ET 794

Gas turbine with power turbine

2E

Learning objectives/experiments

- determining the shaft power
- determining specific fuel consumption
- recording the characteristics of the power turbine
- determining the system efficiency

Description

- **simple model of a gas turbine**
- **two-shaft arrangement with high-pressure turbine and power turbine**
- **display and control panel with illustrative process schematic**
- **propane gas as fuel**

Gas turbines with free-running power turbines are used primarily as drive systems for widely varying power requirements in power plants and on board ships, locomotives, and motor vehicles.

The ET 794 trainer investigates the behaviour during operation of a system with two independent turbines in a two-shaft arrangement. One turbine (the high-pressure turbine) drives the compressor and the other turbine (the power turbine) supplies the effective power. Changes in power output in the power turbine have no influence on the compressor, which is able to keep running at optimum speed at the best efficiency point.

The trainer includes the following components: compressor, tubular combustion chamber and high-pressure turbine; fuel system; starter and ignition system; lubrication system; power turbine; generator; and measuring and control equipment.

The complete unit is called gas turbine. The gas turbine works as an open cyclic process, with the ambient air being drawn out and fed back in. The high-pressure turbine together with the compressor and the combustion chamber are called gas generator as they produce the required gas for the power turbine. To do so, the ambient air drawn in is brought to a higher pressure in the single-stage radial compressor. When the air enters the combustion chamber, only part of it is used for combustion. This air is decelerated with the aid of a turbulence generator such that the added fuel is able to burn with a stable flame. The greater portion of the air is used to cool the combustion chamber components, and is mixed into the combustion gases at the end of the combustion chamber. This reduces the gas temperature to the permissible inlet temperature of the high-pressure turbine.

The gas flows out of the combustion chamber into the single-stage radial high-pressure turbine and discharges a portion of its energy to the turbine. This energy drives the compressor.

In the power turbine, the gas discharges the remaining portion of its energy, which is converted into mechanical energy and drives a generator. The electrical energy generated is dissipated using braking resistors. The gas turbine is started with the aid of a start-up fan.

The speed, temperatures, and pressures and the mass flow rates of the air and fuel are recorded and displayed using sensors. Typical characteristic variables are determined.

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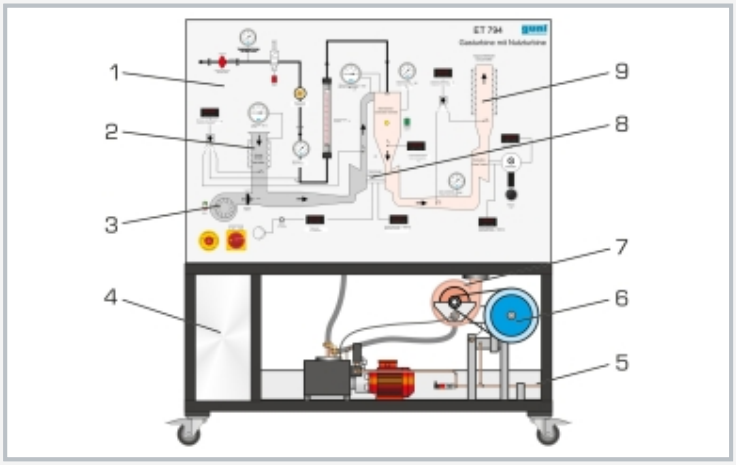
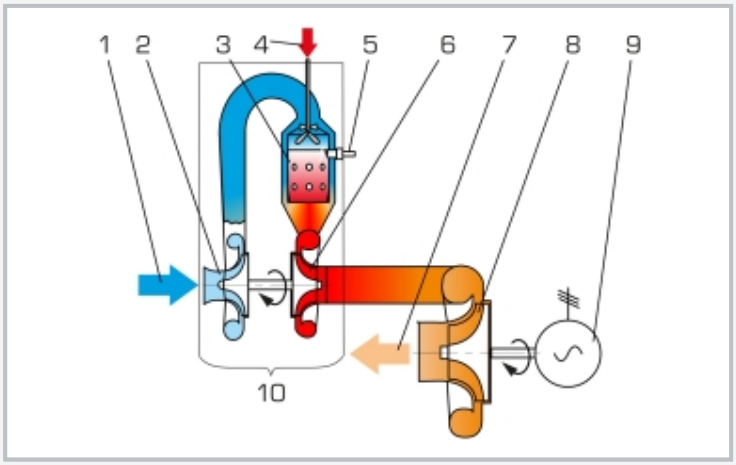
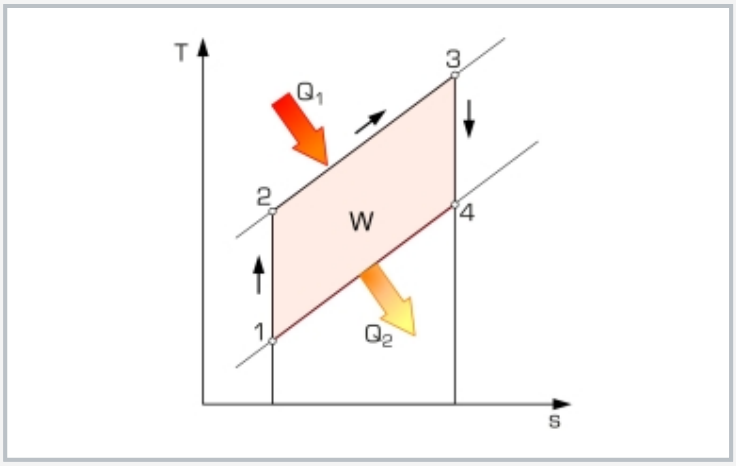


