KINETIC INVESTIGATIONS ON BIOMASS PYROLYSIS AND GASIFICATION

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by

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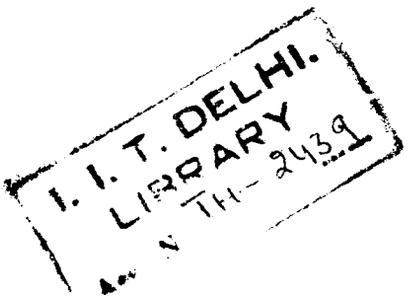
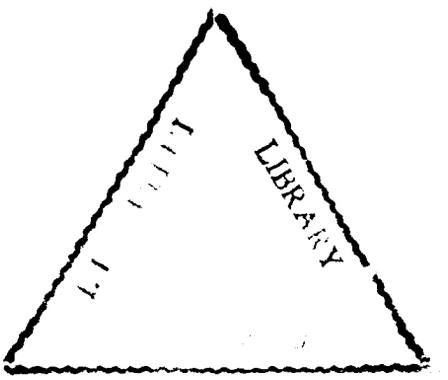
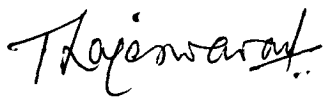




CERTIFICATE

This is to certify that the thesis entitled, " **KINETIC INVESTIGATIONS ON BIOMASS PYROLYSIS AND GASIFICATION** " being submitted by Mr. Atul Sharma to the Indian Institute of Technology, for the award of the degree of " **Doctor of Philosophy** " is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.



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ABSTRACT

Among the various non-conventional energy sources, biomass has gained a considerable research interest and significance not only being a source of energy and renewable source of carbon but it is also a feed stock for many valuable chemical products. Rice husk is one of the biomass species largely produced in asian countries. A proper design of equipments like gasifiers for producing energy carrier gases requires knowledge of the rate parameters for the thermochemical conversion processes like pyrolysis and gasification. From literature review it is found that there are very few studies reported on pyrolysis and gasification of rice husk. In the present work rice husk has been selected for studying some of the thermochemical process for determining the kinetic parameters.

Experiments on pyrolysis are carried out with rice husk in grain form and powdered form in N_2 and CO_2 atmospheres under isothermal and non - isothermal conditions. Temperature range studied under isothermal conditions is 250 - 500 °C and for non isothermal conditions 5 - 100 °C/min heating rate. Analysis of the data based on n^{th} order rate equation generally used for decomposition reaction showed that pyrolysis proceeds in two stages with a transition at 350 °C temperature. The reaction order obtained for low temperature zone is 1.5 and 2.0 for higher temperature zone under both isothermal and non isothermal conditions. A new method is proposed to determine the activation energies and frequency factors for any heating rate values based on a reference heating rate value. The method was found to predict satisfactorily the weight loss data for different heating rate conditions.

Gasification of a rice husk char, prepared in a pyrolyzer is carried out in a temperature range of 675 - 850 °C in CO_2. Experiments are carried out for both char in grain form and pelletized form. The kinetic parameters are determined based on widely used volume reaction model and grain model. The reaction order with respect to CO_2 is also determined by conducting experiments at different partial pressures of CO_2 and found to be 1.0. The analysis of the data showed that the reaction is

chemically controlled upto 800 °C and at higher temperatures influenced by diffusional effects. The activation energies obtained in the two models are in close agreement, and within the range of activation energies for biomass char reported in literature.

A method is proposed for predicting the pyrolysis rates for any biomass material under non isothermal constant heating rate conditions. It is based on the composition and kinetic parameters for pyrolysis of the basic constituting components of the biomass namely cellulose, hemicellulose and lignin. In the present case the kinetic parameters are determined based on n^{th} order rate equation for pyrolysis the method is tested with the data on different biomass materials reported in literature and found to predict satisfactorily the experimental results.

An attempt is made to model a small scale annular finned pyrolyzer used for pollution free heat generation from loose biomass materials. Theoretical conversion and temperature profiles are generated for different number of fins with kinetic parameters obtained for rice husk in the present work. From the theoretical analysis it is found that the performance of the pyrolyzer depends on initial heating rate and number of fins. Few experiments are conducted with rice husk in the pyrolyzer for simulation and testing with the model. It is found that the model predictions are in close agreement with the experiment data.

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