



**APPLICATION OF AHP METHOD IN THE DESIGN OF
REMANUFACTURING IMPROVEMENT PROCESSES FOR
CRANKSHAFT**

This report submitted in accordance with requirement of the Universiti Teknikal
Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering
(Manufacturing Design) (Hons.)

by

MUHAMMAD AIMI BIN ABU HASSAN

B051010054

880402145615

FACULTY OF MANUFACTURING ENGINEERING

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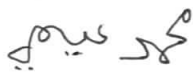
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TIDAK TERHAD

Disahkan oleh:



(Tuan Hj. Baharudin Bin Abu Bakar)

Alamat Tetap:

NO 41 LOT 5988, BATU 18 ¾,
KAMPUNG TELOK SAREH, PULAU
TIGA, 36800 KAMPUNG GAJAH,
PERAK DARUL RIDZUAN

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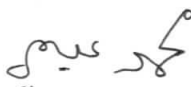
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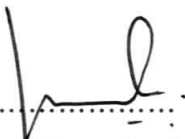
Signature : 

Author's Name : MUHAMMAD AIMI BIN ABU HASSAN

Date : 24/6/2013

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Design) (Hons.). The member of the supervisory committee is as follow:


.....
(Official Stamp of Supervisor)

BAHARUDIN BIN ABU BAKAR
Pensyarah Kanan
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Design) (Hons.). The members of the supervisory committee are as follow:

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ABSTRACT

This project describes an approach, based on the Analytical Hierarchy Process (AHP) that assists decision makers or manufacturing engineers to determine the most appropriate remanufacturing process to be applied in the remanufacturing of crankshaft at the early stage of product remanufactured process. Remanufacturing can be defined as a process of restoring a non-functional, discarded, or traded in product to look and function like new condition, however the process of remanufacturing of crankshaft does not have a specific procedure and is inappropriate. It will make the manufacturing industry to incur more cost and increase time of remanufacturing the crankshaft. The best way to solve this problem is by developing a new process for remanufacturing of the crankshaft. As a result, the new process will give benefits to the manufacturers themselves in terms of income, but it has major benefits to the society as a whole. The selection of critical defects before remanufacturing a crankshaft was determined in this project. The factors influenced in the process selection of manufacturing process have been identified in order to fulfill the requirement of the remanufacturing. By using AHP as a decision making tool at an early stage of the product redevelopment process, the critical defect has been identified. AHP concept can assist remanufacturing engineers to evaluate and select the best remanufacturing process based on the various factors and sub-factors of a decision. The analysis has revealed that the most critical defect before remanufacturing a crankshaft is cracked with the highest percentage is 20.14%.

ABSTRAK

Projek ini menerangkan pendekatan berdasarkan Proses Hierarki Analisis (AHP) yang membantu pembuat keputusan atau Jurutera Pembuatan menentukan proses perkilangan semula yang paling sesuai untuk digunakan dalam perkilangan semula *crankshaft*. Perkilangan semula boleh ditakrifkan sebagai satu proses pemulihan produk yang sudah tidak berfungsi supaya ianya boleh berfungsi semula dan berkeadaan seperti baru. Namun demikian, proses perkilangan semula *crankshaft* masih tidak mempunyai prosedur tertentu dan ianya adalah tidak sesuai. Perkara ini akan menyebabkan industri pembuatan menanggung kos yang lebih dan meningkatkan masa untuk perkilangan semula *crankshaft*. Cara terbaik untuk menyelesaikan masalah ini adalah dengan membangunkan proses baru untuk perkilangan semula *crankshaft* dan hasilnya proses baru ini akan memberi manfaat kepada pengilang sendiri dari segi pendapatan dan akan memberi manfaat yang besar kepada masyarakat secara keseluruhannya. Faktor-faktor yang mempengaruhi dalam pemilihan proses pembuatan telah dikenal pasti untuk memenuhi keperluan perkilangan semula. Dengan menggunakan AHP sebagai membuat alat pada peringkat awal pada proses pembangunan semula produk tersebut, kecacatan kritikal telah boleh dikenal pasti pada peringkat awal. Konsep AHP boleh membantu Jurutera Pembuatan untuk menilai dan memilih proses perkilangan semula terbaik berdasarkan pelbagai faktor dan sub-faktor keputusan. Analisis telah menunjukkan bahawa kecacatan yang paling kritikal sebelum perkilangan semula *crankshaft* adalah masalah keretakan dengan peratusan sebanyak 20.14%.

