Research Progress in Mechanical and Manufacturing Engineering Vol. 4 No. 1 (2023) 246-251
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RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773 - 4765

Design for Manufacture and Assembly (DFMA) of Chainsaw Housing

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DOI: https://doi.org/10.30880/rpmme.2023.04.01.026
Received 25 August 2022; Accepted 31 January 2023; Available online 28 February 2023

Abstract: This research uses DFMA to analyse 372 XP Husqvarna chainsaws. DFMA is an approach for redesigning a product to reduce costs, manufacturing time, and components. This research aims to apply DFMA analysis and compare actual and redesigned model outcomes. Only 72 of the 322-part model were studied. Through the analysis of DFM, the material and manufacturing method for both remain the same. Manual Design for Analysis (DFA) analysis shows that the present design is 10.44% efficient while the modified model is 11.31% efficient with an improvement of 0.876%. Actual model creation takes 862.15 seconds, whereas redesigned model only took 742.65 seconds. Thus, the new model can be made faster. DFA software was used to analyse assembly time, number of entries, DFA index, and product cost. The new model takes 753.74 seconds and 135 entries. The actual model takes 859.30 seconds; therefore, this saves 105.56 seconds. The result for the DFA index 5.8 and 6.6 is for the actual and redesigned models. Overall product costs have fallen 1.26 %, from RM 362.88 to RM 358.32. Comparing manual and software DFA. Manual and software analysis differ by 0.33 % for the existing model and 1.48 % for the modified model with 12.38 % faster.

Keywords: DFMA, DFM, DFA

1. Introduction

The structure of the chainsaw may not seem to be very sophisticated from the outside, but it is rather intricate on the inside. Thus, producing it will take a considerable amount of time. Nowadays, manufacturers want something that is straightforward and economical. Most industries are working toward the goal of producing high-quality goods while also preserving their existing manufacturing costs. The method known as Design for Manufacturing and Assembly (DFMA) should be used whenever it is practical to increase both the pace of production and the amount of time spent on it. There have not been many products that have implemented DFMA based on the already established design that is already available on the market. Thus, more investigation is required. Therefore, the aim of this study is to implement the DFMA analysis on the existing chainsaw and compare the cost and assembly time between the existing model and redesigned model

1.1 Design for Manufacturing and Assembly (DFMA)

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DFMA is a useful way of optimizing a design for mass production at an early stage, ensuring that the product can be manufactured and assembled in an efficient and effective manner [1]. It may also be worthwhile to do a DFMA study on an existing product in order to cut costs while simultaneously improving quality. DFMA tools are effective in lowering the amount of time required to review designs, and as a result, should be included in the design selection process [1].

Design For Assembly is an approach for analysing component designs and the overall design of an assembly. It is a measurable approach to detecting unneeded pieces in an assembly and to determining assembly times and costs. The DFA approach is used to estimate the costs of fabrication in various scenarios involving different fabrication methods [2]. The combination of the two methodologies makes it feasible to estimate the costs of items while simultaneously increasing their competitiveness and efficiency [1].

Design for manufacture (DFM) is a field in which things are designed in such a way that is as simple and cost-effective to create as feasible [3]. Design for manufacturing (DFM) is closely related to design for assembly (DFA), but although DFM is primarily concerned with the manufacturing of separate components, DFA is concerned with the methods of assembling them. Given that most components are integrated into increasingly complicated products, the ability to assemble them efficiently is also crucial, and as a result, these two disciplines are often regarded combined, as designed for manufacture and assembly (DFMA) [3].

1.2 Boothroyd Dewhurst Analysis

In this research, the Boothroyd Dewhurst method will be used. Four important indicators are produced by the adoption of this methodology: product assembly time ™, product assembly cost (CM), minimal number of components (NM), and design efficiency (EM).[2]. Geoffrey Boothroyd, a professor at the University of Massachusetts, started developing the Boothroyd Dewhurst approach in the early 1970s. However, it wasn’t until the 1980s that the method approach was fully established and implemented. Using this technique, the application attempts to enhance the assimilability of the product by focusing on two principles which are minimizing assembly procedures by lowering the number of pieces and making assembly operations more convenient to execute [2].

