

Study of the devolatilization and combustion of coal/biomass mixtures

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In order to study the combustion of pulverized solid fuels such as coal, different experimental facilities have been proposed [1-3]. It has been shown that the quality and the flexibility of the particle injection system was a critical point because of the influence of the quantity, particle sizing, and gas-particle mixture homogeneity in the combustion behavior of pulverized solids. Consequently, to avoid electronic interactions, packing and compressing of the powder or water absorption, a special injection system has been developed by Therssen et al. to generate and carry to a flat flame burner a homogeneous and regular particle cloud which allows the study of the devolatilization of coal particles in flame conditions [4, 5]. This setup which is presented in this paper will be used this year in our laboratory to study the devolatilization and the combustion of coal, biomass and coal/biomass mixtures.

Presentation of the experimental setup

The setup is composed of two devices: a screw feeder and an acoustic sower (see Fig. 1).

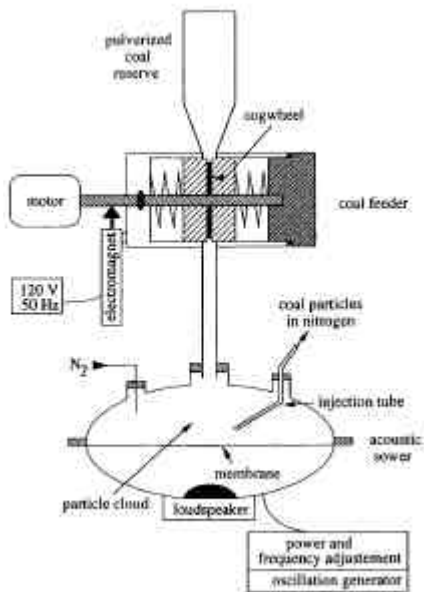


Figure 1: Coal feeder coupled system (screw feeder and acoustic sower) [4]

A. The screw feeder

The pulverized coal is stocked in a conical tank in order to carry all particles to the screw which ensures an effective transport of every particle. In order to fluidize the pulverized coal, an electromagnet generates a mechanical vibration of all the devices by hitting the screw axle.

B. The acoustic sower

The coal particles travel directly from the screw feeder into the acoustic sower which is composed of a thin vibrating metallic membrane driven by a loudspeaker. A frequency generator provides an electrical excitation with adjustable frequency and power. For each experimental parameter like coal particle diameter or gas flow rate, it is possible to find the frequency which provides the highest motion of the particle and the biggest particles cloud. The injection tube put in the center of the cloud is the only escape for the coal particles which can be transported pneumatically to a flat flame-burner (see section D). The acoustic vibration empties correctly the screw crenel when they cross the exit window of the screw feeder. The sower is not the slowest step of the system so the mass flow rate is only determined by the rotation rate of the screw feeder.

C. Characteristics

This original coupled system provides different advantages. Indeed, any compacted particle mass can be immediately dispersed in the acoustic sower, so the particle-gas mixture is very homogeneous. The injection tube diameter is fitted to the particle diameter. This system can be used with a large range of mass flow rates and particle diameters by adjusting the injection tube diameter, the gas flow rate, and the vibration frequency. For pulverized solid particles which are very breakable such as coal particles, no change in particle size distributions can be observed even with very low gas flow rate (e.g. 0,1 l/min). Finally, there is no coupling between the acoustic sower and the burner for acoustic pressure lower than 160 dB and for acoustic frequency higher than 50 Hz.

D. Combustion of the particles cloud

This system allows the injection of a solid particles cloud in a flat air-propane flame at 1400 °C (see Fig.2). Thanks to this configuration, the particle heating rate at the exhaust of the flame is of the order of 6×10^6 K/s, that is to say very close to the industrial heating rate of coal in large pulverized coal furnaces [4].

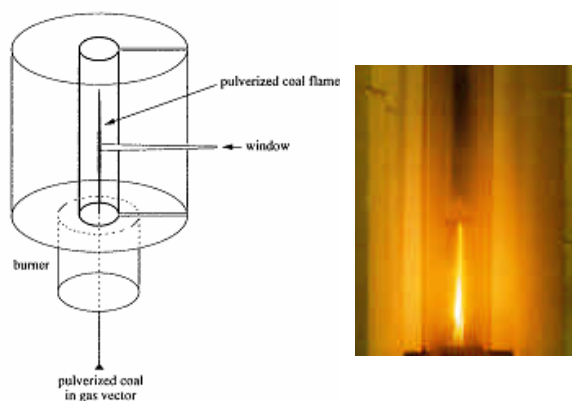


Figure 2: Diagram of the burner and photography of a typical coal flame [4]

Objectives of this work

The aim of this work is to study the devolatilization and combustion behaviors of biomass and coal/biomass mixtures in order to obtain a set of data which could be used to model accurately the combustion of this kind of fuel and then apply such modeling to industrial furnace. Thanks to the setup presented before, it is possible to test new mixtures of coal and biomass in laboratory (it needs a low quantity of fuel and the test is cheap and rapid) in

combustion conditions close to industrial ones. So, by studying the devolatilization and combustion of these mixtures, it would be possible to adjust model of combustion by introducing accurate measurements in the code. Finally, the use of oxygen as carrier gas could be a means to study the combustion of these mixtures under oxycombustion conditions.

The temperature of the fuel particles will be measured by two-color optic pyrometry. It is also planned to use Laser Induced Incandescence (LII) for the measurement of soot volume fraction in flame and in order to study the evolution of the physical properties of soot particles (refractive index, density, specific heat, and diameter). Mappings of soot precursors could also been achieved by Laser Induced Fluorescence (LIF). Finally, samplings could be carried out in the flames in order to analyze the composition, the morphology and the nature of the chemicals adsorbed on the particles surface.

References

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