Technical assessment of the functional and operational performance of a fixed bed biomass gasifier using agricultural residues

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Abstract

Currently, there is a general concern about the effects of CO_2 emissions on the atmosphere that are the major cause of the global warming phenomenon. This situation has necessitated a trend towards the reduction on the dependency on fossil fuels, a challenge facing the present generation. Biomass gasification is the thermal chemical conversion of biomass into a combustible gaseous product (producer gas) by the supply of a gasification agent which can be air, oxygen or steam. Biomass gasification has the potential of contributing to the growing energy needs of the world particularly as a renewable energy technology. The potential sustainable global supplies of biomass encompassing sustainable recoverable residues including crop residues, forest residues and biomass plantations is 293.3 EJ/year. This research, therefore, has investigated the performance of a fixed bed gasifier using various agricultural residues as the feedstock. The atmospheric gasifier was operated in downdraft mode. The agricultural residues considered in this research include groundnut shells, coffee husks, rice husks, bagasse and maize cobs. The proximate analyses to determine the physical characteristics of the agricultural residues such as the moisture content, ash content, bulk density and particle size were carried out. Also, the temperature variations in different regions of the gasifier were investigated. Gas composition was determined at different sampling intervals. Finally, the gasification parameters such as gas flow rate, gasification rate, turn down ratio; equivalence ratio and cold gas efficiency were calculated. The highest gasification rates were obtained in the ranges of 5.9 – 17.9 kg/hr while the average gas lower heating values were in the range of 3.2 – 4.7MJ/Nm^3. The analysis of the functional and operational performance was done for only downdraft mode of operation because of the non-technical limitation of the flexible tube making the connection from downdraft to updraft mode of operation becoming rigid due to the effect of thermal stresses over the years and it has no replacement.