1.3 Chainsaw

A chainsaw is a mechanical saw that is portable and powered by a two-stroke motor. The saw can chop down all sorts of trees because of its sharp cutting teeth, which travel at a fast speed around the machine’s guide bar [4]. The chainsaw may be a harmful product if it is used incorrectly. It is composed of two primary components: a saw blade that is integrated into a chain and is wrapped around a long metal guide bar, and a compact gasoline engine with one cylinder.

The chain looks a little bit like a bicycle chain since it runs around sprockets, but it has around 30 or so sharp teeth produced from a hardened steel alloy attached at intervals around it instead of bicycle cogs. When a piston goes in and out of a cylinder, it exerts a force on a connecting rod, which in turn rotates a crankshaft. The engines inside the crankshaft rotate gears that are attached to one of the sprockets on which the chain is placed via a centrifugal clutch. This causes the chain to rotate around the other sprockets.

2. Materials and Methods

Figure 1 shows the research approach. First, studies the chainsaw to discover all important information. Assembling the conceptual system helps understand the operating mechanism. To complete the work, a gasoline-powered chainsaw is being used. During the selection phase, each model component will be examined. Later, the existing model was examined using DFA and DFM analysis. Interpretation of the findings took place when it has been validated. To reduce the number of parts, changes in the manner of attaching them has been made.

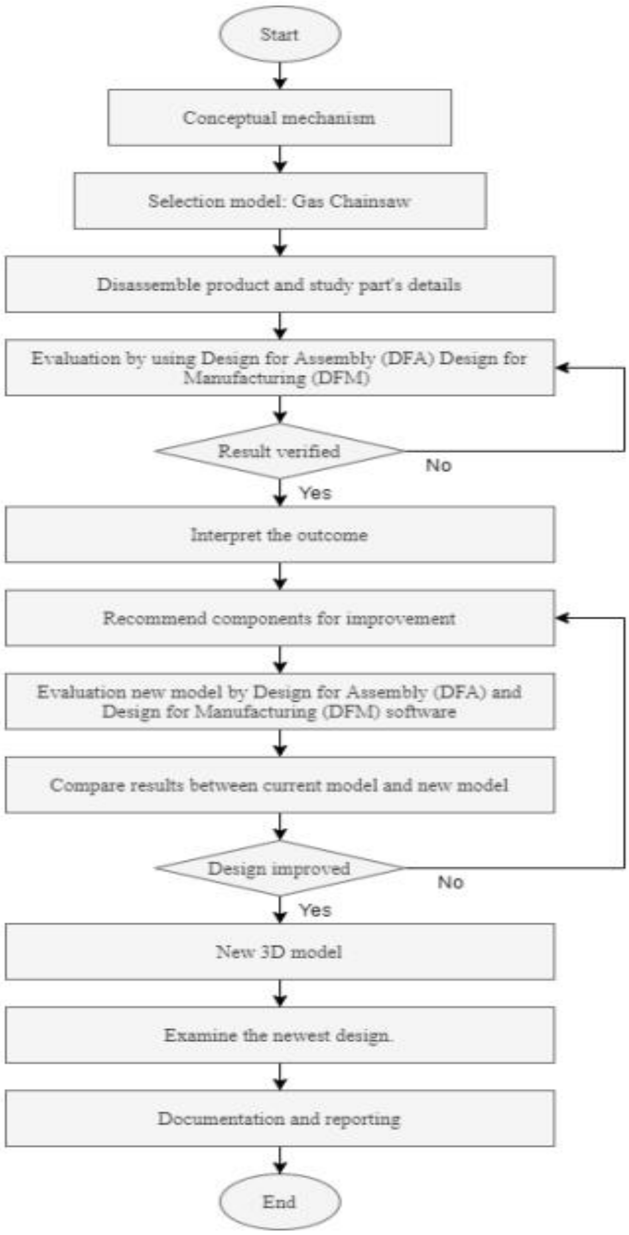

Figure 1 The Flow of The Research

After that, the design for manufacturing and assembly (DFMA) software was used to assess the redesigned model. An evaluation of both current and proposed designs showed that a gas chainsaw with a new design that reduced costs while also lowering the number of components and material costs had the highest efficiency. A comparison of actual and suggested designs was made. If the technique does not increase design efficiency, it will revert to the suggested changes. Once the result is accepted, the new 3D model was created using SolidWorks and analysis was done.

