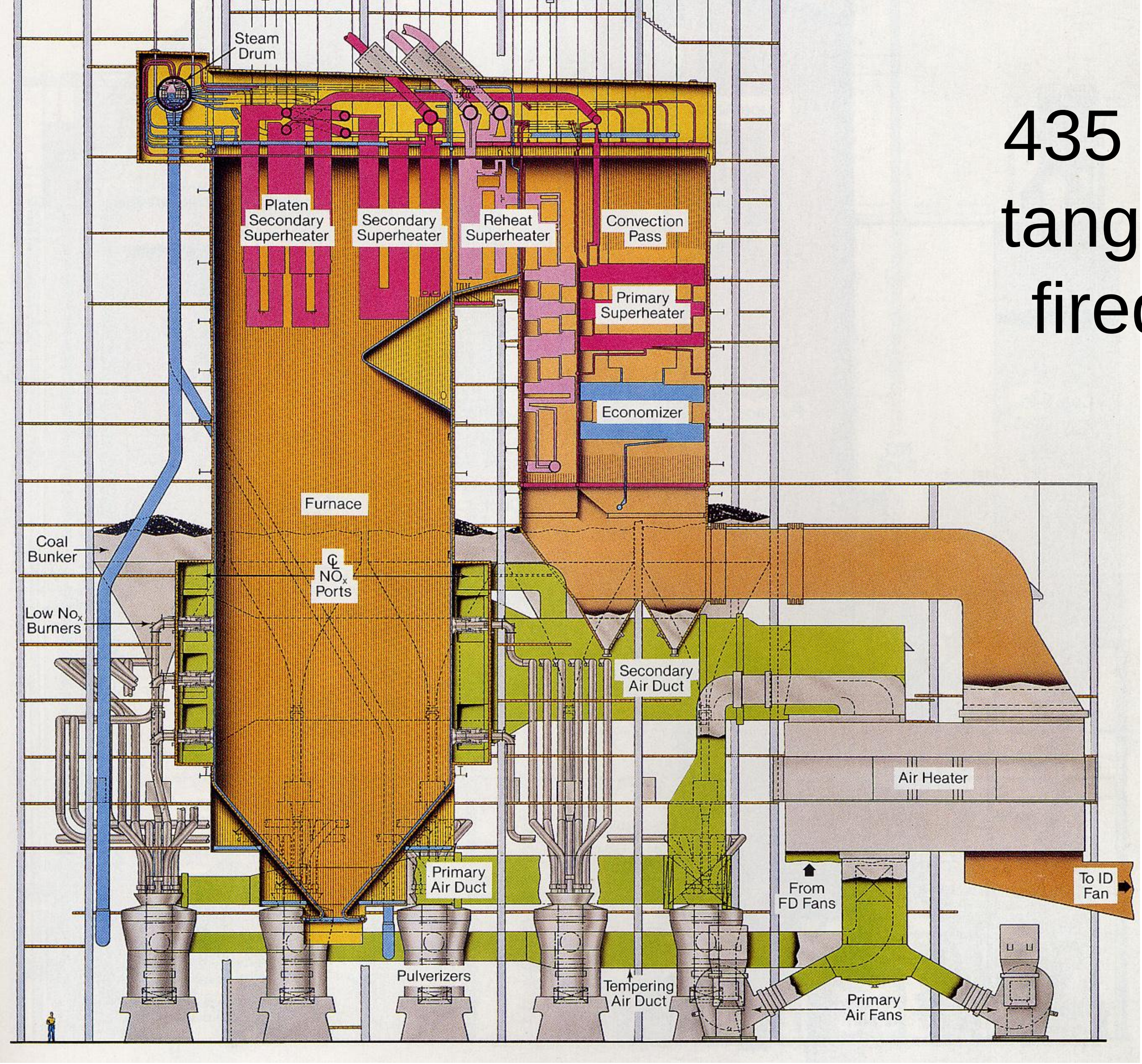
PULVERIZED COAL FIRED FURNACE

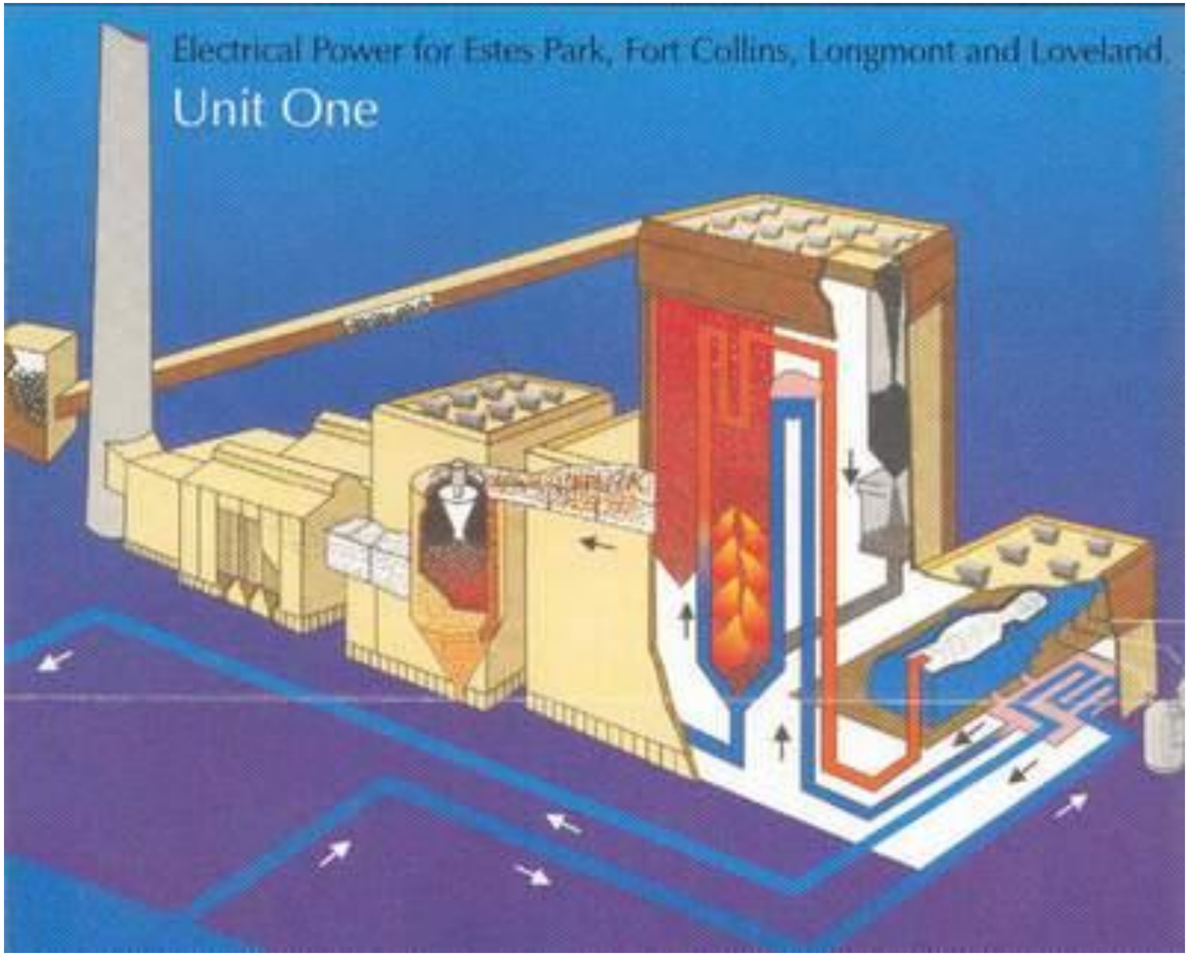
