Characterization of an Auger-type Pyrolysis Reactor using Induction Heating as an Energy Source

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Abstract

Pyrolysis has been used for thousands of years to extract fuel from carbonaceous materials and throughout the development phases of this technology, the source and method of heat application has always been one of the primary focus points in the design process. The different heating methods all have their specific advantages and disadvantages and these normally relate to their ability to impact on important parameters such as temperatures, heating rates and maintenance. Through the years of development various types of reactor configurations have tended to favour certain heating methods and in auger-type reactors the heating rate has been one of this reactor's limitations, especially in biomass pyrolysis where high heating rates are required to optimise pyrolysis oil yields. One of the possible heating methods for these reactors is by means of induction heating which is the method employed in the pilot plant located in BIUST's pyrolysis laboratory. This paper presents results of heating performance tests done in this pilot plant on an inert material with known properties (silica) at different levels of heater duty, feed rates and residence times. The heat transfer into the material was calculated from the measured data and plotted against feed rate and residence time for different heater duties. It was observed that the heat transfer into the material was very efficient at the design feed rates. In order to explore the limits of efficient heat transfer, tests were performed at up to forty times the design feed rate. Even at these rates the heat transfer into the material was still satisfactory. It was concluded that, from a heat transfer point of view, auger-type pyrolysis reactors fitted with induction heaters as energy source have potential of having high efficiencies. This work also forms a good basis from which a mathematical model can be developed to aid in the design of such reactors using software such as MATLAB®.

Keywords
Pyrolysis, Auger, Induction heating

Acknowledgements
The authors would like to appreciate Botswana International University of Science and Technology and Pyro Carbon Energy for the financial support provided in this work.

Biographies

Daniel Erich Botha is a director of Pyro Carbon Energy and is currently doing research in the field of pyrolysis in collaboration with Botswana International University of Science and Technology where he is currently enrolled as a PhD student. Mr. Botha graduated with a master's degree in engineering from the University of Pretoria in 1989 and worked for Sasol Technology and MegChem before relocating to Botswana where he became a founder of Pyro Carbon Energy. Mr. Botha's experience covers a wide range of industries, including petro-chemical and nuclear amongst others.

Mmoloki Makoba is a second year PhD student at Botswana International University of Science and Technology. She is doing her main research on conversion of Botswana coal to synthetic gas which will be used for power generation and as chemical feedstock. Makoba is also involved in conversion of other carbonaceous materials to

synthetic gas, liquids and char. Before going into research, she worked as a metallurgist at Tati Nickel Mining Co. where she was involved with process optimization through sample preparation, reporting plant figures in production meetings and supervising work around the plant. Makoba holds a master's degree in chemical and minerals engineering from University of Leeds. In her spare time, she enjoys travelling.

László-Zsolt Szabó is a PhD student in Chemical Engineering at Babeș-Bolyai University from Cluj-Napoca, Romania. He has a master's degree in Chemistry and a bachelor's degree in Chemical Engineering. His research field is the mathematical modelling of the pyrolysis and gasification of the coal. He worked at the SC.Transvital Cosmetics.SRL (Cluj-Napoca, Romania) as a chemical engineer for two years; his main task was to make physico-chemical characterization of the cosmetic products.

Thapelo Shomana is a full time PhD student and Teaching Assistant in the Department of Chemicals, Materials and Metallurgical Engineering at Botswana International University of Science and Technology, Palapye, Botswana. He holds a BEng and MEng in Chemicals and Minerals Engineering from University of Leeds, United Kingdom where he did a research in investigating novel solvent extraction methods for nuclear reprocessing for his research project. For his PhD research, Mr Shomana is working on developing a mathematical model and process control phenomena for Botswana coal pyrolysis. From March 2014 to October 2016, he worked as a process engineer for BCL, a 100 tph copper/nickel concentrate smelting company where he covered both operational and technical aspects of the process. It was BCL experience that sparked his research interest in process systems engineering field but he has since become even more interested in green energy technologies.

Baboloki Thatayaone Chiwara is a young aspiring innovator at 23 years, who currently is studying his 4th year of B.Eng Chemical Engineering in Botswana International University of Science and Technology. During his 2nd year of study, he had found his path into the innovation and problem-solving world, where he was challenged to design and fabricate an air cooler affordable to the remote communities in Botswana, which rendered successful. In advancement of his studies he focused more into green energy and self-sustainable processes for producing energy, which then led to him participating in the Sixteenth International Waste Management and Landfill Symposium held October 2017. Later in 2017 he had a research paper published in Research Gate by the title "Pyrolysis of Plastic Waste into Fuel and other Products". As of now he is engaged in pyrolysis plant design and fabrication as part of his industrial training for his final semester of the 4th year.

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