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Analysis of Design for Assembly (DFA) in Waste Separation Machine of Ferromagnetic and Non-Ferromagnetic Material

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ABSTRACT

Design for Assembly (DFA) is one of method in the assembly systems to ease the assembly during simultaneous process from the beginning until become new products of the whole components. However, the obstacles in assembly process could be occurred in waste separation machine. Therefore, in order to obtain the optimization of assembly process, it is needed to conduct an analysis of component design before the production. DFA analysis will obtain the value of assembly efficiency. The efficiency value of prototype machine will achieve a way to separate the waste, both ferromagnetic and non-ferromagnetic materials. Furthermore, efficiency value theoretically on assembly of waste separation machine is 14.22% at 548.47seconds. The efficiency value of waste separation machine after assembly process in actual condition is 11.83% at 658.88seconds. The distinction efficiency value is caused by difficulties in assembly of the belt roller and sub assembly of base support on motor. As consequences, the time to get assembly will take more time on actual condition rather than theoretically.

KEY WORDS: *Design for Assembly* (DFA), *Efficiency of Assembly*

1.0 INTRODUCTION

Design for Assembly (DFA) is a method to optimize the assembling process in order to obtain the effective cost and to reduce the number of component. Prior to design the assembly process, it is needed to propose a model, drawing or prototype of the assembly.

2.0 THEORY

2.1 Assembling

Assembling is a process to join a component or sub-component to form the product. Types of Assembling divided into:

1. Manual Assembly
   Manual assembly is an assembly process by using man power to assemble a component or sub-component conventionally.
2. Automated Assembly
   Automated assembly refers to the use of programmed machines and automated devices to carry out the various assembly tasks in an assembly process. The vast majority of automated assembly systems are designed to perform a fixed sequence of assembly steps on a specific product.

2.2 Design for Assembly (DFA)

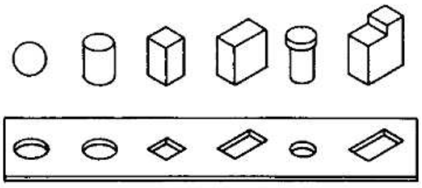
Design for Assembly (DFA) is a method to assemble component and sub-component to form a product in order to optimize the cost efficiency. The manual assembly process could be classified into:

2.2.1 Manual Handling

In a manufacture, the manual handling is an operation of moving part by using hand, arms or some other forms of bodily effort. There are some effects in the process of manual handling such as:

1. Effect of Part Symmetry On Handling Time

Figure 2.1 shows rotational symmetry of part component which is perpendicular to the axis (α) and parallel to the insertion axis (β).



α	0	180	180	90	360	360
β	0	0	90	180	0	360

Figure 2.1: Rotational Symetry of several parts

2. Effect Of Part Thickness and Size On Handling Time.

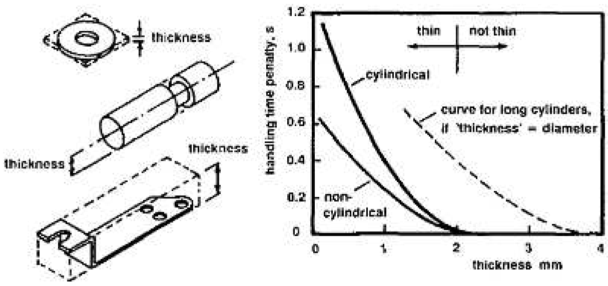


Figure 2.2: Thickness effect

In the figure 2.2 shows the thickness effect to manual handling time in cylindrical and non-cylindrical geometry in assembling process.

3. Effect of Part Size

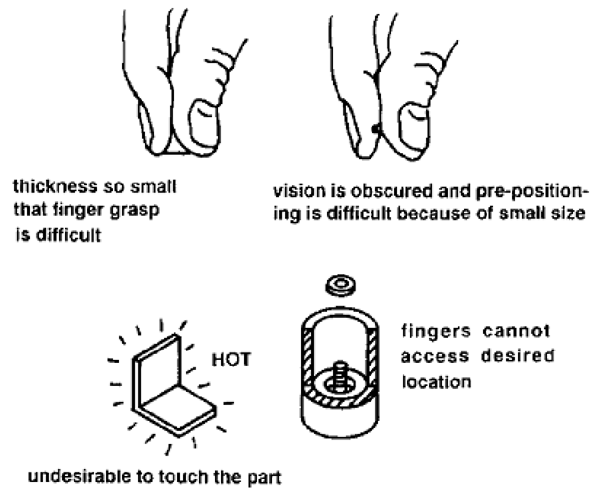


Figure 2.3: Effect of size in manual handling

In the figure 2.3 shows the difficulties of small part in manual handling which can take much time in assembling process.

