A METHODOLOGY TO DETERMINE PRODUCT MAINTAINABILITY BASED ON ASSEMBLY CRITERIA – A CASE STUDY OF REAR MOTORCYCLE BRAKE ASSEMBLY

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Abstract

This paper presented a methodology to determine a maintainability index based on assembly criteria. Typically time is the major parameter or indicator being used measuring the maintainability, but less works are focus on details components assembly and assembly criteria. In the previous works, a customer survey and study on effect of operator skills have been conducted. In this study, by using similar case study the maintainability index is determined. After the assembly type of each component is identified and represented in the form of assembly digraph. Each of the assembly type is weighted based on their characteristics such as disassemblability, cost and assembly direction. Result from redesign shows an improvement in terms of design and maintenance efficiency.

Keywords: Maintainability, assembly type, assembly digraph

1 Introduction

Typically maintenance is taking care after or during product is being used hence it cost higher expense. Nowadays maintenance becomes one of the major criteria in the determining design performance. Design with maintenance friendly features has more advantages in terms of time and cost compared to ordinary design. There are quantitative and qualitative measures used in indicating maintenance efficiency. Maintainability can be defined as ease of which the maintenance activity can be carried out on an item of product or system [7]. There are two aspects of maintainability, serviceability and repairability. Commonly maintainability can be measured based on time consume in completing the task or mean time to repair (MTTR) and maintenance activity time as claimed by Utez [9]. In maintainability analysis, disassembly and reassembly is the most critical factor [3]. Balanchard et al. [2] and Cunningham and Cox [3] include time taken in disassembly, assembly, localization and isolation of least replacement of components. Ehud et al. [5] measure disassembly using difficulty rating, where accessibility, position, force, additional time and special problems is interpreted based on difficulty of disassembly task. Cost of assembly/disassembly is critical only in selection of appropriate tools [10-11]. Meanwhile Tsai et al. [8] introduce modularity operations and considering reliability and maintenance cost as a measure. They also list five problems that should be considered in maintainability analysis, which are disassembly sequence, selection of tools, time required for disassembly and human factor issues such as accessibility and visibility. Clark and Parsch [4] and Parsch and Ruff [6] consider a diagnosability aspect as a major factor in determining maintainability, while Wani and Gandhi [12] consider tribology aspect. Maintainability also should consider optimal resources such as personnel and support equipment [7&13].

The paper begins with introduction where a brief introduction and related works have been discussed. Followed by methodology of the research and then demonstrate by a case study. The result is then discussed and the paper is end by conclusion and future works.

2 Methodology

The methodology begins with disassembly of the components in the product. During the disassembly process, assembly type is identified and recorded. The methodology is summarized in the Figure 1. After that disassembly is constructed, where a circle with component number and an arrow to represent component and direction of assembly. Maintainability is a function of product or system design and maintenance task design [7]. So that by relate it to the assembly criteria such as tools used, assembly direction, accessibility and maintenance frequency, the maintainability index can be measured quantitatively. The relationships have been derived and discussed in [1].

If the result of maintainability index is high or not acceptable, the designer can improve the design either redesign the component or by changing the assembly type. In determining maintainability index, the designer should choose the most critical or the shortest path to access the targeted part.

