USEFUL INFORMATION ON STEAM POWER.

Careful experiments by Favre, Silbermann, and others have shown that a pound of good coal will liberate during complete combustion 14,000 or 15,000 units of heat, each unit being equivalent to 772 foot pounds. The

MECHANICAL EQUIVALENT OF THE HEAT

developed by the combustion of a pound of coal is, therefore say 14,500 × 772 = over 11,000,000 foot pounds. A horse power is always assumed to be equal to 33,000 foot pounds per minute, or 1,980,000 foot pounds per hour. So the combustion of each pound of coal per hour liberates heat enough to develop 11,000,000 ÷ 1,980,000 = say 5 horse power; and in a perfect steam engine the consumption of coal would be about at the rate of one fifth of a pound per hour for each horse power developed.

The greatest economy obtained in ordinary continuous working may be taken at from 3 to 4 lbs. of coal per indicated horse power with non-condensing engines, and from 2 to 2½ lbs. with condensing engines. A consumption as little as 1½ or 1¼ lbs. per indicated horse power has been reported in the case of compound condensing engines, and such results are quite possible. But a consumption of 2 lbs. is as little as can yet be counted on with certainty. The manufacturer, in choosing an engine, would do well to look with some little doubt on promises of a better result than this, and he may feel satisfied if the engine he buys shows itself capable of working with that degree of economy. A consumption of 4 lbs. of coal per indicated horse power per hour means a loss of nineteen twentieths; and 2 lbs. per indicated horse-power, a loss of nine tenths of the power theoretically due to the coal. There is, therefore, ample room for improvement, even upon the best of modern steam engines.

The conditions necessary to

ECONOMY IN THE STEAM ENGINE

are: 1st. The complete combustion of the fuel in the furnace 2d. The transfer of all the heat generated to the water in the boiler. 2d. The passage of the steam through the engine without loss of heat, except such as is converted into motive power, and the conservation of the heat remaining in the steam on its leaving the cylinder. 4th. The absence of friction in the working of the engine. Let us see how these conditions are fulfilled in a good modern steam engine.

As to the

COMBUSTION OF THE FUEL,

with the best coal and most careful stoking, a quantity of the coal falls through the fire bars, either as unburnt coal or ashes. Another portion goes up the chimney unconsumed in the form of smoke and soot; and a further quantity, half consumed in the form of carbonic oxide. The loss from the causes may amount to from 2 to 20 per cent. It all arises from wrongly constructed furnaces and bad stoking, and it may nearly all be avoided.

As to the heat generated, most coal contains a greater or less quantity of moisture, and the evaporation of this moisture causes the first loss of heat. Radiation from the furnace causes a further loss. But the great causes of loss are the admission into the furnace of a large quantity of useless air and inert gases, and the escape of these, with the actual products of combustion, up the chimney, at a very much higher temperature than that at which they entered the furnace. Air is composed of about one third oxygen and two-thirds nitrogen. The oxygen only is required to effect the combustion of the fuel, and the useless nitrogen merely abstracts heat from the combustibles, and lowers the temperature of the furnace. About 12 lbs. of air contain sufficient oxygen to effect the combustion of 1 lb. of coal, but owing to the difficulty of bringing the carbon into contact with the oxygen, the quantity actually required to pass through the furnace is from 18 lbs. to 24 lbs. of air per pound of coal burnt. The surplus air passes out unburnt, but its presence in the furnace lowers the temperature subsisting there, and abstracts a portion of the heat generated. And whereas the whole of the air enters the furnace at about 60° Fah., the unconsumed air and the products of combustion leave the flues at from 400° Fah. to 800° Fah. The total loss from these causes is from 20 to 50 per cent. In other works, whereas each pound of good coal burnt is theoretically capable of evaporating about 15 lbs. of water, in good practice it evaporates but 9 or 10 lbs., and in ordinary practice but 6 or 8 lbs. of water.

There are difficulties in the way of abstracting all the heat from the furnace gases: first, because with natural or chimney draft, the gases require to pass into the chimney at not less than 500° Fah., in order to maintain the draft; and secondly, because the transmission of heat from the gases to the water, when the difference of their temperatures is small, is so slow that an enormous extension of the surface in contact with them becomes necessary in order to effect it. But by having energetic combustion and a high temperature in the furnace, the quantity of air actually required may be much reduced; by suitable arrangements for admitting air and feeding coal into the furnace, the proportions of each may be suitably adjusted to each other; and by a liberal allowance of properly disposed heating surface, the temperature of the reduced quantity of furnace gases may be reduced to that simply necessary to produce a draft, in a furnace with natural draft, or to about 400° Fah. or less, in a furnace where the draft is obtained from a steam jet or fan. Under these conditions an evaporation of from 10 to 12 or more lbs. of water, per pound of good coal burnt, may be expected.

