THE EFFICIENT USE OF STEAM

WRITTEN FOR THE FUEL EFFICIENCY COMMITTEE
OF THE MINISTRY OF FUEL AND POWER

BY

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"In short, I expect almost totally
to prevent waste of steam"

JAMES WATT. Letter
to Dr. Lind, 1765

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245. CYLINDER CONDENSATION. This is by far the greatest loss in most reciprocating engines. It is rather complicated but merits detailed consideration.

Assume that the engine is hot and is being supplied with saturated steam. During the exhaust stroke the cylinder walls, cylinder head, valve passages and piston head are cooling down to exhaust temperature. After the exhaust valve has shut and compression is taking place no further loss of heat to the exhaust can take place. Compression raises the temperature of the compressed steam but most of this heat is given up to the metal of the cylinder. When the admission valve opens the high pressure steam enters and at once gives up much of its heat to heating the steam ports, cylinder head and piston head. If the steam is saturated it can only part with heat by condensation. When the piston moves forward it uncovers comparatively cool cylinder metal. So that during admission condensation continues up to cut-off. After cut-off the pressure in the cylinder falls and, although the steam is still trying to part with heat to the cylinder, this is partly compensated by the production of flash steam from the condensate in the cylinder. However, this balance is upset because the steam is parting with the heat that it is converting into work on the piston. This causes further condensation, as has been explained in Chapter 2. When the exhaust valve opens the sudden reduction in pressure causes a flash of steam from the condensate. During the exhaust stroke the now hot cylinder walls readily give up their heat to evaporating the condensate and are thus rapidly cooled down towards the saturation temperature appropriate to the exhaust pressure. At the end of the exhaust stroke much of the condensate has been re-evaporated at the expense of heat in the cylinder walls, cylinder head, piston and valve passages. The process repeats itself at every stroke.

The greater the amount of expansion in the cylinder the greater will be the temperature difference at the beginning and end of each cycle. So that an attempt to get greater expansion in a single cylinder will be accompanied by much greater condensation losses than if the expansion were shared by two cylinders as is done in a compound engine.

The faster the engine runs the less time will there be for the cylinder walls to absorb heat from the live steam and cause condensation, and the less time will there be for the metal to give up heat to the condensate for evaporation during exhaust.

If the admission and exhaust valves can be entirely separated the inlet ports will not be cooled by the outgoing exhaust.

If the cylinder could be kept sufficiently warm to prevent condensation there would be no loss by the re-evaporation of condensate.

All these things have been tried with varying success. By using a small high speed engine in place of a large slow speed machine the condensation losses are reduced, but frictional losses may be greater. It cannot be affirmed that the high speed engine is always more efficient than the low speed engine. By separating the admission and exhaust valves a definite gain has been achieved, variously estimated at between 10 and 20 per cent., but usually the comparison is difficult as engines with separate valves usually have a quick acting valve gear that is anyhow an improvement on the slide valve or piston valve.

By applying a steam heated jacket to the cylinder a gain of between 5 and 25 per cent. has been found. Heat is supplied by the jacket which greatly minimises condensation in the cylinder although it of course causes condensation in the jacket. But the condensate in the jacket cannot be re-evaporated and this is the cause of the economy. Nowadays jackets are seldom fitted for reasons that will be explained in Section 246. The steam jacket, or " case " as he called it, was invented in 1765 by James Watt, who said : " To make a perfect steam engine it is necessary that the cylinder should always be as hot as the steam which enters it."