DFMA for Early Cost Estimation of Pedestal Fan - A Case Study

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***Abstract*—Design for manufacturing and assembly (DFMA) is a developing analysis tool for all industries that are providing designing services and also for those who are into manufacturing. DFMA plays a key role in helping analyze the costing of a product before being manufactured. DFMA is implemented in the early design stages of a product. Improper design, unplanned manufacturing and assembly practices are the major factors leading to increased cost of product. This is where DFMA comes as a boon to the industries involved in design and production. This paper presents a case study on the application of DFMA in the cost minimization of a pedestal fan, which if widely used in domestic households and office spaces. Solid works software was used to generate the CAD models of the pedestal fan which was further analyzed using the DFMA software tool. Costing results of the existing pedestal fan was compared to that of the re-designed model.**

***Index Terms*—product design, Design for Assembly (DFA), Design for Manufacture (DFM), Design for Manufacture and Assembly (DFMA)**

I. Introduction

Companies worldwide are competing to cut the cost of their product and thereby increase the profits. DFMA thus enables the engineers to adapt a methodology to evaluate the assembly and manufacturability of a product in order to aid its production. Studies by Boothroyd [1] showed that Cost optimization of a product thus begins at early design stages. Design for Assembly (DFA) and Design for Manufacturing (DFM).

Cost data is rarely available for the designer in the usable form. According to the study conducted by Katja. T *et al.* [2], Design for Manufacture and Assembly (DFMA) software can be used to investigate the possibilities of activity based costing, modelling, purchasing and manufacturing processes in providing useful costing information to the designers. A complete DFMA analysis helps to give a categorical approach to the cost to be infused with each division within a firm to help use all resources to the most optimized capabilities which in the end help provide more efficient product to the consumers. This was brought out from the studies by Mark Oakley [3]. M. L. Phillot *et al* [4] through his studies proposed a parametric model for providing manufacturing cost information to engineers at early design stages. The availability of vast range of consumer products like washing machine, mixers etc is the primary reason to take up consumer products for DFMA analysis as they have huge potential for cost reduction [5].

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II. Pedestal Fan – A Case Study

Pedestal fans are also considered oscillating fans. They have an adjustable metal stand so the head of the fan can be set anywhere from 2 to 4 feet off the ground. Also, the head connects to the pedestal on a platform which can be angled up or down. Inside, the fan head is comprised primarily of an alternating current electric motor with a secondary output which attaches to a worm gear at the base of the platform.

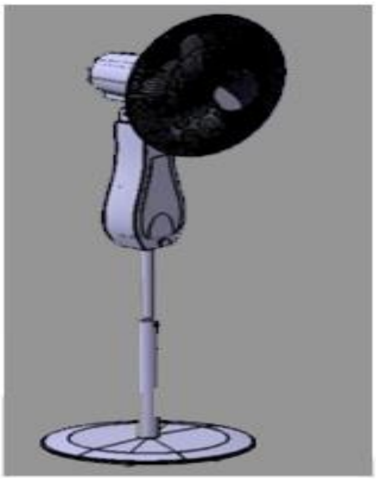

Figure 1. Existing Pedestal Fan Model.

Traditional design of pedestal fan available in market are of two types namely, Single speed and multi speed fans. Multi speed pedestal fans are a little more complex, using a voltage regulator connected to a single phase AC synchronous motor. Because of its complexity, the fan head is bulkier as compared to single speed fans. In this study a multi speed pedestal fan is selected for DFMA

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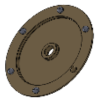
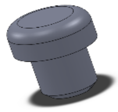
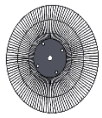
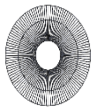
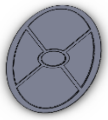
analysis. The CAD model of the existing design is shown in Fig. 1. Using the solid view tool the 3D images are imported to the DFMA analysis tool. The re designed model as shown in Fig. 2 is also subjected to DFMA analysis.

Figure 2. Re-designed Pedestal Fan.

Some of the main parts in the pedestal fan are: fan blades, bottom bulk, front grill, rear grill, cross leg bar, motor housing and some of the manufacturing processes included are: injection molding, cutting (automated), fitting and assembly, tooling and turning, pressing by dies, painting, die punching, metal cleaning. The CAD model of the major parts of pedestal fan is shown in Table I. CAD models of individual parts are created and assembly is done. Each part is thereby made to undergo the analysis on the DFMA tool. CAD models of a few designs are shown in the table alongside.

