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Commissioning, Test and Characterization of Low-Tar Biomass Gasifier for Rural Applications and Small-Scale Plant

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Abstract : Using biomass gasification to make producer gas is one of the promising sustainable energy options available for small scale plant and rural applications for power and electricity. Tar content in producer gas is the main problem if it is used directly as a fuel. A low-tar biomass (LTB) gasifier of approximately 30 kW capacity has been developed to solve this. Moving bed gasifier with internal recirculation of pyrolysis gas has been the basic principle of the LTB gasifier. The gasifier focuses on the concept of mixing the pyrolysis gases with gasifying air and burning the mixture in separate combustion chamber. Five tests were carried out with the use of wood pellets and wood chips separately, with moisture content of 9-34%. The LTB gasifier offers excellent opportunities for handling extremely low-tar in the producer gas. The gasifiers producer gas had an extremely low tar content of 21.2 mg/Nm³ (avg.) and an average lower heating value (LHV) of 4.69 MJ/Nm³. Tar content found in different tests in the ranges of 10.6-29.8 mg/Nm³. This low tar content makes the producer gas suitable for direct use in internal combustion engine. Using mass and energy balances, the average gasifier capacity and cold gas efficiency (CGE) observed 23.1 kW and 82.7% for wood chips, and 33.1 kW and 60.5% for wood pellets, respectively. Average heat loss in term of higher heating value (HHV) observed 3.2% of thermal input for wood chips and 1% for wood pellets, where heat loss was found 1% of thermal input in term of enthalpy. Thus, the LTB gasifier performs better compared to typical gasifiers in term of heat loss. Equivalence ratio (ER) in the range of 0.29 to 0.41 gives better performance in terms of heating value and CGE. The specific gas production yields at the above ER range were in the range of 2.1-3.2 Nm³/kg. Heating value and CGE changes proportionally with the producer gas yield. The average gas compositions (H_2-19%, CO-19%, CO_2-10%, CH_4-0.7% and N_2-51%) obtained for wood chips are higher than the typical producer gas composition. Again, the temperature profile of the LTB gasifier observed relatively low temperature compared to typical moving bed gasifier. The average partial oxidation zone temperature of 970°C observed for wood chips. The use of separate combustor in the partial oxidation zone substantially lowers the bed temperature to 750°C. During the test, the engine was started and operated completely with the producer gas. The engine operated well on the produced gas, and no deposits were observed in the engine afterwards. Part of the producer gas flow was used for engine operation, and corresponding electrical power was found to be 1.5 kW continuously, and maximum power of 2.5 kW was also observed, while maximum generator capacity is 3 kW. A thermodynamic equilibrium model is good agreement with the experimental results and correctly predicts the equilibrium bed temperature, gas composition, LHV of the producer gas and ER with the experimental data, when the heat loss of 4% of the energy input is considered.

Keywords : biomass gasification, low-tar biomass gasifier, tar elimination, engine, deposits, condensate
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