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Possibilities for reconstruction of existing steam boilers for the purpose of using exhaust gases from 14 MW or 17 MW gas turbine

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HIGHLIGHTS

- Utilization of gas turbine exhaust gas heat.
- Reconstruction of the existing steam boiler in purpose of utilizing exhaust gases from a 14 MW gas turbine.
- Reconstruction of the existing steam boiler in purpose of utilizing exhaust gases from a 17 MW gas turbine.
- Selection of the most favorable solution.

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ABSTRACT

Within the energy system in Methanol–vinegar complex (MVC) in Kikinda, beside process boiler and auxiliary equipment, there are three equal steam boilers made by "Minel Kotlogradnja", provided for combustion of natural gas, fuel oil and process gases. Aiming to increase the MVC Kikinda energy plant capacity, one gas turbine of 14 MW or 17 MW is going to be installed. In regard to relatively high gas temperature and a large amount of the unused oxygen from the air in the exhaust gas, it is specified to split exhaust gas into the two equal streams and import them into the two existing steam boilers, each having production of 16.67 kg/s (60 t/h). In order to use the exhaust gas heat, as well as oxygen contained within, it is necessary to replace the existing burners and to reconstruct the heat exchangers in the steam boiler vertical convective pass. Besides, it is necessary to verify if the existing flue gases fan can comply with the new operating regime, during which a half of the turbine exhaust gas is imported into the steam boiler.

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1. Introduction

Within the energy system of Methanol–vinegar complex (MVC) in Kikinda, beside the process boiler and auxiliary equipment, there are three equal steam boilers, having steam production of 16.67 kg/s (60 t/h) each, with turbine (superheated steam temperature $t_s = 455\ ^\circ C$ and pressure $p_s = 77$ bar) made by "Minel Kotlogradnja", designed for combustion of natural gas, fuel oil and process gases. The steam is used for process in the plant and to run two steam turbines. The first steam turbine drives an air compressor and the second one drives a generator with electrical output of 11.5 MW. Aiming to increase energy efficiency in the MVC Kikinda plant, an installation of one gas turbine of 14 MW or 17 MW is considered. The gas turbine should replace the existing steam turbine satisfying the electrical consumption in the factory.

For the purpose of using the heat of hot exhaust gases coming from the gas turbine (temperature around 500 °C) it is necessary to either install a new waste-heat boiler, or carry out a reconstruction of two existing boilers. The exhaust gases, containing a large amount of air (excess air is 3.3), are intended to be distributed in two equal streams, and to be inducted into these two reconstructed steam boilers (Fig. 1). To obtain nominal production of steam boiler, with guaranteed temperature of superheated steam, it is necessary to enable additional natural gas combustion. By using the heat of exhaust gases in cogeneration with steam cycle, it is possible to achieve higher plant efficiency compared to individual cycles. Efficiency model of combined cycle gas turbine (CCGT) power plants is shown in Ref. [1]. Authors of paper [2] considered thermodynamic efficiency of CCGT power plants by taking into account real values of cycle parameters. Paper [3] regards the energy and exergy

