DESIGN FOR MANUFACTURE AND ASSEMBLY ANALYSIS OF BABY STROLLER

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ABSTRACT: This paper presents the study design analysis for manufacture and assembly (DFMA) of a baby stroller (Sweet Cherry SCR8 Series) in the aspect of part for manufacturing, assembly process and also handling and insertion difficulties. The problem identified in this study is on the features of the stroller that show a lot of fastener being used and also the usage of both hands in moving the fold latch to fold the stroller. The study has proven to save assembly time by 452.29s which is 23% more efficient than the original design. The number of parts reduced from 179 parts to be 149 parts. The DFA index is also improved from 9.6 to 12.6. The advantages of using DFMA method has been proved in the redesign of the baby stroller. Lastly, the analyzed results are discussed at the end of this research.

KEYWORDS: *DFMA; Baby Stroller; Design for Manufacturing*

1.0 INTRODUCTION

Nowadays hundreds of stroller models [1-3] are available with different branded and quality. The features of the stroller to be different and unique depends on the designer and company intention to be focused. However, manufacturing process [4-6] is the important things to be considered as it will affect the price of the product itself. In a production of a baby stroller, the features show a lot of fastener being used as the structure need to be foldable. Hence, this project is focusing on analyzing the design of a baby stroller in order to reduce

cost then improve the manufacturing and assembly process. Sweet Cherry SCR 8 Series Stroller has been used for this analysis [7]. Sweet Cherry is a brand for the baby stroller.

Design for Manufacture and Assembly in which being is known as DFMA generally is a combination of Design for Assembly (DFA) [8-9] and Design for Manufacturing (DFM) [10-11]. Through a history of DFMA [12-13], it had been used before the Second World War by Ford and Chrysler that using DFM philosophy in their design and manufacturing process of the weapons, tanks and other military products. Early 1970's the researching job of this new technology had been done by Professors Peter Dewhurst and Geoffrey Boothroyd who originated the Boothroyd Dewhurst, Inc. (BDI) in 1983 [14]. Initially on comprehensive work studies, relating part characteristics to handling, fitting times and degrees of difficulties etc., their work was the genesis of the concept of "scoring" designs for DFA or DFM. Currently, Boothroyd Dewhurst methodology was the inspiration for many of its successors around the world. Boothroyd Dewhurst's, Inc. DFMA software is designed to be used at the concept design stage. The aim is to optimize a design for manufacture and assembly before commitment to detail design and manufacture. The DFMA package contains a DFA module and DFM module. This project fundamentally focused on the design analysis of Sweet Cherry SCR 8 Series Stroller by implementing DFMA method. Hence, Boothroyd Dewhurst methodology had been used to complete this project.

Nowadays, there are a lot of distinct processes which all influence product cost, quality, and productivity of system that cause a huge loss to Business Company. This is because a lot of product is made up of fasteners and redundant features [15]. Boothroyd Dewhurst DFA method could help to overcome the problem by suggested the idle possible way assemble a product with remove fastener. In a production of a baby stroller, from the features show a lot of fasteners such as screw, rivet and much more as the structure need to be foldable. Hence, this project had analyzed the design for assembly to reduce parts as well as the cost of production and come out with some improvement of the design in an efficient way.

2.0 EXPERIMENTAL

In order to achieve the objectives, analysis methods that being used are designed for assembly (DFA)

2.1 Original Design for Sweet Cherry SCR 8 Series

Figure 1 shows that original design of stroller that been used for DFA analysis. The analysis could be performed with the following method. In order to ensure the process is done smoothly. The methods are as follows:

i. Disassembled all the parts and components
ii. Took and recorded the dimension for every each of part
iii. The structure chart was build according to the assembly of the product.
iv. The DFA analysis carried out through DFA software.
v. Suggestion for the redesign was evaluated to improve the design of the stroller.

Figure 1: The original design of Sweet Cherry SCR 8 Series Stroller

2.2 Design for Assembly (DFA) of the Original Product

The evaluation properties are namely as an item type, securing method, minimum part criteria, envelope dimension, and symmetry of the part (alpha and beta symmetry), handling difficulties and insertion difficulties. By using DFA analysis, the basic criteria and the existence of each part are questioned and the designer needs to provide the reasons why the part cannot be eliminated or combine with others as shown in Figure 2.

