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Study on Calculation of Design Efficiency using Boothroyd Dewhurst Method for Lamp Holder

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Abstract: This paper presents a comprehensive analysis to examine the effectiveness of the Boothroyd Dewhurst Method for Assembly that is used to enhance the product design process. The Design efficiency of Lamp holder B22 was calculated by analyzing the number of necessary parts, manual handling time and manual insertion time. The product is then redesigned, considering the manufacturing and assembly aspects and a comparative study using Boothroyd Dewhurst Method was carried out between the original design A0 and modified design A1. Therefore, the modified design of Lamp holder was proposed to increase the design efficiency by minimizing the number of parts and incorporating multiple parts to single part. As a result, the design efficiency of modified design of Lamp holder has increased from 20.23% to 24.73% of around 4.5%.
Keywords: Boothroyd Dewhurst Method, Design for Manufacturing and Assembly (DFMA), Design Efficiency, Necessary Parts, Modified Design

I. INTRODUCTION

Design for Manufacturing and assembly (DFMA) is a strategy of product development to reduce the cost of production in order to compete with other producers, while increasing the profit margin[1]. Designers have been working for many years for potential development issues associated with a concept. Traditionally, the idea was that a competent designer should be familiar with manufacturing processes in order to avoid unnecessary additions to manufacturing costs[2]. The Boothroyd Dewhurst method profits from the reduction of the part count. Reducing part count not only saves assembly and manufacturing costs, but also saves labour, inventory, floor space, documentation and administration. In addition, a product with fewer parts should be of better quality because errors can be avoided. The original and the revamped products are contrasted to demonstrate that the new version would contain fewer components, thereby reducing costs, production time and service[3]. Assembly-oriented product design has a strong potential for simplification. Assembly costs are an significant factor in the total cost of the product. There is also a need for a particular technique for assembly-oriented product design[4]. In the case of manual assembly, parts are moved to workbenches where workers manually assemble the product or components of the product. Hand tools are typically used to support workers. Fixed or hard automation is defined by a custom-built system that assembles one and only one particular object. Obviously, this type of machinery requires a significant amount of capital expenditure. As the amount of output increases, the share of capital expenditure decreases relative to the overall cost of production[5]. Soft automation or robotic assembly includes the use of robotic assembly systems. It may be in the form of a single robot or a multi-station robotic mounting cell with all activities managed and coordinated simultaneously by a PLC or a computer. this form of assembly method may also have high capital costs, its versatility also helps reduce the expense over several different items[6].So based on the assembly technique, the products are redesigned to attain the effective way of producing a component. Using Boothroyd Dewhurst method the design efficiency of the product is calculated to provide the effectiveness of the manufacturing and assembly process based on the number of parts , time for manufacturing, time for material handling and insertion. So in this paper the design efficiency of Lamp holder is calculated and by applying modification to the product, the item is redesigned in such a way that the design efficiency of modified design is greater than the original product design.

II. AIM OF THE PAPER

The major purpose of this study is to determine the Design Efficiency using Boothroyd Dewhurst method and also to enhance the design efficiency through design modification. The objective below laid the foundation of the study:

A. To determine the Design efficiency Using Boothroyd Dewhurst method for Lamp holder by considering the minimum number of necessary parts, material and insertion time.
B. To determine whether the redesign of Lamp holder increases the final design efficiency of the product.

III. METHODOLOGY

A. *Product Selection*

In this study, a Lamp holder is chosen as a case study. Firstly the lamp holder was dismantled and then all the parts were measured using Vernier measuring tools. Creo Parametric software was used to develop the drawing of each individual component. Figure.1 represents the complete assembly model of the original lamp holder that is chosen for the study. Figure.2 represents the exploded view without the outer case. Then Boothroyd Dewhurst principle is applied to generate the design efficiency of the product.