P.Basu

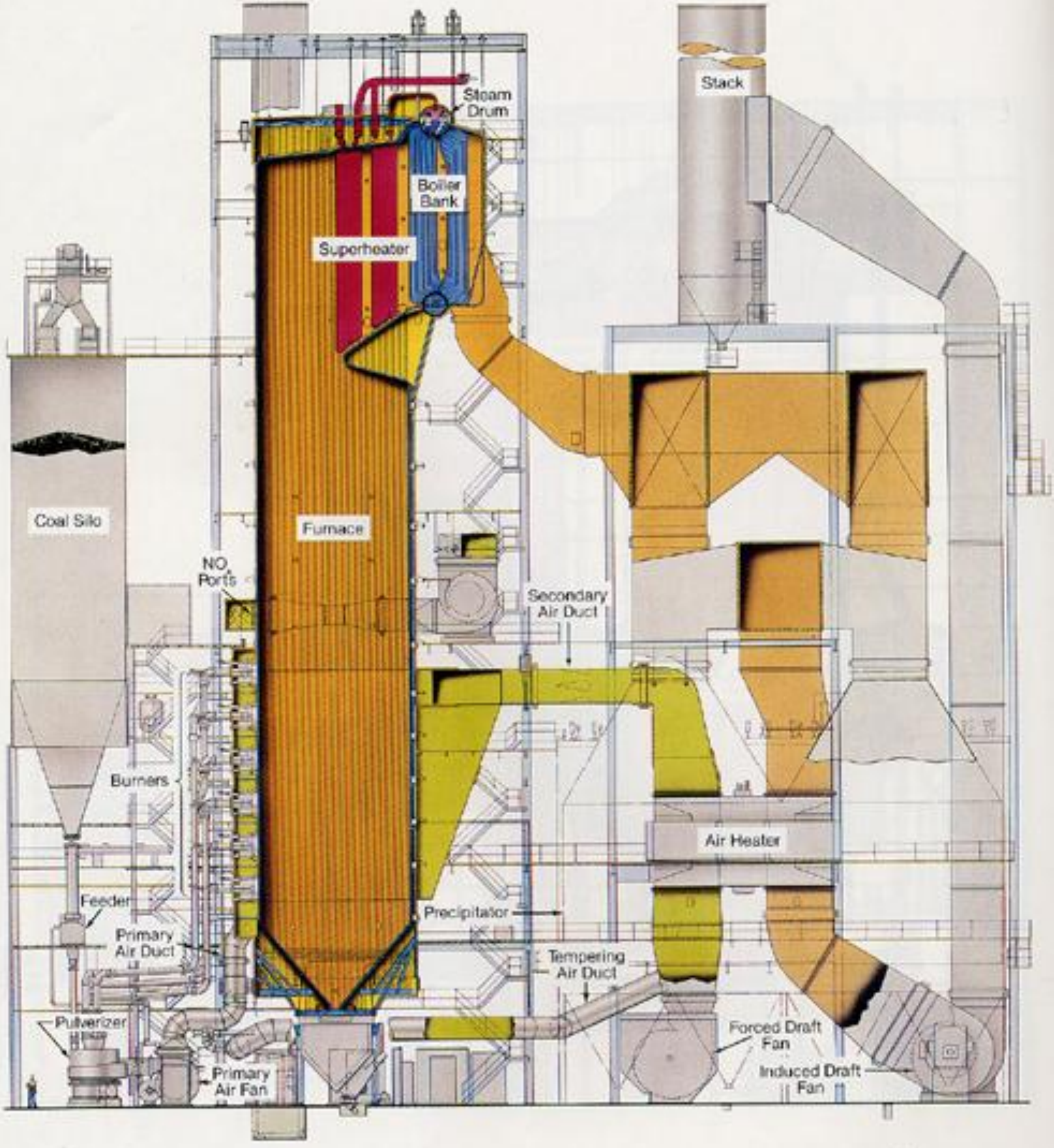
Unit 15

435 MWe tangential fired PF



A PF boiler plant

