W1P111: CHARACTERISTICS OF BIOMASS FUELS AND THEIR IMPACT ON VOLATILE FLAME LENGTH DURING BIOMASS COFIRING COMBUSTION
Melissa Holtmeyer¹, Gengda Li², Benjamin Kumfer¹, Shuiqing Li², Richard Axelbaum¹
¹Washington University in St Louis, USA ²Tsinghua University, China

The cofiring of biomass in pulverized coal boilers for large-scale power generation can only be a viable option if current combustion standards of stability, reliability, emission reduction, and fuel conversion efficiency are maintained and/or improved. While biomass fuels can be highly variable and differ significantly from coal, generally, they have increased volatile matter content and increased particle sizes, which are due to both fuel preparation methods as well as the structure of the biomass material. These two characteristics significantly impact the structure of the volatile flame, which is the zone dominated by the combustion of volatiles in the near burner region. The length and location of the volatile flame envelope is important not only to flame stability, but also to the formation of pollutants including NOₓ and SOₓ.

In this work, pulverized coal and biomass cofired flames are investigated using both experiment and Computational Fluid Dynamics (CFD) to determine the effects of volatile fraction, fuel composition, and particle size on the length of the volatile flame. Volatile flame length is measured experimentally using gaseous species measurements of CO and CO₂ to observe the overall effects of biomass fuels in a 35 kW combustion facility. The numerical study evaluates the impacts of these variables, both individually and combined, on volatile flame length.

This study shows the length of the volatile flame envelope is sensitive to the location of volatile matter release and the amount of volatiles available. For larger particles with high momentum and long heating times, they may pass through the oxygen-lean flame zone and release volatiles outside the volatile flame envelope into areas of higher oxygen. Particle breakthrough of the volatile flame can result in reduced fuel concentration in the near burner fuel-rich zone. Increased volatile matter content, characteristic of biomass fuels, can lead to increased volatile flame length if all volatiles are released in the near burner region. However, if particles breakthrough the volatile flame envelope, then shorter than expected flame lengths may result.

Melissa Holtmeyer: holtmeyerm@seas.wustl.edu

W1P112: PREDICTION OF THAR COAL COMBUSTION CHARACTERISTICS USING ARTIFICIAL NEURAL NETWORK
Muhammad Tayyeb Javed, Muhammad Kashif, Asifullah Khan, Abdul Majid, PIEAS, Pakistan

Pakistan has huge coal reserves in Thar, which are estimated to be 185 billion tons. The use of Thar coal can bridge the gap between power supply and demand. However, due to low-grade, its proper utilization needs rigorous scientific investigation. In this paper, we employ Back Propagation and Generalized Regression based ANNs for predicting the combustion characteristics of Thar coal. Since for the training of ANNs, some samples and their properties are needed to be known, therefore, we first develop a database, containing the combustion rate reactivity of chars derived from coals covering a wide range of rank and geographic origin. The dataset consists of sixteen samples with their physical and chemical properties along with the original combustion rate being provided. The dataset can be very helpful both to academicians and researchers for future studies in this direction.

In this study, feed-forward neural network with back-propagation learning is used to predict the char reactivity/combustion rates. The neural network is trained using Lavenberg-Marquardt optimization algorithm together with a cross validation based on “early stopping” mechanism to prevent over-fitting of data. In addition, Generalized Regression based ANN is also used and the results of both ANN are compared and analyzed.

We focus on developing the neural network model to estimate the combustion rate at low temperatures. Four input parameters are selected; a coal rank parameter (either vitrinite reflectance or fixed carbon content), a parameter representing the extent of pyrolysis, combustion temperature and char surface area. The only output parameter is the reactivity/combustion rate, which is measured using thermo-gravimetric analysis in a temperature range of 420–600°C. The surface area of chars will be measured by BET surface area analyzer.

Muhammad Tayyeb Javed: mtayyebjaved@gmail.com

W1P113: COMBUSTION ENVIRONMENT CONTROL FOR BETTER PRODUCTIVITY IN IRON ORE SINTERING PROCESS
Younghun Lee¹, Sangmin Choi¹, Won Yang², Byungkook Cho³

¹Yonsei University, South Korea ²Hanyang University, South Korea ³Technology Development Corporation, South Korea
An improved solid bed combustion model is presented and newly developed techniques in iron ore sintering processes are systematically described to produce scientific understanding for practical industrial processes. Previously developed unsteady 1-dimensional computational model is extended to account for the various combustion environments, in terms of mass flow rate and oxidant concentration as well as temperature of the gas flow across the bed of solid particles. This improved model is shown to adequately explain the newly developed techniques in modern iron ore sintering process; flue gas recirculation and fuel substitution, both of which are aimed for better productivity and quality. Computational results for the bed of solid particles are examined by employing quantitative parameters of combustion characteristics, which would then be used for optimization of the advanced process.

