Characterization of Biomass Pellets

ABSTRACT

Biomass continues to be relevant in the energy needs of the world, especially developing nations. A considerable part of biomass is in powdery form such as agricultural residues, obtained after threshing and sawdust, which is a waste from timber industry. Transportation of biomass in powdery form can be cumbersome and also costly. Combustion of powdery biomass in many applications can be inefficient, and highly polluting. Thus, pelletization is being looked upon as an important process in the effective use of biomass.

While a large body of literature is available on many aspects of pelletization and the combustion of pellets, most studies on their combustion characteristics carry out combustion of these pellets in controlled furnaces. There are some applications like cookstoves of various sizes where combustion of pellets takes place under natural convection induced flow of combustion air, and every pellet gets ignited by the neighbouring pellet in an environment having temperatures considerably lower than those in industrial furnaces. Such studies are not found in the literature. Moreover, there are very few studies dealing with different types of biomass. Density of the pellet can vary due to the type of biomass, its particle size and the compaction parameters. The pellet density, can in turn, affect the combustion characteristics of pellets.

The present work focussed on five objectives, first one involving thermochemical analysis of a few varieties of biomass using standard methods and a comparative assessment of different biomass types in the light of the results obtained. As part of this objective, improved correlations have been developed for determining the heating value of biomass from ultimate analysis or proximate analysis or a combination of the two. In the second objective, pellets of different diameters and density were prepared in the laboratory using three varieties of biomass along with the determination of their physical and mechanical properties. The third objective involved “single-pellet-combustion” experiments on these pellets as well as those commercially available. The analysis of this data was carried out in the light of the thermochemical analysis of the biomass, as well as with respect to variation in dimensions and density of the pellets. The fourth objective involved combustion of commercially available pellets in a fixed bed having the configuration of a gasifier cookstove and linking the overall burn rate with the single-pellet burn rate obtained in the third objective. Numerical simulations using open-source software and already available tools were carried out for devolatilization of pellets and for their combustion in a fixed bed configuration. The work carried out as part of this doctoral research is expected to be useful in identifying the optimal size and density of the pellets for a given application considering the energy involved in pelletization, durability in transport and also the burn rate.