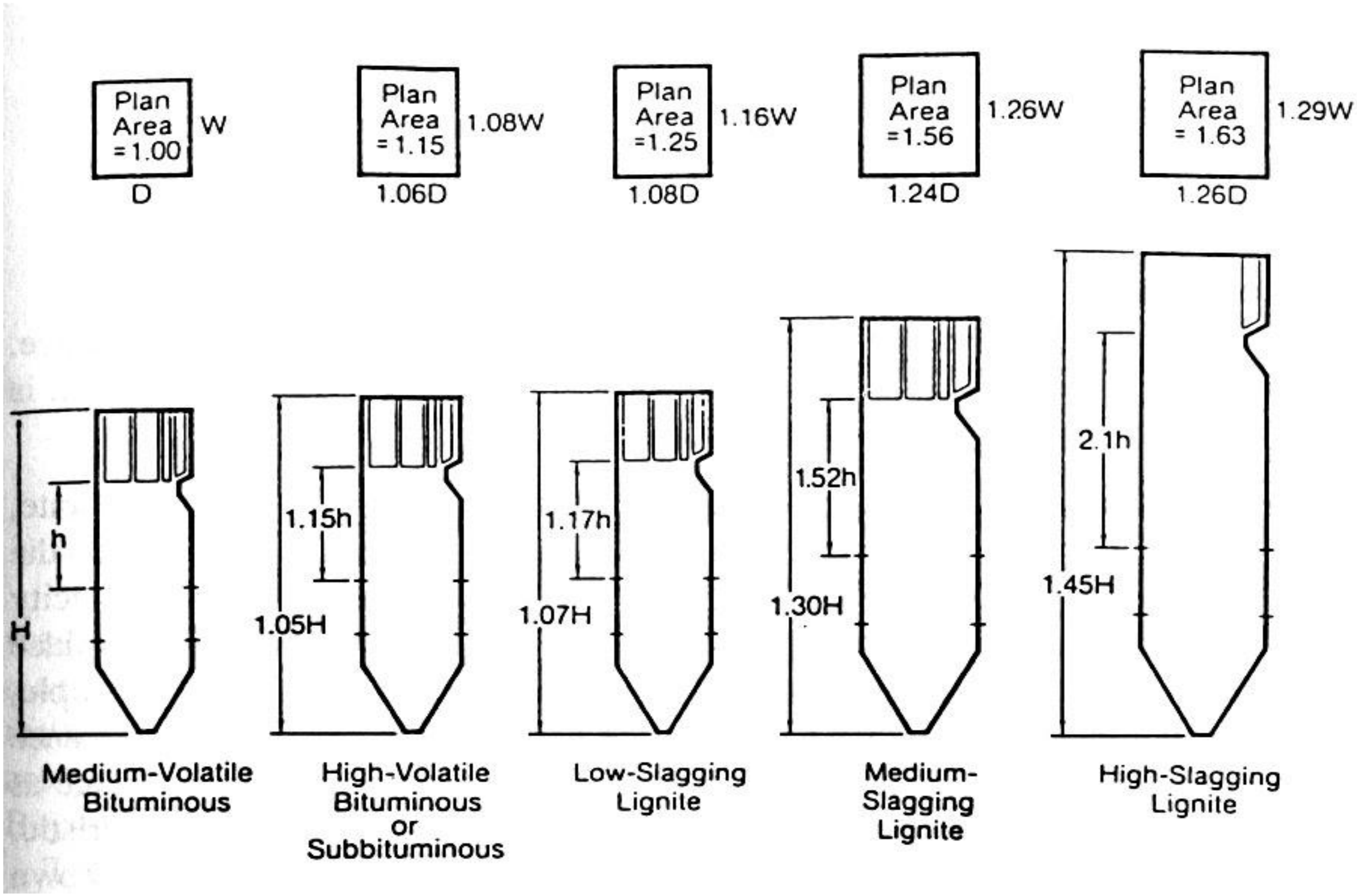




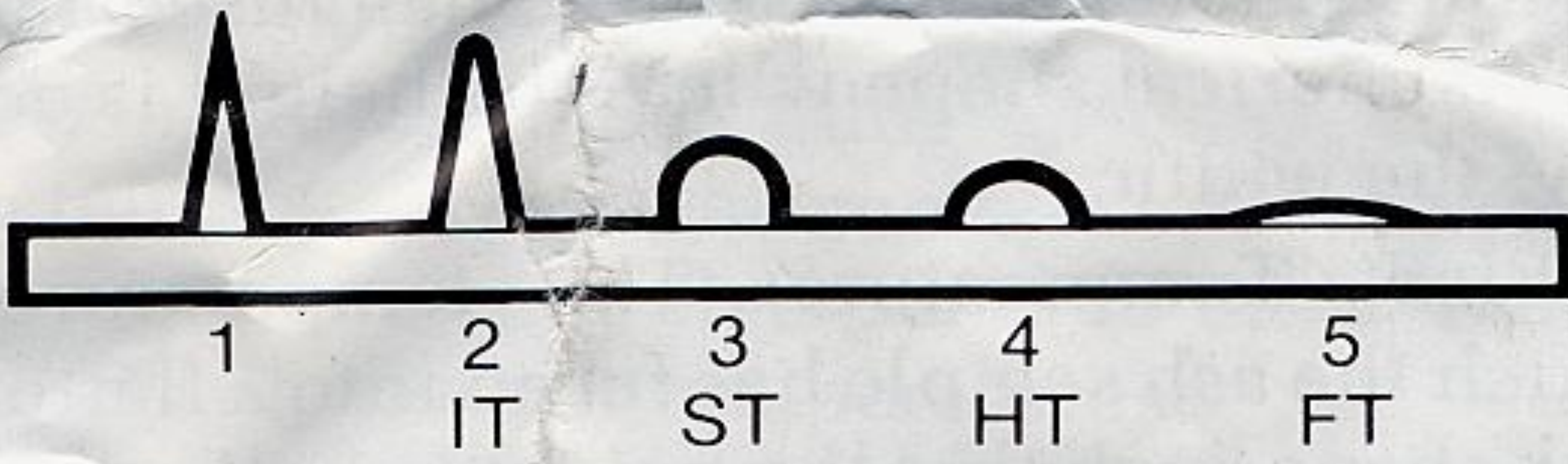
Oil/gas/
PF fired
furnace

Furnace size depends on Fuel

Amount of flue gas, burning rate of fuel and slagging propensity also affects the furnace volume

