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Multi-operation Optimization of Responsive Manufacturing System with Energy Objectives by Taguchi Loss Function

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ABSTRACT:
In a manufacturing unit generally more than one product is made in certain cycle time, and in order to become competitive, the progressive firms run the production facilities optimally. The customer also wants an optimum solution for their requirements. The energy cost constitutes a major portion of manufacturing cost. In current situation the manufacturing must be responsive to customer, vender, share-holder and all types of competition. The manufacturing must be flexible, easy to operate and mistake-proof, this is a **robust** organization. The ecosystem regulation and equilibrium guide us to control variability of production system also.

By this paper a methodology will be develop for batch manufacturing organization to work as responsive manufacturing system with energy considerations. The steel, chemical and pharmaceuticals unit follow batch type of production, because of low volume, high value products. Now the industries, all over the world, whether large or small, are facing challenges on multiple fronts, competition is becoming borderless, new alliances are being formed; internal processes are now being considered for outsourcing. Work-force multiple-utilization and total quality is the objective. The Taguchi loss function is a tool to control variability of performance and energy losses are reduced to minimum and 5-E key decision areas, e.g. environmental, economy, engineering, energy, and efficiency may automatically control.

KEYWORDS: Taguchi loss function, Robust design, Manufacturing cost optimization, Energy Balance, Design for manufacturability

1.0 INTRODUCTION

The efficiency of any plant may be differing from plant to plant, as in every plant different machinery and technology may be used. An engineer knows that all kinds of functions are energy transformations. Some process industries consumes huge amount of energy, as in chemical and steel industries. In each organization energy is the area which can change the organization balance sheet.

The batch production organization also recognized that, it is insufficient for processes to be just effective and efficient, but processes must also be flexible, easy to operate, and mistake-proof. This is called robustness. In a robust organization, (service type or manufacturing type both), performance is insensitive to uncontrollable variations of manufacturing, distribution, use and disposal. Robust processes must also respond to the changing need of the customers, environment and energy needed for all operations. Creating a robust process or product is like putting shock absorbers on a car. Robustness can apply to a wide variety of processes including service,

The selection of manufacturing process and its decision depend on materials, part geometry, technology, tolerances, surface finish, and grouping of parts into subassemblies, etc which causes energy losses and affect energy efficiency.

The paper is organized as follows: section 2 gives an overview of literature on development of energy system for different manufacturing systems, their problems and applications. In section 3 proposed model are discussed and section 4 presents the methodology for proposed model. The conclusion section consist of future proposed development and remarks.

2.0 REVIEW OF RELATED LITERATURE

The energy is needed to alter the work part's shape, physical properties or appearance in order to add value to the material [31]. The manufacturing industry faces the challenge of energy efficiency maximization and responding quickly to the changed energy resources, customers and environment losses. The energy maximization program needed knowledge of different types of industries, some uses old machinery, or having state-of-art technology [65].

3. OBJECTIVE OF THE MODEL:

Energy is the area which can be used to increased performance of any manufacturing system. Energy efficiency maximization can be achieved by reducing energy losses of all forms. To reduce losses is better than or some time as important as to increase efficiency.

The aims and objectives of above model are to reduce variability and performance variation due to human behavior, equipments, resources optimization, use of energy balance principle and to get a robust organization like an ecosystem. It is necessary to understand and to get performance of human

behavior model as per following objectives, so the performance improvement can be achieved by controlling the wastages. It is effective both for service and production organizations:-

- To select right man for right jobs and to develop them as a effective labor force,
- Proper planning of the work,
- Employee training and development,
- Effective utilization of all resources including human resources,
- To maintain suitable / safe working condition,
- To minimize industrial dispute,
- To motivate work force by proper incentive wage plan and team work,
- To develop fool-proof and effective communication system,
- To reduce excessive variations to control environment, resources, human and efficiency losses,
- To create a competitive environments among different plants,
- To develop a feed-back mechanism like ecosystem regulation,
- To develop energy efficiency improvement methodology for the manufacturing system.

