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The Effect of Ambient Temperature on the Performance of the Simple and Modified Cycle Gas Turbine Plants

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Abstract : The disparity in power output between a simple and a modified gas turbine plant is noticeable when the gas turbine functions under local environmental conditions that deviate from the standard ISO specifications. Extensive research and literature have demonstrated a well-known direct correlation between ambient temperature and the power output of a gas turbine plant. In this study, the Omotosho gas turbine plant was modified into three different configurations. The reason for the modification is to improve its performance and reduce the fuel consumption and emission rate. Aspen Hysys software was used to simulate both the simple (Omotosho) and the three modified gas turbine plants. The input parameters considered include ambient temperature, air mass flow rate, fuel mass flow rate, water mass flow rate, turbine inlet temperature, compressor efficiency, and turbine efficiency, while the output parameters considered are thermal efficiency, specific fuel consumption, heat rate, emission rate, compressor power, turbine power and power output. The three modified gas turbine power plants incorporate an inlet air cooling system and a heat recovery steam generator. The variations between the modifications are due to additional components or enhancements alongside the inlet air cooling system and heat recovery steam generator incorporated; the first modification has an additional turbine, the second modification has an additional combustion chamber, and the third modification has an additional turbine and combustion chamber. This paper clearly shows ambient temperature effects on both the simple and three modified gas turbine plants. for every 10-degree kelvin increase in ambient temperature, there is an approximate reduction of 3977 kW, 4795 kW, 4681 kW, and 4793 kW of the power output for the simple gas turbine, first, second, and third modifications, respectively. Also, for every 10-degree kelvin increase in temperature, there is a thermal efficiency decrease of 1.22%, 1.45%, 1.43%, and 1.44% for the simple gas turbine, first, second, and third modifications respectively. Low ambient temperature will help save fuel; looking at the high price of fuel presently in Nigeria for every 10 degrees kelvin increase in temperature, there is a specific fuel consumption increase of 0.0074 kg/kWh, 0.0051 kg/kWh, 0.0061 kg/kWh, and 0.0057 kg/kWh for the simple gas turbine, first, second, and third modifications respectively. These findings will aid in accurately evaluating local power generating plants, particularly in hotter regions, for installing gas turbine inlet air cooling (GTIAC) systems.

Keywords : Aspen HYSYS software, Brayton Cycle, modified gas turbine, power plant, simple gas turbine, thermal efficiency.
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