As to the heat in the steam-amongst the minor causes of loss are radiation from the boiler, steam pipes, and engine)most of which can be prevented by carefully lagging with a good non-conductor of heat), blowing off, and leakage. A greater loss arises from initial condensation in unjacketed cylinders, nearly prevented by using a properly constructed steam jacket. But the great loss arises from the escape of the steam into the atmosphere, with only a portion of its heat utilized. This, of itself, leads to another great loss, of from 40 to 60 per cent.

The use of high pressure steam, high rates of expansion, and of an efficient feed water heater, is conducive to economy, but no practicable means have yet been devised whereby the whole heat may be saved; and the removal of this source of loss in the working of the steam engine offers one of the most promising subject for inventive genius.

In a good modern steam engine, the coal used is thus approximately disposed of:

Lost through bad stoking and incomplete combustion.	10·0
Carried off in the chimney gases	30·0
Carried away in the exhaust steam	50·0
Utilized in motive power (indicated)	10·0
	100·0

ENGINE FRICTION.

A further loss of useful effect ensues from a portion of the motive power actually developed being absorbed in driving the engine itself, and the useful power of the engine is reduced from this cause by from 5 to 25 per cent. The use of equilibrium valves, ample bearing surfaces, careful lubrication, and cleanliness go far to lessen the friction, as well as to increase the working life of a steam engine; but in selecting an engine, it is as well to bear in mind this source of loss, as injudicious improvements, introduced for the attainment of increased economy, may defeat this subject through the excessive power required to drive them.

For engines with cylinders less than 6 or 8 inches in diameter, the simple high pressure non-condensing arrangement should be adhered to, as it makes for small powers the most economical as well as the cheapest engine. The boilers for the smaller powers can be heated by gas instead of by coal, and the cleanliness and convenience of the arrangement quite counterbalance the slight increase of expense. When also the trouble of attending often to the water level is objected to, a boiler of large capacity should be provided. Non-condensing engines with cylinders above 8 inches in diameter should always be provided with expansion valves, steam-jacketed cylinders, and feed water heaters; and the exhaust steam of non-condensing engines should always be used to urge the draft. Condensers cannot well be used for portable engines or engines requiring removal; but fixed engines, having cylinders larger than about 10 or 12 inches, should be fitted with either surface or jet condensers. The jet condenser is less costly and nearly as efficient as the surface condenser, under ordinary circumstances; but when the water from which steam is made contains much impurity, surface condensation is to be preferred. For seagoing purposes, engines are now very generally made on the compound system, and some very good results have been obtained from such engines. Their use for land purposes also is becoming very general, and for large powers the compound engine is to be recommended. But it should be borne in mind that, whereas a compound engine must be both designed and constructed with the greatest skill and care, in order that it may work with greater economy that a good ordinary engine, a bad compound engine may easily be much more wasteful than even a bad ordinary engine.

The unmistakable tendency of modern steam engineering is towards much

HIGHER PRESSURES OF STEAM

than those hitherto used. A pressure of over 100 lbs. per inch means the supercession of what may be termed large capacity boilers. High pressures are as safe as low pressures, provided the boilers are suitably designed to withstand them. But the construction of high pressure boilers should be confided to none but competent engineers; and those who intend putting up new boilers should recollect that the boiler maker who uses the best quality of plates and workmanship is not likely to send in the lowest tender. His boiler may, nevertheless, be the cheapest. For land purposes and moderate pressures, the Cornish boiler will continue to be used. For higher pressures, a modification of the French or elephant boiler is better, and the multitubular boiler is also to be preferred. The enormously thick plates found necessary in some modern marine boilers lead to most serious inconvenience, and it becomes essential to stipulate that steam shall not be got up in less than several hours. Many attempts have been made to use tubulous boilers for very high pressures, but as yet without any marked success. A good boiler of the kind, however, is a great desideratum.

The actual, or useful, or

DYNAMOMETRICAL HORSE POWER

is the net power of the engine, after allowing for friction, etc., and this alone is the power with which users of steam engines are concerned. In small engines the useful power can be ascertained accurately by the application of a friction brake or dynamometer. The dynamometer, however, cannot be conveniently applied to large engines, but the indicated power, less an allowance for friction, gives the actual power near enough for most practical purposes.

In comparing the prices of different engine makers, it is very necessary to look at the actual power an engine exerts, not to the nominal power, or to the size alone of the cylinder. A nominal horse power means anything from 1 to 8 actual horse power; and of two engines of the same size and general construction, one may not only develop much more power than the other, but may do so with a less consumption of fuel per actual horse power.

