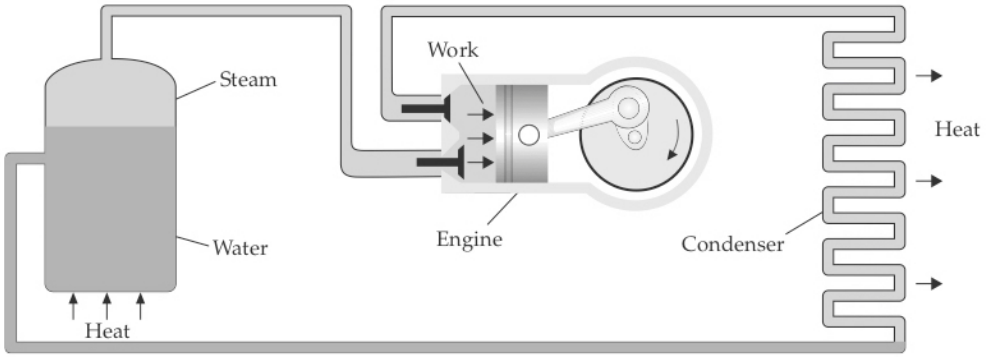
Heat engines

A heat engine is a device that transforms internal energy to mechanical energy. This is possible when heat is allowed to flow from a hot region to a cold region. In the process, some of the heat coming from the hot region can be transformed to mechanical work. The remaining heat flows to the cold region ("waste heat"). It is impossible to transform a given amount of heat completely into work.

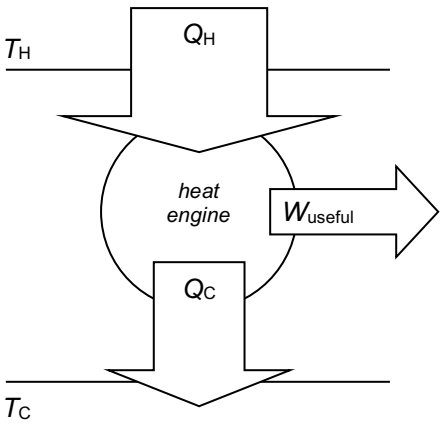
As an example, in a steam engine (see picture) water is heated until it turns into steam. The hot steam expands onto a piston, causing it to move, doing mechanical work. Then the steam cools down a bit, leaves the piston, and passes on to the condensor where it condenses and releases heat. The condensed water goes back to the boiler where it is heated again.



picture: *Physics for Scientists and engineers*, Tipler, Mosca

Efficiency

Even under the most ideal conditions, the efficiency of a heat engine is always less than 100 %.



While heat flows from a region of higher temperature T_H to a region of cooler temperature T_C, only part of the heat Q_H which is absorbed by the heat engine is transformed to mechanical work W_{useful}:

$$Q_H = W_{useful} + Q_C$$

The (ideal) efficiency is the work W_{useful} done by the engine divided by the absorbed heat Q_H:

$$\eta_{Carnot} = \frac{W_{useful}}{Q_H} = \frac{Q_H - Q_C}{Q_H}$$

The transferred heat is proportional to the temperature in Kelvin. Thus:

$$\eta_{Carnot} = \frac{T_H - T_C}{T_H}$$

This is the Carnot efficiency: the "ideal" efficiency of a heat engine, named after Sadi Carnot (1796 - 1832). The efficiency of a heat engine cannot be greater than the Carnot efficiency.