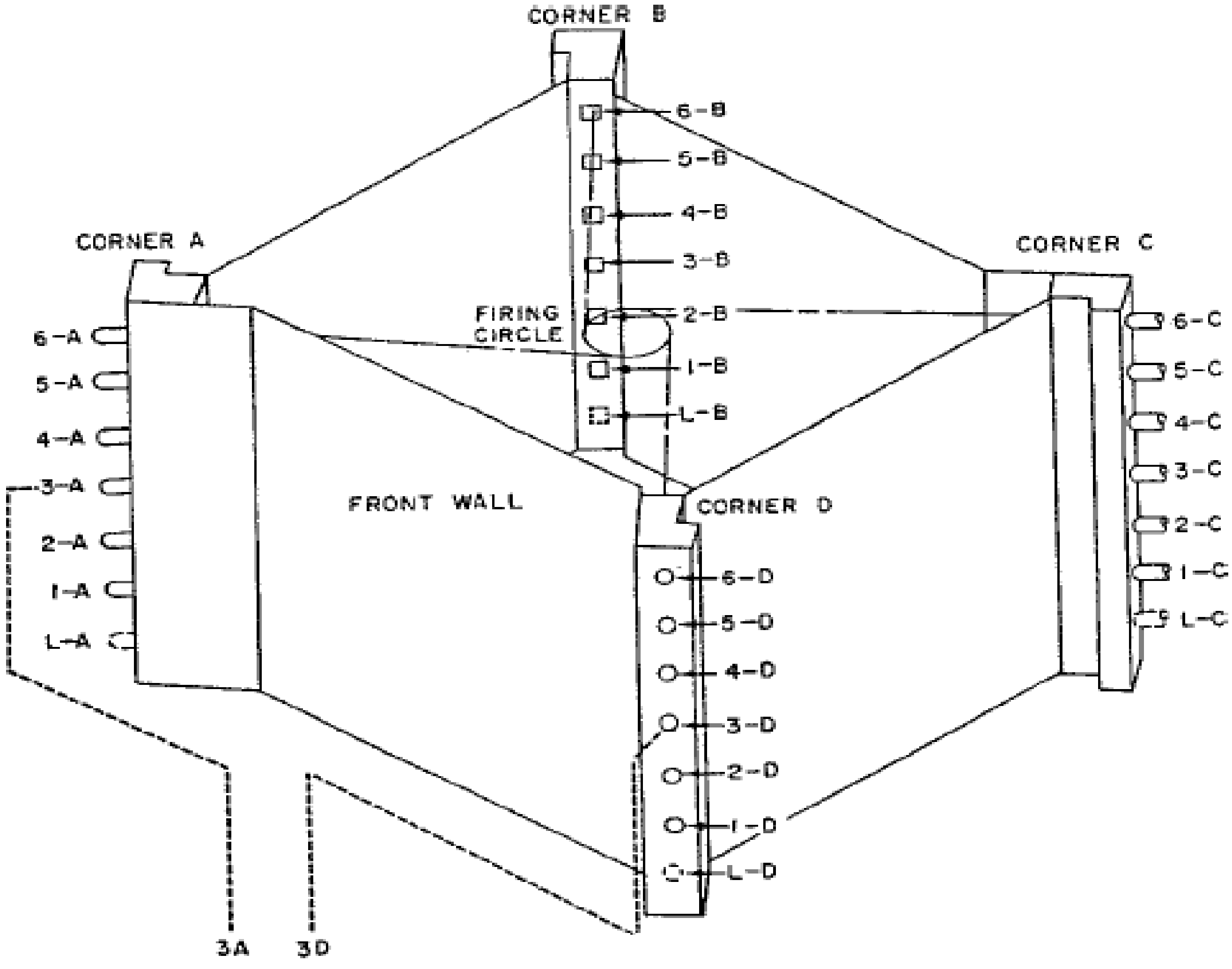


Characteristic temperatures of ash

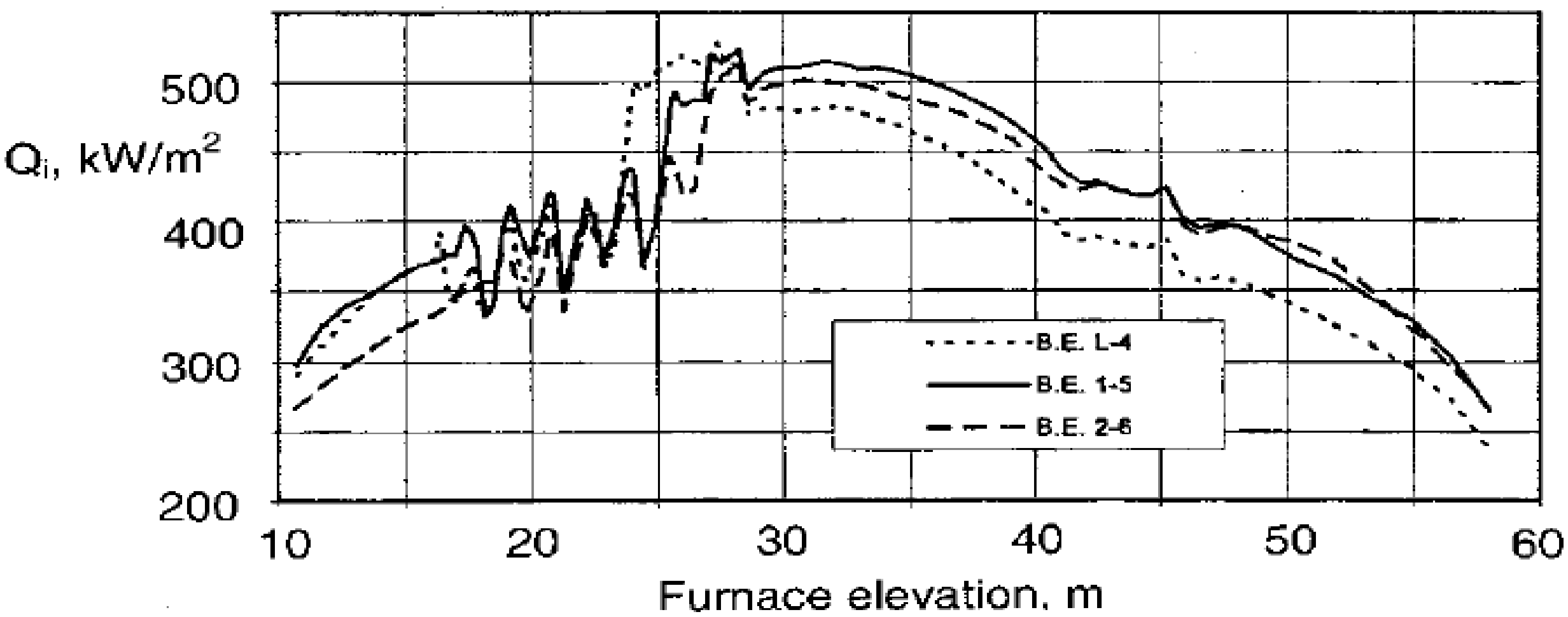


1.	Cone Before Heating
2. IT (or ID)	Initial Deformation Temperature
3. ST	Softening Temperature (H=W)
4. HT	Hemispherical Temperature (H=½W)
5. FT	Fluid Temperature

