ENERGY RECOVERY FROM UNCONVERTED BIOMASS CHAR

Rade M. Karamarković*, Vladan M. Karamarković*, Miloš V. Nikolić*, Nenad P. Stojić*

Faculty of Mechanical and Civil Engineering in Kraljevo, University of Kragujevac,*

Abstract: For the market of the Republic of Serbia the most interesting are biomass cogeneration plants with the thermal input between 100 and 300 kW. In this middle-power range, gas engines are the most suitable technology for electricity production from biomass. To convert biomass into the product gas, downdraft gasifiers are commonly used due to their reliable and tar-free functioning. The drawback of these reactors is the product gas, because it is laden with particulates and has a relatively small heating value. These particulates and the residues from gasifiers consist of unconverted char and ash. Depending on the design, there are typically from 3 to 15% of unconverted char. The increase in the amount of unconverted char linearly decreases the chemical efficiency of gasification process. Because of the heating value of char, the energy loss contained in unconverted char is significant and different measures are performed for its reduction: recuperation, recycling and non-energy use. In this paper, an original downdraft gasifier with a system for char recycling is presented. The advantage of the proposed solution is an enlarged reduction zone, which influences a longer residence time of solids inside the gasifier.

Key words: biomass gasification, cogeneration, unconverted char, downdraft gasifier, char recovery system.

1. INTRODUCTION

According to the availability of biomass and the size of companies in wood processing and agricultural industry, the most interesting biomass cogeneration plants for the market of the Republic of Serbia are those with the thermal input between 100 and 300 kW [1]. In this middle-power range, gas engines are the most suitable technology for electricity production [2] cited by [3]. To fuel gas engines, biomass gasification is used to convert solid biomass into the product gas, which has a useable heating value. This process takes place in a gasifier, which is an integral part of biomass cogeneration systems. Except a gasifier and a gas engine, a cogeneration system includes a product gas cleaning subsystem and auxiliary equipment such as: a hopper, feeding system, heat exchangers etc. In the considered power range, downdraft biomass gasifiers are the most frequently used reactors due to their capability to reliably produce tar-free gas [4]. The shortcoming of downdraft gasifiers is the product gas, because it is laden with particulates and has a relatively small heating value. The conversion of biomass in these type of rectors is never complete due to their kinetic limitations and non-even distribution of air. Depending on the design of a downdraft gasifier, the biomass may also form bridges or channels that influence the conversion rate. There is always an unconverted carbonaceous fraction, which is known as char. Depending on the design of a fixed bed gasifier, the produced amount of char can be as high as 10% of the initial input feedstock, with the values to fluctuate between 2 and 5% [5]. The carbon content of char is typically within the range of 50% to 80% and, thus, char tends to have significant heating value not only per mass of material, but also in respect of the total energy balance [6]. Several potential pathways for utilization of char have been identified: manufacturing of filters, application on agricultural fields, as a catalyst in fluidized bed gasifiers, and in building applications as insulated material [7]. In the same article, Vakalis et al. [7] investigated the possibility of an onsite energy production of additional electricity by introducing a secondary reactor that would convert char and flue gases into a gaseous fuel. The produced gaseous fuel would be utilized for electricity production in a smaller internal combustion engine.