DEDICATION

I would like to dedicate this whole PSM report to my beloved family.

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First of all, I would like to express my grateful to ALLAH s.w.t. for the blessing given to me to complete my PSM 1. In order to complete my work, I have engaged with many people in helping me especially my supervisor Tuan Hj. Baharudin Bin Abu Bakar. I wish to express my sincere appreciation to him for his encouragement, guidance, advices and motivation. Without his support and interest, this thesis would not have been the same as presented here. I also want to thank to all my friends that involve direct or indirect to complete my task. Not forgotten, I would like to express my gratitude to all university staff from Manufacturing Engineering Faculty for being so cooperative and not forgetting all my friends for the support, advice and information sharing. Finally, I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Without endless love and relentless support from my family, I would not have been here.

TABLE OF CONTENTS

Abstract	i
Abstrak	ii
Dedication	iii
Acknowledgement	iv
Table of contents	v
List of Tables	ix
List of figures	xi
List of Abbreviations, Symbols and Nomenclatures	xiii

CHAPTER 1: INTRODUCTION

1.1	Background	1
1.2	Problem statements	2
1.3	Objective	2
1.4	Scope of work	3
1.5	The organization of report dissertation	4

CHAPTER 2: LITERATURE REVIEW

2.1	Introduction	6
2.2	History of remanufacturing	6
2.3	Major environmental problems	7
2.4	Remanufacturing definition	7
2.5	Economic impact of remanufacturing	8
2.6	Element of remanufacturing	8
2.7	Advantage of remanufacturing	16
2.8	Critical factors in remanufacturing	17
2.9	Discussion eco design/ design for environment/ design for reused/ Design for remanufacturing.	18

2.10	Assessing of Remanufacturing	19
2.11	The needs of remanufacturing in machinery industries in Malaysia	20
2.12	The Policy Framework	20
2.13	Remanufacturing in (World/Asian)	21
2.14	Analytic Hierarchy Process (AHP)	22
2.15	History of Analytic Hierarchy Process (AHP)	23
2.16	Limitation of Analytic Hierarchy Process (AHP)	23
2.17	Analytic Hierarchy Process (AHP) Guideline	24

CHAPTER 3: METHODOLOGY

3.1	Introduction	25
3.2	Introduction Methodology	25
3.3	Planning of Study	26
3.4	Research Process Flow	26
	3.4.1 Identify the Objectives, Problem Statement and Scope of Project	27
	3.4.2 Literature Review	28
	3.4.3 Design Methodology	28
	3.4.4 Write Report and Presentation	29
3.5	PSM 2 Planning Strategies	29
	3.5.1 Data Collection	29
	3.5.2 Site Visit	30
	3.5.3 Interview	30
	3.5.4 Analysis	30
	3.5.5 Result	31
	3.5.6 Discussion and Conclusion	31

CHAPTER 4: DATA COLLECTION

4.1	Introduction	32
4.2	Site Visit	32
4.3	MTI Business Area	33
4.4	MTI Remanufacturing process	34

4.5	MTI Facility	36
4.6	Process Flow for Remanufacturing of an Engines	38
	4.6.1 Common Defect for Crankshaft	41
4.7	Product Selection	42
4.8	3D Modeling	44
4.9	The Main Remanufacturing Problems at MTI	46

