STAG-unit with back-pressure steam turbine

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4.1 Introduction

In this chapter a simple example of a STAG unit is shown. This example contains three ‘independent’ cycles, namely a gas turbine cycle, a water/steam cycle and a district heating cycle.
The diagram is shown in Figure 4-1.

4.2 System description

In this example natural gas is fed to the gas turbine via source 1 and air via source 2. The gas turbine consists of compressor 3, combustor 4 and turbine 5. The flue gases from the turbine are passed to stack 6 via surface heat exchangers 18, 17, 14 and 32.
The flue gases are used to heat the water/steam in the water/steam cycle to an inlet temperature for steam turbine 10 of 450 °C. The steam then expands in the turbine and the heat is transferred via condenser 33 to the district heating system. Via pump 11, deaerator 12 and pump 13 the steam condensed to water is passed back to the waste heat boiler (heat exchangers 18, 17, 14 and drum 15) where steam is again produced.
The water from the district heating system is heated in condenser 33 and in an extra heat exchanger 32 in the gas turbine cycle. The heated district heating system is represented by

heat sink 30.

The electric power is supplied by generators which are driven by the gas and steam turbine.

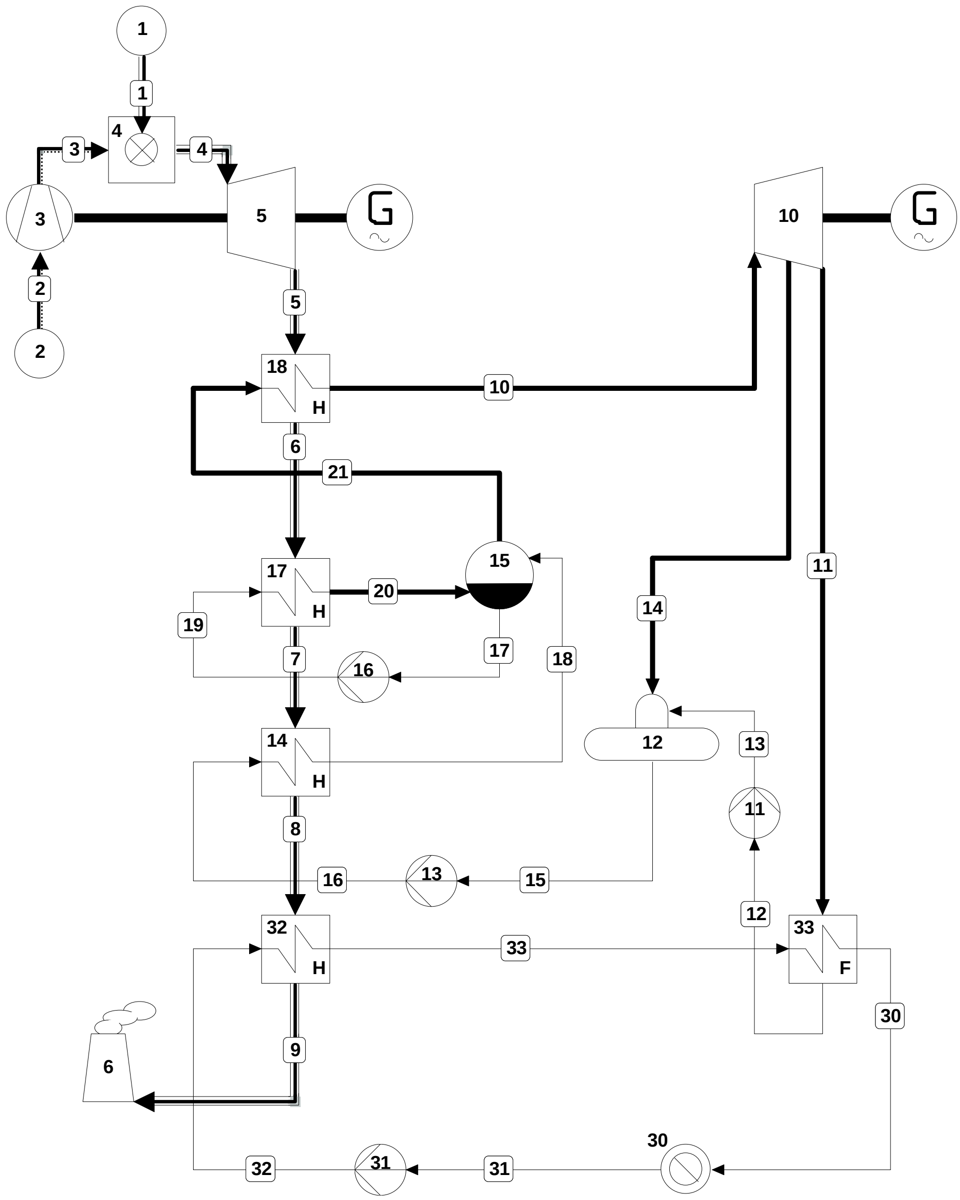

Figure 4-1: STAG-unit with back-pressure steam turbine

4.3 Starting points for the calculation

The most important starting points are:

Gas turbine

fuel:	standard Slochteren natural gas (specified for pipe 1)
oxidant:	standard air (specified for pipe 2)
inlet temperature air:	TOUT = 290 °C
(see compressor 3/8)	
isentropic efficiency:	ETHAI = 0.85
inlet pressure turbine 5/3:	PIN = 8.9 bars
outlet temperature turbine 5/3:	TOUT = 530 °C
power:	SURPMW = 30 MW (specified for the shaft)

Steam turbine 10

inlet pressure:	PIN = 40 bars
inlet temperature:	TIN = 450 °C

Pump 11

isentropic efficiency:	ETHAI = 0.85

Deaerator 12

inlet pressure:	PIN = 2 bars

Pump 13

isentropic efficiency:	ETHAI = 0.85

Heat exchanger 14

pressure drop primary side:	DELP1 = 3 bars
pressure drop secondary side:	DELP2 = 0 bar
temperature difference at	
high-temperature side:	DELTH = 20 K

Pump 16

isentropic efficiency:	ETHAI = 0.85

Heat exchanger 17

pressure drop primary side:	DELP1 = 1 bar
pressure drop secondary side:	DELP2 = 0.005 bar
temperature difference at low-temperature side:	DELTL = 16 K

Heat exchanger 18

pressure drop primary side:	DELP1 = 2 bars
pressure drop secondary side:	DELP2 = 0.005 bar

District heating system 30

outlet pressure:	POUT = 2 bars
outlet temperature:	TOUT = 70 °C

Pump 31

outlet pressure:	POUT = 15.0 bars
isentropic efficiency:	ETHAI = 0.85

Heat exchanger 32

pressure drop primary side:	DELP1 = 2 bars
pressure drop secondary side:	DELP2 = 0.005 bar
outlet temperature secondary side:	TOUT2 = 100 °C

Condenser 33

pressure drop primary side:	DELP1 = 1 bar
pressure drop secondary side:	DELP2 = 0 bar
outlet temperature primary side:	TOUT1 = 110 °C
temperature difference at high-temperature side:	DELTH = 3 K

Generators

efficiency (both):	ETAGEN = 0.975

Pipe data

Pipe 13: pressure drop	DELP = 0.1 bar