<u>Sizing calculations of Boiler Pumps and ID / FD Fans :</u>

Sample sizing calculations for BFW pumps and Fans for a typical Coal fired Boiler generating steam of 50,000 Kg/hr at 67 kg/cm2 and 485 degC. (110,000 lb/hr at 950 PSI & 905 F). Feed Water inlet at 105 C and Exhaust gas temp at 150 C.

Let us first calculate heat load and fuel consumption of the above boiler.

Pressure and temp at 1. Superheater Outlet : 67 Kg/cm2 & 485 C
2. Steam Drum : 73 Kg/cm2 & Saturated
3. Economizer inlet : Water inlet at 105 C

From Steam tables,

Enthalpy of Superheated steam , Hsh = 809 Kcal/ kg = 1456 BTU/lb
Enthalpy of Drum water , Hdwat = 305 Kcal/kg = 549 BTU/lb
Enthalpy of inlet water , Hwat = 105 Kcal/kg = 189 BTU/lb

Assume 3% Blowdown from Boiler.

Total Heat Load of the Boiler = Total heat absorbed by water to convert to steam + heat absorbed to get superheated + Blow down losses
= 50000(809-305) + 50000 x 1.03 x (305-105)
= 35.5e06 Kcal/hr = 140.87e06 BTU/hr

Fuel consumption = Heat Load/ (HHV x Efficiency)
= 35.5e06/ (7278 x 0.8649)
= 5639 Kg/hr = 12428 Lb/hr of coal

From previous article on Combustion and efficiency,
Wet gases = 14.05 and Air = 13.12 kg / kg of coal

Therefore, Exhaust gases produced = Fuel consumption x UnitWetGas
= 5639 x 14.05
= 79,228 Kg/hr of wet gases
Combustion Air required = 5639 x 13.12
= 73,984 Kg/hr of combustion air

Feed Water required = 50,000 x 1.03 : 3% Blowdown
= 51,00 Kg/hr

Sizing Calculations :

a) <u>Boiler feed Water Pumps</u> :

Two pumps of 100 % capacity are required one for working and one for standby.

Each pump discharge capacity minimum= 51500 Kg/hr
= 51500/950 : 950 kg/m3 water density
= 53.8 m3/hr

Margin on discharge capacity : 15- 25 %.
Take 20% margin in this case.

So discharge capacity of each pump : 53.8 x 1.2
= 64.6 m3/hr =say 65 m3/hr

If Recirculation valves are not provided, you need to add min recirculation flow to the above figure, which may be about 6-10 m3/hr depending up on pump type and make.

Pump head required = Drum Pressure + Drum elevation + Piping Losses + Control Valve Loss + Other valve losses

= 75 Kg/cm2 + 2.0 + 2.0 +5.0 +2.0
= 86 Kg/cm2
= 86 x 10/0.95 mts of water head at 105C
= 905 mts of WC

Provide up to 5% margin on head. So final Pump head is 905 x 1.05 = 950 m of WC

So BFW pumps (2 nos) rating is 65 m3/hr at 950 m of WC with feed water at 105 C.

b) Sizing calculations of FD Fan :

Forced Draft Fan is required to pump in primary combustion Air into the Boiler furnace. Air from FD fan passes through Air Heater before entering furnace through Grate. Secondary Air Fan (SA fan) supplies secondary combustion air in to the furnace. Usually primary air is 70 -80 % of the total air and balance is supplied as secondary air through SA fan. Secondary air is supplied at a higher pressure to help fuel spreading on the grate called as pneumatic spreading.

Total combustion Air, Kg/hr = 73,984
= 73994/(1.17 x 3600) m3/s :Air density-1.17kg/m3
= 17.56 m3/s

Primary Air , 70% of total , m3/s = 0.7 x 17.56
= 12.3 m3/s

Take 20% margin on discharge capacity. So FD Fan flow is 1.2 x 12.3 = 14.76 m3/s

Head required = Draft loss across Air Heater + Grate + Ducting & others
= 75 mmWC + 75 + 50 mm : Approximate

= 200 mm WC (approximate)

Take 15-20 % margin on head. So FD fan head should be about 230 mm of WC.

Therefore, FD fan rating is 15 m3/s of air at 230 mm WC static head.

Power requirements of FD Fan :

Let us assume Fan efficiency as 75% and Motor Efficiency as 90%.

Power required for FD Fan, BHP = Flow x Head / (Efficiency x 75.8)
= 15 x 230 / (0.75 x 75.8)
= 60.7 HP

Motor HP required = 60.7 / 0.9 = 68 HP

Annual cost of operation assuming 7 cents per KWH and 7200 hrs of operation per annum. 0.74 is factor for converting HP to KW. Pl note that unit Electricity charges vary widely across different countries.

= 68 x 0.74 x 0.07 x 7200
= $ 25, 362 /-

c) Sizing calculations of SA Fan :

Secondary Air Fan (SA fan) supplies secondary combustion air in to the furnace.

Secondary Air , 30% of total , m3/s = 0.3 x 17.56
= 5.27 m3/s

Take 20% margin on discharge capacity. So SA Fan flow is 1.2 x 5.27 = 6.3 m3/s

SA fan static head is about 630 mm WC.

Therefore, SA fan rating is 6.3 m3/s of air at 650 mm WC static head.

Power requirements of SA Fan :

Let us assume Fan efficiency as 70% and Motor Efficiency as 90%.

Power required for FD Fan, BHP = Flow x Head / (Efficiency x 75.8)
= 6.3 x 650 / (0.7 x 75.8)
= 77.1 HP

Motor HP required = 77.1 / 0.9 = 86 HP

Annual cost of operation assuming 7 cents per KWH and 7200 hrs of operation per annum. 0.74 is factor for converting HP to KW. Pl note that unit Electricity charges vary widely across different countries.

= 86 x 0.74 x 0.07 x 7200
= $ 32,075 /-

d) Sizing calculations of ID Fan :

Induced draft fan or ID Fan is required to evacuate the exhaust gases from Boiler to atmosphere through Duct collectors and chimney. Usually ID should take care of draft loss across the Boiler from furnace to Air heater and then draft loss across Duct Collectors like ESP, Wet Scrubber or mechanical type Cyclone dust collectors .etc.
Total wet gases, Kg/hr = 79,228

Gas Density = 1.3265 Kg/Nm3

Therefore, gas flow in Nm3/hr = 79,228 / 1.3265
= 59227 Nm3/hr
= 16.6 Nm3/s

Gas flow at 150C in m3/s = 16.6 x (273+150)/273 = 25.7

ID Fan capacity taking 20% margin on flow = 25.7 x 1.2
= 30 m3/s

ID Fan static Head = Draft Loss in (Boiler + Duct + Dust collector)
= 150 + 50 + 50 mm WC : Approximate
= 250 mmWC

Taking 20% margin on head, ID Fan head = 250 * 1.2 = 300 mm WC

Power requirements of ID Fan :

Let us assume Fan efficiency as 75% and Motor Efficiency as 90%.

Power required for ID Fan, BHP = Flow x Head / (Efficiency x 75.8)
= 30 x 300 / (0.75 x 75.8)
= 158 HP

Motor HP required = 158 / 0.9 = 175 HP

Annual cost of operation assuming 7 cents per KWH and 7200 hrs of operation per annum. 0.74 is factor for converting HP to KW. Pl note that unit Electricity charges vary widely across different countries.

= 175 x 0.74 x 0.07 x 7200 = $ 65,268 /-