**CHAPTER 5: HIERARCHICAL END OF LIFE DECISION MODEL AND
ANALYTIC HIERARCHICAL PROCESS (AHP)**

5.1	Introduction	47
5.2	Hierarchical End of life Decision Model	48
	5.2.1 Crack	52
	5.2.2 Crooked	55
	5.2.3 Profile	58
	5.2.4 Dented	59
	5.2.5 Scratch	60
	5.2.6 Clogged	61
5.3	Selection Process Using Analytical Hierarchy Process (AHP)	62
	5.3.1 Step 1: Define Problem	64
	5.3.2 Step 2: Develop a hierarchical framework	64
	5.3.2.1 Level 1: Goal	65
	5.3.2.2 Level 2: Criteria	65
	5.3.2.3 Level 3: Sub- Criteria	66
	5.3.2.4 Level 4: Defect	66
	5.3.3 Step 3: Construct a Pairwise Comparison Matrix	66
	5.3.4 Step 4: Perform Judgment of Pairwise Comparison	67
	5.3.5 Step 5: Synthesizing the pairwise comparison	68
	5.3.6 Step 6: Perform the consistency	70
	5.3.6.1 Firstly, calculate the Eigenvalue	70
	5.3.6.2 Secondly, Calculate the Consistency Index (CI)	72

5.3.6.3 Finally, Calculate the Consistency Ratio (CR)	72
5.3.7 Step 7: Step (3-6) are performed for all level in the hierarchy	73
5.3.8 Step 8: Develop Overall Priority Ranking	76
CHAPTER 6: RESULT AND DISCUSSION	
6.1 Result	79
6.2 Discussion	80
CHAPTER 7: CONCLUSION AND RECOMMENDATION	
7.1 Conclusion	83
7.2 Recommendation	84
REFERENCES	85
APPENDIX A	89

LIST OF TABLE

2.1	Remanufactured guideline	9
2.2	Product design to facilitate individual processes in remanufacturing	15
4.1	Example product being remanufactured at MTI	37
4.2	Process Flow for remanufacturing an engine	38
5.1	Summary of Decision Making	47
5.2	Percentage of crankshaft defect at MTI	49
5.3	Defects versus Remanufacturing	50
5.4	Type of defects at crankshaft	51
5.5	Defects in Crankshaft	64
5.6	Scale of Pairwise Comparison	67
5.7	Pairwise comparison of criteria respect to overall goal	68
5.8	Synthesized matrix of the criteria	70
5.9	Calculation to get new vector	71
5.10	Random index of analytic hierarchy process	72
5.11	The Consistency Test for the criteria	73
5.12	The Consistency Test for sub criteria (Cost)	74
5.13	The Consistency Test for sub criteria (Resources & Skills)	74
5.14	The Consistency Test for sub criteria (Product)	75
5.15	The Consistency Test for the critical defect	75
5.16	All priority vectors for criteria, sub-criteria and defect	77
5.17	Overall priority vectors for sub-criteria with respect to the criteria	77
5.18	Overall priority vector for the defect with respect to the criteria	77
5.19	Result of selection	78

6.1	Result decision	80
6.2	Example new worksheet before remanufacturing the crankshaft	82
6.3	Comparison between new process flow and old process flow	82

LIST OF FIGURES

1.1	The step organization of report dissertation flow	4
2.1	A framework for reverse supply chain activities	10
2.2	Manufacturer collects from consumer	11
2.3	Retailers collect from consumer	11
2.4	Third party collects from consumer	12
2.5	Basic remanufacturing product development model	13
2.6	Product remanufacturing matrix	14
2.7	Flowchart of remanufacturing activity	14
3.1	Flowchart in PSM1	26
3.2	Flowchart in PSM2	27
3.3	Chapter 1 development flow	28
4.1	Reverse logistic at MTI	34
4.2	Crankshaft, rod and piston from MTU	34
4.3	MTI remanufacturing process	35
4.4	Crankcase machining	36
4.5	Crankshaft machining	36
4.6	Engine assembly	36
4.7	Example of lightly scratched bearing journal	41
4.8	Example of a broken crankshaft or cracked crankshaft	42
4.9	Example of fillet does not have proper finish	42
4.10	Crankshaft	43
4.11	Crankshaft function	44
4.12	Crankshaft in 3D modeling	44

