University of Nottingham
Department of Mechanical, Materials and Manufacturing engineering

Thermofluids 3

Self Assessment Exercise Sheet – Steam Cycles

1. A supercritical steam cycle is as follows:

Boiler pressure	250 bar
Boiler superheater outlet temperature	600°C

There are three steam turbines.
The high pressure (HP) steam turbine has an isentropic efficiency of 90% and the outlet pressure is 50 bar.
Some steam is bled from the HP turbine outlet to a closed feedheater.
The remaining steam is reheated in the boiler to 600°C and then enters the intermediate pressure (IP) steam turbine.

The IP steam turbine has an isentropic efficiency of 91% and an outlet pressure of 5 bar.
Some steam is bled from the IP turbine outlet to an open feed heater.
The remaining steam then passes into the low pressure (LP) steam turbine.

The LP steam turbine has an isentropic efficiency of 92% and exhausts to an outlet pressure of 0.07 bar into the condenser. The steam is condensed in the condenser and the water leaves as saturated water at 0.07 bar.

In the closed feed heater, the boiler feedwater is heated to 259°C. The bled steam that is fed to this feedheater leaves as liquid water at a temperature of 250°C and is throttled into the open feed heater.

In the open feed heater the boiler feedwater is preheated to 148°C.

Ignoring feed pump work calculate:

i) The cycle thermal efficiency (steam turbine work output/boiler heat input)
ii) The specific steam consumption.
iii) If the heat input to the boiler is 1000 MW and the generator is 96% efficient, what is the generator electricity output?

[i) 48.2 %, ii) 0.74 kg/MJ, iii) 463 MW]

2. An industrial furnace has a flue gas flow rate of 32 kg/s and the temperature is 480°C. These hot gases pass through a heat recovery boiler in which steam is produced to generate electricity. The mean specific heat capacity of the hot gases is 1.07 kJ/kgK at the temperature in the heat recovery boiler. In the steam cycle the steam pressure is 50 bar and the outlet steam temperature is 450°C. The steam turbine has an isentropic efficiency of 89% and the outlet pressure is 0.1 bar.

   i) the pinch temperature difference is 25°C, calculate the electricity output from the steam turbine generator, assuming an efficiency of 94%.

   ii) If the pinch temperature difference was reduced to 5°C, what would the electricity output from the steam turbine generator be, (assuming no changes in steam conditions) and by how much would the evaporator and economiser need to increase in size?

[i) 2.9 MW, ii) 3.2 MW, The economiser would need to increase in size by a factor of 2.1 and the evaporator would need to increase in size by a factor of 1.8]