3. Results and Discussion

There are three analyses involved in this research, which is DFM, DFA manual and DFA software analysis The result for the DFA manual and software can be seen as shown in the Table 1 and Figure 2. However, as for the DFM analysis result, with the involvement of 27 parts of the component that have been analysed, the total manufacture price for the analysed component is RM 413.15.

3.1 Results

Table 1 and Figure 2 show the difference in the amount of time spent on assembly work between manual analysis and software analysis. The findings indicate that the amount of time spent on assembly work is reduced from the actual model to the redesigned model, and this is true whether the study was performed manually or by software. As a result, the percentage difference between software and manual analysis for the existing model is only 0.33 percent, and the same can be said for the redesigned model, where the difference is only 1.48 percent. Therefore, the outcome may be considered valid.

Table 1: Comparison between DFA manual and software analysis

	Total Assembly Labor Time, s		Percentage Difference
	Manual	Software	
Actual Model	862.15	859.30	0.33%
Redesigned Model	742.65	753.74	1.48%
Time Difference	119.5	105.56	12.38%
Percentage of Reduction	14.89%	13.09%	

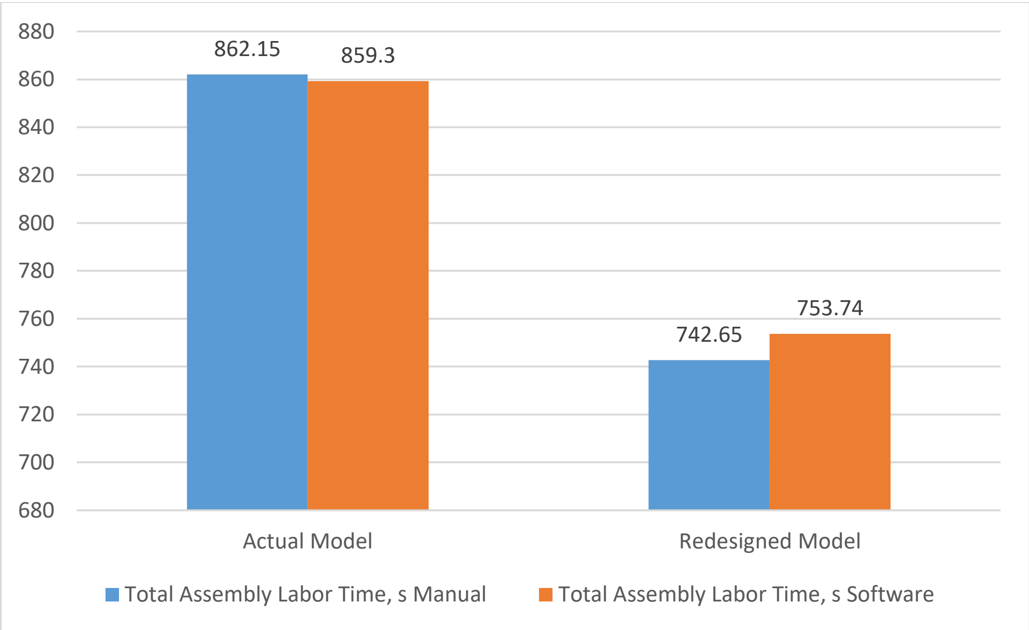

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Figure 2: Total assembly labor time difference between software and manual analysis

Table 2: Comparison between actual and redesigned overall software analysis

	Actual	Redesigned	Difference	Percentage Difference
Number of Entries	135	116	19	15.14%
DFA index	5.8	6.6	0.8	12.90%
Total assembly Labor Time,s	859.30	753.74	105.56	13.09%
Total Cost Per Product, RM	362.88	358.32	4.56	1.26%
Design Efficiency, %	10.44	11.31	0.87	0.87%

