Amirkabir University of Technology
(Tehran Polytechnic)
Vol. 45, No.1, Summer 2013, pp. 31-33

Amirkabir Journal of Science & Research (Mechanical Engineering)
(AJSR - ME)

Multi Objective Optimization of Feedwater Heating Repowering on a Steam Power Plant Using the Genetic Algorithm

A. Mehrpanahi[1], S.M. Hosseinalipour[2*] and S. Sijanivandi[3]

1 PhD student in Mechanical Engineering Department, Shahid Rajaee Teacher Training University, Tehran, Iran
2 Department of Mechanical Engineering, Iran University of Science and Technology, Tehran, Iran
3 Undergraduate student in Mechanical Engineering Department, Iran University of Science and Technology, Tehran, Iran

(Received 19 Apr 2011; Accepted 22 Jun 2013)

ABSTRACT

Repowering as a tested and general method can be effective for repowering steam power plants. There are different repowering methods to choose from based on a plant's specifications. Repowering has been categorized into two main categories: Full repowering and partial repowering. Feedwater heating is one of the best options available for partial repowering. In the feedwater heating based on partial repowering which has been studied in this paper, two heat exchangers have been used in parallel to the existing feedwater heaters and the required heat is supplied by an appropriate gas turbine. Two options have been considered for the added gas turbine. In the first option, a 25 MW gas turbine has been considered while in the other scenario, the considered gas turbine power output has been optimized as a dependent variable. The final result using a 25MW gas turbine is a 1.55% increase in exergy efficiency and an electricity generation cost of 404.15 Rial/kWh. In the other scenario (dependent gas turbine), exergy efficiency is increased by 1.73% and electricity generation cost is 396.22 Rial/kWh.

KEYWORDS

Repowering, Feedwater Heating, Steam Power Plant, Gas Turbine, GAM

* Corresponding Author, Email:alipour@iust.ac.ir

1- INTRODUCTION

Since 1949, when gas turbines entered the field of energy production at power plants, repowering existing power plants using combined cycles gained interest by engineers and researchers of various fields. The first repowered plant in which gas turbine exhaust gas was used to heat feedwater was the ‘Oklahoma Gas and Electric Company Belle Isle Station’. After this event, other companies decided to start researching this method and applying it to their plants as well. Adding gas turbine units to steam power plants for enhancing steam cycle’s properties and regenerating heat from adjunct cycle(s) have been known as repowering. Repowering methods are divided into two main categories, partial and full repowering. One of the latest methods of partial repowering is parallel feedwater heating repowering. Some features of the partial repowering option were presented by Joyce in 1996[1]. The electricity generation cost and exergy efficiency are two main objective functions that have been considered here.

Exergy efficiency of the new repowered cycle was compared with the old one here [3]. Electricity generation costs per kWh electricity production cost were implemented and studied here [4]. Multi objective optimization of the studied repowering option has been done using the Genetic Algorithm Method. In recent years, the feed water heating method for repowering has been known as an effective and accepted method for repowering by researchers and engineers of the field. Even though the effects of this repowering method on steam power plants has been tested and has proven to be an effective and economical method for repowering, the effects of technical and economical parameters of the repowered cycle have not been studied simultaneously. In this paper, these parameters have been considered at the same time and their effects on two important objectives (Exergy efficiency and Electricity’s cost) were studied. Moreover, a multi objective genetic algorithm was used to optimize the results and the final optimized results were presented and explained.

2- METHODOLOGY

In this paper, the mentioned method was applied to ShahidRajaee steam power plant considering its significant properties. Cost functions of generated-electricity and exergy efficiency are defined as objective functions in one and two objective optimizations. The optimization has been done by the genetic algorithm using a combination of EES and Matlabsoftwares. Main stream and steam turbine extraction flows were chosen to be the independent variables of the optimization. Exergy efficiency and cost of generated electricity were the goal function, which were defined as follows:

A. Exergy Efficiency:

$$\eta_{ex,cc} = \frac{\sum_{i=1}^{n} \dot{W}_i}{\sum_{i=1}^{n} \dot{E}_{f_i}} \tag{1}$$

