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Stirling's Engine

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Annotation: The internal combustion engine has supplanted other types of power plants, however, work aimed at abandoning the use of these units suggests an imminent change in leading positions.
Since the beginning of technological progress, when the use of engines that burn fuel inside was just beginning, their superiority was not obvious. The steam engine, as a competitor, contains a lot of advantages: along with traction parameters, it is silent, omnivorous, easy to control and configure [1-2]. But lightness, reliability and efficiency allowed the internal combustion engine to take over the steam.

Keywords: Stirling energy, cycle, phenomena, temperature-volume, pressure-volume.

Today, issues of ecology, economy and safety are at the forefront. This forces engineers to throw their forces on serial units operating on renewable fuel sources. In the year 16 of the nineteenth century, Robert Stirling registered an engine powered by external heat sources. Engineers believe that this unit is able to change the modern leader. The Stirling engine combines efficiency, reliability, runs quietly, on any fuel, this makes the product a player in the automotive market [3].

Stirling engine history

Initially, the installation was developed with the aim of replacing the steam-powered machine. Boilers of steam mechanisms exploded when the pressure exceeded the permissible norms. From this point of view, Stirling is much safer, functioning using a temperature difference.

The principle of operation of the Stirling engine is to alternately supply or remove heat from the substance on which work is performed. The substance itself is enclosed in a closed volume. The role of the working substance is performed by gases or liquids. There are substances that perform the role of two components, the gas is transformed into a liquid and vice versa. The liquid-piston Stirling engine has: small dimensions, powerful, generates high pressure.

The decrease and increase in the volume of gas during cooling or heating, respectively, is confirmed by the law of thermodynamics, according to which all components: the degree of heating, the amount of space occupied by the substance, the force acting per unit area, are related and described by the formula:

$$P*V=n*R*T$$

here
P - is the force of the gas in the engine per unit area;
V - is the quantitative value occupied by gas in the engine space;
n - is the molar amount of gas in the engine;
R - is the gas constant;
T - is the degree of gas heating in the engine K,

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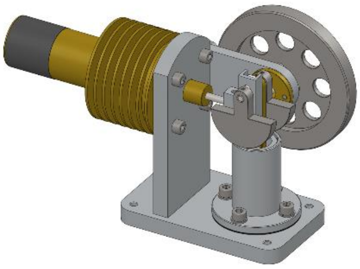
Stirling engine model:



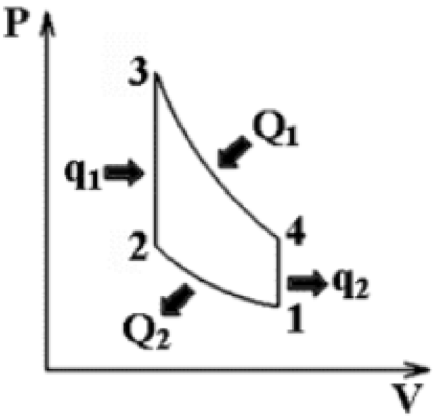
Due to the unpretentiousness of the installations, the engines are divided into: solid fuel, liquid fuel, solar energy, chemical reaction and other types of heating.

Cycle

The Stirling external combustion engine uses a set of phenomena of the same name. The effect of the ongoing action in the mechanism is high. Thanks to this, it is possible to design an engine with good characteristics within normal dimensions.

It should be taken into account that the design of the mechanism provides for a heater, a refrigerator and a regenerator, a device for removing heat from the substance and returning heat at the right time [4].

Ideal Stirling cycle, (diagram "temperature-volume"):



Ideal circular phenomena:

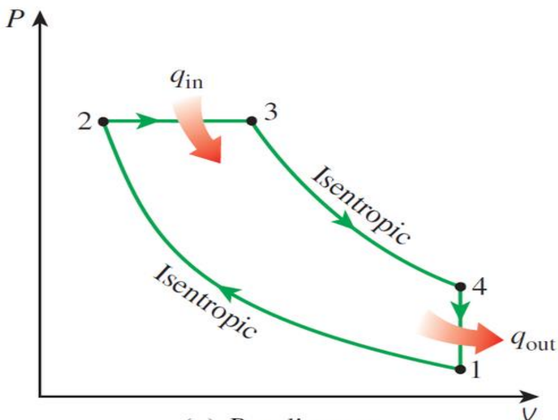
1-2 Change in the linear dimensions of a substance with a constant temperature;

2-3 Removal of heat from the substance to the heat exchanger, the space occupied by the substance is constant;

3-4 Forced reduction of the space occupied by the substance, the temperature is constant, heat is removed to the cooler;

4-1 Forced increase in the temperature of the substance, the occupied space is constant, the heat is supplied from the heat exchanger.

Ideal Stirling cycle, (pressure-volume diagram):



(a) P-v diagram

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From the calculation (mol) of a substance:

Heat input:

$$Q_{1-2} = RT_1 ln\frac{V_2}{V_1} \quad (1)$$

Heat received by the cooler:

$$Q_{3-4} = RT_4 ln\frac{V_2}{V_1} \quad (2)$$

The heat exchanger receives heat (process 2-3), the heat exchanger gives off heat (process 4-1):

$$Q_{2-3} = Q_{4-1}=C_v(T_1-T_4) \quad (3)$$

R – Universal gas constant;

CV - the ability of an ideal gas to retain heat with a constant amount of space occupied.

Due to the use of a regenerator, part of the heat remains, as the energy of the mechanism, which does not change during the passing circular phenomena. The refrigerator receives less heat, so the heat exchanger saves the heat of the heater. This increases the efficiency of the installation.

$$\eta = \frac{Q_{1-2}-Q_{1-2}}{Q_1} = \frac{T_1-T_4}{T_1} \quad (4)$$

It is noteworthy that without a heat exchanger, the set of Stirling processes is feasible, but its efficiency will be much lower. Running the set of processes backwards leads to a description of the cooling mechanism. In this case, the presence of a regenerator is a mandatory condition, since when passing (3-2) it is impossible to heat the substance from the cooler, the temperature of which is much lower. It is also impossible to give heat to the heater (1-4), the temperature of which is higher [5].

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