Younghun Lee: acd1236@kaist.ac.kr

Some of biomass gases are produced by the gasification with the gas furnace and by sewerage processing. Recently, it is required that the low-calorie bio-mass gas is utilized for a renewable energy. It is effective that the bio-mass gas is the substituted fuel. The gas includes various species of components which are such inert gas as Nitrogen N2, carbon dioxide gas CO2 and flammable components as hydrogen H2, methane CH4 and carbon monoxide CO. The fuel calorific value depends on the ratio of each component. It is possible to be widely used for one of substitute fuel. It is difficult to stabilize the flame in the burning technique, when the heat release is low calorie. Holding the flame is an important pole in the burning technique but there are many obscure points of the flame structure, the burning characteristics, extinction and so on. The stability mechanism for holding the flame has been studied. It is found that the parameters for holding the flame are fuel velocity, co-flowing velocity, nozzle diameter (curvature of nozzle), condense of the fuel. The species of the fuels are low-calorie bio-mass gas which is made with putting N2 and/or CO2 into the fuel. The critical conditions of the flame stability limit are highly dependent on nozzle diameter, species of fuel, type of burners and so on. The experiments were conducted to investigate stability limits and flame behaviors with increasing the spout velocity by using the various burner nozzle. The profiles of temperature and chemical species of components in the flame are measured for researching into the structure of the flame. The configurations and behaviors of the flame are observed directly and investigated by the high speed video camera with the method of Schlieren Photography. It is simulated by the numerical calculation. Then experiments and numerical computations by using the PHOENICS are conducted to clarify the flame structure which dominates the flame holding and lifting mechanism. Direct photographs of the flame are shown on the upper stage and Schlieren photographs are on the down stage with progress of time. The stream is observed in the flame because a bit of black lead is mixed with the fuel gas. The lifting velocity of each flame increases the fuel velocity; the results obtained are as follows. (1) The flame base is constantly formed at air side upstream. In case of the horizontal jet diffusion flame, the flame base which is located below the spout slit port of the fuel is lifted bulging outward after it is approaching to the slit port with increasing the jet fuel velocity. (2) Stability of the vertical flame depends on burner inside diameter. And the flame is stabilized with increasing the inside diameter of the burner nozzle. The horizontal radial flame which is formed on the fuel nozzle with narrow slit is stabilized more than on the other with the broad slit. (3) The stability of the diffusion flame depends on the fuel velocity. The flame is stabilized when a bit of H2 and/or CH4 is added to bio-mass gas. CO which is burned completely in the diffusion flame is effective to raise the flame temperature. It is found that the low calorie biomass gas is effective as one of renewable fuel.

Takamitu Yoshimoto: yosimoto@kobe-kosen.ac.jp

We adopted a kiln-type gasification and ash melting furnace for a municipal solid waste (MSW) incineration plants. The MSW is indirectly heated in a kiln to divide it into pyrolysis gas and pyrolysis
residue (char). The char is burned in a melting furnace with very high temperature. The ash in char is turned into molten slag in a melting furnace. In order to design these furnaces, we developed the computational model. First, the computational model of gasification furnace was able to predict the pyrolysis process of MSW. The mass flow of gas and solid was approximated by one-dimensional calculation. The heat transfer coefficient among solid waste, gas and inner cylinder of kiln, which is variously affected by kiln structure and operation condition, was acquired by a scale model examination. Compared to the actual plant data, temperature prediction error is less than 10% at inner cylinder wall, pyrolysis gas, and solid waste. And then, the heat balance computational model of the melting furnace was developed to achieve the following aims, (1) to prevent the ash from adhering, outlet gas temperature of the furnace must be cooled quickly: and (2) to melt ash, the wall temperature must be higher than the melting point of the ash. The calculation results were compared with measured data from a demonstration plant and accuracy of the developed program was verified. Temperature prediction error is less than 40 °C.

Teruyuki Okazaki: teruyuki.okazaki.vm@hitachi.com