January - February 2020
ISSN: 0193 - 4120 Page No. 4703 - 4706

Optimization of Manufacturing Process using DFMA

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Article Info
Volume 82
Page Number: 4703 - 4706
Publication Issue:
January-February 2020

Article History
Article Received: *18 May 2019*
Revised: *14 July 2019*
Accepted: *22 December 2019*
Publication: *23 January 2020*

Abstract:
Nowadays, the redundant manufacturing cost has been increased in various manufacturing industries. Design for manufacturing and assembly (DFMA) is a method of design for the ease of manufacturing of the collection of components that will form the product after assembling which can be significantly used for reducing manufacturing cost of part, assembly time and material. This method eliminates the use of redundant parts in an assembly. This paper provides a detailed review regarding the development of DFMA and its implementation in real-world product design.

Keywords:*Design for manufacture and assembly (DFMA), Design for manufacture (DFM), Design for Assembly (DFA), Taguchi method, Lucas Hull method*.

1. INTRODUCTION

Design for manufacturing and assembly comprises of two categories – Design for manufacture (DFM) and Design for Assembly (DFA), wherein DFM is concerned with overall production cost of the component by minimizing complexity of manufacturing operations and DFA is concerned with only reducing the cost of product assembly by minimizing number of assembly operations. Both the categories seek to reduce material, overhead and material cost. More specifically, DFA is a tool that selects the most cost effective material and process to be used in production process in the early stages of product design, wherein the tool may preferably be a Taguchi method, Failure mode effect analysis or Lucas Hull method. This method can be used frequently in any manufacturing industries were the redundant operations carried out in manufacturing process will be eliminated. This method provides the best optimum solution for the increasing cutting cost of the component by altering the procedure of operations carried out while manufacturing the product. DFMA shortens the time required for the development cycle of a product, were it consists of time of design, time for deciding the manufacturing process and repeatedly calculations.

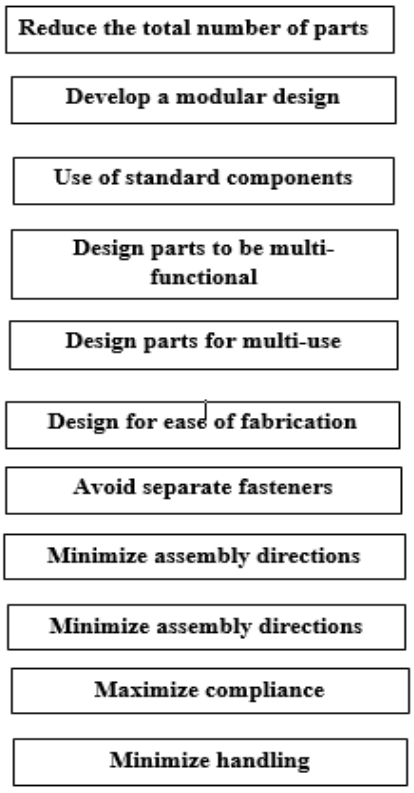

Fig 1: Guidelines for DFMA

Fig 1 illustrates the guidelines for DFMA, wherein it provides all possible ways to design and manufacture the product by eliminating the number of redundant parts in an assembly and reduce the number of parts by maintaining the quality of the product. Modular design has been used so that it will reduce the number of unique parts are reduced which

lowers the cost of assembly. Standard components are used which are already available in the market such as standard nut and bolts with standard pitch of screw threads acting as fasteners which avoids the ordering of any new component for fastening that unnecessarily increase manufacturing cost. Parts should be designed in such a way that it can be used as multifunctional which reduce the cost of manufacturing any other components which has a similar function and also the parts must able to be used in different locations of the assembly. There must be an ease of fabrication of parts so that the geometry of parts is simplified and the unnecessary features are avoided. Fasteners such as nut and bolt must be of similar size so that it can be used to assemble every component in an assembly which eliminates the cost for manufacturing of any other fastener used in assembly. The design of the components should be in such a way that the components will be assembled in one particular direction i.e. from bottom to top.

