Journal of Advances in Science and Technology

Vol. VI, Issue No. XI, November-2013, ISSN 2230-9659

EFFECT OF IMPROVING ENERGY EFFICIENCY ON SYSTEM RELIABILITY

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

www.ignited.in

Journal of Advances in Science and Technology
Vol. VI, Issue No. XI, November-2013, ISSN 2230-9659

Effect of Improving Energy Efficiency on System Reliability

Sumit Kumar

Assistant Professor, Sityog institute of Technology Aurangabad Bihar

Abstract – In the present scenario of energy demand overtaking energy supply top priority is given for energy conservation programs and policies. Most of the process plants are operated on continuous basis and consumes large quantities of energy. Efficient management of process system can lead to energy savings, improved process efficiency, lesser operating and maintenance cost, and greater environmental safety. Reliability and maintainability of the system are usually considered at the design stage and is dependent on the system configuration. However, with the growing need for energy conservation, most of the existing process systems are either modified or are in a state of modification with a view for improving energy efficiency. Often these modifications result in a change in system configuration there by affecting the system reliability.

It is important that system modifications for improving energy efficiency should not be at the cost of reliability. Any new proposal for improving the energy efficiency of the process or equipment's should prove itself to be economically feasible for gaining acceptance for implementation. In order to arrive at the economic feasibility of the new proposal, the general trend is to compare the benefits that can be derived over the lifetime as well as the operating and maintenance costs with the investment to be made. Quite often it happens that the reliability aspects (or loss due to unavailability) are not taken into consideration. Plant availability is a critical factor for the economic performance evaluation of any process plant. The focus of the present work is to study the effect of system modification for improving energy efficiency on system reliability. A generalized model for the valuation of process system incorporating reliability is developed, which is used as a tool for the analysis. It can provide an awareness of the potential performance improvements of the process system and can be used to arrive at the change in process system value resulting from system modification. The model also arrives at the pay back of the modified system by taking reliability aspects also into consideration. It is also used to study the effect of various operating parameters on system value. The concept of breakeven availability is introduced and an algorithm for allocation of component reliabilities of the modified process system based on the breakeven system availability is also developed. The model was applied to various industrial situations.

---------------------------♦-----------------------------

INTRODUCTION

There are three principal forms of energy used in industrial processes namely electricity, direct-fired heat, and steam. Electricity is used in many different ways, including mechanical drive, heating, and electrochemical reactions. Direct-fired energy directly transfers the heat of fuel combustion to a process. Steam provides process heating, pressure control, mechanical drive, component separation, and is a source of water for many process reactions. Industrial energy efficiency has emerged as one of the key issues in developing countries and there is a growing need to bring about improvement in the efficiency of energy use in the industrial sector.

In India the industrial energy consumption is about 40% of the total energy in the country. The studies by Ming Yang pointed out that electricity tariffs in the industrial sector in India are quite high and this encourages industrial entities to develop captive power plants themselves. This is particularly true where there are power shortages. As a result, small power plants or units have been quickly developed in the industrial sector. The small and decentralized captive power plants, however, are less efficient than the large centralized power plants from the national economy viewpoint. Ming Yang also brought out the inadequacies in the national energy policy. For instance, one of the industrial concerns that was analyzed imported a second-hand oil fired 2.6 MW cogeneration power facility from Germany. The equipment was made in the 1970s and it had been phased out in Germany in 1993 due to the high cost of operation and environment pollution. The energy efficiency policy and capital investment policies and measures in India did not prevent such old and inefficient equipment being purchased and installed in India.

Steam has many performance advantages that make it an indispensable means of delivering energy.

These advantages include low toxicity, ease of transportability, high efficiency, high heat capacity, and low cost with respect to the other alternatives. Steam holds a significant amount of energy on a unit mass basis that can be extracted as mechanical work through a turbine or as heat for process use. Since most of the heat content of steam is stored as latent heat, large quantities of heat can be transferred efficiently at a constant temperature, which is a requirement in many process heating applications.