Figure 1

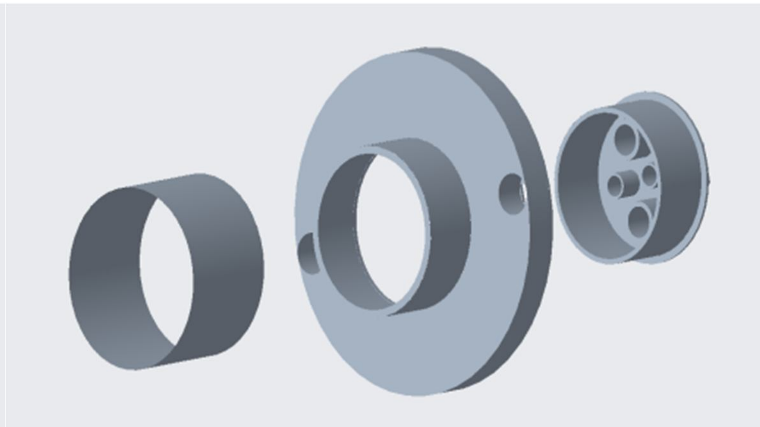

Figure 2

B. *Theoretical Minimum Parts*

The theoretical minimum part count for the system is essential for the identification and analysis based on three criteria. The theoretical minimum part/ essential part is an ideal situation in which separate components are combined into one single part when it meet any of the listed criteria . Necessary parts does not include the parts that are used for aesthetic purpose. Figure.3 gives the clear insight of the criteria being followed to identify the necessary parts being used for the product.

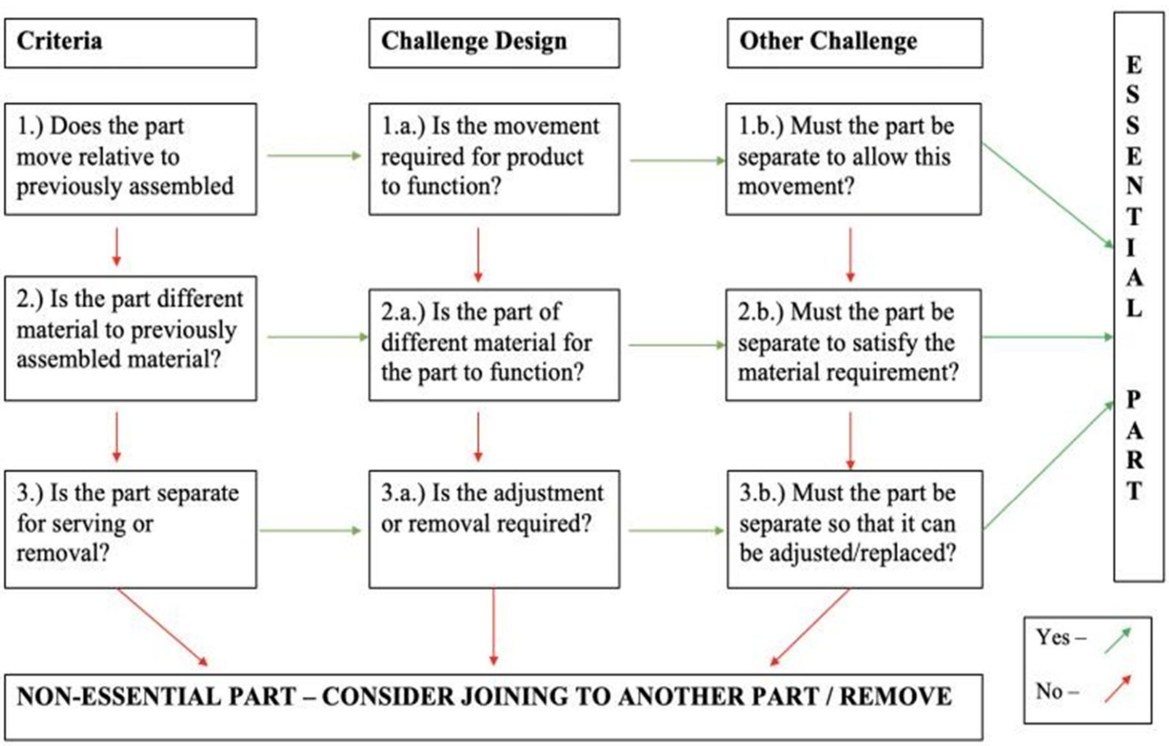

Figure 3

C. Design Efficiency

The Design efficiency of a product is calculated by the below quoted formula (1).

