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Thermo-statistical study of sustainable refrigeration system for stack flow heat recovery of combined gas turbine-steam turbine power generation

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ABSTRACT

The major part of input heat of power plant is lost during the exhaust flow process and this flue gas has tremendous potential for heat recovery and cooling generation. The employment of LiBr-H2O based eco-friendly and less energy consumption vapour absorption refrigeration system (VARS) is integrated with stack flow unit of combined gas turbine and steam turbine (GT-ST) plant. If thestack flow temperature is maintained about 200–250 ^{0}C, the projected VARS is suitable for the generation of efficient cooling effect. The main highlights of this research work have been concluded in terms of exergy losses in components, exergetic& overall efficiency of combined plant. The maximum irreversibility has been found in combustion chamber (CC) of GT system and exhaust flow ofST system as 66.8% and 13.4% respectively. The effect of GT plant efficiency influences the overall performance. The proposed VARS performance coefficient estimated as 0.708 with 05 ton of refrigeration effect which is valuable achievement for space cooling purpose for plant infrastructure and efficiently it can replace high grade energy consumption vapour compression refrigeration system (VCRS) type air conditioning system. This eminence cooling technology of VARS system can save 10,440 USD yearly in terms of energy and carbon emission, and able to map the de-carbonized economy infrastructure. The methane fuel gas has found remarkable performance at 8 bar of compressor pressure and 900 ^{0}C GT inlet temperature (GTIT) of operating condition with all set of operating factors by using MLR method of DOE. The determination coefficient (R^2) is computed as 0.991 which gives minimum deviation between actual and predicted results.

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1. Introduction

The precious quantity of heat vanishes during the thermal utilities operation. The first law of thermodynamic explains work and heat interaction between system and surrounding but it is unable to estimate thermal deficiency due to internal losses. Exergy evaluation approach is use to analyze the actual performance of thermal system and quantify the useful energy [1–4].Various studies have been conducted on performance analysis of different energy conversion systems, thermal utilities of plant, and heat recovery systems.A conceptual scheme for the optimized design and techno-economic model of a combined cooling, heating and power (CCHP) system was studied along with environmental performances of another thermodynamic systems like combined heating and power (CHP)-Organic Rankine cycle (ORC) system. The authors have compared the standalone CHP system performance in different climate zones [5–10]. In another study about entropy generation minimization (EGM) method was introduced, and concluded that if entropy generation is minimized, than available energy will

Abbreviations: GT, Gas Turbine; ST, Steam Turbine; C, Combustion chamber; VARS, Vapour absorption refrigeration system; VCRS, Vapour Compression refrigeration system; GTIT, Gas Turbine inlet temperature; CCHP, Combined cooling, heating and power; CHP, Combined heating and power; ORC, Organic Rankine cycle; EGM, Entropy Generation minimization; MLR, Multiple Linear regression; DOE, Design of experiment; ANN, Artificial neural network; ARIMA, Auto regression integrated moving average; HRSG, Heat Recovery steam generator; HEx, Heat exchanger; VAM, Vapour absorption cooling machine; TR, Ton of refrigeration; GWP, Global warming potential; ODP, Ozone depletion potential.

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