A reliable and repeatable system shows fewer variations. The best levels of control factors are achieved at maximum signal to noise (s/n) ratios. The product manufacturability and reliability should improve from the start, at design stage by off line control, as no amount of inspection can improve a product. Loss includes cost to repair and failure, customer dissatisfaction and lost sales, maintenance, and replacement cost etc. Loss may be control by reducing variability of product functional parameters and by adjusting the target.
The value of loss should be minimized, as they cost to society. Taguchi argued that such losses would inevitably find their way back to the originating corporation, and by minimizing them, the manufacturer would enhance brand reputation, win markets and generate profits. The Taguchi define quality performance as the loss imparted by the product to the society from the time when the product is shipped to the consumer. Loss occurs if products functional features or removing of causes may be expensive and some time very difficult and impossible.

The idea behind robust design is to improve the quality of various functions to its desired value. The signal measures the closeness of design product by minimizing the effects of variations without eliminating their causes. The signal deliver, what a product or part is trying for. The noise affects the performance. Fig. 2 shows parameter design process. The tool of parameter design is an important tool to control energy losses of all form and their variability control.

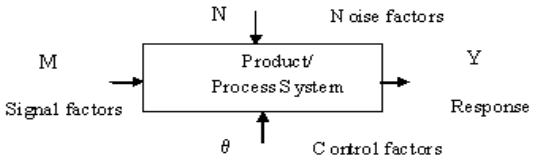

Fig. 2 Parameter design frame work for a dynamic product or process for energy efficiency maximization. The dimensional features differ from the nominal value and causes variations. The loss function recognized the consumer's desire to have products that are more consistent from part to part and producer desire to make a low cost product. The loss function may be used to evaluate the effect of performance improvement. The losses are due to, production expenses and cost that is required for product manufacturing and costs encountered during use, by the consumer such as repair, modifications and lost sale.

The other harmful effect to the society is pollution, accidents and presence of hydrocarbons etc. A system which functions under initial set of nominal conditions is to be developed, just as prototype design for meeting the customer needs. In parameter design an optimum level of controllable factors is determined at which, a high level of performance is obtained in presence of noise factors. The control factors are the design features which may be set and maintained. It is very important to determine the best combinations of components tolerances. For complicated parts tolerances stack-up and variance buildup are to be applied.

High tolerance cost is associated with tight process tolerances. The TM is also used to specify dimension feature detail and follow design for manufacturability and assembly (DFMA) activities. The MMT include DFMA activities. To control wastage and life cycle costs, the designer and product engineer shall have capability to assess the impact of design modification on process selection, assembly inspection, tool and dies and product cost. It is essential to establish quantitative relationship in order to optimize the design for ease of manufacturing and assembly at minimum cost.

The MMT is very useful to reduce the life cycle costs. Design and manufacturing can never be viewed as separate departments. Each parts or component of product shall be designed, so that it not only meet design requirements but also can be manufactured economically and with relative ease.
The MMT includes practice of designing product with manufacturing in mind so that they can be-
* Designed in least time with minimum development cost.
*Smooth transition from design phase to manufacturing.
*The assembly and testing can be performed with minimum cost and time to achieve the quality level and reliability considerations.
* A better competitive position is achieved in these environments by better consumer satisfaction for the products.

By help of improved model the energy losses may be reduced from design stage due to all types of variables in presence of noise factors.
It works on lean team principles to developed team to transform organization into robust organization. The use of MMT makes the process competitiveness for energy flow model and energy balance principles. The 5-E-key decision areas can be useful tool as it provides competitive advantage over other company. By studying and reducing energy losses, the energy efficiency is maximized and a clean and green environment may be developed.

In a batch production industry the various products and various operations were involved and to get an optimum or best possible output, the relationship of losses and their effect on output is to be studied. These looses may be for particular quantity, quality and products. Due to economy the process variance are generally improved in last as required better equipments,

4.0 THE PROPOSED METHODLOGY

[Fig.-4]

Energy is the most important input of the responsive production system .The ideal energy efficiency is 1. It is measure of best possible performance and excellent indicator of organization profit. Every operation requires energy. In every loss energy loss is associated. Energy can not be saved but can only be spend wisely. The energy is the prime resource which is essential for survival of organization and human being. The maximum energy efficiency is linked with resources, environments and recycling of parts/products. The steps are under as:

Step I: To estimate energy losses: The energy losses are developed due to factors of-
(a) Losses due to resources variations,
(b) Losses due to energy balance variations,
(c) Losses due to human factor variations,
(d) Losses due to environment variations.

