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Improvement Thermal Efficiency of Al-Rumaila Gas Turbine Power Plant in Basrah by Upstream Inlet Air Cooling System

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Abstract

The efficiency of gas turbine units is highly affected by the variation of ambient temperature. Increasing the ambient temperature decreasing the efficiency of gas turbine. Cooling the inlet air to the compressor of the gas turbine units is an essential and economical technique for improving its efficiency. Al-Rumaila gas turbine power plant was located in Basrah city, Iraq, which is characterized by its hot climates for more than six months during the year. A novel upstream inlet air cooling system was applied and tested for Rumaila gas turbine power plant. This article represents a thermo-economic evaluation of applying upstream inlet air cooling system. The analysis is based on the test results for operating single unit of Rumaila gas turbine power plant using upstream inlet air system for cooling. The test was performed during July of 2019 for 90 minutes of operation period with ambient temperature of 45 °C. The evaluation analysis shows that, the power output increased from 217.71 MW to 250.11 MW during the period test with percentage increase in power by 15%. This increase in power output led to net economic gains is approximately 1000 $/h.

1. Introduction

Although gas turbine power plants are considered one of the plants that are rapidly spreading because the low capital cost and short time required for their construction, also the time required to operate and reach the rated load is small compared to other stations, but the gas turbine power output is greatly affected by the temperature of the external environment, where the capacity decreases by 20% when the ambient temperature rises more than 40 °C. Because of the increased demand for electrical energy in the summer, especially in Iraq, and the decrease in energy output due to high temperatures, it is necessary to search for ways to cool the air temperature inter to the turbine. Many researchers have investigated various cooling methods (systems) to enhance the gas turbine plants performance operating at high climate temperatures. Abdalla and Adam [1] presented feasibility technical and economic study of turbine inlet air cooling and its impact on gas turbine performance in Khartoum County. They investigated three options (cooling, fogging, and evaporative cooling with wetted media), where cooling with coolant had the lowest air inlet temperature but was costly. AL-Salman et al. [2] parametrically studied the air inlet cooling system with fog for a power plant gas turbine in order to reduce the ambient air temperature. The ambient temperature, humidity, firing temperature, and pressure effects on the output of the gas turbine were investigated. Results revealed decreased in the output power and efficiency as the ambient temperature increased. Bagabir et al. [3] investigated two techniques to rise the gas turbines output power (cooling intake air and using an intercooler between two compressors). The power enhancement of a microturbine test unit 4 kW using evaporative and coil cooling systems was investigated experimentally. A parameter study was conducted to investigate the climate air conditions effects (temperature, humidity, and pressure) for the gas turbine cycling with evaporative and coil cooling. Results shown that the performance of gas turbine cycles can be improved by lowering the inlet air temperature. The application of an intercooler between two compressors to enhance the gas turbine performance was also studied theoretically. They concluded that the method can improve turbine performance, notably at a high value of expansion ratio. Ibrahim et al. [4] studied several cycles (single cycle gas turbine, two-shaft gas turbine, gas turbine with intercooler and renovation gas turbine). Simulation results indicated that the influence of climate temperature and compression ratio had significantly affects the performance of a combined cycle gas turbine power plant for different gas turbine configurations. Santos and Andrade [5] conducted a thermodynamic analysis for performance of gas turbine to estimate the heat rate, output power and efficiency at different inlet temperatures and relative humidity. They computationally implemented three cooling techniques and solved for different inlet conditions. Under different cooling methods gas turbine was tested at two Brazilian locations. The comparison between the cooling systems (mechanical chiller and absorption chiller) demonstrated that the absorption chiller introduced the highest increase in the annual energy production at a lower cost per unit. Evaporative cooling, additionally, offered the lowest energy cost per unit but was associated with limited cooling potential. Kodituwakku et al. [6] investigated the performance of a gas turbine plant in Kelanitissa (GE MS5001 R) as a function of changes in ambient temperature. Two approaches were used to investigate this phenomenon. First, the