PREFACE

Due to rapid industrialization the energy consumption is increasing day by day. The global energy demand has increased from 188 in 2011 to 328 Million Tonnes of Oil Equivalent in 2018. Fossil fuels are predominantly used to fulfil these skyrocketing global demands for energy. But the uses of fossil fuels have faced mankind with two major concerns: a) depletion of fossil energy resources and, b) deterioration of the environment by adverse environmental impacts with release of significant amount of pollutants such as NO_X, SO_X, particulates and, CO_2. In light of this, there is a need to develop an alternative renewable energy source from partial fulfilment of required energy demand.

Chapter 1 explains current energy scenario, energy related environmental issues, biomass as a solid waste and as a source of energy. The release of CO_2 in atmosphere from fossil fuels was only 20.5 gigatonnes (Gt) in 1990 which was increased gradually and reached to historical high 33.2 Gt in 2018. Because of the growth of the population, the agricultural wastes are increasing day by day inevitably. Coconut is grown in more than 86 countries worldwide in which India occupies the premier position in the world. But, approximately 80 to 85 % of green coconut nut by weight is considered as waste. Green coconut coir does not degrade easily and thus it becomes disposal problems for farmers. Moreover, it gives suitable place for unwanted microorganism to grow on its surface. Thus, proper disposal of these wastes are very important for the good hygiene of the society. Therefore, these wastes generate negative economic value to the farmers. However, this chapter reveals the utilization of high lignin biomass through thermochemical conversion. This chapter reveals the origin of the problem and objectives of the research work.

Literature review was summarized in **Chapter 2**, which includes the utilization of biomass for gasification process. It also describes the literature of available current technologies in fixed bed and fluidized bed. The variations of composition of components of product due to presence of natural or synthesized catalysts have also been reviewed in this chapter. To understand the selection criteria of biomass for the energy generation, the characterisation of biomass has also been introduced in the start of the chapter. And, in last the summaries of recent study on fixed bed and fluidized bed regarding gasification of biomass have been tabulated.

The **Chapter 3** elaborates the process of the experimentation on both fixed bed and fluidized bed. The temperature is one of the most important and crucial operating parameters for the performance of biomass gasification. The experiments of gasification were initiated with air as gasifying medium at gasifying temperature from 700 to 900 °C in fixed bed column. Furthermore, the pre-treated unripe coconut husk (UCH) was impregnated with pulp and paper waste water at impregnation temperature 25, 65 and 105 °C and definite biomass/waste water ratio for the impregnation of metals present in it. Then after, comparative study of impregnated and raw unripe coconut husk using air, humidified air, and mixture of humidified air and CO_2 mixtures as gasifying medium was performed. Humidified air was generated by passing air through water bubbler which was kept in temperature controlled water bath. Optimized conditions were opted for the further analysis of fuel gas composition in fluidized bed gasification with sand as bed material. Furthermore, the experiments were performed and optimized for maximizing the concentration of H_2, CO and minimizing CH_4 and CO_2 using Box-Behnken method of response surface methodology (RSM) in fluidized bed gasification. The process parameters for the optimization were temperature 800 to 900 °C, equivalence ratio from 0.1 to 0.4 and air to CO_2 ratio from 1 to 4.

Chapter 4 explains the results of each experiment carried out at different conditions. It was inferred that higher temperature decomposes biomass with more amount of H_2. Higher quality of fuel gas was generated with impregnated coconut husk as feedstock with respect to untreated coconut husk. Furthermore, the quality was further improved when air as gasifying medium was replaced with the humidified air. In addition, the optimized parameters have also been discussed in this chapter.

Chapter 5 summarizes the conclusion drawn on the basis of results of this research work. The unripe coconut husk and wastewater of pulp and paper industry were utilized to produce fuel gas via gasification. Both have negative economic value for their disposal. The comparative study showed better performance for impregnated coconut husk in terms of H_2 composition in produced fuel gas. Furthermore, gasification with humidified air as the gasifying agent increased H_2 formation. ED-XRF results confirmed the impregnation of Na, Ca, etc. onto the ICH surface. These results encourage of using pulp and paper waste water for the impregnation of metal constituents present in it. The use of humidified air instead of steam to increase H_2 content in the fuel gas is added advantage of gasification, which is easily available in plenty from the cooling towers of any thermal power plants. Finally, some recommendations for future work have also been made and given in this chapter.