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## **On some principles of the functioning of machines from the perspective of nonequilibrium thermodynamics**

### Abstract

The article describes the thermodynamic operating conditions of all types of machines as nonequilibrium thermodynamic systems of the active type, which allows a new assessment of their properties, as well as the functions of spool valves and other devices that ensure their continuous operation.

Keywords: thermodynamics, nonequilibrium, machine, spool, system.

Thermodynamic processes in thermodynamic systems occur both within and between them.

According to internal processes, systems are distinguished [1]:

- passive, in which there is a redistribution of available energy, for example thermal, tending to an equilibrium thermodynamic state;
- active, in which one type of energy is converted into another, for example chemical into thermal, tending to a non-equilibrium thermodynamic state.

According to the nature of interaction with the environment, systems are distinguished [2, 3]:

- isolated, unable to exchange either energy or matter with the external environment [2, 3];
- adiabatically isolated, not capable of exchanging matter with the external environment, but allowing the exchange of energy in the form of work [3]. The exchange of energy in the form of heat is excluded for such systems [2];
- closed, unable to exchange matter with the external environment [1], but capable of energy exchange with the environment [2, 3];

- open, capable of exchanging matter (and, consequently, energy) with other systems <sup>[4]</sup> (the external environment).

Any engine, regardless of the design and the type of energy used, performs the function of converting one type of energy into another, necessary to perform the work. Thus, by the nature of thermodynamic processes, engines belong to thermodynamic systems of the active type, which are in a nonequilibrium thermodynamic state.

It follows that the nonequilibrium thermodynamic state must be continuous. Even with a short-term equilibrium state, the engine will not be able to switch to a non-equilibrium state on its own.

A number of devices are used to ensure the conditions of a continuous non-equilibrium state.

For steam or pneumatic engines, a spool or an inertial valve is used, which switch the direction of supply of the working fluid to the piston, for internal combustion engines – the moment of inertia, in connection with which they operate at idle, for electric motors – the potential difference of electric energy sources.

However, the operation of the engines is associated with energy losses due to friction and others. Therefore, the nonequilibrium thermodynamic state of the engines has a certain minimum value at which its operation is possible.

Thus, one of the basic principles of engine operation is the continuity of their minimum nonequilibrium state.

#### Literature

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