PROGRESS IN BIOMASS AND BIOENERGY PRODUCTION

Edited by **S. Shahid Shaukat**

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Preface

The fossil fuels that are principally used to provide energy today are in limited quantity, they are diminishing at an alarming rate, and their worldwide supplies will eventually be exhausted. Fossil fuels provide approximately 60 percent of the world's global electric power. Carbon dioxide levels in the atmosphere will continue to rise unless other cleaner sources of energy are explored. Biomass has the potential to become one of the major global primary energy source in the years to come. Biomass is the source of bioenergy which is produced by burning biomass or biomass fuels and provides cleanest energy matrix. Biomass, currently the most important source of energy, is organic matter which can be in the form of leaves, wood pieces, grasses, twigs, seeds and all other forms that plants and animals can assume whether living or recently dead. Often biomass has to be converted to usable fuel. This book addresses the challenges encountered in providing biomass and bioenergy. The book explores some of the fundamental aspects of biomass in the context of energy, which include: biomass types, biomass production system, biomass characteristics, recalcitrance, and biomass conversion technologies. The natural resistance of plant cell walls to microbial and enzymatic breakdown together is known as biomass recalcitrance. This characteristic of plant contributes to increased cost of lignocellulose conversion. Some of the articles included here address this issue. Besides exploring the topics of biomass and bioenergy, the book also deals with such diverse topics as biosorption, waste water treatment, fuel production including ethanol and hydrogen, and bio-economics.

The book is divided into seven sections which contain different number of chapters. Section I includes papers on Gasification and pyrolysis. The first Chapter by Jernej Mele presents a cold-flow model of FICFB biomass gasification process and its scale-up to industrial pilot plant. In Chapter 2, B. Fakhim and B. Farhanieh focus on Second Law analysis of bubbling fluidized bed gasification. Chapter 3 written by Milan Hrabovsky elucidates some new results on the production of syngas through thermal plasma technique, using gasification as well as pyrolysis. Chapter 4 authored by Jiri Jenista provides a numerical investigation of hybrid-stabilzed argon-water electric arc used for biomass gasification.

The Section II of the book covers biomass production and includes two chapters. In Chapter 5 Janis Abolins and Janis Gravitis present a simple analytical model for remote assessment of the dynamics of biomass accumulation. H. Viana, D. Lopes and J. Aranha, in Chapter 6 suggest a methodology for assessment of forest above ground biomass and dynamics using remote sensing and geostatistical modelling.

Section III which contains three chapters deals with Metal Biosorption and Reduction. Chapter 7 by J. F. Cardenas-Gonzalez and I. Acosta-Rodriguez describe a technique of removal of hexavalent chromium using a strain of the fungus *Paecilomyces* sp. Chapter 8 presents a comprehensive review of biosorption of metals by R.C. Oliveira and C. Palmieri which includes general features of the biosorption phenomenon as well as potential applications for environmental and technological processes. Chapter 9 authored by Zhu Guocai examines reduction of manganese ores using biomass as reductant. Section IV that deals with Wastewater treatment contains two chapters. Chapter 10 by Nima Badkoubi and H. Jazayeri-Rad attempts to investigate the parameters of wastewater treatment plant using extended Kalman filters (EKF) and some constrained methods. In Chapter 11 Dr. P. Vega discussed different control strategies for wastewater treatment. Section V, a large section, devoted to Characterization of biomass, pre-treatment, recovery and recalcitrance, comprises of seven chapters. Chapter 12 written by Yufu Xu, Xianguo Hu, Wendong Li and Yinyan Shi provides an elaborated review on Preparation and Characterization of Bio-oil from biomass. The investigation on bio-oils led to the conclusion that the bio-oils present bright prospects as an alternative renewable energy source instead of the popular fossil fuels. In Chapter 13 S. Adena-Elena focuses on Combined microwave-acid pretreatment of the biomass. Chapter 14 by Olfa Bouzaiane investigates the relationships of C, N and DNA content of municipal solid waste during the composting process. In Chapter 15 Hale Sütcü characterizes activated carbon produced from Oleaster stones. In Chapter 16 by A. Wijanarko, the effect of substituted urea and ammonia in the growth medium on the lipid content of *Chlorella* is investigated.

