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Thermodynamic Analysis of Wet Compression Integrated with Air-Film Blade Cooling in Gas Turbine Power Plants

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Abstract : In order to achieve high efficiency and high specific work with lower emissions, the use of advanced gas turbine cycles for power generation is useful and advantageous. Here, evaporative inlet air cooling is analyzed thermodynamically in the form of air film blade cooling of gas turbines. As the ambient temperature increases during summer months, the performance of gas turbines particularly the output power and energy efficiency are significantly decreased. The utilization of evaporative inlet cooling in gas turbine cycles increases gas turbine performance, which can assist to solve the problem in meeting the increasing demands for electrical power and offsetting shortages during peak load times. In the present research, because of the importance of turbine blade cooling, the turbine is investigated with cold compressed air used for cooling the turbine blades. The investigation of the basic and modified cycles shows that, by adding an evaporative cooler to a simple gas turbine cycle, for a turbine inlet temperature of 1400 °C, an ambient temperature of 45 °C and a relative humidity of 15%, the specific work can reach 331 (kJ/kg air), while the maximum specific work of a simple cycle for the same conditions is 273.7 (kJ/kg air). The exergy results reveal that the highest exergy destruction occurs in the combustion chamber, where the large temperature differences and highly exothermic chemical reactions are the main sources of the irreversibility.

Keywords : energy, exergy, wet compression, air-film cooling blade, gas turbine
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