UNIVERSITY OF MINNESOTA

Department of Bioproducts and Biosystems Engineering
College of Food, Agricultural and Natural Resource Sciences
College of Science and Engineering

BBE North
Kaufert Lab
2004 Folwell Avenue
St. Paul, MN 55108-6130
612-624-1293
Fax: 612-625-6286

BBE South
BioAgEng Building
1390 Eckles Avenue
St. Paul, MN 55108-6005
612-625-7733
Fax: 612-624-3005

E-mail: bbe@umn.edu
Web: www.bbe.umn.edu

Project Title: Development of a novel gasification technology for distributed power generation from solid wastes

Contract Number: RD4-1 Milestone Number: 2 Report Date: September 3, 2017

Principal Investigator: Roger Ruan
612-625-1710

Contract Contact: Kevin McKoskey
612-624-5599

Congressional District: 5

Congressional District: 4

MILESTONE REPORT

Executive Summary: Unlike biomass combustion to electricity technology which directly burns biomass to supply stream for steam-electric generators, gasification to electricity technology converts solid feedstock to a combustible gas that can then fuel steam generators or gas turbines. Compared with direct combustion, gasification has higher conversion efficiency; its gas products are easier to handle; it has less emission problems; it has less solid residue left in the equipment; and last but not the least, gas product can be used in a greater variety of power plant configurations, either internal – combustion engines, gas turbines or CHP units. Gasification is considered by most the “Clean Biomass Technology”, the equivalent of Clean Coal Technology. In addition, gasification technology can be operated in scales suitable for distributed/decentralized power generation, and hence compatible with the distributed nature of biomass feedstock production.

The University of Minnesota (University) will conduct a three year research project to develop a fast gasification-based electricity generation technology. The University will investigate and fabricate a gasification method based on microwave heating to raise the process temperature and increase heating rate. This will improve biomass conversion efficiency and syngas quality and cleanness. A fast microwave assisted gasification (fMAG) system and electricity generator will be designed and demonstrated as a prototype to evaluate techno-economic and other benefits of the proposed technology. Incorporated into the prototype system developed will be microwave susceptors (MWS) which are effective at raising temperatures to a very high level at extremely fast rates.

The technology to be developed is scalable and portable which will enable distributed and decentralized electricity generation from biomass and other sold wastes that are intrinsically widely distributes in loose form. Unlike biomass combustion to electricity technology which directly burns biomass to supply steam for steam electric generations, gasification to electricity technology converts solid feedstock to a combustible gas that can then fuel steam generators or gas turbines.

The goal of this milestone period was to characterize and screen microwave susceptors (MWS) or microwave absorbents. In the six months period, we chose activated carbons (AC), SiC, MnO, magnetite and char from the experiments based on Milestone 1 preliminary results. The microwave absorption ability of absorbents as a function of type, amount, and particle size of the absorbents and the size of the reactor was investigated. Based on the data from the experiments, handling properties, and commercial availability, we concluded that SiC (silicon carbide) is the best microwave absorbent for practical use in microwave assisted pyrolysis. In summary, the current milestone has been completed and the outcome meets the expectation.

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Technical Progress: In this milestone period, activated carbons (AC), SiC, MnO, magnetite and char were investigated for their ability to absorb microwave energy in our bench microwave assisted pyrolysis system (Figure 1). Methods were developed to measure the temperature rise under different process parameters including type, amount, and particle size of the absorbents and the size of the reactor. Our data show that both SiC and MnO have desirable heating characteristics (high heating rate and high temperature). Among the three particle size studied, we found the medium size (36 grit) was better than smaller or larger size. Generally the smaller amount resulting in higher heating, which may be attributed to greater energy density the absorbent received. However, optimal ratios of absorbent to feedstock must be determined through observation of the interactions between absorbents and feedstock in the next milestones. With regard to the reactor size, we found that heating was better in the larger reactor than the smaller one because at given amount the absorbent formed a thinner but larger layer in a larger size reactor than in a smaller reactor. This suggests the need to spread out absorbent particles either by adapting a large reaction surface or mixing so that absorbent particles are well exposed to microwave irradiation. We also found that the heating rate increased when microwave power input was increased from 400W to 800W but further increase in power input did not significantly increase the heating rate, indicating that there is a limit on how much energy a given mass or volume absorbent can absorb. Based on the experimental observation and other considerations such as commercial availability/cost and handling/recycling/reuse properties, we concluded that SiC (silicon carbide) is the best among the microwave absorbents screened, and will be used for the future studies.

Additional Milestones: N/A

Project Status: The project is on schedule and within budget.

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