1.1 Lucas Methodology:

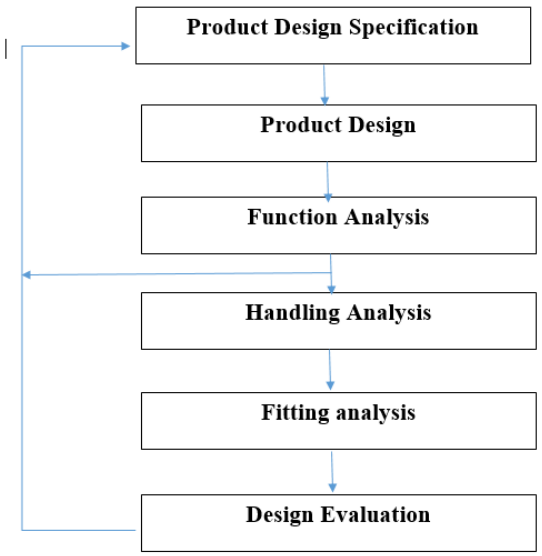

Fig 2 Lucas method

Fig 2 illustrates flowchart of Lucus method which comprises of three categories in the design process of a product, wherein it consists of Functional Analysis, Handling analysis and Fitting analysis. Before initiating the manufacturing and design process of a product, the "Product Design specification" (PDS) is developed that changes the requirement of the customer into engineering specifications. The design engineers will try to find alternate procedures for manufacturing the product which fulfil the requirement of customer. All the parts which are not essential are separated from the parts of the product which are essential that will reduce the cost of assembly, this will be termed as Functional analysis. The handling analysis is further divided into two stages i.e. Automatic hand ling analysis and manual handling analysis. The fitting analysis consist of method of sequencing the parts which are to be assembled in an assembly, wherein the gripping and fitting process is to be analysed. If this method is followed, the deficiency occurred in the design can be evaluated at the early stages of design.

1.2 Taguchi method:

Taguchi method consist of various stages of design for finding the optimum solution for the problems occurred in functioning of product. This method initially identifies the failure mode of the product then target the factors that need to be changed to

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avoid the problems such as noise and vibrations occurred during functioning of the product. Later the objective function is to be optimized and the factors are evaluated at each level according to their dependencies with one another and the optimized values are set off by an orthogonal array matrix experiment and further the data is to be analysed to eliminate the occurrence of failure. These values are set as standard values which can be further used as an optimum set of parameters.

2. LITERATURE SURVEY:

The literature shows that eliminating the redundant parts from the product along with an improvement in design of the product reduces the manufacturing and assembly cost. For example, a water nozzle comprising of 13 parts has been reduced to 8 parts by modifying the design. As a result, the manufacturing cost was reduced to 47.6% and the efficiency was increased from 23% to 25% , wherein "Teamset - Lucas Hull" base software was used to evaluate the product [1]. Some of the factors such as material, tooling, environment, testing, tolerance, etc. play a vital role in early stages of design of a product, these factor will make a significant impact on total lifecycle cost of the product. And these factors are termed as Design for X (DFX) [2]. Engineers design the products according to the principles or guidelines of DFMA, but all those principles are not universally applicable. Some DFMA principles must be adapted to a developing world context because there exist some differences in culture, customer needs, manufacturing capabilities and tradition. For example, the literature shows the method of redesigning a pineapple juice apparatus which is designed by using modified DFMA principles that validates the design with customer in the premises of amazon of Brazil, whereas farmer in this region sells one pineapple for 3 reais (the Brazillian currency), but juice of one pineapple was sold for 9 reais, so the juice making apparatus triples the income of the farmer [3]. One of the DFA tools used in DFMA is a Taguchi method for obtaining “robust design”, wherein to produce high quality products with low development and manufacturing cost. The literature shows an end milling cutter assembly comprising of two flutes, wherein two major tools are used in robust design which are signal to noise ratio that measures quality with emphasis on variation and orthogonal arrays that accommodate many design factors simultaneously. Various factors were chosen to evaluate signal to noise ratio to optimize the milling parameters to get better (i.e. low value) surface roughness and resultant force values [4]. There exist various categories of Design for X (DFX), wherein it consists of Design for manufacturing (DFM), Design for Assembly (DFA), Design for quality (DFQ), Design for Reliability (DFR), Design for Disassembly (DFD), Design for Maintainability (DFMa), Design for Obscelence (DFO), Design for Supply Chain (DFSC)., Design for logistics (DFL), Design for networks (DFN). If the systematic methods for analysis manufacturability of product design consisting of these factors are chosen then the difficulties coming across the manufacturing process will be avoided at early stages as the cost of product design and their manufacturing process planning does matters while developing a new product [5]. The literature shows that a slight change in design of a specific part of the product can bring a significant impact on the overall cost of the manufacturing process. For example, the redesigning of sheet metal parts of a “Swing line Classic 747 stapler” resulted in reduction of manufacturing cost of the stapler and the time required for manufacturing the parts was also reduced [6].

3. RESULTS AND CONCLUSION:

All the methods of DFMA proved to be very effective to increase the productiveness, decrease the cycle time and cost of manufacturing and assembly. These method helps to provide the best optimum solution for design and manufacturing. As compared to all traditional method of design and manufacturing of a product, DFMA shortens the time required for manufacturing, decrease the cycle

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time and maintain the quality of the product and increases the robustness of the design.

Methods used in DFMA provides systematic procedure for planning the whole product cycle right from the selection of the material to the final product entering into the market. Various alternative solutions for solving the problems occurring at an early stages of design are obtained. Analysing of various factors can be done at different levels according to their dependency with each other, wherein further the factors can be controlled to obtain the best optimum solution to overcome the problem.

3.1 Shortcomings of DFMA:

1) In case of Lucas Hull base software, it has an insufficient scientific base as number of parameters are added as an input such as materials, the functions of calculation of cost and cycle time, the parts which can and cannot be assembled, etc. to the database and let the software find all the possible combination to the final objective.

2) DFMA do not play any vital role at the conceptual design stage were much of the product cost is fixed.

3) This method cannot provide the suggestions to redesign a product by modifying the shape in case of an unsuitable design.

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