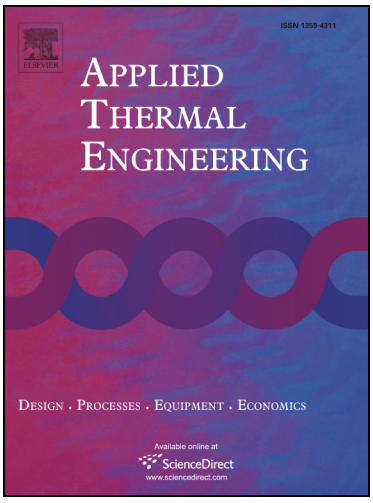

Research Paper

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PII: S1359-4311(16)32641-2
DOI: http://dx.doi.org/10.1016/j.applthermaleng.2017.06.139
Reference: ATE 10659

To appear in: *Applied Thermal Engineering*

Received Date: 21 October 2016
Revised Date: 29 May 2017
Accepted Date: 28 June 2017

Please cite this article as: A.G. Memon, R.A. Memon, S. Qureshi, THERMO-ENVIRONMENTAL AND ECONOMIC ANALYSES OF COMBINED CYCLE POWER PLANTS WITH REGRESSION MODELLING AND OPTIMIZATION, *Applied Thermal Engineering* (2017), doi: http://dx.doi.org/10.1016/j.applthermaleng.2017.06.139

THERMO-ENVIRONMENTAL AND ECONOMIC ANALYSES OF COMBINED CYCLE POWER PLANTS WITH REGRESSION MODELLING AND OPTIMIZATION

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ABSTRACT

A 144 MW combined cycle power plant (CCPP) based on simple and regenerative gas turbine units working on natural gas is investigated. By establishing mathematical model to simulate the power plants, thermo-environmental and economic analysis are conducted. The effects of five key parameters including compressor inlet temperature, compressor pressure ratio, gas turbine inlet temperature, pinch point temperature difference and main steam pressure are investigated on net power output, energy and exergy efficiencies, CO_2 emissions, exergy destruction/loss and levelized cost. The multiple regression models are developed to determine the correlation amongst these variables. Moreover, a multi-dimensional optimization using Nelder-Mead method is carried out to find optimal operating parameters for maximum efficiency and minimum levelized cost. Results show significant impacts of gas turbine inlet temperature and compressor pressure ratio on the performance and costs. The optimum energy efficiency of simple and regenerative CCPP are in the range of 36.2-56.6% and 35-58.2%, respectively under varying operating parameters while the optimal levelized costs US$ 0.0398 and 0.037 per kWh, respectively are estimated. The combustion chamber and HRSG are the major contributors towards exergy destruction amongst all components, followed by exergy loss due to stack.

Keywords: exergy, environmental impact, levelized cost, regression, optimization.

INTRODUCTION

There has been an enormous increase in the demand for electricity in Pakistan due to industrial development and population growth in contrast to enhancement in its production. Therefore, an incredible electricity supply and demand gap is developed recently, which causes the emergence of socio-economic crisis. The main reasons for this electricity shortfall are spiraling fuel prices,