COAL

varies so much in quality that the consumption of a certain weight per horse power is not in itself sufficient to show the economy with which an engine works. When an engine consumes so little as 2 lbs. of coal per horse power, we know that the coal used must be of good quality, and that the engine is an economical one. But the consumption of three or four times that weight of coal per horse power does not necessarily prove the engine to be a bad one, because the coal used may be but one third or one fourth as good. Generally, no doubt, the best coal is also the cheapest; but when an inferior quality as used, and it is desired to test the efficiency of a steam engine, an analysis by a competent chemist will show the relative heating value of the fuel, compared with that of standard quality. The best steam coal is capable of generating sufficient heat to evaporate about fifteen pounds of water, from and at 212° Fah., per pound, properly burnt. The same coal after a long sea voyage or long exposure to weather often loses much of its calorific power, owing to its partial decomposition, pulverization, absorption of moisture, and other causes. Other kinds of coal contain a large percentage of incombustible matter, and knowing its chemical composition will alone enable one to judge of its comparative theoretical efficiency. Anthracite coals give the best result in generating steam, but bituminous coals may be burnt with a high degree of efficiency under suitable arrangements.

After the engineer has done all he can to attain economy, much of the result remains in the hands of the steam user. A reduction of ½ lb., of coal per indicated horse power, under 2 lbs. can only at present be effected by the greatest skill on the part of the engineer, while a careless or unskillful stoker may easily counteract all the engineer's ingenuity. The use of a high class steam engine involves the necessity of employing an intelligent, careful attendant: not that the work is more difficult, at any rate, with good coal, nor is it so laborious, as less coal has to be thrown into the furnace for a given power.

Clean fire bars, an evenly spread grate, preliminary coking on the dead plate, and the exercise of some little intelligence in the admission of air and regulation of the draft, are the main points to be attended to by the stoker, and these cannot be said to involve an unreasonable amount either of labor or vigilance. A self feeding grate is conducive to economy, especially when the coal is small or of inferior quality. Its use lessens the stoker's labor considerably, and it is not easy to find a reason for its comparatively limited adoption.—*Henry Northcott.*

Aversion to Manual Labor.

The practice of educating boys for the professions, which are already overstocked, or for the mercantile business, in which statistics show that ninety-five in a hundred fail of success, is fearfully on the increase in this country. Americans are annually becoming more and more averse to manual labor; and to get a living by one's wits, even at the cost of independence and self-respect, and a fearful wear and tear of conscience, is the ambition of a large proportion of our young men. The result is that the mechanical professions are becoming a monopoly of foreigners, and the ownership of the finest farms, even in New England, is passing from Americans to Irishmen and Germans. Fifty years ago a father was not ashamed to put his children to the plow or to a mechanical trade; but now they are "too feeble" for bodily labor; one has a pain in his side, another a slight cough, another "a very delicate constitution," another is nervous; and so poor Bobby or Billy or Tommy is sent off to the city to measure tape, weigh coffee, or draw molasses.

It seems never to occur to their foolish parents that moderate manual labor in the pure and bracing air of the country is just what these puny, wasp-waisted lads need, and that to send them to the crowded and unhealthy city is to send them to their graves. Let them follow the plow, swing the sledge, or shove the foreplane, and their pinched chests will be expanded, their sunken cheeks plumped out, and their lungs, now "cabined, cribbed, and confined," will have room to play. Their nerves will be invigorated with their muscles; and when they shall have cast off their jackets, instead of being thin, pale, vapid coxcombs, they shall have spread out to the size and configuration of men. A lawyer's office, a counting room, or a grocery is about the last place to which a sickly youth should be sent. The ruin of health is as sure there as in the mines of England. Even of those men in the city who have constitutions of iron, only five per cent succeed, and they only by "living like hermits, and working like horses"; the rest, after years of toil and anxiety, become bankrupt or retire: and having meanwhile acquired a thorough disgust and unfitness for manual labor, bitterly bemoan the day when they forsook the peaceful pursuits of the country for the excitement, care, and sharp competition of city life.—*M., in What Next?*

Artificial Alizarin in Printing.

Hitherto artificial alizarin has been chiefly used as a steam color, but it can also be employed like garancin and *fleurs de garance.* To prepare the dye beck, chalk to the extent of 1 per cent of the alizarin paste to be employed is stirred into the beck, which is heated to 190° Fah. The goods, previously printed with the mordants, aged, dunged, and washed, are unwound into the beck, and heated quickly to a boil. The dyeing is complete in ten minutes. The alizarin in the spent bath, in combination with the excess of chalk, is precipitated with hydrochloric acid, and recovered from the precipitated thus formed. The dyed pieces are washed in warm and cold water, and then three times, using each time ½ lb. soap per piece: the two first soap baths at 145° and the third at 190° Fah. They are then placed in a weak solution of chloride of lime for half an hour at 88° Fah., washed again, dried, and finished.—*Farber Zeitung.*