2.2.2 Manual Insertion

The factors which could affect the time of manual insertion consist of:

1. Effect of Chamfer Design on Insertion Operations.

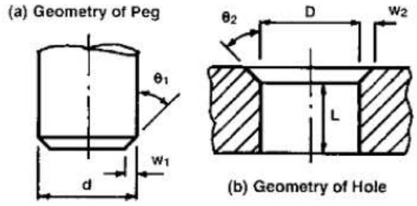


Figure 2.4: Peg and Hole geometry

Figure 2.4 shows the assembly process of two geometries in different chamfer position as shown in figure 2.4 (a) the chamfer in the peg and figure 2.4 (b) the chamfer on edge of geometry.

2. Effect Of Holding Down

This condition can be defined as holding in certain time in order to wait the sequence process of assembly.

2.2.3 Boothroyd-Dewhusrt Table Matrices

Boothroyd-Dewhusrt performed some experiments to identify the resistances and difficulties of assembly process. The combination of them was tabulated which refers to Table 3.2 and Table 3.3.

2.2.4 Assembling Efficiency

The assembling efficiency of product could be calculated as follow:

$$E_{ma} = \frac{N_{min} t_a}{t_{ma}} \tag{2.1}$$

Where,

N_{min} =Theoretical minimum number of parts
t_a = Basic assembly time for one part (3s)
t_{ma} = Estimated time to complete

3.0 METHOD

3.1 Flowchart

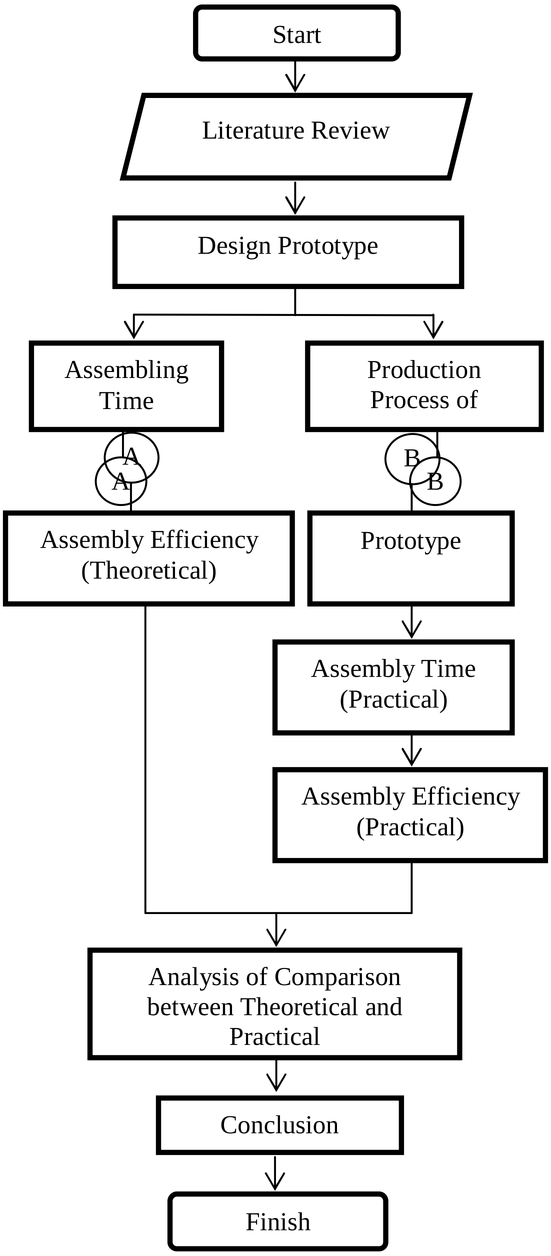


Figure 3.1: Flowchart of research

3.1.1 Theoretical Time estimation

The estimation of Assembling Time theoretically can be seen in the flowchart below:

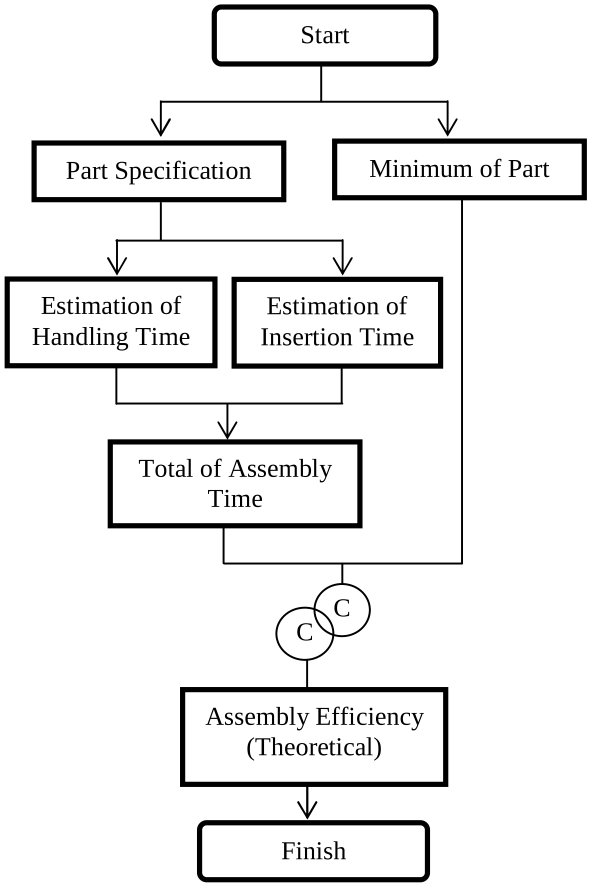


Figure 3.2: Estimation of Assembly Time in theoretical

Table 3.1 explains how to determine the estimation of assembling time per part of unit. Afterward, the assembling time of each part will be inserted to the worksheet analysis table.

Table 3.1: Worksheet Analysis

Items Name	*Number of item (RP)*	*Handling Code*	*Handling Time (TH)*	*Insertion Code*	*Insertion Time (TI)*	*Total Time (s) (RP)*(TH+TI)*	*Min. Part*	
Total								

The items of worksheet analysis can be explained as follow:

a. Number of items (RP) is the number of same part unit.
b. Handling code consists of two-digit of number which is used to determine the handling time according to Table 3.2 Estimation of handling time.
c. Handling Time (HT) is the required time to handle the part.
d. Insertion Code is two-digit number to determine the handling time of insertion according to the Table 3.3 estimation of handling time.
e. Insertion Time is the required time to joint each of part that needed to be assembled.
f. Total Time is number of item (RP) which is multiplied by increment of handling time and insertion time.
g. Minimum Part is one of the important parameter to determine assembly efficiency.

3.1.2 Estimation of Assembly Time in Practice

After the prototype of products was complete, the next step is preparing the assembly process in order to take the required time to establish the product. The assembly process involves five operators to assemble the machine. Each of operator assigned three times of assembly process in rotation, and each of assembly process run along with stopwatch to count the time taken. The process of required time in assembling can be described by flowchart below:

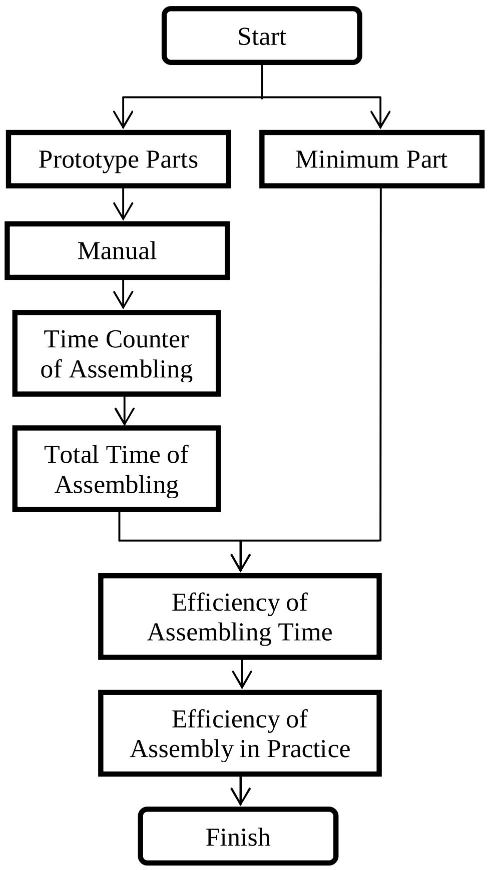


Figure 3.3: Flowchart of Assembly Time in Practice

3.2 Material of Research

In this research, the design of waste separation machine is showed in Figure 3.4 (a) and the prototype showed in Figure 3.4 (b).

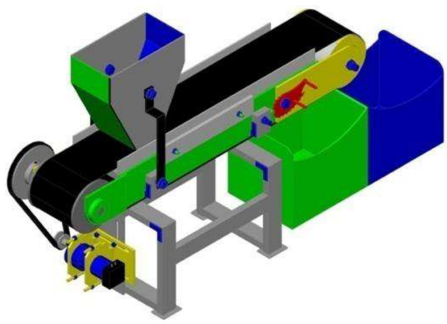


Figure 3.4: (a) Design of waste separation machine.