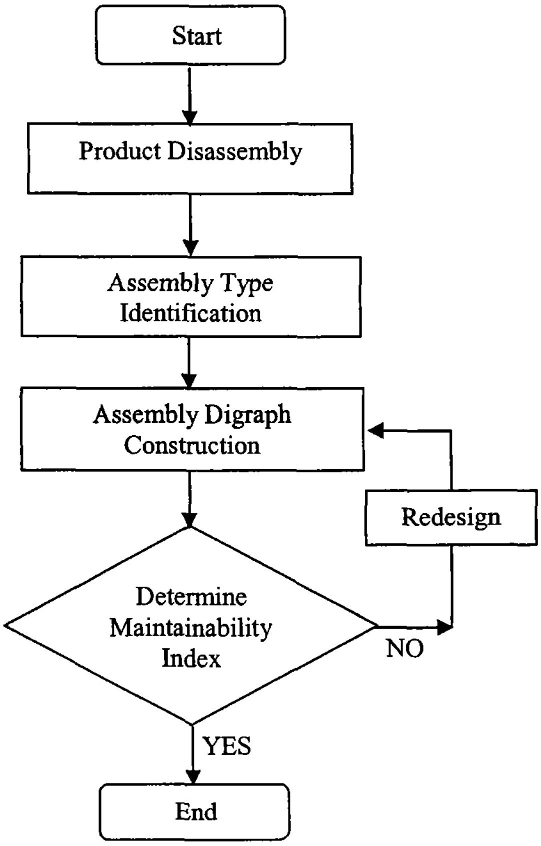

Figure 1. Methodology used to determine maintainability index

3 Case Study

In this study, a motorcycle rear brake assembly has been used as a case study. After disassembly procedure has been made (Figure 2), a list of components is identified as in Table 1. Note that components No. 11, 12 and 17 are not in the list, while components 9, 10, 13 and 16 are not considered as component.

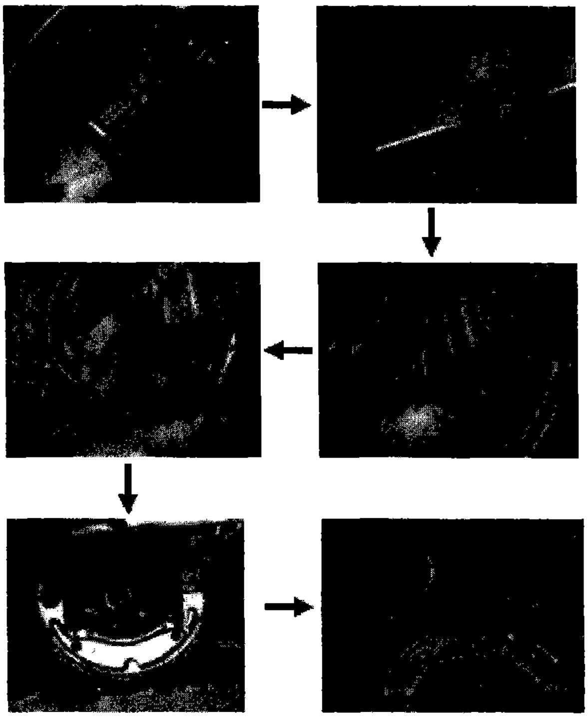

Figure 2. Disassembly procedure of rear brake assembly

Table 1. List of components in rear brake assembly.

#	Component	#	
1	Axle Rear Wheel	15	Rear Brake Arms
2	Rear Brake Panel Side Collar	16	Nut Hexagon 8mm
3	Rear Brake Panel Component	18	Rubber Stopper Arm Wheel
4	Shoe Brake Component	19	Bolt Brake Stopper
5	Spring Brake Shoe	20	Rear Brake Rod
6	Rear Brake Cam	21	Nut Brake Road Adjustable
7	Dust Sheal Brake Cam	22	Joint Brake Arms
8	Rear Brake Indicator	23	Spring Brake Rod
9	Bolt Flange 6x28		
10	Nut Hexagon 6mm		
13	Bolt Flange 6x32		
14	Nut Flange 6mm		

After assembly type for each of the components is identified, the disassembly digraph can be constructed. The disassembly digraph is shown in Figure 3.