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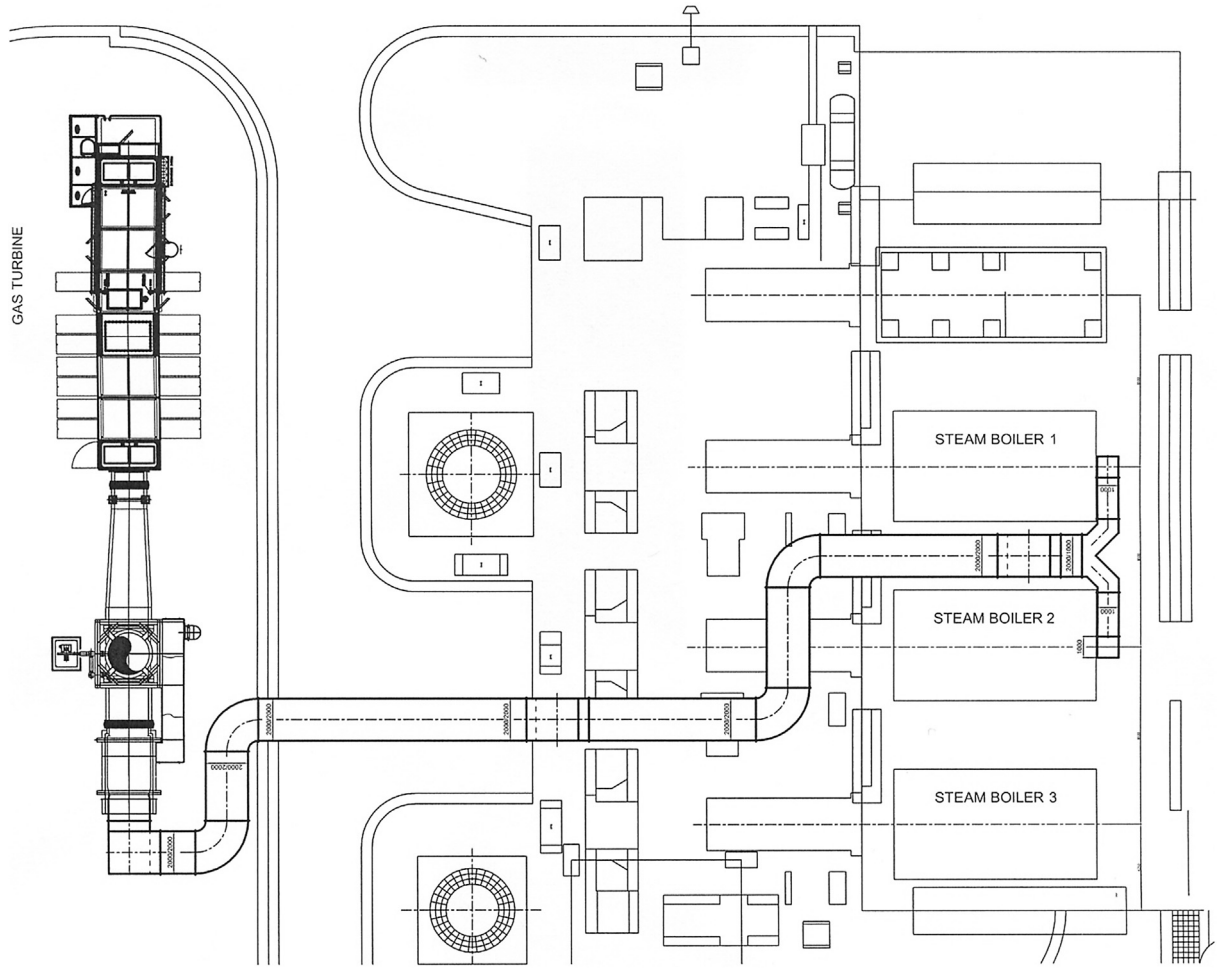

Fig. 1. Exhaust gases duct route from gas turbine to new biler burners 1 and 2.

analysis of combined cycle during the combustion of municipal waste, while paper [4] analyses the advantages of combined cycle with closed-loop steam cooling. Bandyopadhyay, in Refs. [5], emphasizes pitch point as a dominant influence on the efficient of combined cycle, while Reddy, in Refs. [6], in addition defines the temperature of flue gases at the HRSG outlet, pressure drop in the unit, and the environmental temperature as influential parameters. Authors in Ref. [7] considered the correlation between efficiency and cost in the design of a power plant, while [8] represents a perennial experience of combined cycle usage. Manassaldi in Ref. [9] presented a model for optimal design of HRSG, taking into consideration the geometry of heating surfaces.

Usage of combined cycles also reduces the emission of polluting gases, which are harmful to the environment [10]. These cycles are used worldwide because of their advantages [11].

This study highlights the significant energy and economical benefits which could be achieved through implementation of the combined cycle.

In this paper, heating recovery steam generator is represented with two existing steam boilers, after the suggested reconstructions. Reconstruction of the steam boiler, presented here, considers the replacement of existing burners with the new ones that are suitable for new working conditions. Scheme of connection between the gas turbine and the steam boiler by means of the burners is shown in Fig. 2. Fresh air fan (Fig. 2) is used if greater steam boiler production is required, when the amount of oxygen in exhaust gases is insufficient.

Besides, it is necessary to complete the reconstruction of heating surfaces in the vertical convective pass of the steam boiler. Because of the maximum temperature reduction in the furnace, caused by mixing of turbine exhaust gases with gaseous products of additional, natural gas combustion in the burners, heat exchanged in the steam boiler furnace is insufficient for complete vaporization in radiant evaporator. Therefore it is necessary to install an additional convective evaporating heating surface in the form of inclined evaporator. It is also required to disassemble the existing air heater, and to install an additional economizer section in its place.

Bearing in mind the specified reconstructions, research within this project included optimization of individual heating surfaces for the purpose of gaining the higher boiler efficiency and retaining the existing steam production and parameters. Based on

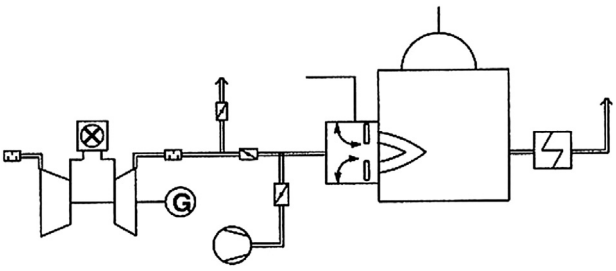

Fig. 2. Connection of gas turbine and steam boiler.

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