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# THERMODYNAMIC ASSESSMENT OF EXISTING GAS TURBINES WITH INLET EVAORATIVE AND OVERSPRAY FOGGING

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## 1. INTRODUCTION

Compressor intake air cooling is developing to be an important area of research in the Modern Gas Turbine Power Plants. The state of art literature survey of this area is briefly described below.

## 2. REVIEW LITERATURE

The present literature can be classified into the following categories:

a) Evaporative Cooling
b) Refrigeration Cooling
c) Hybrid System cooling

The literature review of these systems is described below:

### 2.1 Evaporative Cooling

Kumar and Krishna (1), investigated the improved gas turbine efficiency using spray coolers and through Alternative Regeneration Configuration. Cooling of air at compressor inlet helps in increasing the density of air flowing through the plant while alternative regeneration causes the air to enter the combustion chamber at a higher temperature. The plant performance characteristics were examined for a set of design and operational parameters including ambient temperature, relative humidity, turbine inlet temperature and pressure ratio. At design point for reference plant (simple cycle), the efficiency was 34% whereas by using alternative regeneration and spray cooler, it increased to 47%.

Bejan et al (2), gave the method of exergy analysis of the thermal systems. The physical and chemical exergy of various common substances was given. Al-Amiri and Zamzam (3), assessed the benefits of incorporating combustion turbine inlet air cooling systems into a reference combustion turbine plant, which was based on a simple cycle under base load mode. The main performance characteristics of both evaporative and refrigerative cooling systems were explored by examining he effect of several parameters including inlet air temperature, air flow-to-turbine output ratio, coefficient of performance and degree of hours. The impact of these parameters was presented

against annual gross energy increase, average heat rate reduction, cooling load requirements and net power increase. Finally, a feasibility design chart was constructed to outline the economic returns of employing a refrigerative cooling unit against prescribed inlet air temperature values using a wide range of combustion turbine mass flow rates.

Alhazmy and Najjar (4), studied the performance enhancement of gas turbine power plants using spray cooling (water spraying system and cooling coil), Spray cooler reduces the temperature of incoming air 3-15 C enhancing the power by 1-7% and improving efficiency by 3%. Lucia et al (5), presented a comparative analysis of different solutions for cooling compressor inlet air for LM 60-0 gas turbine in a cogeneration plant operated in base load. Reference was made to two sites in northern and southern Italy whose climatic data series for modeling the variations in ambient temperature during he single day were used to account for the effects of climate in the simulation. The results confirmed evaporative cooling to be cost effective while absorption systems have a higher cost but are more versatile and powerful in base-load operation.

Bhargava and Meher-Homji (6), did a parametric analysis on the effects of inlet fogging and evaporative conditions on a wide range of existing gas turbines. Arora (7), presented a basic as well as applied thermodynamic treatment of refrigeration and air conditioning in a very comprehensive manner. A sound physical basis had been laid for obtaining fairly precise estimates of refrigeration and air-conditioning equipment.

Moran (8), presented an effective and systematic method that uses both he first and second laws of thermodynamics for the performance analysis and design of energy systems known as availability analysis. It included he use of availability equation as an important unifying concept, a thorough discussion of meaning and use of second law efficiencies, exact and appropriate methods for availability calculation and use in field of engineering economics.

Cammarataet at (9), investigated an application of exergonomic theory to an air-conditioning system for opt.mization purposes. The thermodynamic model was stated according to recent formulations of exergy for moist air streams, while the economic model was based on cost balance equations and real cost data for mechanical equipment. The optimum configuration was obtained through an iterative procedure aimed at the design improvement.

### 2.2 Refrigeration cooling

This system includes vapour compression and vapour absorption systems which are in use for a long time in industries.

Haselden and Chen (10), developed and tested a steady state design simulation program for air conditioning systems using binary refrigerant mixtures. The pinch method was introduced to facilitate the refrigerant cycle simulation. Horuz and Caliander (11), did an experimental investigation of performance of a commercially available Vapour Absorption SystemThe response of system to variations in chilled water inlet temperature, chilled water level in evaporator drum, chilled water flow rate and variable heat input were presented. Waked (12) carried out the Second Law Analysis for a Cogeneration Power-Absorption Cooling Plant. A typical reference steam

power plant was used to show the efficient use of fuel in producing both power and process heat to operate absorption cooling units for air-conditioning purposes.

### 2.2.3 Hybrid system cooling

The hybrid system demonstrated a higher gain in power output and efficiency than evaporative cooling for a simple gas turbine, independent of ambient air temperature.

## 3. CONCLUSIONS

By the study of present literature following conclusions can be drawn:

A) Evaporative cooling system is the cheapest cooling system in use today.
B) Gain in output is approximately 5% by the use of evaporative cooling system.
C) Vapour compression and vapour absorption system produce more degree of cooling than evaporative cooling system.
D) Vapour compression and vapour absorption system are more expensive than evaporative cooling system.
E) Performance of the selected system is largely affected by the local weather patterns.
F) Hybrid systems offer a greater degree of cooling and therefore power output and efficiency of the gas turbine plant is higher.

## 4. SCOPE OF THE WORK

From the literature survey of work done by different people on the compressor intake air-cooling, it is very clear that lot of scope is lying in analyzing the methods of air-cooling. Evaporative cooling and absorption chiller system are the good choice for economical and efficiency purpose. In the present work , energy and second law analysis of water/LiBr vapour absorption refrigeration system has been investigated by the exergy method.

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