Step II: Energy flow model development: The energy flow model tells us energy input, energy used or stored and energy lost or not used. A model as parameter design will be developed for each function. A suitable model which is applicable in all conditions is to be finally developed. In this model losses developed due to each variation are also summarized with cause and effect support.

Step III: Identify source of noise factors, affecting energy efficiency: The key parameter to create robustness is the identification of noise or uncontrollable factors which affect the process. Then the process is made insensitive to these factors which causes performance variations. The noise factors may be classified as internal, external and unit to unit noise factors. The priorities order is controlled by the cost effectiveness. Some time it is too costly to make to make robustness to each and every noise factor. Here priorities order of having largest effects play the key role. Attack area and priorities order selection in any organization is governed by human, economical and technical considerations and their losses and variations. Here loss function may be used as a tool and a map similar to value steam mapping (VSM) will guide us.

Step IV: Consolidate Process / product parameters for maximum energy efficiency by DOE: Identify and consolidates the prominent parameter by conducting design of experiments (DOE) for product and process both, so they may insensitive to environmental factors, variability of components and target centering.
This is instituted at both the product and process design stage to improve product manufacturing ability and reliability. This is done by off line and on line control.

Step V: Improvement by MMT: Any improvement required a team effort, and lean team is best team. The production system evolutions start with mechanization, than on automation and now by flexibility and MMT applications. They are best combination of 5'E i.e. Environments, Energy, Engineering, Efficiency and Economy. The MMT are most profitable to face challenges on organization. The MMT integrate design, manufacturing, management and strategic functions.

Step VI: Optimization by Taguchi method™: The TM of optimization is based on:

a. System design

b. Parameter design
c. Tolerances design

The Taguchi methods are used to optimize the parts, elements, subsystem, system and assembly against the performance variations. The identification and consolidation of the prominent parameter by conducting design of experiments (DOE) for product and process both, so they may insensitive to environmental factors, variability of components and target centering. This is instituted at both the product and process design stage to improve product manufacturing ability and reliability. This is done by off line and on line control.

Step VII: Improved energy flow model development: The energy conversion efficiency decreases as its end uses length increases. For examples steam energy losses increases with its travel, etc. It is based on energy efficiency pyramid principle. It start with robust inputs, processed with robust parameters and robust output may be obtained. Finally a methodology will be developed to confine the losses/wastages and thus improving the system energy performance. The utilization of resources will be optimum, and better value product will be provided to consumer than the competitors. Team work, right attitude and exploring the opportunity at right time will be the patented weapons.

Robust feed back system development: To implement changes for robustness without any resistance required a team work and a robust feedback system like ecosystem feed back system with both positive and negative feedback, so whole transformation process will be carried out systematically without any failure continuously. The aim of proper system working, losses reduction and continuous improvements can only be obtained with robust feed back system. Also the batch production has capability to handle variability of feedstock and product dynamism and plant than has flexibility to achieved full capacity utilization.

5.0 CONCLUSION

The energy and effort are the factors which determine the success of any manufacturing organization. In this variable situation use of 5-E key decision factors is a wise decision. The manufacturing organization can perform best if 5-E, key decision variables e.g. environment, economy, engineering, energy, and efficiency may properly club with MMT. These decision variables are also useful to apply Taguachi concept of quality and performance improvements.

The MMT development and uses are always associated with Japanese manufacturer. First there focus was on mass production, then on quality, afterward on service and now on flexibility and variability reduction. It is the time when for their survival, most of organization are investing on strategic technologies than hardware technologies. The use of combined effort of various MMT is very useful and correct solution for all type of industries in all situations. Only a specific technique may not be suited for current situation of globalization. All MMT has different advantages and disadvantages and to earn more profit with customer satisfaction is the central aspect of manufacturing.

