A Stirling engine is a heat engine that operates through the cyclic compression and expansion of air or other gases. An external heat source applied to one portion of the engine results in an expansion of the contained gas, which flows into the colder portion where it compresses. Key components of the engine are the heat source, the heat sink and one or more heat exchangers. The regenerator is an internal heat exchanger and temporary heat store placed in between the cold and hot compartments. Its function is to retain heat within the system that might otherwise be lost from intermediate temperature stages to the surroundings: this is what enables Stirling engines to approach the limiting Carnot efficiency.

The ideal Stirling cycle shown can be analysed as follows:

Process 1-2 is an isothermal (constant temperature) compression process, during which the piston in the hot cylinder compresses the working fluid, which loses heat to the cooling medium or environment as it compresses. Work WC is done on the system (a force is applied in the direction of compression), while an equal amount of heat QC is lost by the system, thus maintaining a constant temperature TC.

Process 2-3 is a heat exchange process in which the pressure of the gas increases due to heat QR being absorbed by the gas without a change in the gas’s volume.

Process 3-4 is an isothermal expansion process, during which an amount of heat QE is added to the system by the heater and the system does an equal amount of work WE, thus maintaining a constant temperature TE. The piston in the cold cylinder is pushed out in this part of the cycle.

Process 4-1 is a constant volume process in which heat QR is removed from the working gas by the cooling medium.

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