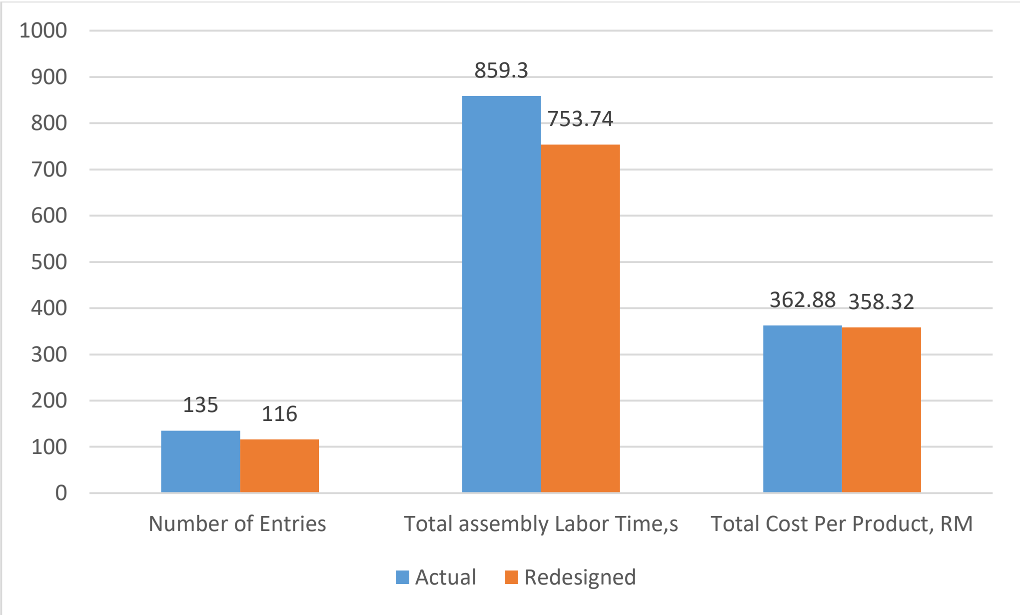

Figure 3: Difference between actual and redesigned

The differences between the actual model and the redesigned model are shown in Table3 and Figure 3 respectively, and these differences are shown in terms of the total cost per product, the total assembly labour time, and the number of entries. All these data reveal a decline in numbers when comparing the actual model to the one that was altered. On the other hand, when compared to the actual model, the value of the redesigned model has been shown to have a higher DFA index. The DFA Index, which is an essential part of the DFA, provides a means for measuring how efficient the assembly process is. It is a ratio that contrasts the amount of time it takes to put something together with the amount of time it would take in perfect circumstances. On this scale, which ranges from 0 to 100, a higher score indicates a more efficient overall design. As a result, it is possible to demonstrate that the concept behind the redesigned model is more efficient than the concept behind the actual model.

4. Conclusion

In conclusion, the objective of this research is achieved as all the results for the redesigned model are lower compared to the actual model except for the value of the DFA index. However, the higher the DFA index the more efficient the design will be. Thus, it is proven that the redesigned model is greater compared to the actual model in terms of the assembly factor. Hence, although the objective was achieved, there are still flaws in this research, thus further studies are required in other to improve the result obtained. Therefore, based on this research there are several suggestions can be made in order to improve the use of DFMA analysis and make it more effective by ensuring that all part of the product is included in the analysis with an accurate dimension, material, manufacturing method, ways of handling and insertion method. Other than that, the selection of the best material for a component with a certain purpose, contrast the DFMA analysis with Ansys, Solidwork or any suitable software and run a strength test to fit the purpose of the product.

Acknowledgement

The authors would like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Dejene, N. D., & Nemomsa, S. K. (2020). Design for Manufacturing and Assembly-Review.

[2] Ezpeleta, I., Justel, D., Bereau, U., & Zubelzu, J. (2019). DFA-SPDP, a new DFA method to improve the assembly during all the product development phases. Procedia CIRP, 84, 673-679.

[3] 2019Geoffrey.B, Peter.D, & W.A. Knight (2011). Product Design for Manufacture and Assembly. 3rd E. Broken Sound Parkway NW;CRC Press.

[4] Kaljun, J., & Dolsak, B. (2012). Ergonomic design recommendations based on an actual chainsaw design: case study. South African Journal of Industrial Engineering, 23(2), 215-229.