1 process schematic with displays and controls, 2 air intake with silencer, 3 start-up blower, 4 switch cabinet, 5 cooling water connection, 6 generator, 7 power turbine, 8 gas generator (compressor, combustion chamber, high-pressure turbine), 9 exhaust silencer



Function schematic of the system: 1 cold air, 2 compressor, 3 tubular combustion chamber, 4 fuel, 5 spark plug, 6 high-pressure turbine, 7 exhaust gas, 8 power turbine, 9 generator, 10 gas generator



T-s diagram of open gas turbine process: 1-2 compression, 2-3 heat addition, 3-4 expansion; Q_1 heat input, Q_2 heat output, W useful work

Specification

[1] experiments relating to the function and behaviour during operating of a gas turbine in a two-shaft arrangement
[2] operation with power turbine and generator
[3] asynchronous motor with frequency converter as generator
[4] start-up fan to start the high-pressure turbine
[5] conversion of generated electrical energy into heat using four 600W braking resistors
[6] effective silencing at intake and exhaust for laboratory operation
[7] sensors record all relevant data visualised on displays in the process schematic

Technical data

Gas generator (compressor and high-pressure turbine)
- speed range: 60000...125000min^{-1}
- max. pressure ratio: 1:2,0
- max. mass flow rate (air): 0,115kg/sec
- max. fuel consumption: 120g/min

Power turbine
- speed range: 10000...40000min^{-1}
- mechanical power: 0...1,5kW
- electrical power: 0...1kW
- sound level at 1m distance: max. 80dB(A)
- temperature exhaust gas: 700°C

Measuring ranges
- temperature: 4x 0...200°C / 3x 0...1200°C
- speed: 0...199999min^{-1}
- electric power: 0...1999W
- velocity: 0...28m/s (air inlet)
- flow rate: 1,5...10,5kg/h (fuel)
- supply pressure: 0...25bar (fuel)
- nozzle pressure: 0...4bar (fuel)
- combustion chamber pressure loss: 0...20mbar
- pressure (inlet):power turbine 0...2,5bar (power turbine)
- pressure (inlet): 0...250mbar (power turbine)

230V, 50Hz, 1 phase
230V, 60Hz, 1 phase
230V, 60Hz, 3 phases
UL/CSA optional
LxWxH: 1510x770x1810mm
Weight: approx. 300kg

Required for operation

cooling water: 200L/h, propane gas: 4...15bar
ventilation 500m^3/h, exhaust gas routing

Scope of delivery

1 trainer
1 set of instructional material