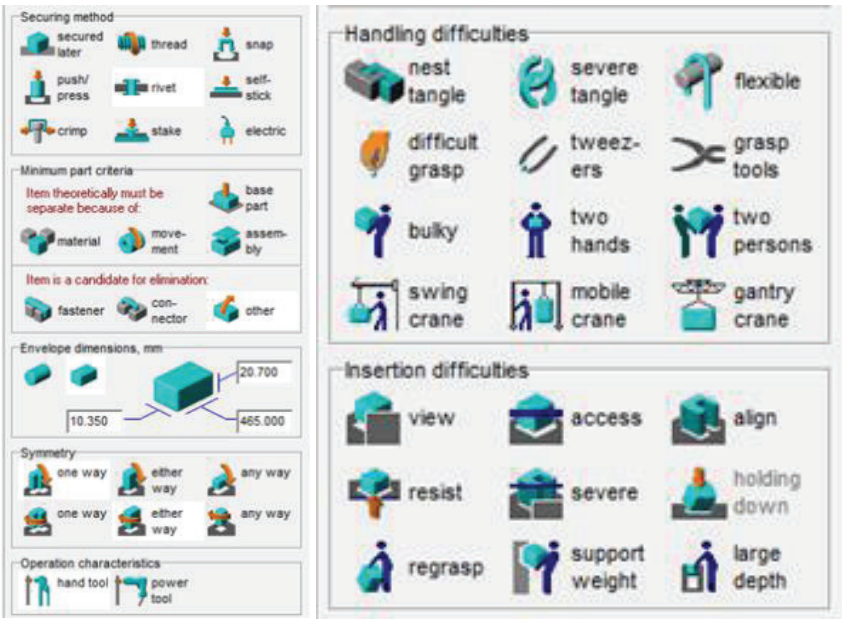


Figure 2: The evaluation properties interface in boothroyd analysis software

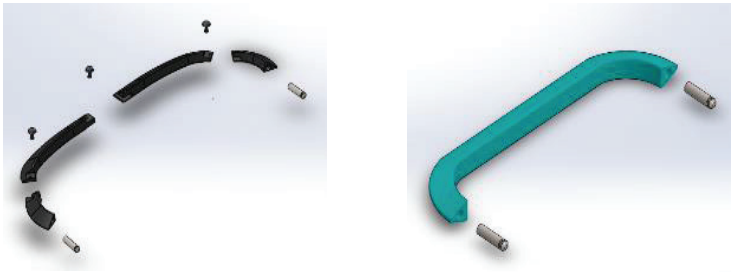
2.3 Research Methodology

2.3.1 Design for Assembly (DFA) software

i. In this stage, construct a structure chart to identified sub-assemblies and part of the whole assembly.
ii. Next, the user is required to answer DFA question precisely; minimum part criteria, securing method, envelop dimension, symmetry of the part, handling and insertion difficulty.

2.3.2 Redesign of the front bar of baby stroller

i. There is some unnecessary part that suggested by the software to eliminate or combine.
ii. Figure 3 shows the design of front bar before and after improvement based on the analysis gathered.



(a) (b)

Figure 3: Design Comparison of front bar, (a) original and (b) redesign

Based on Table 1, the minimum part criteria for the front bar A and front bar B is 2 meanwhile for handle the value is 1. For the securing method, rivet had been chosen because both of front bar A and front bar b are connected together and can be moved about 60 degrees with the rivet secured. The symmetry (the orientation of product) chosen for the front bar and handle is only one way of alpha and also one way for beta symmetry.

Table 1: DFA analysis of front bar part and handle part

Part Name	Part Number	Repeat Count	Item Type	Securing Method	Minimum Part Criteria	Symmetry		Handling Difficulties	Insertion Difficulties
						α	β		
Front bar A	FB-a1	2	Part	Rivet	Other	One	One	None	Holding Down
Front bar B	FB-b1	2	Part	Rivet	Base	One	One	None	Holding Down
Handle	H-1	1	Part	Secured Later	Base	One	One	None	View

In this case, there are no handling difficulties but the insertion difficulties at a front bar have been set as holding down. This is because rivet required an enough way of holding down to ensure the part can be secured correctly. Meanwhile, for the handle, the insertion difficulties have to be set as view due to the inner component of the handle that needs to be considered.

2.4 Redesign of Front Bar for Sweet Cherry SCR 8 Stroller

The design had been improved from the original design to new design in order to compare the efficiency before and after analysis. The design had been simplified to make it more reliable in term of manufacturing cost and assembly time. Figure 4 shows the redesign of the Sweet Cherry SCR8 stroller.

Figure 4: Redesign of front bar for sweet Cherry SCR8 stroller

No	Part Name	Quantity
1	Front Bar	1
2	Shaft (stainless steel)	2
Total		**3**

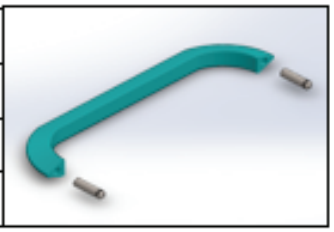


Figure 5: Exploded view of front bar sub-assembly and bill of material

Figure 5 shows the exploded view the improvement design of Sweet Cherry SCR8 stroller. The new design reduced from 9 parts to be 3 parts. The new design eliminates the usage of the rivet and makes it just a simple design of front bar that could not fold as compared to the original one. This is because the function of front bar is unnecessary to fold hence the amount of fastener can be reduced. The suggestion of part had been stated in DFA analysis as it was assigned to others in the minimum part criteria to make it an idle candidate to be eliminated.

