

# THE INEFFICIENT HEAT ENGINE

## *Is There an Alternative?*

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WHEN our grandchildren look back and contemplate the progress made in the mechanical arts of the present generation they will find without doubt very much to admire, but it is not unreasonable to suppose that they will be astonished at the complacency with which we regard our very inefficient methods of producing power by means of heat engines.

The usual prime mover, as exemplified in an ordinary petrol engine, may be roughly defined as an apparatus which converts the energy derived from an exothermic chemical reaction into motive power. The term exothermic means that the process produces energy in the form of heat, as in the case of the burning of a lump of coal, but it sometimes happens that the energy produced by such a reaction may be made to appear in some other form.

It is a characteristic of most of our existing prime movers that they convert the chemical energy derived from the chemical substances they use first into heat and then into motive power. The first of these processes can be carried out with a very high efficiency, but the efficiency of the second is limited. Taking concrete figures, the conversion of chemical energy into heat can be done with an efficiency of nearly 100 per cent., but the using of this heat energy to produce motive power cannot be effected with an efficiency greater than about 45 per cent. as a maximum, and there is little likelihood of this figure being improved. Actually, this figure of 45 per cent. has only been approached by a few special engines of the internal combustion type, and is considerably higher than the figure obtained on engines in practical use.

It is not proposed here to discuss the reasons for stating that this figure of 45 per cent. is not likely to be improved, as the arguments can be found in any text-book dealing with the thermodynamics of heat engines. But this low efficiency is connected definitely with the production of heat as part of the process of energy conversion, and there is no theoretical reason why it should not be increased to any figure less than 100 per cent. if some other process of conversion, not using heat, could be found.

No other process of producing power in the quantities required for, let us say, aircraft is known, and there is no possibility in sight of being able to obtain the power required in any other way, but it seems that the intrinsically low efficiency of the heat engine must lead to this type being eventually abandoned.

There are other ways of obtaining motive power from chemical energy, some of which are in extensive use on a small scale, and it seems worth while making a general survey of them, as it is not unlikely that among them may be found the germ of the future process of power production.

Let us take first the motive power produced by animals with the aid of muscles. The source of this energy seems to be the breaking down of a carbohydrate called glycogen in the muscle, with the production of carbon dioxide and lactic acid. This process is an exothermic chemical reaction and it is not yet fully understood, but it seems clear that the production of lactic acid in quantities greater than the blood can remove causes accumulation of this acid in the muscles, and gives rise to the sensation of fatigue. According to those who have studied this subject, the thermal efficiency of the process is about 25 per cent. without counting energy used by the breathing muscles and the heart, etc., so that the net efficiency is certainly less than this figure. It seems that a great deal of the loss is due to internal friction in the muscle itself owing to the viscous material with which this organ is formed. It follows, therefore, that the thermal efficiency is greater when the movements are slow rather than fast. Apart from any

question of the difficulty of carrying out such a process mechanically, it would seem that the efficiency to be expected is less than that attained by an ordinary heat engine of the internal combustion type, so that any attempt to imitate this method of power production is not worth while.

It is possible in certain cases to make the energy produced by an exothermic chemical reaction reappear in the form of electricity instead of heat, and if this could be done with the chemical substances normally used for power production, there would be a considerable advantage in the process provided that the chemical energy could be converted into electricity with a high efficiency. This arises from the fact that the electric motor is a highly efficient piece of apparatus, and in the sizes that would be suitable for aircraft, an efficiency from electricity to rotary power of 90 per cent. could be attained without difficulty. Unfortunately, there is no known means by which the energy given by the chemical combination of the oxygen of the air with the hydrocarbons used as fuel by aircraft engines can be converted directly into electricity. If we split the hydrocarbon into carbon and hydrogen, we are somewhat better off, as it is quite possible to produce electricity from the combination of oxygen and hydrogen on a small scale in the laboratory, but this cannot be done with carbon and oxygen.

In the well known gas cell due to Sir W. Grove, oxygen and hydrogen are contained in two test tubes inverted and partly immersed in acidulated water. Into each of these test tubes platinum wires are fused reaching down to the water. This apparatus will produce electricity directly from the combination of oxygen and hydrogen, and the test tubes will slowly fill with water as the gases are used up, and by supplying oxygen and hydrogen to the two test tubes the production of electricity might be continued indefinitely. The efficiency of this process is high, possibly over 90 per cent., but it has so far been operated only on a minute scale. Even if it could be done on a large scale it would be impracticable, as pure hydrogen is hardly suitable as a commercial fuel. But at the same time the process may contain a germ capable of immense development.

This process of the production of electricity by an exothermic chemical reaction is that used in the ordinary primary battery used in electric torches. Of these there are many types, but the commonest is that producing zinc sulphate by the combination of zinc and sulphuric acid. The voltage produced by this method is almost exactly that which is expected from theoretical considerations, hence, when small currents are taken from the cell, so that the loss due to high internal resistance is negligible, the efficiency of the energy transformation is close to 100 per cent. But it is obvious that the use of zinc and sulphuric acid is impracticable for power production on a large scale.

We have therefore got back to where we started, that there is no known method other than by the use of a heat engine, whereby the power required for the propulsion of an aeroplane can be obtained, but it is clearly possible to obtain energy in the form of electricity from certain exothermic chemical reactions, and the question arises as to why this cannot be done in all such cases, especially with regard to carbon and oxygen. Theoretical considerations indicate that the voltage from such a reaction should be low, and it is probable that appropriate conditions may require the discovery of a new principle, but there is a large reward waiting for the successful inventor who can produce an apparatus which will solve this problem. The use of fuel oil in anything resembling a primary battery would appear to be still more difficult, but even that may be solved one day.