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EXERGY ANALYSIS OF A BIOMASS COGENERATION SYSTEM

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This paper is dedicated to energy and exergy analysis of a usual biomass cogeneration system with a thermal power in the range from 100 to 300 kW. The analyzed system consists of a downdraft biomass gasifier, a producer gas cleaning system and a gas engine. The heat exchangers in the system use the sensible heat of producer and flue gases and waste heat from the gas engine to heat water in a district heating system 90/70 0C and for a domestic hot water supply 25/60 0C. The system has the overall electrical efficiency of 22.04%, whereas the total efficiency is 96.72% due to the omission of the system heat loss. The exergy efficiency of the system is barely 35.83%. The reason for this are the irreversibilities created in the gas engine, gasifier and in the heat exchanger network. The system efficiency can be improved by the use of waste heat to preheat gasifying air, to produce gasifying steam, or to perform biomass pyrolysis prior to its gasification. These measures enable production of a more valuable producer gas with a higher calorific value and a smaller amount of nitrogen. The use of a better gas produces higher temperature in the gas engine, which result in a higher gas engine efficiency.

Key words: biomass gasification, exergy, cogeneration, efficiency

0. INTRODUCTİON

High cost of energy and limited energy resources for the present knowledge require the improvement of energy efficiency of the existing energy transformation processes. This together with the need for the use of electrical energy as a final energy led to the development of cogeneration plants, which produce electricity and useful heat from the same plant. The introduction of a feed-in tariff system for the electricity produced from renewable sources spark many activities in developing biomass cogeneration plants in Serbia.

Karl [1] cited by Karellas et al. [2] gave typical power ranges and efficiencies of currently available power systems. Figure 1 shows that gas engines, microturbines and fuel cells are well-suited systems for small scale power production because of their high efficiency at low-power ranges. These technologies are only compatible with gaseous fuels. This is the reason for developing better biomass gasification systems. Gas engines is the most suitable technology for electricity production in the middle-power range, from a few kW up to 10 MW. For electricity production in large-power ranges of more than 10 MW combine process are the most desirable option. Ahrenfeldt et al. [3] give the state-of-the-art of biomass gasification and cogeneration technology with the most important pilot and commercial products for the future.

The availability of biomass in Serbia, the size of lumber industry and agriculture facilities make the biomass cogeneration system in the range from 100 to 300 kW very interesting. The most common are plans of the biomass cogeneration system shown in Fig. 2. The goal of this paper is to analyze the biomass cogeneration system shown in Fig. 2 and to recommend the measures for its improvement.

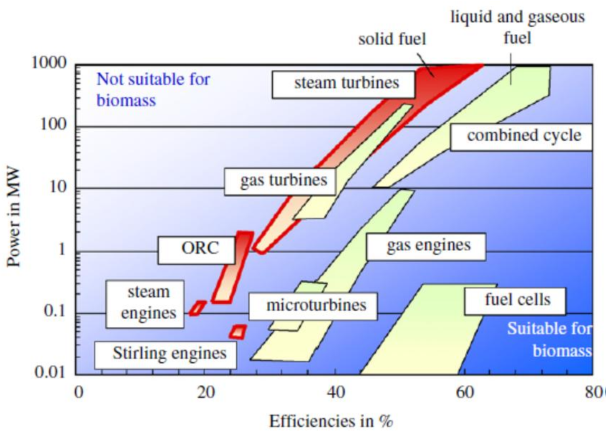

Fig. 1. *Efficiency and power range of known plant types.ORC – Organic Rankine Cycle [1] taken from [2].*

1. SYSTEM DESCRIPTION

Figure 2 shows the analyzed cogeneration system, whose main components are a gasifier and a gas engine. Downdraft biomass gasifiers are the most frequently used reactors due to their capability to prduce tar-free gas. Tar is a mixture of heavy hydrocarbons that condenses below 500 °C and presents the main obstacle for the wider use of producer gas. Low retention time of gases in the rector, low temperatures, and the lack of oxygen are the main reasons for tar creation. Opposite, presents of steam, high gasification temperatures, and passing of gases through a char layer leads to tar destruction. The shortcomings of downdraft gasifiers are a low calorific value and high temperature of produced gas. The latter is the reason for the use of two heat exchangers between the gasifier and the gas engine in the system shown in Fig. 2.

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