STEAM DISTRIBUTION AND UTILIZATION

A paper plant has an extensive steam network. The steam is generated at a pressure of 10 bar and the condensate is not recovered. The plant management is planning to generate flash steam (from the condensate) for use as low pressure process steam and to recover as much steam condensate as practical.

With the help of the data provided, calculate the following:

1. Quantity of flash steam generated (kg)
2. Annual savings from flash steam recovery in US$/year
3. Annual savings from flash steam recovery and condensate recovery in US$/year

The following data is provided:

- Total enthalpy of steam at 10 bars: 672 kCal/kg
- Condensate quantity: 1000 kg/hr
- Condensate pressure: 10 bar
- Cost of steam: US$ 25/ton
- Annual operating hours: 8000
- Low pressure process steam pressure: (Flash steam pressure) 2 bar
- Sensible heat of condensate at 10 bar: 187.1 kCal/kg
- Sensible heat of condensate at 2 bar: 134.4 kCal/kg
- Latent heat of steam at 2 bar: 517.5 kCal/kg
- Boiler efficiency: 82%
- Fuel used in boiler: Furnace oil
- GCV of Furnace oil: 10,200 kCal/kg
- Specific gravity of furnace oil: 0.92
- Condensate temp. when recovered: 95^{0}C
- Make-up water temperature: 35^{0}C
- Cost of furnace oil: US$ 350/kiloliter

The following equation is given:

Flash steam generation potential condensate (%) = (S_1-S_2/L) X 100

Where,
S1 = Sensible heat of condensate at high pressure
S2 = Sensible heat of condensate at low pressure
L = latent heat of steam at low pressure

SOLUTION

1. Calculate the quantity of flash steam generated (kg)

Flash steam generation potential condensate (%) = (S_1-S_2/L) X 100

Where,
S1 = Sensible heat of condensate at 10 bar = 187.1 kCal/kg
S2 = Sensible heat of condensate at 2 bar = 134.4 kCal/kg
L = latent heat of steam at low pressure = 517.5 kCal/kg

= (187.1–134.4) / 517.5
= 0.1018 kg / kg of condensate

Flash steam generated from 1000 kg/hr condensate at 10 bar
= 1000 * 0.1018
= 101.8 kg/hr

2. Calculate the annual savings from flash steam recovery in US$/year

Annual steam savings = 101.8 kg/hr x 8000 hr/yr / 1000 = 814 tons/yr
Equivalent annual steam heat savings = (101.8 kg/hr x 672 kCal/kg) = 68,410 kCal/hr
Annual monetary savings = (814 tons/yr x US$ 25/ton)= US$ 20,350

3. Calculate the annual savings from flash steam recovery and condensate recovery in US$/year

Condensate available for recovery after flash steam = (1000 kg/hr – 101.8 kg/hr) = 898 kg/hr
Heat recovery potential through condensate recovery
= Mass of condensate x Specific heat of condensate x Temperature difference
= 898 kg/hr x 1 x (95-35)
= 53880 kCal/hr

Heat savings from flash steam recovery and condensate recovery
= (68410 kCal/hr + 53880 kCal/hr) = 122,290 kCal/hr

Annual fuel oil savings
= (heat savings x hours per year) / (boiler efficiency x GCV of fuel)
= (122,290 kCal/hr x 8000 hr/yr) / (0.82 x 10,200 kCal/kg)
= 116,968 kg/yr
= 116,968 / 0.92 = 127,139 liters = 127.1 kiloliters

Annual monetary savings
= 127.1 kiloliters x 350 US$/kl
= 44,485 US$/yr