Burner locations in tangential PC

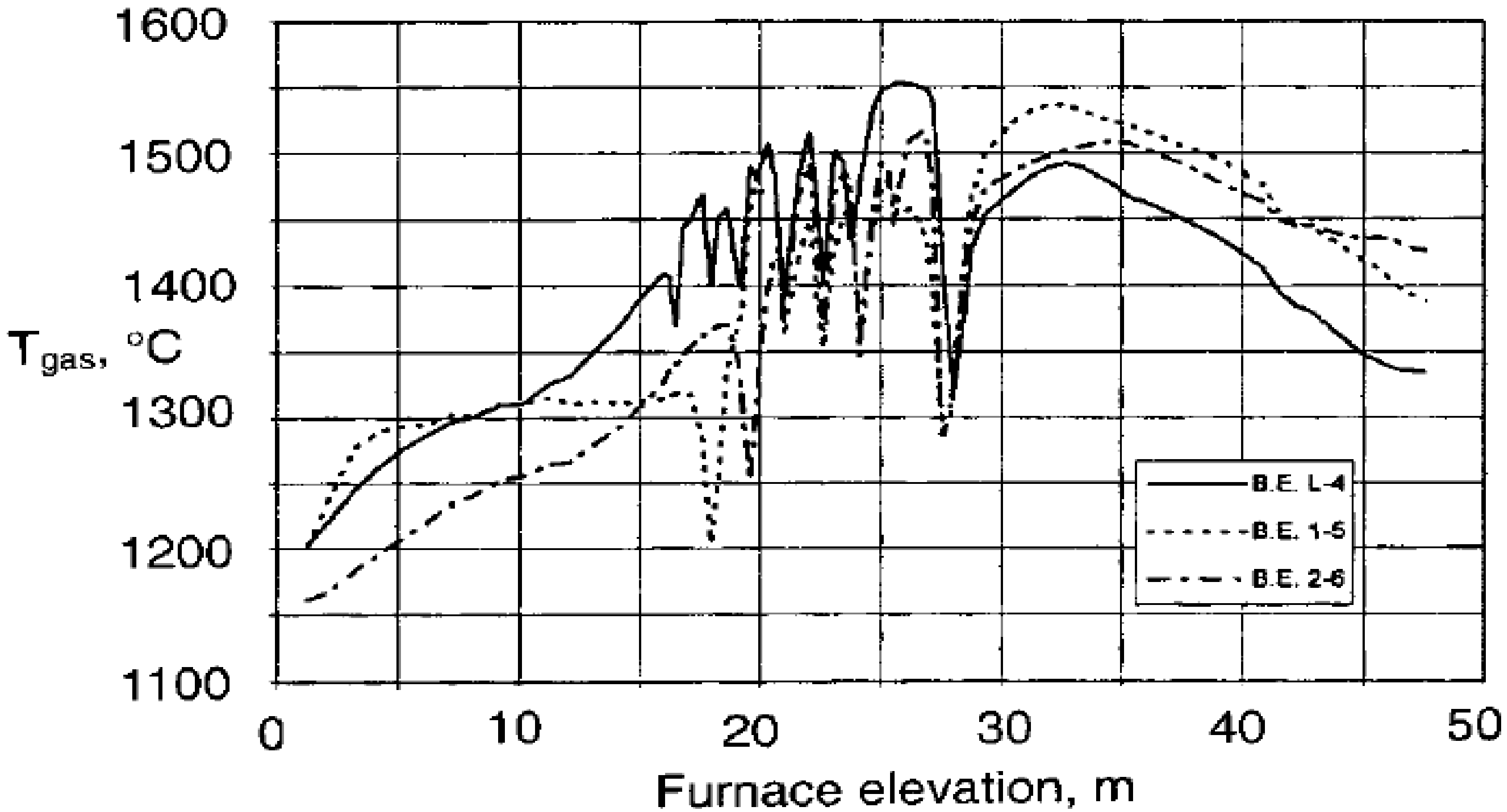


Axial heat flux in a PC furnace

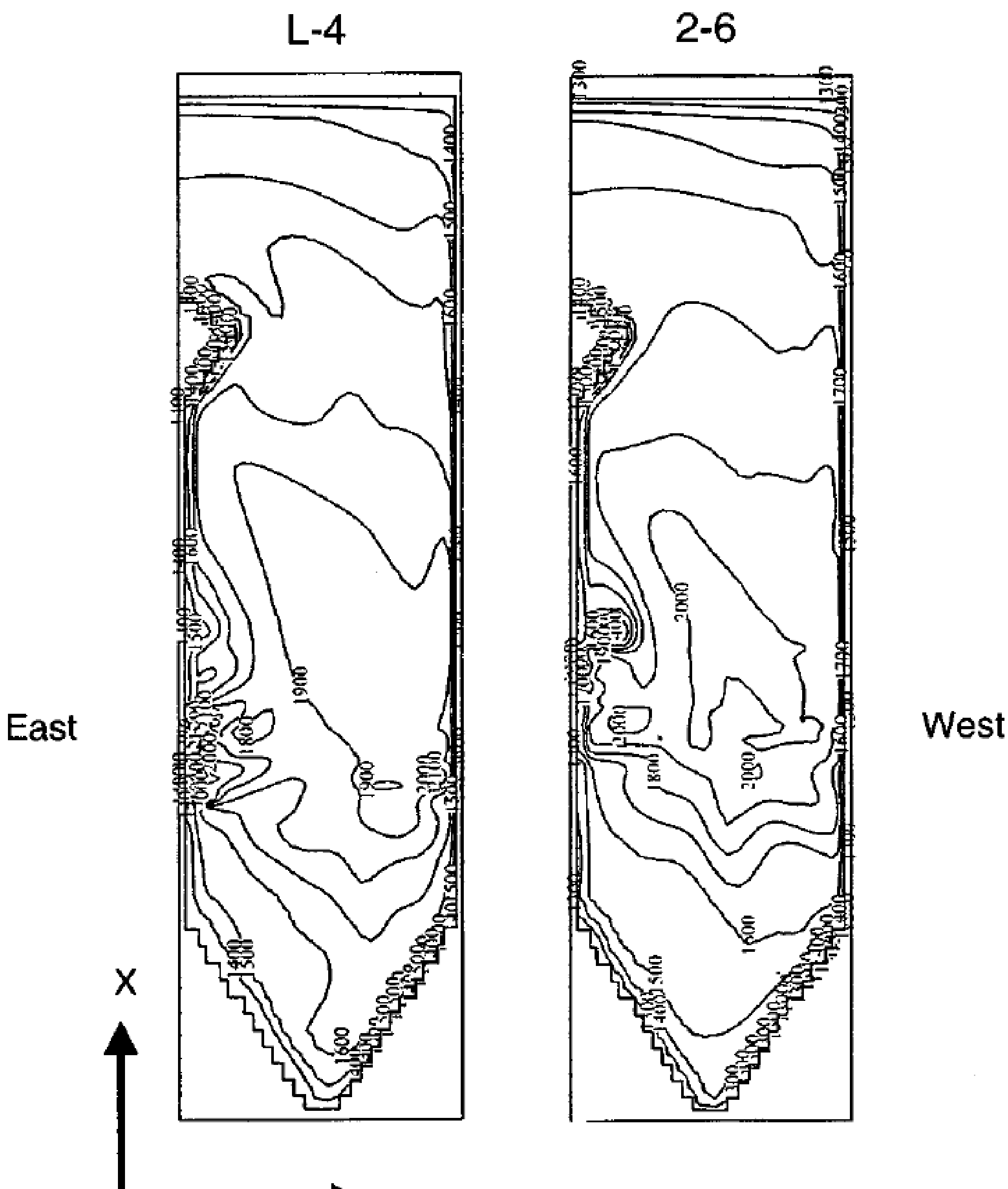


- The heat flux in mid-height is much more than elsewhere

Axial temperature distribution in PC



Isothermal in PC furnace



- Highest temperature is 2000^0
- Considerable temperature non uniformity in furnace

