SPG course MJ2405

Exercise 5: Combined Cycle – detailed calculations

An old steam power plant is refurbished (repowered) by scrapping the steam boiler and adding a gas turbine as a topping cycle, thus converting it into a combined cycle. The gas turbine has the following characteristics:

Gas Turbine	Electrical Power Output (MW)	Electrical Efficiency (%)	Exhaust Gas flow (kg/s)	Exhaust gas temperature (ºC)
Alstom GT11N2	115	33.1	399	531

The gas content in the exhaust gas flow is x ~ 30%.

The old steam turbine already exists and would use a single-pressure HRSG, without supplementary firing. Steam needs to be produced at 50 bar, superheated to 510 ºC. The isentropic efficiency of the steam turbine is 88%. The mechanical and electrical efficiencies of the steam turbine are together 98%. The electrical power output from the steam turbine is 56 MW. The pressure in the condenser is 0.05 bar.
The steam cycle will be simplified and all feedwater preheaters demolished. For the sake of clarity the feedwater tank can also be neglected for this calculation.

Main Tasks:

1. Calculate the necessary steam mass flow for the existing steam turbine.
2. Calculate the pinch point temperature difference in the HRSG.
3. Calculate the combined cycle electrical efficiency.
4. Calculate the flue gas temperature at the end of the HRSG (in the stack).

Additional Tasks:

5. Find the exact gas content if the fuel is pure methane with LHV = 50 MJ/kg.
6. If supplementary firing is added in the HRSG to raise the gas temperature to 600 ^{o}C – how much would be the new combined cycle electrical efficiency?
7. Convert the HRSG into a double-pressure system by changing the steam turbine with a new one demanding HP steam input at 90 bar and LP steam at 10 bar, where the HP and LP steam mass flows are equal. Recalculate for finding the new overall electrical efficiency value.