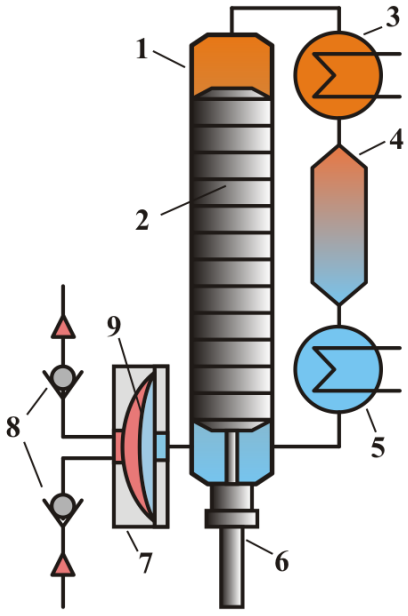
Isobaric expansion machines as heat driven pumps, compressors and heat-to-electricity converters

The isobaric expansion (IE) engine is a novel, simple, cost-effective and efficient machine for the conversion of low- and medium-grade heat (60°C and higher) to mechanical energy or electricity. Generally, the engine is a direct heat-driven pump producing a pressurized flow of liquid i.e. hydraulic power output. In this form, it can be used as an alternative to today's electricity-driven pumps. The hydraulic output can also be converted to shaft power and electricity, turning the machine into a power generator with power up to several MW.

The basic principle of the engine/pump is shown in the figure below.



It consists of a cylinder (1), filled with a liquid working fluid, with a piston (2) inside. The piston divides the internal volume of the cylinder into two parts – hot and cold, shown in orange and blue. Both parts are communicated through a heater (3), a regenerator (4) and a cooler (5) connected in series. The reciprocating piston is driven by a linear actuator (6). The pump can also be made without the actuator, i.e. with a self-driven piston.

The pump also includes a diaphragm unit (7), provided with suction and discharge check valves (8) and a flexible diaphragm (9) (flat or tubular), separating the working fluid and the liquid to be pumped.

Moving down, the piston displaces some part of the working fluid from the cold to the hot part of the cylinder. The working fluid passes the cooler, the regenerator and the heater and heats up, turning into vapor. The pressure in the converter rises and the rest part of the cold working fluid is displaced to the diaphragm unit. The diaphragm transmits the pressure to the pumped liquid, forcing it through the discharge check valve.

Moving up, the piston displaces the hot, compressed working fluid through the heater, the regenerator and the cooler back to the cold part of the cylinder. The pressure in the cylinder drops down. As soon as it becomes less than the suction pressure, the pumped liquid forces the working fluid from the diaphragm unit back to the cylinder.

The same principle can be used for the compression of gases, turning the engine into a gas compressor.

Many liquids can be applied as working fluids (light hydrocarbons, refrigerants, carbon dioxide, etc.). Depending on the heat source temperatures, the pump can create a pressure difference up to several hundred Bar.

The simplest application is the compression and transfer of liquids which also can be used as the working fluid in the thermodynamic cycle of the machine itself. Light hydrocarbons, liquefied gases and cooling agents are examples of such liquids. In this case the diaphragm is not necessary.

Since the machines do not need lubrication, they also can be of great interest in cryogenic applications.

Distinguishing features of the IE machines include close to isentropic operation (high thermal efficiency), high power density and technical simplicity, all together resulting in low cost conversion of thermal energy to mechanical power.

If the liquid to be pumped is hydraulic oil, the IE engine serves as a heat-driven hydraulic power pack. The flow of the high-pressure hydraulic oil can be used for actuation of different rotary and reciprocating equipment. It also can be converted into shaft power/electricity by means of hydraulic motors, turning the engine/pump into a heat-to-electricity converter. Such converters can be a very simple, flexible and economical alternative to the current organic Rankine cycle (ORC) installations.

In contrast to ORC installations, IE engines are well tailored for intermittent and part-load operation. The most expensive and critical part of an ORC, the turbine - which usually exceeds half of the total capital costs - is eliminated. Due to a great variety of industrial hydraulic motors, the shaft power can be produced with the most convenient combinations of speeds and torques, even using a very low grade heat input (below 100 °C).

About Us

Encontech BV is a high-tech R&D company which was founded in 2008 as a University of Twente spin-off, specializing in the development of unconventional energy conversion technologies.

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