COGENERATION

QUESTION

A process industry has decided to install cogeneration plant. The process requirements are:

- The plant requires 4.5 MW of electrical power
- The boiler has a maximum steam generating capacity of 31.25 TPH at 63 kg/cm^2 pressure and a temperature of 486 °C
- The table below gives the process steam requirements

Process	Steam flow (TPH)	Pressure (kg/cm^2)	Temperature (°C)	Enthalpy (kCal/kg)
Boiler	31.25	63	486	808
Process # 1	3.25	21	310	669
Process # 2	8.00	8.0	174	662
Process # 3	20.0	5.0	160	659

1. Determine the total power that could be generated by a single turbine that meets the process steam requirements
2. Calculate the additional amount of power to be purchased from the grid
3. Calculate the heat to power ratio of the cogeneration plant

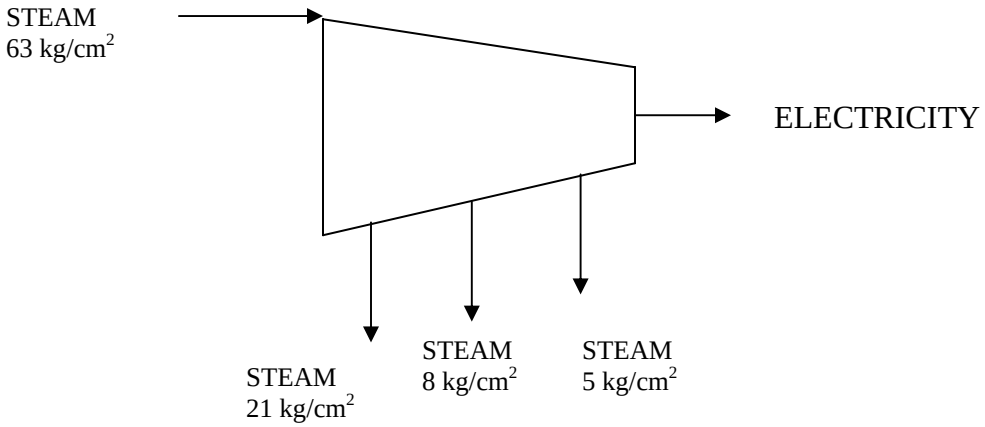
The following data are given:

Alternator efficiency:	95%
Transmission efficiency:	95%
Thermal efficiency of turbine:	80%
1 kW electricity:	860 kCal

SOLUTION

1. Determine the total power that could be generated by a single turbine that meets the process steam requirements

The figure below illustrates the steam extracted through the turbine for process 1, 2 and 3.



The amount of heat remaining after steam has been extracted for process 1, 2 and 3 is calculated as follows:

Total enthalpy of steam = enthalpy of steam x total quantity of steam

Therefore the steam enthalpy of steam going in and leaving the turbine is

- Turbine inlet = 808 kCal per kg x 31250 kg = 25,250,000 kCal/kg
- Outlet to process # 1 = 669 x 3250 = 2,174,250 kCal/h
- Outlet to process # 2 = 662 x 8000 = 5,296,000 kCal/h
- Outlet to process # 3 = 659 x 20000 = 13,180,000 kCal/h

Total amount of heat remaining

= Total enthalpy of steam at turbine inlet – Total enthalpy of steam at outlets to processes
= 25,250,000 – (2,174,250 + 5,296,000+ 13,180,000)
= 4,599,750 kCal/h

Total amount of power generated

= (Total amount of heat remaining x turbine efficiency x transmission efficiency x generator efficiency) / 860 kCal per kW
= (4,599,750 x 0.8 x 0.95 x 0.95) / 860 kCal per kW
= 3861 kW = 3.86 MW

2. Calculate the additional power to be purchased from the grid

Additional power required
= total power required - Total amount of power generated
= 4.5 – 3.86
= 0.64 MW

3. Calculate the heat to power ratio of the cogeneration plant

Heat for the process requirement
= Total enthalpy of steam at outlets to processes / 860 kCal per kW
= (2174250 + 5296000+ 13180000) / 860
= 24,000 kW = 24MW

Heat to power ratio
= Thermal energy / Electrical energy
= MW_{th} / MW_e
= 24 MW / 3.86 MW
= 6.22