In which

$$\sum_{i=1}^{n} \dot{W}_i = \dot{W}_{gt} + \dot{W}_{st} + \dot{W}_{HN} \tag{2}$$

$$\sum_{i=1}^{n} \dot{E}_{f_i} = \dot{E}_{f,b} + \dot{E}_{f,g} = e_f.\dot{m}_{f,b} + e_f.\dot{m}_{f,g} \tag{3}$$

B. Electricity Generation Cost:

$$Z_E = \left(\frac{TCI.CRF.\varphi}{\dot{W}.H}\right) + C_f.HR_{pp} [\$/kWh] \tag{4}$$

In the end, the “4 extraction case” has been chosen to apply this method on, considering desirable technical and economic parameters. The simulation results of the chosen design for a 25MW gas turbine are: 1.5% increase in exergy efficiency and 404.15 Rial/kWh generated electricity cost (for added capacity). As for the dependent

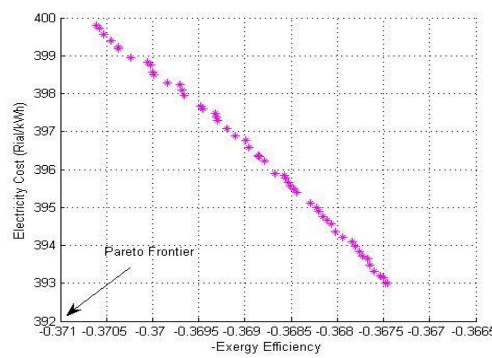

Figure1: Multi objective optimization results for simulation of “4 extraction” in the dependent gas turbine

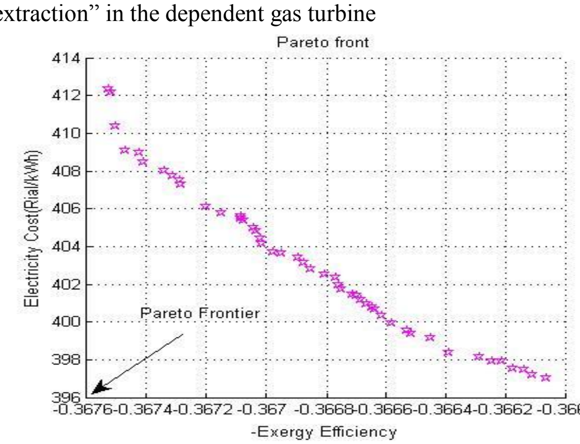

Figure2: Multi objective optimization results for simulation of “4 extraction” in $\dot{W}_{gt} = 25MW$

Gas turbine case, the results are: 1.73% increase in exergy efficiency and 396.22 Rial/kWh generated electricity cost (for added capacity). These results are the non-weighted optimum point of the graphs below.

3- CONCLUSIONS

Since there is a significant lack of efficiency in Iran's steam power plants, repowering is one of the best options available to rejuvenate some of their lost efficiency for older plants and increase their efficiency for newer plants which are not efficient. To improve the country's thermal plant properties, both technical and economical properties are considered. Results for applying the parallel feedwater heater method repowering on the ShahidRajaee plant were shown in this paper.

Other new steam power plants like the one studied here can be considered for implementation of this repowering method.

4- REFERENCES

[1] Tripanagnostopoulos, M. Souliotis, "Integrated collector storage solar systems with asymmetric CPC reflectors." Renewable Energy. no. 29 pp. 223–248, 2004.
[2] Madhlopa a, R. Mgawi b, J. Taul, Experimental study of temperature stratification in an integrated collector–storage solar water heater with two horizontal tanks.Solar Energy, no. 80, pp. 989–1002, 2006.
[3] Souliotis, S. Kalogirou, Y. Tripanagnostopoulos. "Modelling of an ICS solar water heater using artificial neural networks and TRNSYS." Renewable Energy.no. 34, pp. 1333–1339, 2009.
[4] Souliotis, Y. Tripanagnostopoulos. "Experimental study of CPC type ICS solar systems." Solar Energy, no. 76, pp. 389–408, 2004.