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Abstract of the PhD thesis:

„Assessment of using low-calorific synthesis gas as a source of heat in an industrial bogie hearth furnace"

Reducing anthropopressure on the Earth's climate at the level assumed by the Paris Agreement forces the exclusion of the use of fossil hydrocarbons also in the manufacturing industry. The partial replacement of fossil fuels in an energy-intensive industry such as the metallurgical industry will translate into a significant reduction in carbon dioxide emissions in this sector of the economy. On the other hand, technological processes require maintaining appropriate thermal conditions for a certain time, e.g. reaching the required average temperature while avoiding local overheating of the processed material.

A significant part of the heat treatment processes is based on the combustion of natural gas, the replacement of which with a fuel of different physicochemical properties, especially the calorific value and composition (and the resulting density, Wobbe index and combustion kinetics) may change the parameters of the flame and the amount of exhaust gases, and as a consequence – the conditions of heat exchange.

This study aims to determine whether it is possible to replace 40% of the natural gas burned in an exemplary industrial furnace with a low-calorfic synthetic alternative fuel while maintaining the required thermal parameters of the process. The considered substitutes for natural gas are alternative gaseous fuels, with particular emphasis on syngases from the biomass gasification process, due to their zero greenhouse gas emissions in the light of the European Union regulations.

A computational fluid dynamic model of a chosen reheating bogie hearth furnace has been created. The model covers unsteady turbulent gas flow, combustion and heat exchange. The influence of partial natural gas substitution on the heating process course and the temperature of the load has been investigated. The effects of feeding the furnace with different shares of the alternative fuel, as well as different methods of syngas supply, the influence of excess air and burner power on the operation of the installation have been analysed. The mathematical model of the furnace was successfully validated based on measurement data from the existing installation. Experimental tests of a burner capable of co-firing natural gas and syngas (produced on-site from biomass) have also been discussed. The possibility of supplying hot syngas to the dedicated burner without tar condensation has also been evaluated.

In order to find an effective way of reducing natural gas consumption in the bogie furnace, multiple powering scenarios have been considered. At the first stage, analysis of the possibility to introduce various alternative fuels has been carried out to indicate the most promising way of feeding new, low-calorific fuels into the furnace. Beforehand, the most suitable type of alternative fuel for this task has been chosen.

Next, the thermal effects of substituting different shares of natural gas with syngas have been numerically examined. Furthermore, the impacts of supplying different amounts of comburent air and modifying the thermal power output of the installed burners have been studied with the emphasis on the natural gas substitution criteria.

As a result, the research hypothesis was verified that it is possible to replace 40% of natural gas with biomass-derived synthesis gas as a heat source in the heat treatment process while maintaining the thermal parameters of the process and lowering carbon dioxide emissions to the atmosphere. Technical measures were also specified to enable co-firing for various operating conditions of the industrial furnace.

Słowa kluczowe: CFD modelling; heat treatment process; industrial furnaces; natural gas substitution; syngas co-firing

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