$$E = \frac{N_{min} \times t_a}{t_{tot}} \qquad (1)$$

where,

N_{min} = minimum number of essential parts

t_a = average assembly time

t_{tot} = total assembly for component (t_1+t_2+t_3…….)

*In Boothroyd Dewhurst manual process t_a is 3 seconds.

D. Design Efficiency Table

The total operation time which is required for design efficiency calculation is obtained from the standard tables. Manual handling time of the component is obtained by knowing if the product can be held with one hand or two hand or more than one man power is required. Based on the insertion process such as placement, fastening and so on , the manual insertion time of the component is obtained. So considering all the aspects such as necessity of the part, handling and insertion time, design efficiency table is created. With the final cumulative time , efficiency of the product is calculated.

Items	Number of Items	Handling code	Handling time	Insertion code	Insertion time	Total operation time	Essential part	Cumulative time
Plastic holder - Threaded	1	10	1.5	-	-	1.5	E	1.5
Insert holder - copper	2	21	4.2	06	11	15.2	E	16.7
Spring	2	21	4.2	00	9	13.2	E	29.9
Copper insert	2	21	4.2	37	18	22.2	E	52.1
Brass frame	1	12	2.06	35	7	9.06	E	61.16
Rivet	2	19	6.76	91	14	20.16	E	81.32
Screw	2	02	3.76	92	5	8.76	E	90.08
Base cover	1	30	1.95	00	1.5	3.45	E	93.53
Plastic case - threaded	1	13	2.06	92	5	7.06	NE	100.59
Outer case	1	30	1.95	92	5	6.95	NE	107.54
Clamp to hold in wall	1	13	2.06	98	9	11.06	NE	118.6

Table.1

Design Efficiency = $E = \frac{N_{min} \times t_a}{t_{tot}}$

Design Efficiency = $E = \frac{8 \times 3}{118.6}$ = 20.23%

IV. REDESIGN OF PRODUCT

A. Product redesign

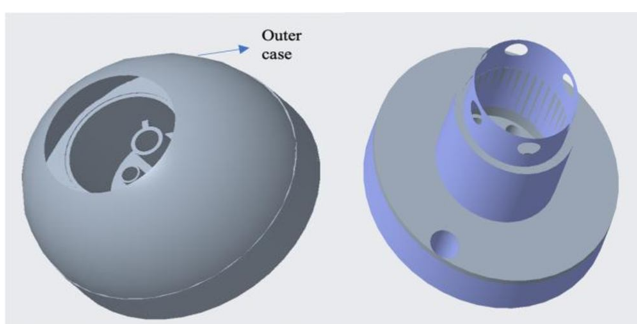

Figure 3.1 – Original Design Figure 3.2 – Modified Design

From the Figure 3.1 and 3.2 it is observed that, the outer case used in the original design has been removed to minimize the complexity of the structure. According the theoretical minimum part, we can eliminate the outer case because it is used for aesthetic purpose.