TABLE I. CAD MODEL OF PEDESTAL FAN MAJOR PARTS

Part Name	CAD Model	Part Name	CAD Model
Fan blades		Hollow support shaft	
Bottom Bulk		Locking screw	
Back grill cover		Motor housing	
Front grill cover		Buttons	

A. *DFM and Concurrent Costing of Pedestal Fan Components*

To estimate the manufacturing cost, it is necessary to give the cost of material, hourly rate for manufacturing and labour cost. Manufacturing cost for each part is estimated with a batch size of 10,000 each. Table II below is the record of the manufacturing cost of the parts created. Part name, quantity and process of manufacturing are to be given as inputs. Cost of manufacturing is thus obtained.

TABLE II. DFM COSTING ANALYSIS OF THE FINAL ASSEMBLY

Sl. No	Part Designation	Part Name	Total Count	Process	Total Cost($)
1.	Part 1	Hollow support shaft	1	Machined	27.04
2.	Part 4	Shafts lock cap	1	Injection modeling	0.49
3.	Part 5	Wire	1	Injection molding	0.35
4.	Part 6	Motor housing	1	Blow modeling	0.16
5.	Part 8	Ring	1	Injection molding	1.06
6.	Part 9	Rotating big shaft	1	Machined	0.13
7.	Part 10	Rotating lean shaft	1	Machined	0.01
8.	Part 11	Rotating support	1	Injection molding	1.88
9.	Part 12	Inner shaft with collar	1	Machined	13.55
10.	Part 16	Buttons	1	Injection molding	0.56
11.	Part 17	Electric Housing front	1	Injection molding	3.32
12.	Part 18	Electric housing back	1	Injection molding	1.67
13.	Part 19	Fan with nub	1	Injection molding	1.75
14.	Part 20	Front grill cover	1	Assembly fabrication	0.35
15.	Part 21	Bolt	1	Machined	0.01
16.	Part 22	Bottom bulk support	1	Injection molding	3.71
17.	Part 23	Back grill cover	1	Assembly fabrication	0.35
Total Cost					56.39

TABLE III. DFA OF FINAL ASSEMBLY

Per Product data	Entities (Including repeats)	Number of Different Parts	Total Assembly Time (s)	Labour Cost ($)
Component Parts	1	1	3.45	0.03
Subassemblies Partially or Fully Analyzed	0	0	0.00	0.00
Subassemblies (named only)	16	14	210.40	2.06

Subassemblies not to be Analyzed (excluded)	0	0	0.00	0.00
Standard and Library Operations	0	0	0.00	0.00
Total	17	15	213.85	2.09

TABLE IV. DFA ANALYSIS OF RE-DESIGNED PRODUCT

Part Name	Quantity	Time Savings, s	Percentage Reduction, %
Bottom bulk	1	1.50	0.66
Bottom bulk support	1	1.50	0.66
Hallow support shaft	1	1.50	0.66
Bottom lock washer	1	1.50	0.66
Lock pin	1	1.50	0.66
Inner shaft with collar	1	1.50	0.66
Electric housing from	1	1.50	0.66
Electric housing back	1	1.50	0.66
Rotating support	1	1.50	0.66
Rotating big shaft	1	1.50	0.66
Motor housing	1	1.50	0.66
Back grill cover	1	1.50	0.66
Fan wing nub	1	1.50	0.66
Front grill cover	1	1.50	0.66
Ring	1	1.50	0.66
Wire	1	1.50	0.66
Total	16	34.40	15.17

B. DFA and Concurrent Costing of Pedestal Fan Assembly

Table-3 below shows the costing of the final assembly of parts of the designed pedestal fan. Total number of parts is 23. Total assembly time was calculated to 213.85 seconds and the overalllabour cost as $2.09.

C. Re-design and Analysis of Re-designed Pedestal Fan

After the re-design process, the new designs are again subject to analysis by DFMA. The design for assembly (DFA) results of the new design is shown in table-4. Total part count is now found to be 16. Total time saving in assembly was obtained as 34.40 seconds which in terms of percentage is 15.17.

III. CONCLUSION

DFMA is an age old proven method that helps cost cutting of products at early design stages. DFMA has not been implemented by many industries. This may be due to the constraints in the methods of incorporating DFMA in to an industry. Our study has shown that implementation of DFMA is not unique and the procedure is easy to adapt for any industry that aims to build good quality products for clients by reducing the cost of production. Comparison in costing of the pedestal fan after the re-design with the former showed a reduction of $ 4.1061 per pedestal fan.

Total number of parts was reduced by one. Assembly time for the product after the re-design was found to be 34.40 seconds which in-turn is a percentage reduction of 15.17. For a volume of 10,000 units of pedestal fans, this proves to be of a great financial benefit to the manufacturer. DFMA can be used on a lot more products that hold great importance in our daily lives. This will help the manufacturers to bring out new products as well as enable a wide choice and ensure good quality products at the buyers end.

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