Lecture 40: Thoughts on energy balance

Content

Preamble

What is to be done more beyond fuel saving

Key Words: Dry quenching technology, coke making, energy balance

Preamble

In the earlier lectures we have discussed the role of energy balance on fuel saving and hence on conservation of natural resources. Energy balance is a very powerful tool to address the issues of saving natural resources.

What can be done more beyond fuel savings? Let us think.

Facts about use of natural energy resources

Fossil fuel based energy availability is associated with

a) Discharge of CO_2 in the environment and other harmful gases like SO_2, NO_x etc. 1 kg mole of carbon discharges 1 kg mole of CO_2 in the environment. In other words 1 kg carbon produces 3.7 kg CO_2.
b) Large amount of heat is carried away by the products of combustion. In metal extraction processes at high temperatures, products like liquid metal, slag, gases and coke carry a large fraction of heat. Sensible heat is the issue of concern.In this connection it is important to understand quality of heat. Quality of heat is decided by the temperature. Higher is the temperature of discharged product, higher is the quality of heat.

Sensible heat in products:

In thermo –mechanical processing, steel is heated to $1200℃$. Steel is rolled at this temperature and then cooled by water. Large amounts of emissions are discharged.

In coke making coke is discharged at around $1200℃$ and water cooled. Large amount of sensible heat is lost and as well as emission arising from water contaminants are discharged into atmosphere. Environmental pollution is a concern.

Sensible heat in waste gas may not be possible to use since waste gases contain fine solid particles. However potential energy can be utilized.

Energy balance and environment cleanliness

Let me illustrate how energy balance can lead to environment cleanliness. Consider coke making technology. The details are discussed in lecture 27.

As discussed in lecture 26, coke is an important source of chemical and thermal energy in integrated steel plants producing steel from iron ore. In fact 1 ton of steel would require around 940 kg coal (Assuming coke consumption is 500 kg/ton of hot metal), thus 10,000 tons of steel would require 6600 tons of coke (assuming 0.75 ton of steel is produced from 1ton hot metal). For annual production of few million tons of steel, Coke requirement would be very high. Let us consider coke-coke conversion materials and heat balance. Material balance has already been discussed in lecture 27.

Consider heat balance of a by-product coke oven. The details of heat balance calculations can be seen in video lecture 40 on materials and heat balance. Heat balance is given for 1000kg coal.

Heat input $8184 \times 10^3 \text{kcal}$

$$\text{Calorific value of coke oven gas} = 704 \times 10^3$$

(It is assumed that 40% of coke oven gas of calorific value $(113 \times 10^3 \text{ kg cal/kg. mole})$ is used to produce heat in coke oven)

Heat out put	kcal
Calorific value of coke	5416x10^3
Calorific value of tar	351x10^3
Calorific value of coke oven gas	1053x10^3
Sensible heat in coke	305x10^3
Sensible heat in coke oven gas	174x10^3

Analysis of heat output

Calorific values of coke, tar and coke oven gas can be utilized by combustion. Sensible heat in coke is notutilized since coke is wet quenched on wet quenching all sensible heat $305 \times 10^3 \text{ kcal}/725 \text{ kg}$ coke is lost. In addition to this loss, air born coked us emissions 50 kg/ton coke are produced. Also huge water is required say around $0.5 - 0.6 \text{ m}^3/\text{ton}$ coke. The contaminants in water are discharged in environment.

Energy balance and technology development

The above analysis puts a pressure to develop a new technology which can capture and reuse the sensible heat in coke. This new technology will also contribute simultaneously to the cleanliness of environment.

Dry quenching technology (DQT) has been developed. The advantages are:

i. Elimination of emissions
ii. Capturing heat and reuse- cogeneration.

DQT has to components

- Capture of heat in gas flowing counter current to coke
- Production of superheated steam in a boiler which can be used for example to run a turbine. Figure 40.1 is the arrangement of various reactors in DQT.

Figure 40.1: Arrangement of vessel to capture and reuse head in DQT.