Steam is also used in many direct contact applications. For example, steam is used as a source of hydrogen in steam methane reforming, which is an important process for many chemical and petroleum refining applications. Steam is also used to control the pressures and temperatures of many chemical processes. Other significant applications of steam are to strip contaminants from a process fluid, to facilitate the fractionation of hydrocarbon components, and to dry all types of paper products. The many advantages that are available from steam are reflected in the significant amount of energy that industry uses to generate it. Hence, the focus in majority of the industrial energy conservation programs will be on steam systems. Typical methods for improving the steam system efficiency includes proper insulation of steam lines, use of waste heat recovery devices like economizers and air pre-heaters, return of condensate to boiler, minimizing boiler blow downs, recovering heat from boiler blow down, use of vapors recompression to recover low-pressure waste steam, flashing of high-pressure condensate to regenerate low-pressure steam, replacing pressure-reducing valves with backpressure turbo generators, and considering steam turbine drives for rotating equipment.

ENERGY EFFICIENCY EVALUATION TOOLS

The primary sources of energy, such as heavy oil, natural gas and other conventional sources are limited resources formed by geological processes through solar energy accumulation into the earth over millions of years. Because of their fluctuations in reserves and prices and due to the increased costs of power stations, it is very important to consider new measures for energy conservation. Energy related problems are likely to become more and more important in the forthcoming millennium. To improve energy-utilization efficiency, people analyze energy-utilization features of a process with the aid of theoretical method of mathematics as well as graphics, etc., and try to find out the location, quantity and reason of energy-loss, e.g. adopting the thermodynamic analysis method graphically. Typical graphical tools used to evaluate the energy utilization efficiencies are the Sankey diagram, also called as the enthalpy flow diagram and the Grassman diagram, also called the energy-flow diagram.

The energy-utilization situation of the system can be visually understood by the branch and the width of each input and output flow in the Sankey diagram. Similarly, the Grassmann diagram is a graphic analysis tool to show the input and the output relations of the energy balance. It obviously illustrates the quantities and directions of energy-flow to evaluate the energy-utilization efficiencies. The energy-utilization diagram was proposed by Ishida et al. The diagram not only can be used in heat exchange process, but also in other energy conversion processes, such as chemical reaction, compression, expansion and so on.

These graphical thermodynamic analysis methods are all fairly simple and visual. However, they are inadequate in describing the structure characteristics of a process scheme and embodying the energy supply-demand relation between utilities and the energy-consuming processes from the view of process technology, and indicating the energy recovery or utilization relation of the concrete equipment or stream, as well as showing the stream balance relations either, because they do not combine with the process scheme closely. Zheng et al. Proposed a new graphic method that can visually reveal the features of energy transformation and the system losses to find out the energy-utilization shortage and energy-saving opportunities, through describing the energy supply demand relation between utilities and energy consumption process.

DIFFERENT APPROACHES TO RELIABILITY ANALYSIS

We can distinguish between three main branches of reliability:

- Hardware reliability
- Software reliability
- Human reliability

The present textbook is concerned with the first of these branches: the reliability of technical components and systems. Many technical systems will also involve software and humans in many different roles, like designers, operators, and maintenance personnel. The interactions between the technical system, software, and humans are very important, but not a focused topic in this book. Within hardware reliability we may use two different approaches:

- The physical approach
- The actuarial approach

In the physical approach the strength of a technical item is modeled as a random variable S. The item is exposed to a load L that is also modeled as a random variable. The distributions of the strength and the load at a specific time t are illustrated in A failure will occur as soon as the load is higher than the strength. The reliability R of the item is defined as the probability that the strength is greater than the load,

$$R = Pr(S > L)$$

Where Pr(A) denotes the probability of event A.

The load will usually vary with time and may be modeled as a time-dependent variable L(t). The item will deteriorate with time, due to failure mechanisms like corrosion, erosion, and fatigue. The strength of the item will therefore also be a function of time, S(t). A possible realization of S(t) and L(t) is illustrated. The time to failure T of the item is the (shortest) time until S(t) < L(t),

$$T = \min\{t; S(t> < L(t))$$

And the reliability R(t) of the item may be defined as

$$R(t) = Pr(T > t)$$

The physical approach is mainly used for reliability analyses of structural elements, like beams and bridges. The approach is therefore often called structural reliability analysis (Melchers 1999). A structural element, like a leg on an offshore platform, may be exposed to loads from waves, current, and wind. The loads may come from different directions, and the load must therefore be modeled as a vector L(t). In the same way, the strength will also depend on the direction and has to be modeled as a vector S(t). The models and the analysis may therefore become rather complex. In the actuarial approach, we describe all our information about the operating loads and the strength of the component in the probability distribution function F(t) of the time to failure T. No explicit modeling of the loads and the strength is carried out. Reliability characteristics like failure rate and mean time to failure are deduced directly from the probability distribution function F (t). Various approaches can be used to model the reliability of systems of several components and to include maintenance and replacement of components. When several components are combined into a system, the analysis is called a system reliability analysis.