Figure 3.4 (b): Prototype of waste separation machine

4.0 THE RESULT OF ESTIMATION TIME AND EFFICIENCY

Table 4.1 shows the result of estimation time (t_{ma}) and efficiency either in theoretical or practical. Based on the theory, the total time of assembly to all components is 548.47second and the value of assembly efficiency is 14.22 %. Whereas in practical, the total time of assembly to all of component is 658.88second and the value of assembly efficiency is 11.83 %.

Table 4.1: The Result of assembling time estimation

Items Name	Number of item (RP)	Handling Code	Handling Time (TH)	Insertion Code	Insertion Time (TI)	Total Time (s) (RP)*(TH+TI)	Min. Part
1.Body Mounting	1	93	3	-	0	3	0
2. Body	1	93	3	7	6.5	9.5	0
3.Body Bolt	4	10	1.5	6	5.5	28	0
4.Body Nut	4	1	1.8	38	6	31.2	0
5.Rear Bearing Roller	2	0	1.13	7	6.5	15.26	2
6.Rear Roller	1	10	1.5	6	5.5	7	1
7.Rear Roller Arm	1	30	1.95	6	5.5	7.45	1
8.Rear bolt arm	3	10	1.5	6	5.5	21	0
9.Rear nut arm	3	0	1.5	38	6	22.5	0
10.Pulley 4.5"	1	10	1.5	6	5.5	7	1
11.Magnet-steel	1	15	2.25	2	2.5	4.75	1
12.Front roller cover left hand side	1	10	1.8	8	6.5	8.3	1
13.Front roller	20	1.8	2	2.5	4.3	1	20
14.Front roller cover right han side	1	10	1.8	8	6.5	8.3	1
15.Front bearing	2	0	1.13	7	6.5	15.26	2
16.Bushing	2	0	1.13	0	1.5	5.26	0
17.Front roller arm	2	30	1.95	6	5.5	14.9	0
18.Front shaft ring	2	3	1.69	0	1.5	6.38	0
19.Front shat nut	2	0	1.13	38	6	14.26	0
20.Belt tensioner shaft ring	2	3	1.69	0	1.5	6.38	0
21.Belt tensioner	2	30	1.95	0	1.5	6.9	2
22.Hollow shaft	1	0	1.13	6	5.5	6.63	
23.Adjuster shaft	1	0	1.13	6	5.5	6.63	1
24.Adjuster shaft nut	1	0	1.13	38	6	7.13	0
25.Front Sub-assembly roller	1	95	4	98	7	11	0
26.Belt bracket	1	20	1.8	1	2.5	4.3	1
27.Belt roller	1	80	4.1	32	4	8.1	1
28.Belt stopper	2	30	1.95	6	5.5	14.9	2
29.Belt stopper nut	4	10	1.5	38	6	30	4
30.DC motor	1	10	1.5	0	1.5	3	1
31.Bracket motor	2	20	1.8	6	5.5	14.6	
32.Motor bracket nut	4	10	1.5	38	6	30	
33.Motor belt	1	0	1.13	0	1.5	2.63	1
34.Motor mounting	1	30	1.95	7	6.5	8.45	1
35.Motor mounting bolt	4	10	1.5	7	6.5	32	0
36.Motor mounting nut	4	10	1.5	58	10	46	0
37.Inlet arm	2	30	1.95	6	5.5	14.9	2
38.Underneath inlet arm nut	2	10	1.5	38	6	15	0
39.Inlet	1	20	1.8	6	5.5	7.3	1
40.Inlet bolt	2	10	1.5	0	1.5	6	2
41.Inlet nut	2	10	1.5	38	6	15	0
42.Adjusting belt roller	1	-	-	98	9	9	0
43.Adjusting belt motor	1	-	-	98	9	9	0
TOTAL						548.47	26

5.0 DISCUSSION

The assembly process obtained the difference between theoretical assembly efficiency and in practical. In theoretical, it resulted 14.22% and in practical, it resulted 11.83%. So the difference is 2.39%. This condition indicates the assembly process in practical is faster than estimation time in theoretical because of some part can be assembled in the same time during the assembly process which can save the time in the same result. The assembly process is showed in Figure 5.1 and 5.2.

Figure 5.1: Assembly of belt roller.

Figure 5.2: Assembly of Motor Mounting

6.0 CONCLUSION

The assembly efficiency in practical is less than theoretical. Based on Design for Assembly (DFA), it indicates that the assembly time can be short and also reduce the cost of assembly.

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