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Thermal optimization of combined heat and power (CHP) systems using nanofluids

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A B S T R A C T

In the present work, we focus on an incomplete combined heat and power (CHP) system. The supplementary thermal performance has been designed to increase the efficiency of the heating system by designing a shell and tube heat exchanger to recover the heat from the exhaust gases. A plate heat exchanger has also been designed for cooling the biogas-diesel generator and the exhaust gases. Two types of nanofluids with the same concentration (4% v/v) were then prepared for use as the circulating fluid to recover heating power from the CHP system. The results show that using nanofluids enhances the thermal performance of the CHP system, and the use of aqueous CuO is more advantageous than the use of aqueous Al_2O_3 as a cooling nanofluid. This change also causes a dramatic increase in the outlet flow of the hot water from the unit.

1. Introduction

One of the major problems confronting the world is climate change and greenhouse gases. Earth is warming day by day because of atmospheric changes. One of the most important sources of emissions of greenhouse gases, especially methane, is municipal waste landfills [1–8].

If domestic wastes are buried in the absence of oxygen, organic compounds contained in the buried wastes ferment, and gases such as methane, carbon dioxide and hydrogen are emitted. Recycling of the gas emitted from the landfill and changing of this emitted gas to energy prevents direct emission of the gases as pollutants. There is also a reduction in the indirect emission of pollutants because the gas that is produced replaces coal and oil for the production of energy. The use of the gases emitted from the landfill also reduces the emission of many pollutants such as sulfur and carbon dioxide and helps to reduce acid rain [9]. Some researchers have been trying to reduce these gases by designing a CHP system [10–17].

Also, one of the advantages of recycling the available energy from landfill gases is that this practice can reduce climatic change significantly. This landfill gas is the biggest source of methane emitted as a result of human actions [18,19]. Methane will decompose 24 times faster than carbon dioxide, so inhibition of the production and emission of methane can accelerate the reduction in climate change [20].

At a municipal landfill for a specified period and with aerobic or anaerobic decomposition, bio-fuel gases are produced. If pressurization and a gas refining station are located in the emission stream of the landfill gases and transport those gases using a gas transfer line to biogas-diesel generators (CHP system), these biogas-diesel generators will produce electricity [21].

Burning these gases in biogas-diesel generators, however, can produce excess heat in the pipeline of exhaust gases and in the internal parts of generators. This thermal power can also be recovered using heat exchangers and can be used in the surrounding office buildings. In one case the analysis reveals that the use of a thermal store more than doubles the return on investments (as measured in net present value) compared with the same size of a plant without a thermal store [22]. In previous years, steps were taken to enhance the heat transfer, to reduce the heat transfer time, to minimize the size of the heat exchangers, and, finally, to increase the energy and fuel efficiency [22,23]. Most of these efforts to enhance the heat transfer are restricted by the inherent limitations of the thermal conductivity of the fluids such as water and ethylene glycol that are conventionally used for heat transfer. The poor heat transfer properties of these fluids commonly

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