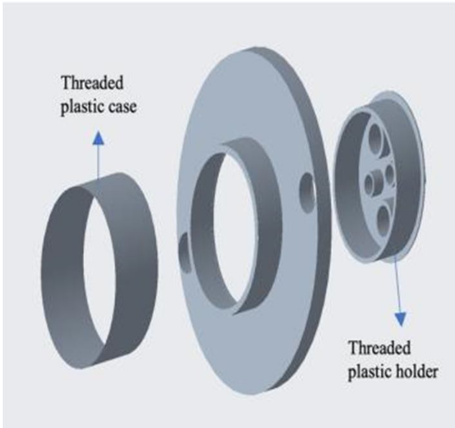

Figure 4.1 – Original Design

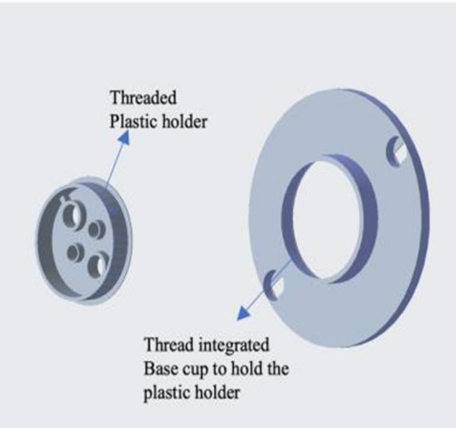

Figure 4.2 – Modified Design

From the Figure 4.1 and 4.2 we can note that a part has been eliminated. Elimination is based in the fact that, in original design, threaded plastic case is used to hold the plastic holder, whereas in in modified design the thread has been integrated in the base case to eliminate a part.

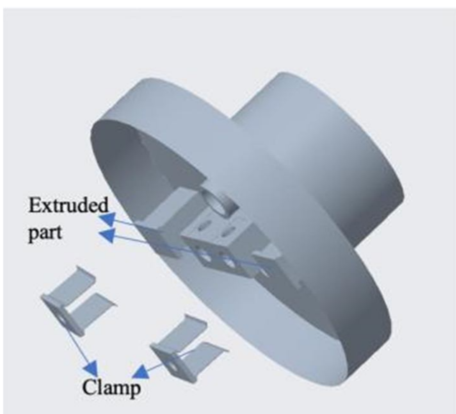

Figure 5.1 – Original Design

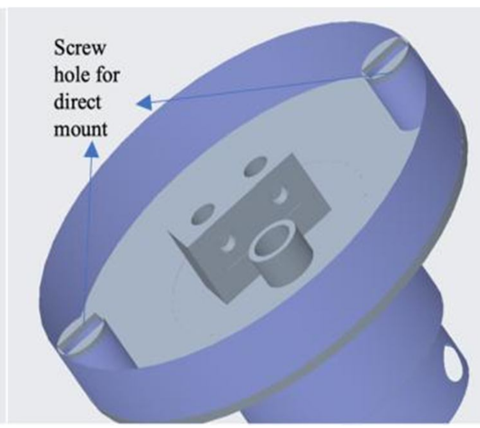

Figure 5.2 – Modified Design

From Figure 5.1 and 5.2 , the method of mounting the bulb holder has been changed. In original design, first two clamps has to be fixed on the wall with screw fastening and then the holder is clamped against the wall with the help of wall mount, whereas in modified design the screw holes are directly provided in the base cup itself to reduce the number if parts.

B. *Recalculation of Design Efficiency for Modified design*

Items	Number of Items	Handling code	Handling time	Insertion code	Insertion time	Total operation time	Essential part	Cumulative time
Plastic holder - Threaded	1	10	1.5	-	-	1.5	E	1.5
Insert holder	2	21	4.2	06	11	15.2	E	16.7
Spring	2	21	4.2	00	9	13.2	E	29.9
Copper insert	2	21	4.2	37	18	22.2	E	52.1
Brass frame	1	12	2.06	35	7	9.06	E	61.16
Rivet	2	19	6.76	91	14	20.16	E	81.32
Screw	2	02	3.76	92	5	8.76	E	90.08
Base cover	1	30	1.95	92	5	6.95	E	97.03

