Pasir탄의 사전연소 실험

Analyses ofPasir coals for use in utility boilers

신 용승⁰, 최 상민, 김 재성*

한국과학기술원 기계공학과, 한국전력공사*

1. INTRODUCTION

Coal properties exhibit wide variations depending on the type, rank and preperation methods, so the prediction of coal combustion performance is generally difficult. It is necessary to test the coal properties sufficiently before newly-introduced coals are used in utility boilers. In the prediction of coal combustion performance, it is appropriate to conduct the combustion performance tests in combustion environments similar to real ones in scale, and to predict the coal combustion performance based on the results from the above tests. But this method is practically difficult. Therefore, laboratory-scale coal analysis methods are widely used. But standard coal analysis methods can't predict the overall coal combustion performance. Each method can perdict only particular coal combustion performance. Moreover, the combustion environments of these standard coal analysis methods are different from the combustion environments in utility boilers.

In the present work we have designed the laboratory scale experiment to simulate the combustion environment when pulverized coals are injected into utility boilers. Pulverized coal particles are observed with bright luminosity when they are injected into combustion environments. We observed the time-dependent change of overall shape and magnitude of pulverized coal particle flames which were dependent on the characteristics of the coal type and the combustion environments.

We are reporting here the test results with four different coals and its combustion performance results in utility boilers.

2. EXPERIMENTAL APPARATUS AND PROCEDURES

In order to measure the time-dependent change of coal particle flames in combustion environments, we have made laboratory-scale experimental apparatus simulating the real combustion environments. The reactor was composed of a flat flame burner, a coal feeder and a gas supplier. An atmospheric premixed flat plate flame can be formed using methan, hydrogen and an air mixture. ϕ 5mm steel spheres were filled in the burner, and cooling water was used to prevent the burner temperature rising, and a porous plate (5mm thick, ϕ 1mm hole) was installed to maintain the flat flame. Methan, hydrogen and air were mixtured in gas supplier. Methan was the primary fuel, and hydrogen the secondary fuel. The coal feeder was composed of ϕ 1.5mm steel tube and a motor for agitating the steel tube. The pulverized coal particles used in this experiments were a mean size of 100 μm.

A Kodak high speed motion analysis system and image processing system was employed to measure quantitatively the time-dependent change of coal flames in combustion environments. The Kodak high speed motion analysis system can record a 1000 frames per second. The CCD camera has a 192 x 338 pixel element. The video image detected by the CCD camera was converted into a standard video signal (RS170) and recorded in video processor.

This video operation along with the optical magnification imposed limitations on the spatial resolution. It was found that the minimum area resolution was not smaller than 120 x 120 μm. Since the size of the apparent flame was calculated by counting the number of pixels in the exposed area, and automatically converting them into equivalent diameters, the percentage errors in the diameter decreased as the measured diameter increased. The potential error was estimated to be 12 percent when the diameter was 500 μm, and 6 percent at 1000 μm. However, there was further uncertainties related to the saturation and smear-out characteristics of visual image sensors. A point light source was seen to broaden after passing through the image intensifier, which was constructed of phosphor screens, along with a micro channel plate (MCP) type accelerator, and fiberoptic image couplers. This configuration imposed additional uncertainties in quantifying the images in absolute terms. However, the relative quantification was insured with very high repeatability. The reported data can thus be interpreted as semi-quantitative.

3. RESULTS

Four different coals were selected for the combustion tests from the steaming coals being consumed on a long term basis at the power plants of the Korea Electric Power Corporation. The combustion gas environment was selected so that the oxygen concentration was maintained at 10, 5, and 0 per cent in volume, respectively. Gas temperature measured by a thermocouple at the center portion of the flow is 1250 K and typical gas velocities was 0.6 m/sec for the case of 0 % O_2.

3.1 RT coal

The test results of RT coal are shown in Fig 1 (a). It indicates that the magnitude of coal particle flames in 0 % oxygen concentration is larger than that in 5 % and 10 % oxygen concentration. In 5 % and 10 % oxygen concentration, the magnitude of coal particle flames reach their first maximum point before 10 msec, rapidly decrease, and then return gradually to their second maximum point. The formation of the second maximum point after 50 - 100 msec in the combustion procedures can be observed in other high volatile contained coals like Alaska coal. The fact that RT coal forms the second maximum point in the late stages of the pulverized coal particle combustion is considered an important phenomena.

3.2 SM coal

Fig 1 (b) shows the test results of SM coal. The result of proximate analysis of SM coal is similar to that of RT coal, except for the total moisture content (RT = 16 %, SM = 38 %). Generally the experimental results of SM coal is similar to that of RT coal, but the flame magnitude is somewhat large. SM coal reaches rapidly to the first maximum point, and forms the second maximum point in the late stages of combustion like RT coal.

3.3 CNR coal

CNR coal is a typical bituminous coal. Regardless of the oxygen concentration, it is difficult to observe the second maximum point. The magnitude of coal particle flames increases as the oxygen concentration dicreases. This tendency has been observed in Ulan, Drayton and Palmco coal, which have 20 -30 % volatile materials.

