Fuel Element	Atomic Mass	Heat released on oxidation	Oxidized product
Hydrogen (H)	1	119,950 KJ/kg	H_2O
Carbon (C)	12	32,770 KJ/kg	CO_2
Sulphur (S)	32	9,163 KJ/kg	SO_2

Air contains appx 21% O_2 & 79% N_2 by volume. Mol. wt of $O_2 = 32$ & $N_2 = 28$

Mol wt of $CO_2 = 44$, Mol wt of $SO_2 = 64$

mol wt of NO = 30.

Element	kg of O_2 needed	kg of Air Needed	m^3 of Air needed
C (1 kg)	2.67	11.5	9.7
H (1 kg)	8	34.33	28.97
S (1 kg)	1	4.3	3.63

$C + O_2 \rightarrow CO_2$

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$

2 kg 16 kg

1 kg 8 kg

$S + O_2 \rightarrow SO_2$

Heat released by a fuel.

Fuel → C, H, O, S, N

For coal with certain C : H : O : S : N mass ratio the released is given by

$$\text{kJ} \rightarrow Q = 32770 \times m_C + 119950 \times (\underbrace{m_H - \frac{1}{8} m_O}_{\text{mass of H bound in } H_2O}) + 9163 \times m_S.$$

Amount of air needed to fully burn coal,

& $\underline{m_{Air}} = 11.5 \times m_C + \cancel{3} \; 34.33 \times \left(m_H - \frac{m_O}{8}\right)$

$+ 4.3 \times m_S$

Amount of CO_2 emitted

$$m_{CO_2} = \frac{44}{12} m_C$$

If thermal efficiency of a powerplant

is $\eta = \frac{\dot{W}_{out}}{\dot{Q}}$

$\dot{W}_{out} \rightarrow$ electric power production (kW)

$\dot{Q} \rightarrow$ heat generation (kW)

Eg:- A 400 MW coal power plant has 37% efficiency & burns anthracite coal with heating value of 29 MJ/kg. The coal contains 94% C by weight & 1.2% S by weight. During combustion NO_2 is formed at the rate of 0.02% of the formation rate of CO_2. Determine the amount of CO_2, SO_2, NO_2 that is emitted by the power plant per day.

$\dot{W} = 400\,MW$

$$\eta = \frac{\dot{W}}{\dot{Q}} = 0.37 \Rightarrow \dot{Q} = 1081\,MW$$

So net heat input by combustion per day needed by the this powerplant is

$$\dot{Q}\Big|_{day} = 1081 \times 60 \times 60 \times 24$$
$$= 93.4 \times 10^6\ MJ/day.$$

Heating value of coal is 29 MJ/kg

Total coal supply being burnt per day

$$\dot{m}_{coal} = \frac{93.4 \times 10^6 \text{ MJ/day}}{29 \text{ MJ/kg}} = 3.22 \times 10^6 \text{ kg/day}.$$

$= 3220$ tons of coal per day.

$C \rightarrow 94\%$

$$\dot{m}_C = 0.94 \times \dot{m}_{coal} = 3.03 \times 10^6 \text{ kg of C/day}.$$

CO_2 emitted per day

$$\dot{m}_{CO_2} = \frac{44}{12} \dot{m}_C = 11.1 \times 10^6 \text{ kg of } CO_2\text{/day}$$

$= \underline{11,100}$ tons of CO_2 per day.

$$\dot{m}_{NO_2} = 0.02\,\% \text{ of } \dot{m}_{CO_2}$$

$$= 0.02 \times 10^{-2} \times \dot{m}_{CO_2}$$

$$= 2.22 \times 10^{3} \text{ kg of } NO_2/\text{day}$$

$$= 2.22 \text{ ton of } NO_2/\text{day}.$$

$$\dot{m}_S = 1.2 \times 10^{-2} \times \dot{m}_{coal} = 38.64 \text{ ton of sulphur/day}$$

$$S \rightarrow SO_2$$

$$\dot{m}_{SO_2} = 2 \times \dot{m}_S = 77.3 \text{ ton of } SO_2/\text{day}.$$