Chapter 17 by E. Fumoto, T. Tago and T. Masuda focuses on the recovery of ammonia and ketones from biomass waste. Recovery of ammonia is achieved through adsorption while that of ketones through catalytic cracking process. Chapter 18 written by O. Senneca characterizes biomass as nonconventional fuels by thermal techniques and presents a comprehensive protocol for the same. Section VI contains articles on Fuel production: ethanol and hydrogen. In Chapter 19 V.P. Obade, D.E. Clay, C.G. Carlson, K. Dalsted, B. Wylie, C. Ren and S.A. Clay provide the Principles and Applications of using remote sensing of nonharvested crop residue cover. In Chapter 20 Elisabeth Schröder discusses activated carbon production from waste biomass. In Chapter 21 M. Sveinsdottir, M.A. Sigurbjornsdottir and J. Orlygsson deal with the production of ethanol and hydrogen using thermophilic bateria from sugars and complex biomass. Harun Razif and M.K. Danquah in Chapter 22 focus on the analysis of process configuration for bioethanol production from microalgal biomass. Chapter 23 by R. Heard and C.R. Ozansoy reviews the Microbial conversion of biomass concentrating on microbial fuel cells.

Section VII contains one Chapter on Bio-economics. Chapter 24 written by D.V. Filatova and M. Grzywaczewski presents structural and parametric synthesis of bio-economic models using stochastic differential equations. Estimation procedures involved Monte Carlo simulation. The strength of the book rests more or less on all the contributions, my sincere thanks are due to all the authors for providing their in depth individual studies or comprehensive overviews of their research areas and the state-of-art in their fields and meeting the various deadlines.

I would like to express my gratitude to the faculty members of the Institute of Environmental Studies, University of Karachi and to postgraduate students and Prof. Dr. Moinuddin Ahmed (Foreign Faculty) of Ecological Research Laboratory, Federal Urdu University, Karachi, for some useful discussions and moral support. Finally, I would like to thank Ms Ana Pantar, Publishing Process Manager and Mr. Niksa Mandić, Publishing Process Manager, InTech Open Access Publisher, Croatia for bearing with me with delays and being generously helpful throughout the process of putting this book together.

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Part 1

Gasification and Pyrolysis

1

Scale-Up of a Cold Flow Model of FICFB Biomass Gasification Process to an Industrial Pilot Plant – Example of Dynamic Similarity

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1. Introduction

In this chapter we are introducing the research of particles hydrodynamics in a cold flow model of **F**ast **I**nternal **C**irculating **F**luidized **B**ed (FICFB) biomass gasification process and its scale-up to industrial pilot plant. A laboratory unit has been made for the purposes of experimental research. The laboratory unit is three times smaller than the later pilot plant. For a reliable observation of the flow process, similar flow conditions must be created in the laboratory unit and the pilot plant. The results of the laboratory model will be similar to those of the actual device if geometry, flow and Reynolds numbers are the same. Therefore, there is no need to bring a full-scale gasificator into the laboratory and actually test it. This is an example of "dynamic similarity".

FICFB biomass gasification is a process for producing high caloric synthesis gas (syngas) from solid Hydrocarbons. The basic idea is to separate syngas from flue gas, and due to the separation we have a gasification zone for endothermic reactions and a riser for exothermic reactions. The bed material circulates between these two zones and serves as a heat carrier and a catalyst.

While researching the 250kW fluidized bed gasification pilot plant certain questions concerning particle dynamics in gas flows control arose. There is a zone where fluidized bed conditions are made with superheated steam, pneumatic transport with hot air and a pair of secondary gas inlets of CO_2. These particle flows are difficult to describe with mathematical models. This is the main reason why the three-times smaller cold-flow laboratory unit has been made. The hydrodynamics of particles will be studied in the air flow at arbitrary conditions. Flow conditions in the laboratory unit and pilot plant must be similar for a reliable evaluation of the process in the pilot plant.

2. Laboratory unit

The laboratory unit is a device three times smaller than the pilot plant. Its main purpose is to simulate the hydrodynamic process of FICFB gasification in a cold flow. It is made from stainless steel and in the case of the parts that are of greatest interest to the present study is made of glass, so that the particle behaviour may be observed. Fig. 1 shows a model of laboratory unit. Its main elements are:

- Reactor (A),
- Riser (B),
- Cyclone (C),
- Siphon (D),
- Chute (E),
- Gas distributor (J_1 and J_2),
- Auxiliary inlets (I_1 and I_2).