Originally, handle part as shown in Figure 6 is not connected to the folding system of the stroller. But after the redesign, the button to fold the stroller had been changed to the handle to make it easier for a user to fold the stroller just by using one hand only. This is because, for the original design, user needs to use both hands to conduct the fold latch (right and left side) simultaneously to fold the stroller

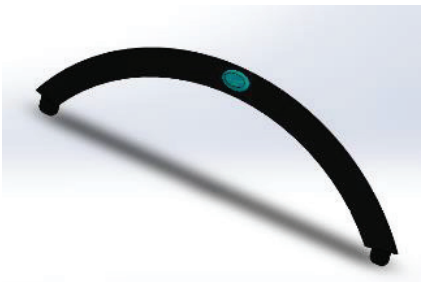


Figure 6: Exploded view of handle sub-assembly and bill-of material

2.5 Suggestion for Redesign of Baby Stroller

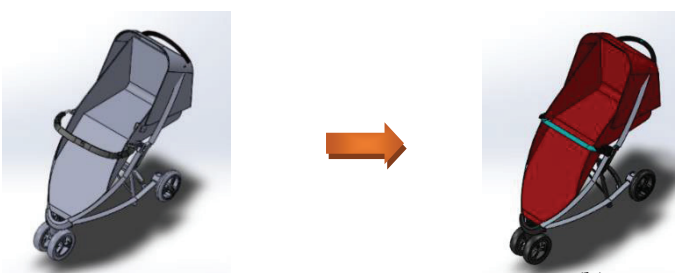
In order to minimize the part count of the assembly, DFA analysis is an idle method to identify a suitable part to eliminate or simplify the design by giving suggestion and also design improvement. The analysis also helps in summarized the information by breaking down the area for design improvement and listed all the entries in certain categories. DFA analysis stated which part to be eliminated, modified, or combines to simplify the product as a suggestion to the designer to be considered. Table 2 shows the part of the baby stroller that had been eliminated, modified and simplified.

Table 2: Suggestion for redesign parts

Part Name	Quantity	Time Saving	Percentage Reduction	Note
M5 Hex Head Bolt	7	53.30	2.93	Eliminate/Reduce
M5 Hex Nut	7	68.00	3.74	Eliminate/Reduce
#4 Slotted Flat Head Screw	14	107.90	5.94	Eliminate/Reduce
Lock	1	8.30	0.46	Eliminate
Fold Latch	2	14.80	0.81	Eliminate / Combine
Basket Holder	2	14.50	0.8	Eliminate / Combine
Screw Cover	2	6.00	0.33	Eliminate
Front Bar A	2	6.20	0.34	Combine
Front B	2	6.20	0.34	Combine
Anodized Aluminum Frame	2	4.40	0.24	Redesign
Basket Fabric	1	4.40	0.24	Eliminate
Box Assemblies	1	3.11	0.17	Eliminate
Plastic Bag Assemblies	1	8.00	0.44	Eliminate
Semi – Tubular Rivet	24	50.40	2.77	Eliminate/Reduce
Velcro	8	12.00	0.66	Eliminate/Reduce

3.0 RESULTS AND DISCUSSION

Figure 7 illustrates the full assembly of the original design and redesign for the stroller. The differences can be seen on the design of the handle and also the front bar that had been improving. The original design and redesign consist of 179 and 149 parts respectively.



(a) (b)

Figure 7: Design comparison of baby stroller, (a) original and (b) redesign

Table 3 shows the comparison of DFMA result for original and redesign of the baby stroller.

Table 3: Comparison of DFMA for original and redesign of the baby stroller

Elements	Original	Redesign
Product Life Volume	10,000	10,000
Number of entries (including repeats)	179	149
Number of different entries	71	61
Theoretical minimum number of items	63	63
DFA Index	9.6	12.6
Total Weight, kg	9.59	8.46
Total Assembly Labor Time, s	1932.40	1480.11

The result for DFMA had given the differences value of assembly time. By reducing the part count, the DFA index had been increased by 3 after improvement on the redesign. Even though the value of reduction was not really high, but the efficiency of the new design still can be improved with another redesign.

4.0 CONCLUSION

Based on the improvement design of the baby stroller, the research has proven that the total assembly time could save about 452.29s, in which 23% more efficient than the original design. The value of efficiency is not high because this project focused on two sub assembly in which front bar and handle parts only. Furthermore, the difficulty of the user to fold the stroller (use both of their hands to move the fold latch at the same time) had been simplified. The solution is by changing the fold latch with a push button on the handle part. The user can easily fold the stroller just by pushing down the button with one hand only. This proved that the objective had been achieved.

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