Basic knowledge

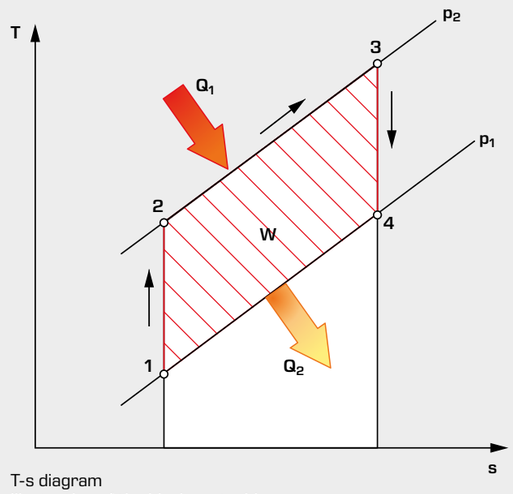
Gas turbines

Thermodynamic principle

The gas turbine works as an open cyclic process. Typical for an open cycle: the working medium is taken from the environment and fed back to it after the process is complete. The cyclic process of a gas turbine can be described by the following idealized changes of state:

- **adiabatic compression** of the cold gas with compressor **(A)** from ambient pressure p_1 to pressure p_2, associated with temperature rising from T_1 to T_2.
- **isobaric heating** of gas from T_2 to T_3 because of heat input. Heat input by burning fuel with oxygen from the air in combustion chamber **(B)**.
- **adiabatic expansion** of hot gas in a turbine **(C)** from pressure p_2 to p_1, associated with temperature decreasing from T_3 to T_4.

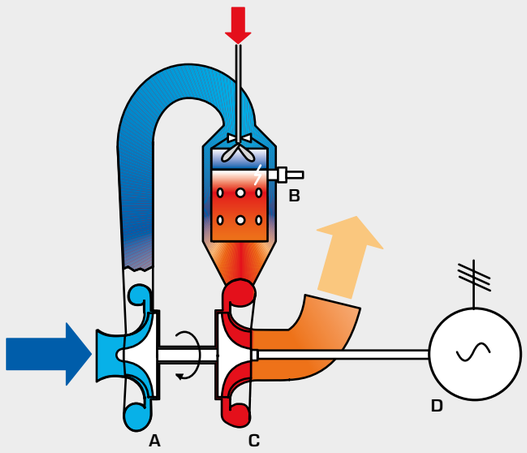
One part of the mechanical power generated by the turbine is used for driving the compressor. The rest is available as effective power for driving a generator **(D)** etc.



T-s diagram
Illustration of the ideal gas turbine process

Q_1 heat input, **Q_2** heat output, **W** useful work,
T temperature, **s** entropy;
1 - 2 compression, **2 - 3** heating, **3 - 4** expansion

Fields of application



Schematic of a simple gas turbine system

A compressor, **B** combustion chamber,
C turbine, **D** generator;
arrows: **blue** air, **red** fuel, **orange** exhaust

Gas turbines are used when high power and lightweight are required:

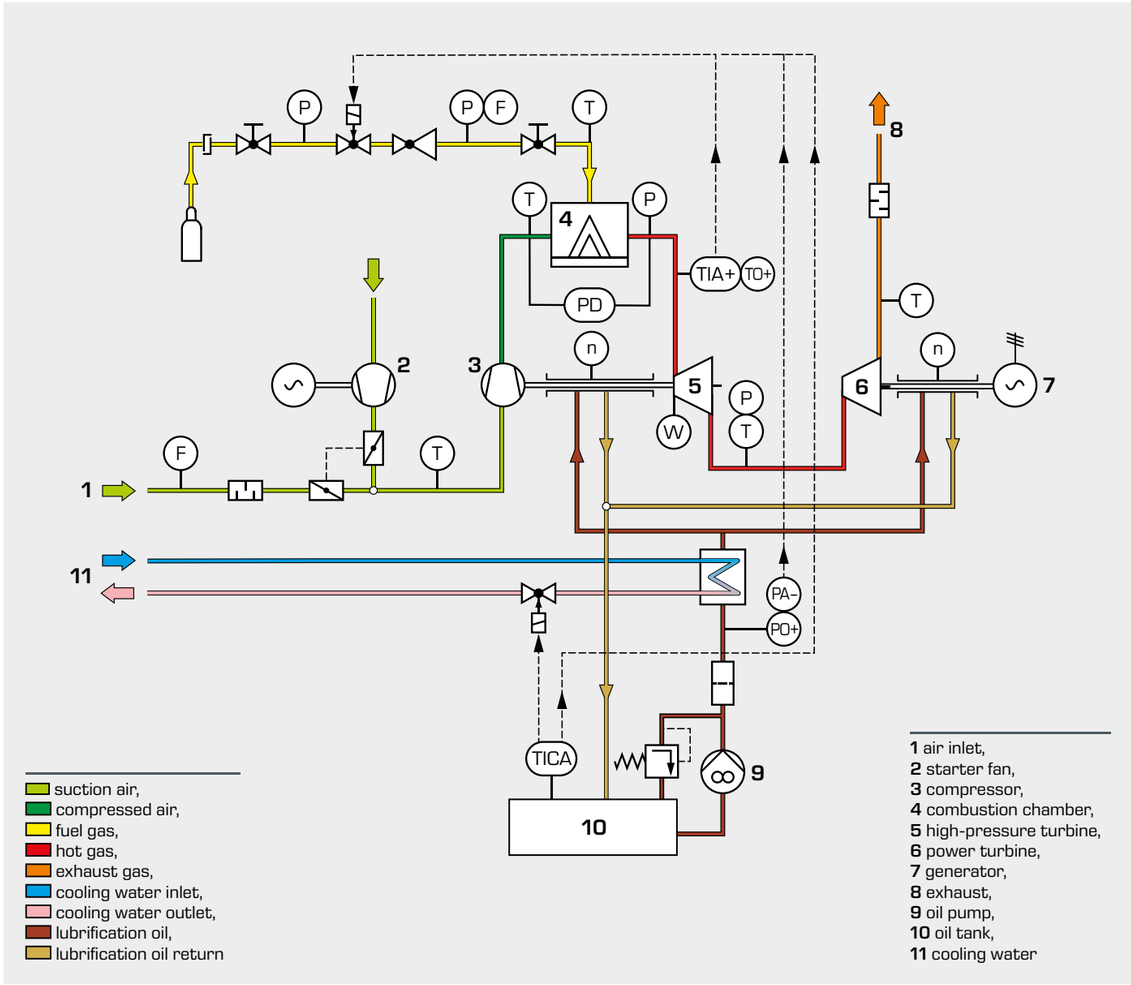
- driving aircraft with propeller or jet engine
- driving fast ships, locomotives, or heavy motor vehicles
- driving generators in power plants
- driving compressors and pumps in the petroleum and natural gas industries

Quick starting is another advantage of gas turbines. They run up quickly to full load and therefore are often used as backup drives and for peak loads. In comparison with diesel engines, higher fuel consumption is a disadvantage.

Principle of a two-shaft gas turbine

A two-shaft gas turbine consists of two independent turbines. The first turbine (the high-pressure turbine) is coupled tightly to the compressor and drives the compressor. The second turbine (the power turbine) is not mechanically coupled with the high-pressure turbine, and generates the effective power of the system. A vehicle, a propeller, or a generator can be driven.

The advantage of the two-shaft gas turbine is that compressor and high-pressure turbine are driven at optimal speed for the respective power. Speed or torque at the power turbine can be adapted and optimised to the respective drive function. Vehicles require a variable speed, whereas a synchronous generator needs a constant speed.



Process schematic of two-shaft gas turbine ET 794 with independent power turbine and generator

The turbine is operated with combustion gas. An electrically driven auxiliary compressor (starter fan) starts the turbine. At a certain minimum speed, fuel gas is fed into the combustion chamber and is electrically ignited. After reaching idle speed, the auxiliary compressor is turned off and the turbine runs on its own.

An oil circuit with a thermostatically controlled oil-to-water cooler, pump, and filter lubricates and cools the turbine bearings.

The turbine shuts down if the oil temperature is too high or the oil pressure is too low.