4.13	Side view	45
4.14	Four side view	45
4.15	Top view	45
4.16	Process flow to remanufacture a crankshaft	46
5.1	Hierarchical model	49
5.2	Pie chart defects in crankshaft	50
5.3	Hierarchical for common defect	52
5.4	Level 1 for hierarchical model	52
5.5	Magnetizing Scheme	53
5.6	Crankshaft magnetic particle crack testing	54
5.7	Example of a cracked crankshaft after the crack test	54
5.8	Level 2 for hierarchical model	55
5.9	Straightness test for crankshaft	56
5.10	Example of result after straightness test	56
5.11	Dial indicator	57
5.12	V block	57
5.13	Level 3 for hierarchical model	58
5.14	Crankshaft profiling	58
5.15	Level 4 for hierarchical model	59
5.16	Example of dented at crankshaft	59
5.17	Level 5 for hierarchical model	60
5.18	Example of lightly scratched bearing journal	60
5.19	Example of crankshaft after through the polishing process	61
5.20	Level 6 for hierarchical model	62
5.21	Clogged on the journal bearing hole	62
5.22	Flow Chart for Analytical Hierarchical step	63
5.23	Hierarchical structures for selecting the critical defect in the crankshaft	65
6.1	Hierarchical for common defect	81

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

EOL	-	End of life
CLSC	-	Closed loop supply chain
PDCA	-	Plan do check act
AHP	-	Analytic Hierarchical Process
CR	-	Consistency Ratio
MTI	-	Motor Teknologi & Industri
MRO	-	Maintenance, Repair and Overhaul
APMM	-	Agensi Penguatkuasa Maritim Malaysia
OEM	-	Original Equipment Manufacturer
SOP	-	Standard Operation Procedure
SLM	-	Service Lifecycle Management
CNC	-	Computer Numerical Control

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the literature review on remanufacturing. It started with an introduction about remanufacturing and its function. The element in remanufacturing and major environmental impact for remanufacturing will be reviewed in this chapter. This chapter also presents the advantages of remanufacturing, a policy framework for remanufacturing, barriers in remanufacturing and difference between design environments, design for reused and design for remanufacturing.

2.2 History of Remanufacturing

Remanufacturing has proliferated and is now a well-established, but an almost unnoticed activity. Remanufacturing began in 1930, where Henry Ford has applied manufacturing activity when car's price decreases. In 1940 the remanufacturing activity was first developed in the United States and the United Kingdom, but in 1945 the manufacturing activities in the United States have been closed due to the Second World War. In 1947, the manufacturing activity has started operate in Germany. In the period 1930 to 1940 many countries have begun remanufacturing activities because of these activities have much effect on the generation of an economy. After seeing some of the effects resulting from the activities of remanufacturing, European countries began remanufacturing

activities in 1970. In 1990 a company called Fuji Xerox started its remanufacturing activities. After seeing the profits generated by the Fuji Xerox Company, other companies began to see the remanufacturing activity as an activity that will give advantage to tie up. In year 2000, Ricoh and Canon started applying the remanufacturing activities in their company.

2.3 Major Environmental Problem

According Amezquita et al. (1995), every year the United States produced 700 million tons of hazardous waste and 11 billion tons of hazardous waste caused by the extraction, processing and manufacturing of materials. In 1990, more than 190 million tons of solid waste were generated in the United States where nearly 87% is generated waste material by the extraction, processing and manufacturing required in producing a product. For maintaining a safe and secure ecosystem, Amezquita et al. (1995) and Ijomah (2009) suggested that the remanufacturing activities should be carried out in each country, because remanufacturing can reduce pollution and the cost of the landfill. Besides that, remanufacturing also can reduce the use of raw materials, waste disposal and water.