CONCLUSIONS

Process reliability study was conducted at different industrial situations in order to study the impact of system modification with a view for improving energy efficiency on system reliability. The developed valuation model was used as a tool for the analysis. The concept of breakeven availability was introduced and based on this an algorithm was also developed to allocate component reliability goals. The major research findings are listed below.

I) Modification of a system with a view for improving energy efficiency need not necessarily improve process system availability and reliability and vice versa.

2) A huge improvement in efficiency of a subsystem need not necessarily have the same effect on the overall system efficiency. On the other hand, the consequence of the decrease in the subsystem reliability and availability may have a serious impact on the overall system availability and reliability.

3) 73% improvement in feed water pumping system efficiency resulted in 24% reduction of pumping reliability and 0.6% decrease in availability. The impact of this modification on captive power plant is a 3% increase in thermal efficiency at the cost of 33% process system reliability and 0.8% process system availability.

4) The impact of modification on the process system value will depend on the relative value of the change in reliability and availability vs. energy efficiency.

5) In the case of power plant the change in process system value is negative as magnitude of the loss due to unavailability and unreliability is more than monetary benefit resulting from improvement in efficiency.

6) Decrease in process system reliability and availability after modification need not necessarily make the change in system value negative, provided that the monetary benefits resulting from improvement in energy efficiency are relatively more than the loss due to unavailability and unreliability.

7) Modification at concentrator part of a gelatin plant resulted in a reduction of 5% reliability and 0.6% availability for an increase of 51 % efficiency and the resulting change in system value works out to be positive.

8) Increase in process system reliability and availability at the cost of energy efficiency can make the change in process system value negative if the magnitude of loss due to inefficiency is greater than the benefits resulting from high reliability and availability.

9) In the case of chocolate manufacturing company a 33% improvement in reliability and 0.16% improvement in availability resulted in about 13% reduction of efficiency

and a negative change in process value of Rs. -17.6 lakhs for a system life of 15 years.

10) A modified system with a negative change in process value requires the breakeven availability to be allocated among the components. The breakeven value of availability need not be necessarily greater than the process system availability before modification. The improvements in reliabilities required IS more for those components that already have a low value for reliability.

REFERENCES

1. Armen, D. K., O. D. Ditlevsen and J. Song. (2007) Availability, reliability and downtime of systems with repairable components. Reliability Engineering and System Safety 92:231-242.

2. August, J. Reliability-centered maintenance. (1999) Penn Well Publishing; Tulsa, Oklahoma.

3. Babcock and Wilcox Co. (1978) Steam: Its Generation and Use. B & W, New York.

4. Badino, V. and G. L. Baldo. (1998) LCA, instructions for use. Bologna: Progetto Leonardo Edition (in Italian).

5. Bain, I. J. (1974) Analysis of linear failure rate life testing distribution. Technometrics 16:551-60

6. Barlow, R. and F. Proschan. (1975) Statistical theory of reliability and life testing probability models. Rinehart and Wins ton Inc., New York.

7. Barringer, H.P. (1999) Practical reliability for refinery and chemical plants. Barringer & Associates. Humble.

8. Barringer, P.E. and P. D. Weber (1996). Life-cycle cost tutorial. Gulf Publishing Company, Houston, TX.

9. Barringer, P.E. (2000) Reliability engineering principles. Barringer & Associates, Humble.

10. Bartow, R.E. and F. Prochan. (1975) Statistical theory of reliability and life testing. Rinehart and Winston Inc. NY (USA).

11. Blanchard, B.S. and WJ. Fabrycky. (1998) Systems engineering and analysis. Prentice-Hall, Upper Saddle River, NJ.

12. Blanchard, B. S., D. F. Verna and E .L. Peterson. (1995) Maintainability: a key to effective serviceability and maintenance management. John Wiley and Sons, New York (USA).

13. Chen, T.e. and T.e. Hsu. (2006) A GAs based approach for mining breast cancer pattern. Expert Systems with Applications, 30:674-681.

14. Chern. M. S. (1992) On the computational complexity of reliability redundancy allocation in a series system. Operations Research Letters 11: 309-315.

15. Coffin, K. (1998) Evaluating customer support during new product development: an explorative study. International Journal of Operations & Production Management 21(3):21-222