3.4 Alaska coal

Alaska coal which containes very high volatile material and has a calorific value of 5800 - 6000 kcal/kg, exhibits unique coal flame formation procedures. As shown in Fig 1 (d), the flame formation procedures of Alaska coal in the case of 0 % oxygen concentration is similar to that of RT and SM coal in 5 % or 10 %. However, in the case of 5 % and 10 % oxygen concentration, it does not exhibit first maximum point, but the second maximum point is well developed. Moreover, the magnitude of the second maximum point for 10 % oxygen consentration is larger than that for 5 %. While Alaska coal has very high volatile material, like RT and SM coals, it clearly differs from RT and SM coals in the formation of the first maximum point. This coal shows that the formation of volatile flame in the early stages of coal combustion is scanty, but in the late stages it is good.

4. APPRECIATION OF PASIR COALS.

Available methods to predict the combustion performance of coals are existing coal analysis methods, and a single particle flame anlaysis method suggested in this work. In this comprehensive apperciation, we are intend to compare RT and SM coal ,which was not used in the practical boiler with Alaska coal, which was used in practical boiler for many years.

For RT and SM coals, the volatile material is high, the magnitude of coal flame at the early stages of coal combustion is large, and the volatile evolution duration time is long, so that flame formation and stability in the vicinity of a practical burner affected mainly by a volatile flame are considered to be good. RT and SM coals have 20 % higher calorific value than Alaska, lower ash material, higher ignition temperatures and higher H.G.I. From the above results, the supply of coal, the volume of the dust collector, the load of the coal grinder, and the probability of self-ignition are expected to be lower than those of Alaska coal. Conclusively, RT and SM coals will be good in combustion of a practical boiler. In practice, according to the results of combustion test of RT and SM coals conducted in steam power plants, the combustion performance of RT and SM is reported to be good.

5. CONCLUSION

This study involves the observation of the first 0.1 sec of combustion of pulverized coal particles. But the duration time of pulverized coals in practical boilers is about 2 - 3 sec. Therefore, the results of this study can be related to the flame formation and stability in the vicinity of a practical burner. The single coal particle flame measurement in a combustion environment is a good method for comparing and appreciating the procedure for the volatile flame formation of coals. This coal analysis method, as well as other existing coal analysis methods, does not predict an overall combustion performance, but a particular combustion perfomance, i.e., formation and stability of flame in the vicinity of a burner.

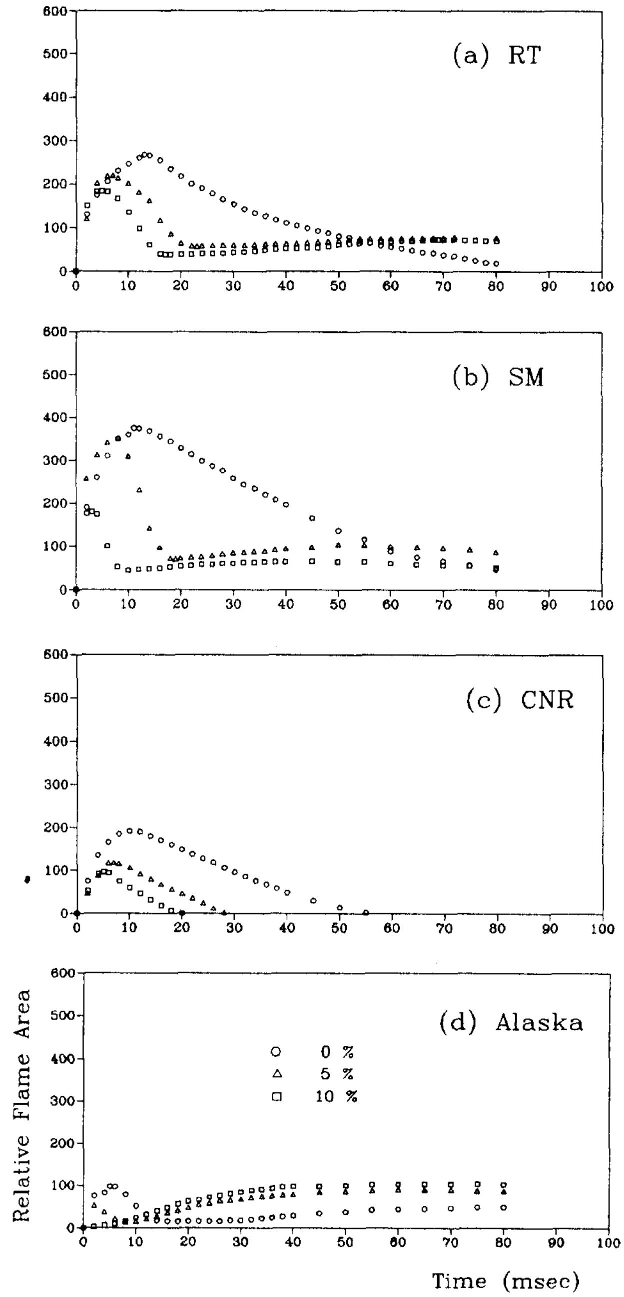

FIG. 1