Two Trial Models for the Rate of Combustion and Gasification of Slurries or Liquid Biomass Sprayed on Inert Fluidized Particles

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Fluidized-Bed technology has been successfully applied for the use of solid fuels as energy source. It proved to be an improvement on traditional methods such as pulverized or suspension for combustion and fixed-bed for gasification. Biomass. low-quality coals, industrial and urbane solid residues are among the solids for which the fluidized-bed technique is especially advantageous. As the fluidized bed usually requires an inert solid (such as sand) as temperature regulator and support media for fluidization, the ash content of a fuel can replace part or even the total amount of that inert. Therefore, the bed can accept fuels with low heat values. Among these there are the biomass and forest residues. In the case of coal or other fuels with high sulfur content, removal of that pollutant can be very efficient through the addition of limestone or dolomite to the bed. In addition, when compared with pulverized-fuel combustion, the relative low and uniform temperatures found in fluidized-beds lead to low NO, emissions, not to mention savings in building materials.

Apart from solid fuels or residues, liquid or pastes are also an important segment of the possible energy sources. Among them, there are slurries prepared from biomass, residual resins obtained from extractions, and very heavy or viscous oils, which are cumbersome fuels. The case of slurries are particularly important because biomass usually are fibrous materials. Feeding of fibers to pressurized equipment often lead to disastrous results. A solution is to finely grind the fibers and suspend the resulting powder in water. Posterior deterioration of those particles might lead to the consistency of a solution of organics in water. In addition, liquid residues may present low combustion enthalpy, which implies in great difficulties to employ as a single fuel in conventional processes. On the other hand, all these can be injected into fluidized-bed boilers or gasifies where sand, or any other inert solid, is present. The liquid – or apparently liquid-- fuel usually coats the inert particles and the process occurs as if a solid fuel has been fed to the bed. Proper operational settings may allow the consumption of these residues as useful sources of power.

The present work assumes isothermal conditions in the layer of fuel and inert particles. The local temperature of particles as well temperature, pressure, and composition of the surrounding gas should be given by a comprehensive model for fluidized-bed equipments. The governing equations that constitute the whole mathematical model of fluidized-bed reactors can be found elsewhere as for instance [1 to 5]. The only objective here is to shown the equations proposed for the reaction rates between gases and the injected liquid fuel into the reactor already containing fluidized inert solid particles.

In the case of liquid fuels, the following possibilities can be visualized:

?? As the liquid fuel is injected into the bed, they immediately coat the inert solid particles. Then, the fuel goes through devolatilization and the resulting coke layer remains on the inert particle. That layer is then, attacked by gases. This model is called here as CIP (Coated Inert Particle) and the situation is illustrated by Figure 1.

?? As the liquid fuel is sprayed into the bed, the drops go through devolatilization before the opportunity of meeting any inert particle. A coke layer forms at the drop surface and the volatile in its interior escape through small holes in that layer. At the end of the devolatilization process, a cenosphere of coke remains and continue to react with the gases. The size of the cenosphere is assumed the same as the average drop size in the original spray. This model is called here as CSP (Coke Shell Particle) and the situation is illustrated by Figure 2.

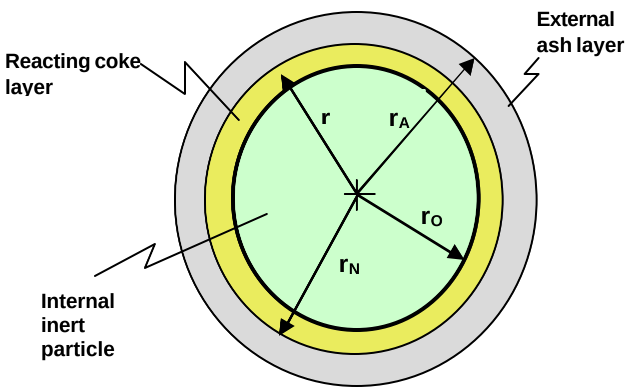

Figure 1. Illustration for the CIP model

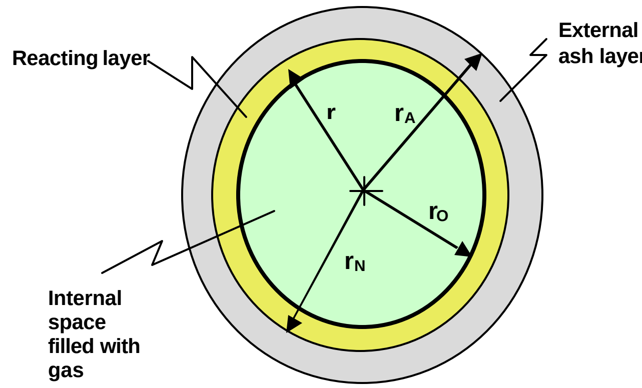

Figure 2. Illustration for the CSP model

The results are presented in easy-to-use formulas and can be implemented in existing simulation models and computer programs.

Some preliminary comparisons between simulation and experimental results indicate that the CIP model seems to be the best choice for cases of bubbling fluidized beds while the application of CSP may fit better to circulating fluidized beds. However, additional experimental work would allow more accurate and reliable conclusions.

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