2.4 Definition of Remanufacturing

Remanufacturing can be defined in various ways but most of it has a similar purpose which is changing the end of a product's life for the better. Besides that, according to Robert et al. (1996) remanufacturing restoring non-functioning, discarded, or traded-in products to a new performance. In addition, remanufacturing can be defined as the process of rebuilding a product where the product cleaned, inspected and disassembled. In addition Ramstetter, (2011) reported that the remanufacturing of strategic importance as a concept that allows a large part of the value added to the product during the initial production should be retained. Moreover Steve Statham, (2006) claims that

remanufacturing is a process that uses the product and the installation of a new state back to them with minimum waste and spending on materials and energy that ensures the repair can be carried out on time and the item is returned to the function in an efficient manner.

2.5 Economic Impacts of Remanufacturing

Normally a company or a country must be conscious of their profit for a long term before starting an activity or a project. One of the activities that can guarantee good returns and profits are remanufacturing activities. According to Ron Giuntini, (1993) the product has been manufactured mostly just need cost 40 percent to 65 percent less than the production of new products, while the energy consumption of manufacturing also takes 15 percent of the energy needed in manufacturing; due to the activities remanufacturing process requires only a small part in the production of new products. One example of an activity that has been applied remanufacturing is an automotive activity, which Holzwasser, (1997) estimates that the manufacturing process can save 8.2 million of crude oil in the manufacture of steel, 51 500 tons of iron ore and 6000 tons of copper. This was supported by Hauser and Lund (2003) who claimed remanufacturing activities could benefit 1 million to 2 million per year.

2.6 Elements of Remanufacturing

According to Robert, (1978) a product is considered to be remanufactured based on characteristics as shown in Table 2.1.

Table 2.1: Remanufactured guideline

Its main components come from a used product.
The used product is disassemble to the extent necessary to determine the condition of its components
The used product's parts are thoroughly cleaned and made free from rust and corrosion.
All missing, defective, broken or substantially worn parts are either recovered to sound, functionally good state, or they are change with new, remanufactured, or sound, functionally good used parts
To put the product in sound working state, such machining, rewinding, refinishing or other operations are conducted as necessary.
The product is reinstallation and a determination is made that it will work like a similar new product.

For remanufacturing industries, a closed loop supply chain management (CLSC) of EOL product is the main challenge. Closed loop supply chain management is important and an integral part of remanufacturing process. Success of perfect launching of a remanufactured product mainly depends upon CLSC. Vasudevan et al. (2012) identified some important key elements in the remanufacturing sector to support CLSC. The first element in remanufacturing is product acquisition management, which is it stated that reverse flow of used product with the right quantity and good quality at the right price and right time is the most important aspect in remanufacturing industries.

