ABSTRACT

DEVELOPMENT AND INVESTIGATION OF A SOLAR-BIOGAS HYBRID MICRO GAS TURBINE FOR POWER GENERATION

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The growth of demand for energy is increasing rapidly, and the most current power generation methods are heavily dependent on fossil fuels. Using fossil fuels for power generation is not secure for two reasons. First, the fossil fuels’ combustion production significantly increases greenhouse emission effects by emitting CO₂. Second, the price and availability of fossil fuels are not stable. These two reasons have led researchers, governments, and organizations to seek another source of energy that is available, secure, environmentally friendly, and renewable. Most of these specifications are available with renewable energy.

The most important source of energy – also knowns as the “mother of renewable energies” – is solar energy. There are two methods to convert solar irradiation to useful energy: photovoltaic cells and concentrated solar collectors. Because of the low performance and high cost of photovoltaic cells, they are avoided. Therefore, concentrated solar power collectors are the best choice to convert solar energy to heat which can then be used to drive heat engines. There are many engines that are used for power production. A promising one, which also is
suitable with renewable energy, is the gas turbine engine. The main advantages of gas turbines are its simplicity, fuel flexibility, low emissions, low maintenance cost, high power density, small size, and low water consumption. Solar energy cannot be a standalone energy source for the heat engine because of solar radiation fluctuation due to weather conditions. Therefore, a hybrid concept is needed to eliminate the disadvantages of both solar energy and fossil fuel combustion.

Over the past decade, most research on hybrid solar gas turbines has emphasized using fossil fuels alternatively with solar energy. In the absence of fossil fuels, the solar power generation cannot fulfill the electricity demand. Therefore, seeking another source of renewable energy is valuable to compensate for the shortage of power generation. Using biogas with solar energy instead of fossil fuels like natural gas is the best idea to have electricity from 100% renewable energy sources. That will also eliminate the disadvantages of fossil fuel combustion, such as its cost and CO₂ emission.

Most studies in the field of hybrid power generation have only focused on either solar or biogas alone. In addition, no research has combined solar and biogas as a form of hybrid power generation or specifically investigated the solar-biogas hybrid micro gas turbine. Additionally, far too little attention has been paid to the potential of using a hybrid of biogas and solar energy for power generation. In this research, the thermodynamic model for the solar-biogas hybrid micro gas turbine is developed and its performance is investigated using Aspen-HYSYS software. The impact of the solar tower technology and the solar share fluctuations on the system performance are studied as well. The energy and exergy analysis for the solar-biogas hybrid micro gas turbine are conducted. The results revealed solar-biogas hybrid micro gas turbine is a future promising technology and it is economically feasible and environmentally friendly.