Chapter 7

Conclusions

The objective of the present research study is to develop a user-friendly method of exergoeconomic optimization method to predict the cost effectiveness of an energy intensive thermal system such as AAVAR system and suggest ways of improving the cost effectiveness from both thermodynamic and economic points of view.

It is a well known fact that means can be found out to improve thermal system performance using the exergy analysis. It is also a well known fact that exergy analyses is well suited for finding the location, cause and true magnitude of the losses to be determined in a thermal intensive system. The analysis enables for more effective utilization of energy resource and thereby having higher exergetic efficiency of thermal system and also estimates the parameters like the exergy destruction and the exergy loss which adds to the hidden cost. If these destruction and losses are to be prevented, the thermal system needs more investment. Thus, the cost of the component of a system or the whole system increases with an increase in its capacity and efficiency. Therefore, it is necessary to correlate the exergy with cost value. It can be carried through exergoeconomic analysis.

The exergoeconomic analysis suggests improvement in the thermal system which is associated with the increase in investment and operation & maintenance cost. Thus the cost optimization problem involves the maximization of thermodynamic performance and minimization of investment cost. These are the contradictory disciplines. The exergoeconomic concept combines them together and develops effective tool for design the thermal system with higher efficiency and lower cost.

A number of exergoeconomic modeling and optimization methods are suggested by various researchers and are applied to various thermally intensive systems. However, a review of literature indicated that a very little interest is shown towards vapour absorption refrigeration system in general and AAVAR systems in particular. This may be due to the fact that AAVAR system is a less popular refrigeration system as compared to vapour compression systems. Further, they are less capital intensive compared to other thermal intensive systems like power plants. However, AAVAR system used with huge chemical industries needs greater attention as slight modification in the system parameters brings substantial savings in energy and production cost. Considering this important observation, the present research work on the optimization of AAVAR system is undertaken.

There are a number of exergoeconomic optimization models available in open literature. However, most of them are either complex to translate or incomplete in their availability in open literature. Thermoeconomic Evaluation and Optimization (TEO) method suggested by Tsatsaronis and his associates is a user friendly method which needed some alterations to suite to the optimization of the industrial brine chilling unit using AAVAR system. In the present work, such modification is suggested.

The brine chilling unit using AAVAR system employed in a large fertilizer plant considered for the present optimization study utilizes heat source from the steam generated in an independent boiler. The optimization study is then extended by considering two other options of heat sources available with the fertilizer industry, viz., steam from GT-HRSG and tapped steam from steam turbine to assess the cooling cost effectiveness of the source of heat energy.

Since a rigorous design optimization of complex energy systems is practically very difficult and time consuming, the exergoeconomic method originally developed by Tsatsarnois and modified in the present work is a valuable and powerful tool in the optimization of complex energy systems by identifying all the cost sources. Optimization is carried out through an iterative procedure rather than through a search of the global optimum of a predetermined function by solving it mathematically. The results show how far is the improved design from the reference design, although based on typical data. The term optimization in this context implies improvement rather than calculation of the global optimum. The notable feature of the present method as compared to that of the simple energy based costing and optimization is the identification of the source of exergy destruction and subsequent corrective measures possible to reduce the same.

The exergoeconomic analysis of a thermal system improves the engineer's understanding of the interactions among the system variables and reveals opportunities for cost-effective improvements in system design by means of changes in the structure of the system, which is not possible through the mathematical or numerical techniques. Moreover, operator's suggestions based on experience can be incorporated. However, the optimization technique requires engineering judgments and critical evaluations at every step of the optimization process such as proper definition of fuel-product-loss for every component, proper selection of local decision variables, but allows the designer to carry out an energy-conscious design.

The following conclusions are derived from the study pertaining to the possible overall improvement in the operation of a brine chilling unit incorporating an AAVAR system, gas turbine power plant with HRSG and steam turbine power plant with regeneration in a fertilizer plant.

1. An overall cost reduction in terms of exergoeconomic product cost (chilled brine) of the order of about 27% and that of fuel cost of the order of about 12.76 % ensures a significant reduction in the consumption of the fuel for the existing brine chilling unit with steam generated in the independent boiler as a heat source when optimum design worked out (i.e. switch over from existing base case to optimum case) using the present technique is incorporated.
2. When the option of heat source for the operation of AAVAR system is steam generated at HRSG of the available gas turbine power plant in the fertilizer plant, the cost of steam is reduced by about 12 % and there by the cooling cost of VAR system is also reduced from 1.36 ₹/sec to 1.086 ₹/sec. The optimization of gas turbine power plant reduces the cost of electricity generated from 2.61 ₹/kWh to 2.49 ₹/kWh and cost of steam generated at HRSG is reduced to 790 ₹/1000 kg compared to 900 ₹/1000 kg with independent boiler.

3. When the option of heat source for the operation of AAVAR system is the tapped steam from steam generated at the steam power plant available in the fertilizer plant, the optimization of steam turbine power plant reduces the cost of electricity generated, from 1.99 ₹/kWh to 1.91 ₹/kWh and the cost of tapped steam is 389 ₹/1000 kg. The reduced steam cost reduces the cooling cost of AAVAR system to 0.68 ₹/sec.
4. If the findings from the present study is to be incorporated in to the plant, then switching over from independent boiler and to tapped steam of steam power plant as heat source, steam is to be transported a distance of about 1 km as steam power plant is housed 1 km away from AAVAR plant. The total installation cost including pipe material cost and insulation cost will be ₹1458000. The total saving in steam cost shows that this installation cost can be recovered in 12 days only. The saving in the steam cost per 1000 kg steam will be ₹ 511/-. The annual steam consumption in AAVAR system is 90403200 kg/year. Therefore, the annual saving in the monetary term will be ₹ 46196035/-.
5. It can be concluded that the best option of the minimizing the cooling cost of the brine chilling unit using AAVAR system is to provide heat source from the tapped steam of the steam power plant.