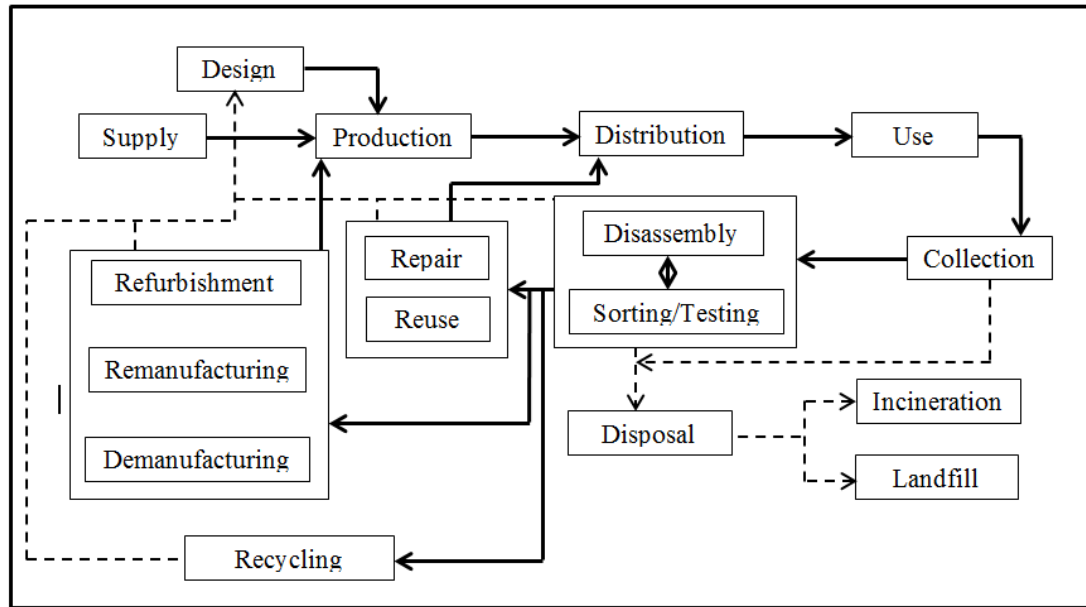


Figure 2.1: A framework for reverse supply chain activities

Figure 2.1 shows the framework for reverse logistics, describes about the remanufacturing process and the sequence of the process which disassembled the parts were in some are fitted into remanufacturing and some are fitted for recycling (Sasikumar, 2008).

Vasudevan et al. (2012) stated that the reverse logistics collection models are also one of the important elements in remanufacturing. This has been supported by Ravi et al. (2005) observed that “reverse logistics programs in addition to the various environmental benefits and the cost benefits can proactively minimize the threat of government regulation and can improve the cooperate image of the companies”. As a result, reverse logistics are now realized by organizations as an “investment recovery” as opposed to simply minimizing the cost of waste management. There are basically three methods for collection of end of life products for the purpose of remanufacturing. Usually it involves remanufacturer, retailer, third party and consumers. Figure 2.2 show that the consumer directly returns the used product to manufacturer. However, the

retailer is not involved in the reverse logistic collections. Many remanufacturing companies like Xerox, Canon and Hewlett Packard are collecting products directly from customers.

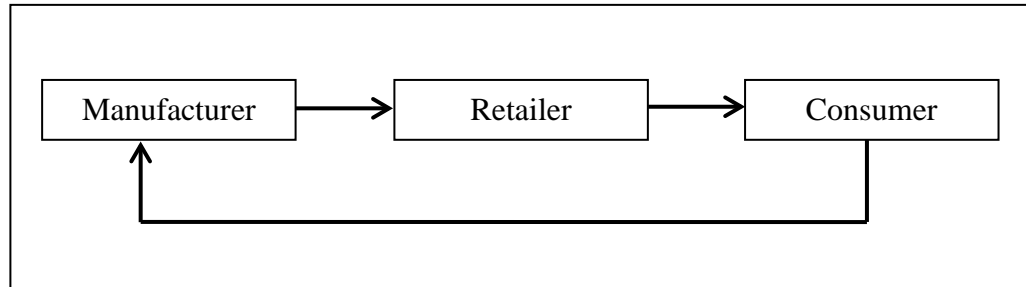


Figure 2.2: Manufacturer collects from consumer.

Figure 2.3 shows about the sequence involving of retailers in the collection of end of life product from the consumer, which is retailers supply the end of life product to the manufacturer. Usually Consumer always feels comfortable to return end of life product to retailers, for example camera, television, refrigerators are returned from consumer to the retailer. Usually most of the remanufacturers adopted this method.

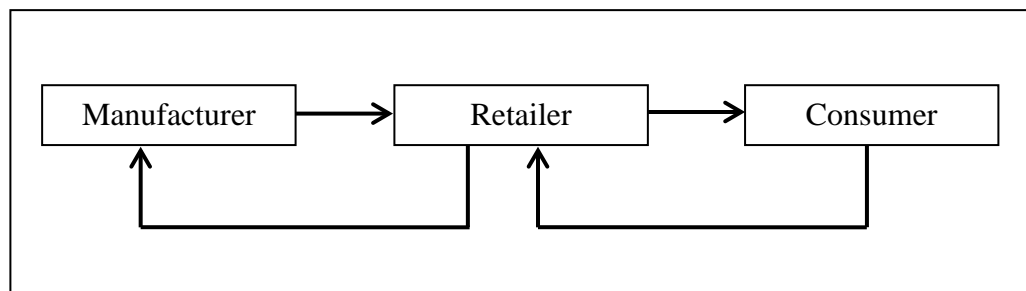


Figure2.3: Retailers collect from consumers.