated succinctly as follows: Is it desirable that the nation as a whole should transfer from the national treasury to the individual shipowners the money equivalent (\$9,000,000 a year) of the actual disadvantages under which our shipowners labor as compared with the shipowners of a competing nation? After a careful review of the whole situation, it appears to us that such a policy, if carefully followed out for a period of years, would so far stimulate ocean-going shipbuilding, that the decreased cost of production due to increased output, the decreased fixed charges, and the decreased cost of operation due to improved ships and better methods, would enable us sooner or later, and rather sooner than later, to dispense with the subsidy and take our place as one of the great maritime nations of the world.