

Abstract

The main theme of the work carried out and reported in this thesis is to understand the processes involved in a co-current downdraft biomass gasification reactor and to analyse the data obtained with an attempt to provide a consistent and rational scientific reasoning of the behaviour and processes studied. The work carried out largely comprises of experiments involving parametric and investigative studies on an experimental setup built specifically for this purpose.

The background for this study is based on the IISc design for the biomass gasifier where the technology developed at CGPL, IISc has been well recognized for its performance in the field with many industrial applications, meeting electrical and thermal energy requirements. However, even though the processes have been well defined, based on the literature it was found that adequate insight into the processes and the parametric dependence of the process are not brought out adequately and required further study on this. The present work is an effort in reducing this gap.

The theme of the study is set out in two streams, one in establishing basic process parameters that influence the behaviour of the reactor and the other one, to establish the characteristics of the reactor in its functional aspects. The first part of the study involves use of only primary air to the reactor and to carry out the parametric studies. This part of the study has enabled understanding the basic phenomena that controls the processes in the reactor. The second part of the experiments involves introducing secondary air to the reactor along with the primary air and to extend the study that gives an insight in to the change in the behaviour of the reactor with dual mode air injection and to evaluate the performance of the reactor in this configuration.

The structure of the thesis is set out with five chapters enabling the presentations to be made, categorising the theme of work. Chapter 1 provides an introductory background of biomass usage as an effective renewable fuel and its relevance to the current energy scenario. The principle involved in biomass gasification, a process that

lets to have a clean combustion which has been known to be a challenge with biomass. Chapter 2 provides description of experimental setup, measurement options and experimental procedure for carrying out test. Chapter 3 provides the report of the experimental work carried out on the reactor with primary air, to have a comprehensive study of propagation rates and gas compositions at varied conditions of air flux, differently for biomass moisture content and biomass species. The chapter presents the experimental data with analysis, modelling and interpretations with consistent and scientific reasoning on all the observations. Chapter 4 provides the results and details of experiments carried out with dual mode air inductions, with both primary and secondary air to the reactor and gives an account of systematic parametric study carried out that provides an insight into the process behaviour and performance of the reactor, over the spectrum of study. The parameters, particularly the flux ranges selected are much beyond the normally reported so as to get an overview on the functional limits of the reactor. Chapter 5 gives out a consolidated review of the work and provides a comprehensive overview on the data obtained during the experiments along with the concerned analysis carried out and also narrates the limitations in the studies carried out. Chapter 6, sums up the outcome of the work providing a highlight of the contributory points. Each of the chapters have been provided with a summarising note at their tail end that provided the reader an overview of what is addressed and presented in the chapters concerned.

The experimental test-runs were quite time and resource demanding, lasting for 3 to 8 hours for each run and including the resetting of setup for the next run, the test cycles are seen to take it to 2-3 days. In view of this, priority was set for the study parameters in addressing and understanding the processes and to characterise their influence on the processes in the reactor. With the time constraints and based on the priority set out, some of the studies that include the measurement of tar and particulates in the gas produced were taken off from the theme of this work. However, in conjunction with fair amount of studies carried out on this parameter by earlier researchers, though not tagged to the entire range of parameters studied here, it makes the present study of practical relevance and offer a higher quality of design guidelines.

The recognizable outcome of the study from the work carried out for this thesis includes reliable data from carefully designed and carried out experiments, well resolved behaviour of flame propagation in the biomass bed, the distinct differences in the behaviour of the reactor under single and dual mode of air inductions, gas compositions and performance evaluation at all the parametric variants. A detailed overview of the outcome of the thesis work and contributory points are provided in the concluding note in the chapter 6.