Editorial Corner

Technology Trends on Waste and Biomass to Clean and Efficient Energy Reforming

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Biomass fuel offers potential replacement for fossil fuel resources towards the path for clean and sustainable energy production [1]. Biomass includes lignocellulosic materials such as wood, grass, agricultural residue, animal manure, and energy crops, food wastes and bio-wastes. Biomass is inherently carbon neutral due to its ease of biomass generation and carbon sequestration. The relatively fast growth of trees and bio-wastes generated from direct/indirect carbon sequestration compared to fossil fuels means that the carbon cycle is complete in only a short period of time span (years and not decades and centuries), as in the case of fossil fuel resources. Such attributes in their production and use is the main attraction for ongoing research into biomass utilization [2]. The availability and carbon positive nature, meaning unbalanced carbon emissions with carbon sequestration from fossil fuels, has driven the motivation of many researchers to seek into alternative means of energy production. Although other renewable energy techniques are currently being developed, the potential of energy production from biomass and bio-wastes is very attractive since they offer sustainable carbon-based resources for energy production. The choice of carbon-based resources is necessary to utilize the existing advanced infrastructure for energy utilization, which is mostly carbon-based fuel driven. This supports for lower infrastructure expenditure unlike other renewables, such as direct solar energy utilization. As an example, photovoltaics requires a major overhaul for infrastructure development for energy production, transfer and grid energy utilization.

Although the technology for energy production by combustion and gasification of high-quality biomass pellets is already in place, the availability and maintenance of such biomass are not scalable to replace fossil fuels [3]. Medium-low grade biomass/bio-wastes, which are abundantly available, can supplement these high-quality biomass and other feedstocks in maintaining constant energy output from the energy production plants. Municipal solid wastes such as food and paper waste, agricultural wastes, and animal manure are some of the potential feedstocks that can provide energy by co-gasification or co-pyrolysis with high-quality feedstocks [4]. On-site energy production from industry-specific bio-wastes such as animal manure in poultry and meat industries can be very helpful in providing an additional energy source for the industry along with an efficient waste disposal strategy. The variation in grade, refers to the presence of high inorganic content and high moisture content which lower the energy density of these wastes to result in decreased amounts of energy yield that is also of lower grade/quality.

Gasification is an ideal technique for co-processing of bio-wastes and coal, high-quality biomass or high energy density plastic wastes. Gasification includes thermochemical decomposition of carbonaceous feedstocks into syngas (major gas phase species being: H_2, CO along with minor components of CO_2, C_xH_y) in the presence of controlled oxidizing agents, such as H_2O, CO_2, O_2/air at very high temperatures. The uniformity in the product produced and the versatility of syngas utilization is the most attractive feature of gasification. Gasification helps convert heterogeneous, varying grade solid feedstock into uniform, high calorific value syngas which can either be used directly as fuel for energy production, or further converted to liquid fuels for use in transportation, or reformed to value-added chemicals which makes not only efficient energy production, but also helps the downstream processes. Details into the state of the art of gasification are omitted here but can be found in the literature [5]–[8]. A major issue with gasification is to deal with designing reactors that considers for the varying quality and form of the feedstocks of different moisture content while maintaining high energy output. Designing of such a feedstock flexible gasifier needs a concrete understanding of the thermophysical and thermochemical aspects biomass gasification. One of the major aspects of such understanding is the reaction kinetics and mechanism of biomass gasification. Biomass gasification includes thermal decomposition/pyrolysis of biomass while the gasifying agent reforms the volatile yields formed. There our further understanding on the decomposition/pyrolysis of different kinds of biomass/bio-wastes is essential for the design of advanced feed-flexible gasifiers.

Many studies can be found in the literature that reveal the effects of various operational parameters and role of the reactor used on the product gas yield for different types of biomasses/bio-wastes, including animal manure wastes [6], [9]. Investigations into detailed reaction mechanisms can also be found in the literature for some of the biomass [10]–[12]. Furthering knowledge on gasifier design, development of simplified, extensive model is necessary in order to support computational fluid dynamics modeling and simulation studies.

The energy requirement for solid material decomposition is also important. Here the role of catalysts on thermal decomposition of the material can help provide an important role with low cost reusable catalysts at normal or elevated pressures. The use of solar energy in the process can further help improve conversion and process improvement. Continued efforts in this area will help improve greater development of the technology at different sizes and scales for use in local areas where the biomass and wastes are produced.

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