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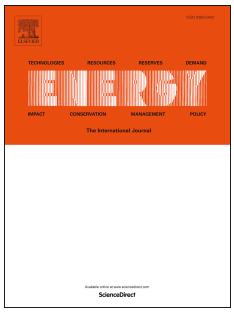

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Thermoeconomic Analysis and Optimization of a Novel Inlet Air Cooling System with Gas Turbine Engines using Cascaded Waste-heat Recovery

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Abstract:

Gas turbines usually suffer from remarkable drop in power and excessive increase in fuel consumption when running under part load or high ambient temperatures. The two deficiencies are overcome by cogeneration and inlet air cooling respectively.

Energy analysis was previously carried out for this innovative system. In this work, a thermoeconomic analysis is further done using specific exergy costing method by combining the energy and the exergy analysis with the economic analysis to evaluate the total operating cost of the system over a wide range of operating variables, namely: Expander 1, Turbine inlet temperatures, pressure ratios of gas turbine, upper and lower propane cycles. Beside the total operating cost of CWHRS as the main performance variable, total generated power, thermal and exergy efficiency are considered in the analysis. The results at the design point are: $\dot{C}_{Total}$= 2.69 (USUS$/s), $\dot{P}_{Net}$=48.46 MW, $\eta_{Thermal}$= 30.38 % and η_{11}= 37.23 %.

Optimization, by using the direct search method and the EES Software resulted in a final value of$\dot{C}_{Total}$=1.715 (USUS$/s), $\dot{P}_{Net}$=27135 (kW) and $\eta_{Thermal}$= 28.34%. Furthermore, sensitivity study is carried out showing the drop of 10 % of the operating variables and its effect on the total operating cost.

Keywords: Gas turbines; Novel inlet-air cooling; Exergoeconomics; Thermoeconomic optimization; Cascaded waste-heat recovery.

Nomenclature

A	Area of heat transfer, m^2
CC	Combustion chamber
$\dot{C}$	Cost rate, USUS$/s
C	Cost per exergy unit, USUS$/kJ
CWHRS	Cascaded Waste Heat Recovery System
Exp	Expander