ABSTRACT

The mechanism of combustion of coal particles was studied at controlled conditions in a bubbling fluidised bed combustor (100 mm diameter), specially with single particle and batch mass. Such studies are useful to obtain basic data to be used for modelling purposes. Both volatile and char combustion mechanisms were studied using three different types of coal/char. Using basket technique (cluster of particles), structural changes (diameter, density, volume shape factor, surface area, etc.) as combustion progressed were evaluated and mode of combustion studied. With batch mass charge, the visual burn out time was noted, bed temperature history recorded and off gas concentration (volume % CO_2) analysed to study heat and mass transfer around burning particles. The operating conditions varied were: fluidising velocity, 0.28-0.71 m/s; bed material (crushed refractory) size, 0.4267 and 0.6769 mm; temperature, 973-1173 K; coal/char particle diameter, 0.928-5.74 mm and batch mass charge, 1-10 gm.

Volatile burning times were found to be in the range 2-28 s. Theoretical predictions were made for volatile burning time from heat transfer model and combined

kinetic and heat transfer model and compared with experimental observations. The agreement is good with heat transfer model for small sized particles.

Structural change studies indicate that, for lignite char, reaction occurs at the surface. Despite attrition due to surface asperities to the extent of 2-8%, shrinking sphere mode combustion prevailed. Burning of lignite char, similar to volatile burning, appears to follow a relationship $t = a\, d_i^n$. An intermediate value of n between 1 and 2, as obtained under existing operating conditions, suggests that lignite char burns under a combined mechanism of bulk diffusion of oxygen to and chemical reaction at the surface. Separating the effect of mass transfer from the combustion rate, the chemical reaction rate coefficient and apparent reaction order were determined. Thus, for a reaction order, $n = 0.6$, the proposed correlation for reaction rate coefficient is

$$R_c = 2.90 \exp(-80458/RT_p) \quad kgC/m^2 s(KPa)^{0.6}$$

The Sherwood numbers (N_{SH}) evaluated for burning particles appear to fit the modified Frossling's equation well. Based on the above correlations for N_{SH} and R_c (for $n = 1$), predictions were made for single particle and batch burn out times as well as overall resistances to

combustion. The agreements with measured values are good. From heat balance around burning particles, the Nusselt number (N_{Nu}) was calculated and the effect of Reynolds number (N_{Re}) on it evaluated.

Further, a simple isothermal shrinking core model was used to study the mechanism of high ash washery rejects. Based on a log mean diffusivity value obtained from experimental observations the burn out times were predicted and compared with measured values. The agreement is satisfactory for small sized particles.

Key words : Combustion, Fluidised bed, Fluidised bed combustion, Coal/char, Lignite char