Installation & Testing of The Fog Inlet Air Cooling System for the Shahid Rajaie Combined Cycle Power Plant

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SUMMARY

One of the major problems for the gas turbines during the hot summer days is their output power drop. Combustion turbines are almost constant volume machines at a given constant shaft speed. However, the gas turbine output power depends strongly on the inlet air mass flow rate. Therefore if the air density reduces at high ambient temperatures the available output will be considerably reduced. This power output reduction is from 0.5% to 0.9% of the ISO output power for every 1°C rise in the ambient temperature. The solution of this problem is very important because the peak demand season also happens in the summer. One of the useful methods to overcome this problem is to apply the inlet air cooling system for the gas turbines. In this paper the Shahid Rajaie Power Plant site climate conditions in the summer have been studied. The design conditions regarding the dry bulb temperature and relative humidity have been selected. The different inlet air cooling systems have been studied and the Fog system has been chosen. The Fog system has been designed, manufactured and installed for a GE Frame 9 gas turbine in the Shahid Rajaie Power Plant. The economical study has shown that this system is very cheap in comparison with the installation of the new gas turbines. The testing of this system at 35°C and Relative Humidity of 11% has shown that the average power capacity of the gas turbine No.2 is increased by 9.2 MW (or 11%) and prevented the installation of a new gas turbine.

INTRODUCTION

Gas turbines have gained widespread acceptance in the power generation, mechanical drive, and gas transmission markets. Their compactness, high power to weigh ratio, and ease of installation have made them popular prime movers. The improvements in hot section materials, cooling technologies, and aerodynamics have allowed increases in firing temperatures. Consequently, thermal efficiencies are currently very attractive, with simple cycle efficiencies ranging from 32% to 42%. The combined cycle efficiencies approach to 55%. The fact that both turbine output and efficiency are reduced during high ambient temperature periods poses a significant problem for turbine operators in the rapidly deregulating power generation segment. The structure of supply agreements and the dynamics of an open market usually mean that power producers are paid significantly more for power generated during high demand periods (typically hot summer afternoons). This creates an additional incentive to attempt to overcome the inherent loss of gas turbine power output during high ambient temperature periods. Peaking power plants also need to augment power during high demand periods. An increase in peaking capability is typically needed during the late afternoon when temperatures are at the highest levels and turbine output is at the lowest. As the power industry becomes more competitive, there is growing interest in increasing power capability without the large capital investment associated with the addition of new capacity. Power augmentation methods available for existing gas turbines include:

- Inlet cooling of the compressor: This will be explained later.
- Steam or water injection into the combustor: While commonly applied for NOx control, it also boosts power due to the increased mass flow and higher specific heat of the products of combustion going through the turbine. The increased specific heat of the products of combustion and better heat transfer results in higher blade metal temperatures, and control systems often compensate for this by backing off on the firing temperature.