Design Efficiency = $E = \frac{N_{min} \times t_a}{t_{tot}}$

Design Efficiency = $E = \frac{8 \times 3}{97.03}$= 24.73%

V. RESULT AND DISCUSSION

A. Result

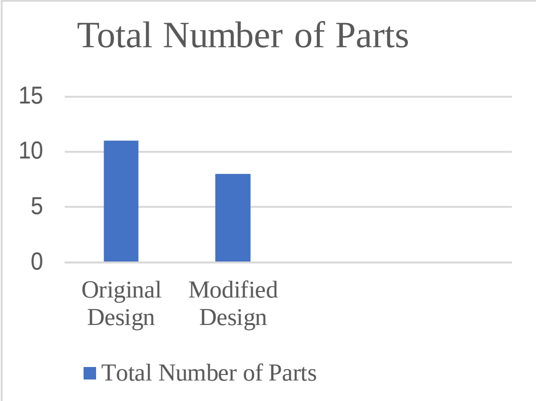

Figure 6.1

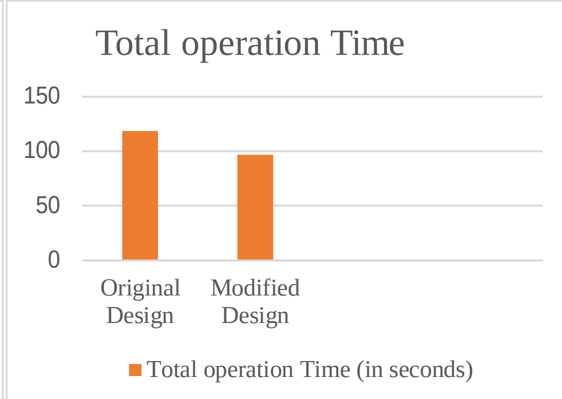

Figure 6.2

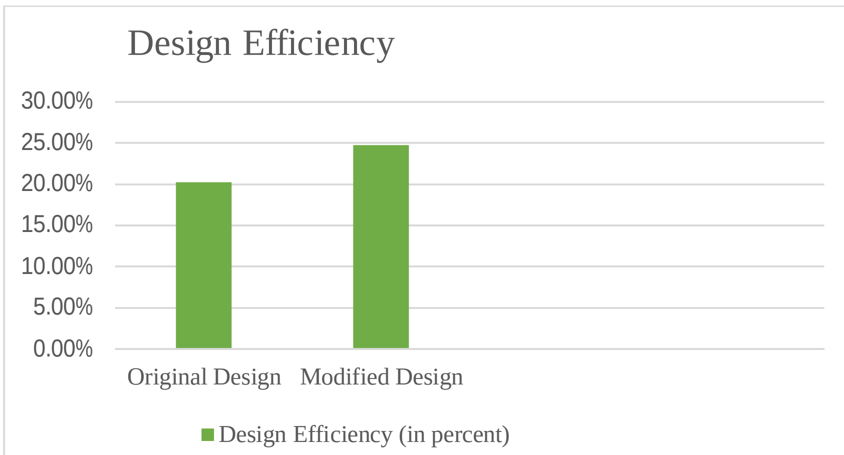

Figure 6.3

B. Discussion

1) Total number of components has been decreased on considering the Boothroyd Dewhurst DFMA approach
2) Total operation time for assembly has been decreased with modification in product design.
3) Design Efficiency of the product increase with decrease in total number of parts and decrease in total operation time.

VI. SUMMARY

A. Initially the product is dismantled and CAD drawing is done for each individual component.
B. By applying the DFMA theoretical number of parts , the total number of essential parts has been obtained .
C. Calculation of Design Efficiency has be carried with the help of determining the total handling and insertion time for individual part.
D. The product is then redesigned and again the Design efficiency of the product is obtained.
E. The obtained results are in match with the DFMA principle.

VII. CONCLUSION

The number of components and assembly strategy are the basic elements that influence a product's expected productivity. By considering the Boothroyd Dewhurst method, the product has been redesigned and the total number of components of Lamp holder has been reduced from 11 to 8, the total time of operation for assembly has been decreased from 118.6 to 97.03 sec. This in turn increases the Design efficiency of product from 20.23% to 24.73% of around 4.5%. Thus through this study the DFMA principle is proved, that when number of components decreases , time for operation decreases and finally design efficiency.

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