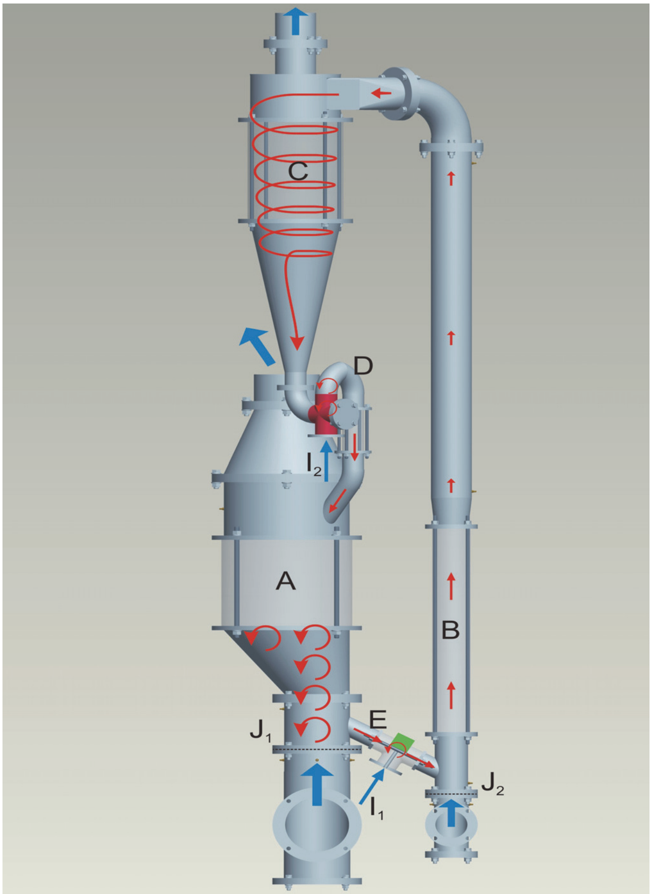

Fig. 1. 3D model of laboratory unit

Firstly, let us look at the process. There are two gas distributors at the bottom of the reactor and riser, through which air is blown vertically. The pneumatic transport of the particles takes place in the riser, where they are separated from the air flow in cyclone and finally gathered in siphon. The second auxiliary inlet acts to fluidize the gathered particles and transport them to the reactor. Here, the fluidized bed is created with the upward blowing air. From here, the particles are transported to the riser through the chute and the speed of transportation is regulated by means of the first auxiliary inlet.

	Laboratory unit	Pilot plant
$D_{gas,1}$ [mm]	100	300
$D_{gas,2}$ [mm]	190	600
D_{comb} [mm]	50	150
H_{comb} [mm]	1500	4500

Table 1. Main dimensions of laboratory unit and pilot plant

We are primarily interested in how to establish a stationary and self-sustainable process. In the laboratory unit there are glass parts through which the process in course can be directly observed. However, in the hot flow model we will not be able to see what happens inside the pilot plant, and therefore our control system must be able to initiate the process, keep it in a stationary state and halt it on the basis of measured data such as relative pressure and flow velocities. For this mater, our laboratory unit consists of 7 pressure and 2 flow velocity measuring points. Fig. 2 details the positions of the pressure places.

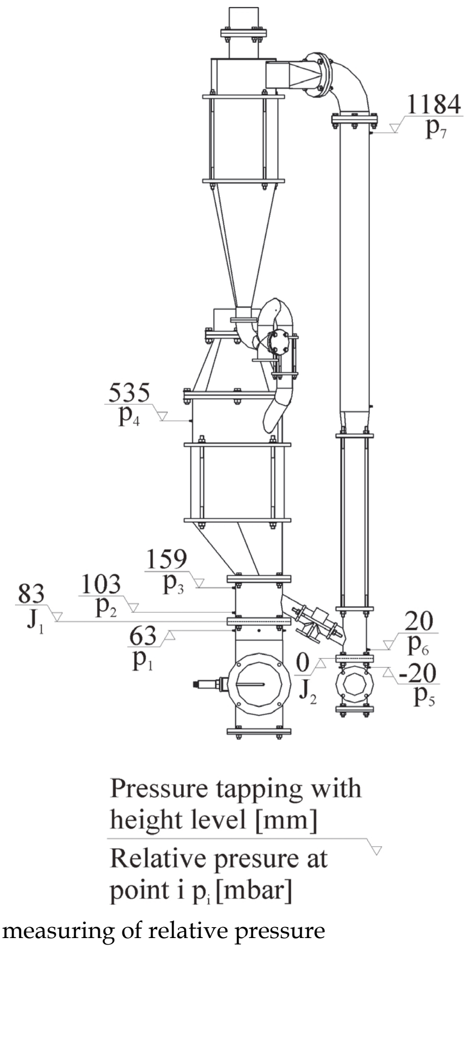

Fig. 2. Openings for the measuring of relative pressure