

Abstract

Biomass gasification process involves complex chemical reactions which converts solid biomass into gaseous fuel, water vapour, char (solid carbon) and tar (aromatic higher hydrocarbons). This work focuses on co-gasification of different blends of coal and biomass in the fuel. The share of biomass or coal in co-gasification is one of the important parameters that affect the gasification process. In this study, the effect of biomass and coal blends on the production of output gas from gasification process has been carried out. Chemical Equilibrium with Applications Program (CEA), a non-stoichiometric equilibrium model based on Gibbs free energy minimization technique is used for thermodynamic optimization of the co-gasification process.

The output gas composition from gasifier, over a wide range of operating conditions is studied to understand the effects of different operating parameters on the gas composition and lower heating value. The various operating parameters viz., percentage of coal to biomass (0%, 10%, 20%, 30% and 40%), equivalence ratio (ER), gasification temperature (700 to 1400°C), gasifying medium (air, oxygen, air + steam and oxygen + steam) and carbon conversion are considered in the study. The simulation result shows as the gasification temperature increases the mole fraction of CO increases for a particular equivalence ratio irrespective of gasifying agent and reverse is the trend for CO₂. Again the mole fraction of CO increases with decrease in equivalence ratio for all temperature likewise reverse is the case of CO₂ irrespective of gasifying agent. It is also found as the percentage of coal increases in the mixture of coal and biomass the mole fraction of CO increases and reach maximum value at lower temperature and reverse is the case for CO₂ for all temperature at a particular equivalence ratio. With decrease in equivalence ratio the mole fraction of CO increases with increase in percentage of coal in the mixture of coal and biomass for a particular temperature and reverse trend is followed by CO₂. However, as the carbon conversion increases the mole fraction of CO decreases for all ER at a particular temperature and as in case of CO₂ reverse is the trend. The mole fraction of H₂ decreases with increase in percentage of coal in the mixture of coal and biomass (except only biomass) for all temperature for a particular equivalence ratio. Also with the increase in percentage of coal, the maximum value of mole fraction of H₂ decreases and the maximum point gradually shift towards the increasing equivalence ratio for a particular temperature. Again as the carbon conversions increases the maximum mole fraction of H₂ increases for all equivalence ratio at a particular temperature. Also with increase in carbon conversion maximum peak value of mole fraction will shifts towards decreasing equivalence ratio. The lower heating value of producer gas increases with increase in percentage of coal in the mixture of coal and biomass for all temperature for all equivalence ratios. The lower heating value of the producer gas decreases with increase in equivalence ratio at a particular temperature, where as there is no effect of carbon conversions on lower heating value at a particular temperature. The lower heating value of the product gas is always higher for oxygen gasification in comparison of air gasification because of the absence of nitrogen in the former case. As the SBR increases, the H₂ mole fraction increases for all ER for both the gasifying agent.

Also as the ER decreases for a particular SBR, H₂ mole fraction first increases reach a maximum value then decreases with further decrease in ER at a particular temperature irrespective of gasifying agent. Again, as the SBR increases, the adiabatic temperature decreases and with decrease in temperature and the H₂ mole fraction increases and as the ER increases, the adiabatic temperature increase and H₂ mole fraction decreases. The actual performance of gasifier deviates from the model prediction, as the equilibrium conditions are difficult to achieve in field gasifier. However, the overall trends of the gas composition predicted by the model at various operating parameters remain unchanged.

The single particle study of different blending of coal-biomass sample has been carried out to understand the combustion process. The different diameter spherical spheres of 100% biomass, 10% coal+ 90% biomass, 20% coal+ 80% biomass, 30% coal+ 70% biomass and 40% coal+ 60% biomass are used for this study. In the experimental study, flaming time and char combustion time of all these different coal-biomass blended spheres are measured. The adiabatic flame temperature has been calculated by CEA simulation tool by balancing energy method. It shows that the adiabatic flame temperature decreases with the increase in percentage of coal with biomass for air as oxidizing agent. However, reverse is the trends when oxygen is used as oxidizer. It has been observed that approximately 80% of the mass has lost during flaming time combustion for all types of spherical balls. Flaming time is independent of particle density, whereas burning time and ratio of burning time and particle density increases with the increase in diameter. The mass degradation rate is highest for biomass irrespective of diameters during flaming mode combustion. Char combustion time is minimum for biomass for all diameters. As the diameter increases the ignition flux decreases for all type of mixture.