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The optimum performance of the combined cycle power plant: A comprehensive review

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ABSTRACT

Improving the efficiency and reducing the pollutants are the critical concerns for any design of power generation plants. Identifying the characteristics of the Combined Cycle Gas Turbine (CCGT) system and locating the optimum operation conditions via simulation models are irreplaceable route due to the huge system and the impossibility of experimental investigations. To that end, this paper presents modelling analysis with the aim of enhancing the performance and optimization conditions seeking of the (CCGT) power plant with various configurations. The developed simulation models are integrated to encapsulate thermal analysis according to thermodynamics principles, optimization techniques, error analysis, and performance metrics assessment of the various CCGT system configurations using the MATLAB 10A software. A statistical tool, ANOVA, is utilized to assess the results and to develop correlations between the power outputs and performance metrics of the CCGT plants. The new correlations which are developed within the frame of this work are of acceptable accuracy for all the considered range of the simulation data. The coefficient of determination (R^2) is calculated as 0.985 which is considered satisfactory as well. The validity of the correlations is investigated against actual performance and operation data extracted from an actual power generation plant, the MARAFIQ CCGT plant in KSA. Consequently, an error analysis which is carried out considering the actual operation and performance records of MARAFIQ CCGT plant as a benchmark proved the validity of the model. An error of about 0.8104% is found. The operation parameters and performance metrics of the CCGT plant are ultimately assessed against variations of selected parameters via the developed model. Adaptive Neuro-Fuzzy System (ANFIS) is used as an optimization technique. The highest attained power output and thermal efficiency were 1540 MW and 61%, respectively. Turbine inlet temperature is found to be the key parameter for the optimum performance (power and thermal efficiency). The models developed in this work are a powerful tool for analyzing and optimising CCGT which take the place of very expensive and strenuous experimental works.