Int. Symp. on Heat Transfer in Gas Turbine Systems
9-14 August 2009, Antalya, Turkey

TECHNICAL AND ECONOMICAL FEASIBILITY OF AIR COOLING GAS TURBINE UNITS IN THE MIDDLE EAST AREA

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The performance characteristics of gas turbine units are inherently tied to ambient air conditions. Gas turbine output suffers significantly at increased temperature levels due to the reduced available combustion air mass flow rate. The cooled denser air, on the other hand provides a higher mass flow rate and pressure ratio; resulting in an increase in the gas-turbine output and hence an overall increase in the system efficiency. In addition, the carbon emission per kWh of electricity produced is reduced as lower exhaust temperatures are attained. This results in reducing the environmental impact of such power producing units. Recently, gas-turbine compressor inlet and/or outlet air cooling systems have received considerable attention as a practical design option in boosting the power output of existing gas-turbine units. Such cooling systems allow the gas-turbine units to operate close to the design operating condition, regardless of the climatic conditions. The available technologies that can be used for air cooling may be classified either passive (evaporative) or active (classical refrigeration) cooling systems. The former include typical evaporative coolers and fogging options while the latter include standard vapor-compression or absorption chillers. The absorption systems are driven by waste heat, which is typically available at such power generating units. However, vapor-compression chillers are powered by electricity, which can easily be coupled with a thermal energy storage system to capitalize from the off-peak generated electricity. In general, evaporative cooling systems are viewed to be feasible for hot and dry climates such as

central region of Saudi Arabia. The cooling capability of these systems is limited to the ambient wet bulb temperature, which places a restriction on the power to be increased. Though, it has several advantages such as it requires minor alterations to the inlet and/or outlet of gas-turbine compressors, low capital investment cost. It is important to note that these cooling systems typically have low operating and maintenance costs. On the other hand, the active chiller systems are somewhat complex. They generally require higher capital investment as well as additional operating and maintenance costs. It should however, be noted that their applications are not constrained by the ambient wet bulb temperature. Thus, higher power production is possible without changing the main components of the gas-turbine units.

The overall objective of this paper is to highlight the related benefits of employing either an evaporative and/or an active air cooling systems under various weather patterns in Saudi Arabia. The choice of the most suitable system will be discussed based on thermo-economical considerations. The current study is expected to provide general guidelines with regard to the potential of air cooling systems for gas-turbine units in hot and humid weather conditions of this region, since it represents one of the harshest conditions. It is important to note that the weather data of Saudi Arabia will be considered for performing the details of the investigation as a representative sample of the regional climate. In particular, the combined effect of evaporative inlet cooling and after-cooling on cycle efficiency and performance characteristics will be studied in detail. In this regard, a systematic parametric investigation will be reported due to the turbine inlet temperature on the optimum pressure ratio, cycle efficiency and specific power for some selected layouts of air-cooling systems by closely examining their impact on the predicted annual gross energy increase, average heat rate reduction, cooling load requirements, and net power increase.