Basic knowledge

Steam power plants

Steam power plants play a key role in supplying electrical energy. In addition to electricity production, some steam power plants use part of the heat generated to supply district heating. This is why the Rankine steam cycle is still one of the most important industrially used cyclic processes today.

In a steam power plant, a steam turbine – driven by steam – generates mechanical energy. A generator then converts this mechanical energy into electrical energy. The steam required can be generated from nuclear energy, fossil fuels, solar energy or geothermal energy, for example.

Thanks to optimised processes, it has been possible to continuously improve the efficiency of electrical energy generation over the past years. Today, a total efficiency of almost 45% has been achieved.

Steam power plants essentially have the same design:

Heat source – **Steam generator** – **Turbine with generator** – **Cooling**

The following types of steam power plants are distinguished according to the heat source that provides the thermal energy:

Nuclear power plant

Coal-fired power plant

Oil-fired power plant

Rarely exclusive use of oil, mostly as an additive to coal.

Solar thermal power plant

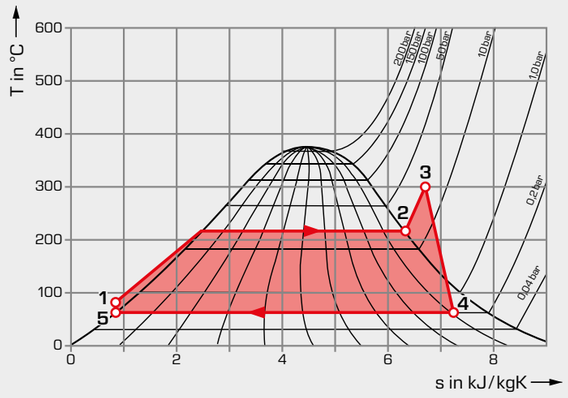
Gas and steam turbine power plant

Theoretical fundamentals of the cyclic process of a steam power plant

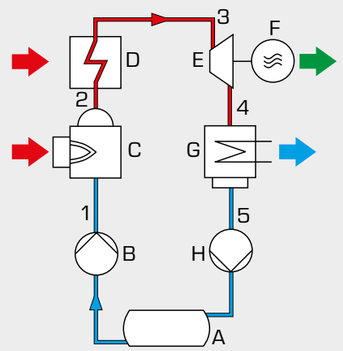
Rankine cycle

The Rankine cyclic process is used to assess, evaluate and compare steam power plants. This thermodynamic cyclic process describes the conversion of thermal energy into mechanical energy and vice versa. As with all thermodynamic cycles, it cannot exceed the efficiency of the corresponding Carnot process.

In steam power plants, first the thermal energy of a working medium (usually water but also ammonia, for example) is converted into mechanical energy. To this end, the working medium is alternately condensed at low pressure and evaporated at high pressure. The pressure is applied by the feed pump through expending work and reduced in the turbine while releasing work. The working medium is carried in a closed circuit.



T-s diagram of a steam power plant



Process schematic for a steam power plant

A feed water tank, **B** feed water pump, **C** steam boiler, **D** superheater, **E** steam turbine, **F** generator, **G** condenser, **H** condensate pump;

thermal energy, low temperature,
thermal energy, high temperature,
mechanical/electrical energy

The T-s diagram represents the Rankine cycle of a steam power plant. The working medium is water or water steam.

1 – 2
the water is **isobarically** heated and evaporated in a steam boiler at a pressure of 22 bar

2 – 3
isobaric superheating of the steam to 300°C

3 – 4
polytropic expansion of the steam in the steam turbine to a pressure of 0,2 bar; mechanical energy is released in the process

Point 4
wet steam area: the wet steam content is now only 90 %

4 – 5
condensation of the steam

5 – 1
increase of the pressure to boiler pressure via the condensate and feed water pump, the cyclic process is complete