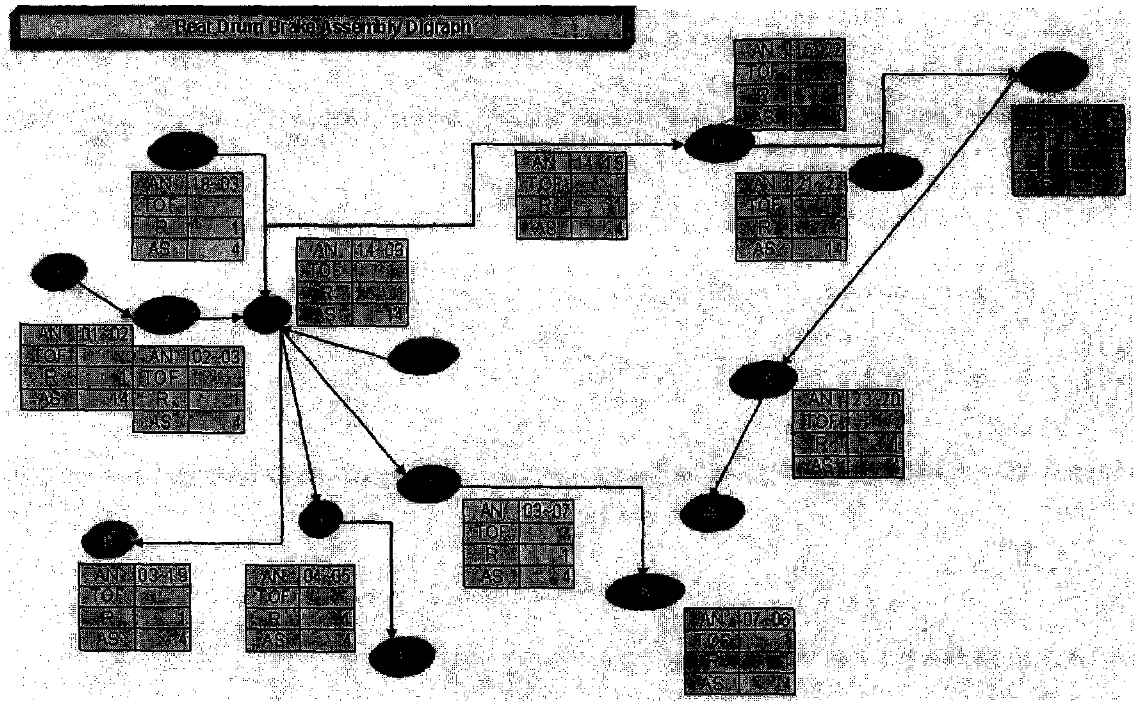

Figure 3. Disassembly digraph of the rear brake assembly

The maintainability index can be more systematically determined by using stand chart. For that purpose a Maintainability Evaluation Chart (MEC) has been developed, where maintainability for each of the individual component can also be identified, named maintainability degree. In the chart maintenance rate is used to represent of how frequent the component need to be maintained. After the calculation has been made, the result is as shown in Table 2.

Table 2. The maintainability index for rear brake assembly

Rear Brake Drum Assembly					
# Comp.	**Name**	**Maintenance Rate, Mr**	**Critical Path, Cp**	**Assembly Score, Ar**	**Maintenance Degree, Md**
1	Axle Rear Wheel	1	1	14	0.07
2	Rear Brake Panel Side Collar	1	2	18	0.06
3	Rear Brake Panel Component	1	3	22	0.05
4	Shoe Brake Component	4	4	26	0.15
5	Spring Brake Shoe	3	5	30	0.10
6	Rear Brake Cam	1	6	34	0.03
7	Dust Sheal Brake Cam	2	5	30	0.07
8	Rear Brake Indicator	1	3	22	0.05
15	Rear Brake Arms	1	2	18	0.06
18	Rubber Stopper Arm Wheel	2	3	18	0.11
19	Bolt Brake Stopper	2	5	36	0.06
20	Rear Brake Rod	1	4	26	0.04
21	Nut Brake Road Adjustable	2	1	14	0.14
22	Joint Brake Arms	1	2	18	0.06
23	Spring Brake Rod	2	3	22	0.09
			Maintainability Index =		**1.12**

4 Conclusion and Future works

The paper has presented the methodology to determine maintainability index by using rear brake assembly as a case study. The contribution of this work is that, the developed methodology can be used to measure component, product and system maintainability. The approach used is very simple and can be used easily by utilizing the standard chart named Maintainability Evaluation Chart (MEC). This approach is more practical and the result is consistence. For the future works, a Maintainability Index Template is to develop in order to automate the calculation process and can be used as online.

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