Fig. - 4

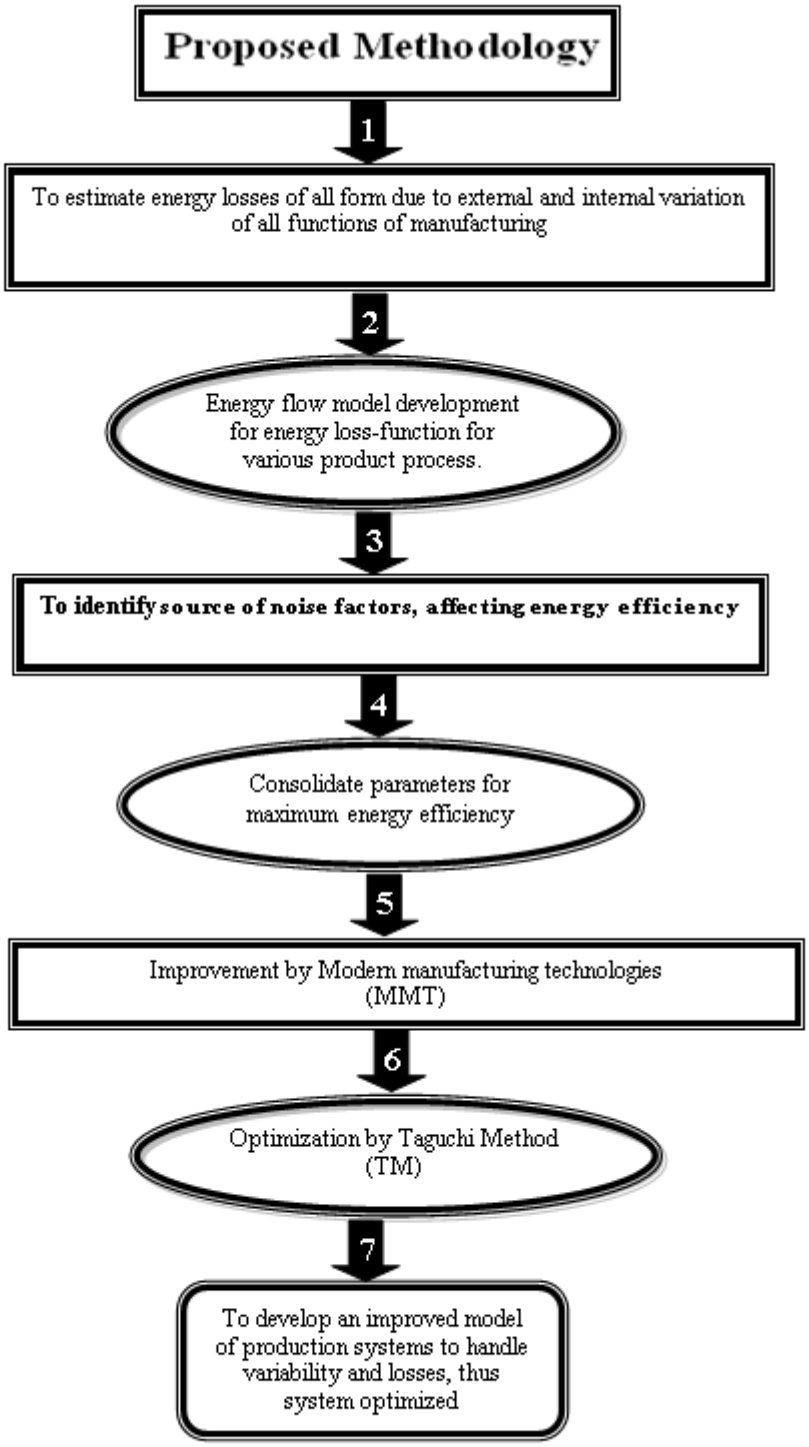

Fig. 4 OPTIMIZATION OF RESPONSIVE ORGANIZATION FOR ENERGY OBJECTIVES

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