Heat release rates

- Volumetric heat release rate

$$q_v = \frac{B \quad LHV}{V} \qquad \text{kW/m}^3$$

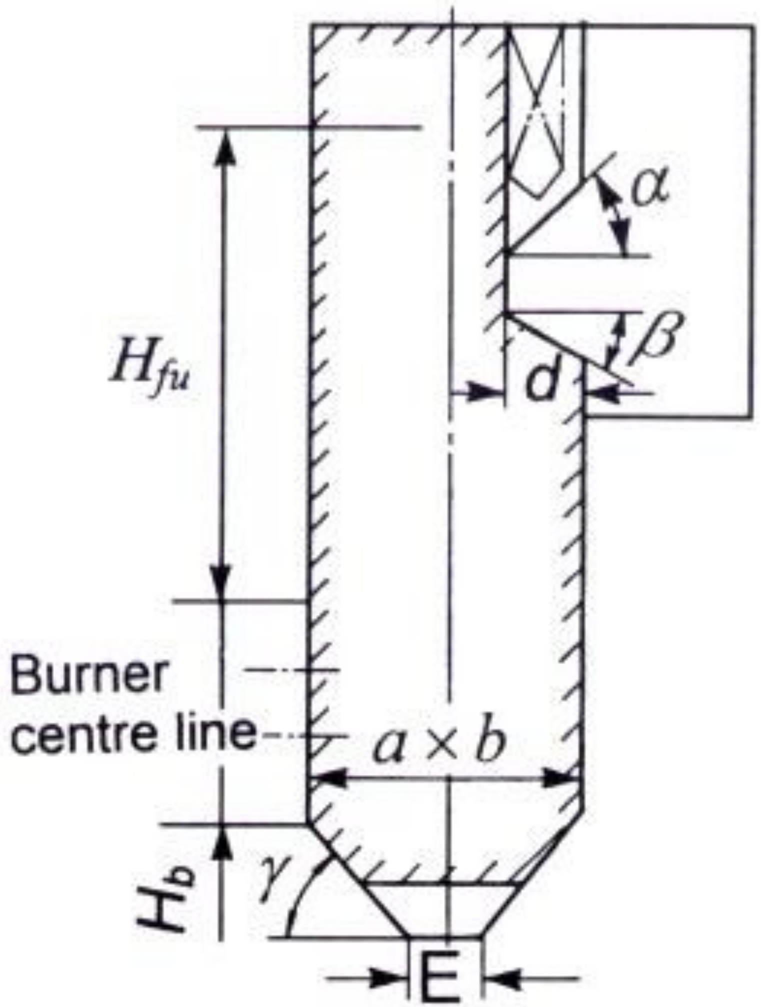
B= kg/s fuel burnt

- Grate heat release rate

$$q_F = \frac{B.\,LHV}{F_{grate}} \qquad \text{kW/m}^2$$

B. LHV = Heat released in furnace in kW

Furnace volume is shown by hatched area



Typical values of Vol. Heat release rate, q_v

Coal Type	Dry-bottom furnace			
	MW/m^3			
Anthracite	0.110-0.140			
Semi anthracite	0.116-0.163			
Bituminous	0.14-0.20			
Lignite	0.09-0.15			
Oil	0.23-0.35		Grate release rate	Grate velocity
Biomass	0.176		1.5-3.5 MW_t /m^2	6.1m/s
Gas	0.35			

Upper limits of Average Grate heat release rate, q_F

Boiler capacity	Upper limit of q_F in MW/m2 (ST= Softening Temperature)		
(tons/h)*	ST ≤1300 °C	ST =1300°C	ST≥1300 °C
130	**2.13**	**2.56**	**2.59**
220	**2.79**	**3.37**	**3.91**
420	**3.65**	**4.49**	**5.12**
500	**3.91**	**4.65**	**5.44**
1000	**4.42**	**5.12**	**6.16**
1500	**4.77**	**5.45**	**6.63**

•One ton/h steam is roughly equivalent to 0.75 MWth heat input

•To get the electrical power output (MWe) of the plant multiply heat input with (plant efficiency/100), which gives 1 t/h approx equal to 0.3 MWe.

Minimum depth of furnace

It ensures that flame does not hit the wall facing the burner causing damage

Boiler capacity (t/h)	130	220	420	670	>670
Coal (m)	**6.0**	**7.0**	**7.5**	**8.0**	**$\geq(5\text{-}6)d_r$ ***
Oil (m)	**5.0**	**5.0**	**6.0**	**7.5**	5

d_r *-maximum nozzle diameter of swirl burner

Note: A square cross-section is good for tangential firing. However the depth must not be shallower than the above limit

Burner region heat release rate, q_b

$$q_b = \frac{B \quad LHV}{2(a+b)H_b}$$

B.LHV = Furnace heat release in MW/m^2

It ensures that the peak heat flux and temperature is not too high to cause dry out and other severe conditions in wall

Fuel	q_b in MW/m^2
Brown coal & Bituminous coal	0.93 -1.16
Anthracite and semi-anthracite	1.4 - 2.1
Lignite	1.4 - 2.32

Shortest distance between burner and Heating surface (H_{fu})

It avoids any potential flame impingement on the Superheaters hanging from the wall, which might rupture the tubes

Boiler capacity (t/h)	65-75	130	220	420	670
Anthracite (m)	8	11	13	17	18
Bituminous (m)	7	9	12	14	17
Oil (m)	5	8			

H_{fu} is the height between top of the burner zone and superheater section

Furnace exit gas temperature (FEGT)

- High *FEGT* makes the furnace compact but increases potential for fouling (coal firing) or corrosion (oil firing)
- *FEGT* < 1250-1400 ^{0}C for oil
- *FEGT* < Lesser of Ash *DT* or (*ST*-100) C
- Gas temp before Platen < 1100-1250 C
- Gas temp. after platen <(*DT*-50) or
  < (*ST*-150) C

Where, *DT* and *ST* are ash deformation & softening temperatures

Heat transfer in furnace

- Furnace heat absorbed, Q_{abs}

$$Q_{abs} = \phi B(Q_{fu} - I_{ou}) = \phi BVC_p(T_{th} - FEGT) = a_s \psi \sigma F(T_{fl}^4 - T_{fw}^4)$$

F- furnace surface area, ψ – fraction of flame radiation absorbed by surface, a_s – flame-wall emissivity, T_{fl}, T_{fw} – Temperature of flame and wall respectively

- *FEGT* is related to flame temperature

$$\theta_{fl} = \frac{T_{fl}}{T_{th}} \propto \left(\frac{FEGT}{T_{th}}\right)^n \propto \theta_{ou}^n$$

Substitution yields

$$\frac{a_s C}{B_0}\theta_{ou}^{4n} + \theta_{ou} - 1 = 0$$

Furnace heat transfer

- From experimental results (a_s~a_{fu})
- From above we get heat transfer surface area, *F*

$$\frac{\theta_{ou}}{1-\theta_{ou}} = \frac{1}{M}\left(\frac{B_0}{a_{fu}}\right)^{0.6}$$

$$F = \frac{B.q'}{\sigma a_{fu}\psi M.T_{th}^3 T_{ou}}\left[\frac{1}{M}\left(\frac{T_{th}}{T_{ou}}-1\right)\right]^{0.66}$$

- *FEGT* (T_{ou}) from empirical relation

$$T_{ou} = \frac{T_{th}.B_0^{0.6}}{M.a_{fu}^{0.6} + B_0^{0.6}}$$

Problem

- Find the size of a dry bottom pulverized coal fired furnace to fire 19.8 kg/s medium bituminous coal having LHV of 18,289 kJ/kg . Ash softening temperature is 1350 C