

APPLYING DESIGN FOR 3R AND DESIGN  
FOR DISASSEMBLY METHOD TO  
DETERMINE THE END-OF-LIFE STAGE OF  
THE BICYCLE.

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APPLYING DESIGN FOR 3R AND DESIGN FOR DISASSEMBLY METHOD  
TO DETERMINE THE END-OF-LIFE STAGE OF THE BICYCLE.

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requirements for the award of the degree of  
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### **SUPERVISOR'S DECLARATION**

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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## **STUDENT DECLARATION**

“I declare that this thesis is the result of my own research except as cited references.  
The thesis has not been accepted for any degree and is concurrently submitted in  
candidature of any degree”.

Signature : .....  
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Date : .....

Dedicated to my beloved

“family“

For their endless support in term of motivation,  
supportive and caring as well throughout the whole project

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## **ABSTRACT**

Recycling is one of the popular ways to ensure that the product is environmental friendly. There are several value recovery processes, including cannibalization and remanufacturing. However, the design of most products does not favor the recovery of added value. Product designed for optimal marketing and ease of manufacturing are not necessarily good candidates for a recovery scheme. Design measure such as recyclability, disassemblability, and reusability are defined and used as the basic of the product recovery time. This project proposed a framework for design method that adopts the environmental – friendly philosophy via the concept of reuse, recycle and remanufacture. The bicycle is adopted as a case study. The expected output is the design method that considers 3R philosophy.

## **ABSTRAK**

Kitar semula adalah salah satu cara yang terkenal dalam memastikan sesuatu produk yang dihasilkan mempunyai ciri-ciri mesra alam. Terdapat beberapa nilai dalam proses pengawalan semula termasuk penjenteraan dan pembuatan semula. Walaubagaimanapun, kebanyakan rekaan produk tidak memenuhi nilai penambahan pengawalan semula. Produk yang direka untuk pasaran yang optimum dan mudah untuk di hasilkan adalah bukan pilihan yang baik untuk pengawalan semula. Ukuran rekaan seperti kitar semula, penceraian dan penggunaan semula telah di tentukan dan digunakan sebagai asas dalam menentukan masa pengawalan produk. Projek ini mencadangkan langkah-langkah yang dapat menyesuaikan diri dengan persekitaran menggunakan konsep 3R. basikal digunakan sebagai bahan kajian dalam projek ini.



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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

During the industrial revolution, environmental issues were not addressed when designing and manufacturing products. However, in the last decade or so, Environmentally Conscious Manufacturing and Product Recovery (ECMPRO) has become an obligation to the environment and to the society itself, enforced primarily by governmental regulations and customer perspective on environmental issues.

Environmentally conscious manufacturing (ECM) is concerned with developing methods for manufacturing new products from conceptual design to final delivery and ultimately to the end-of-life (EOL) disposal such that the environmental standards and requirements are satisfied. Product recovery, on the other hand, aims to minimize the amount of waste sent to landfills by recovering materials and parts from old or outdated products by means of recycling and remanufacturing (including reuse of parts and products).

Many thinkers have adopted the “three Rs” banner- remanufacture, recycle, and reuse-in order to develop environmentally conscious production process. Remanufacturing represents the combination of the three Rs in to single activity. It is the process of making renovated products or assemblies with some components or subassemblies that have previously been used. It requires the disassembly of the used item, selection parts that can be reuse, inspection and renovation of critical components, reassembly into a final product.

## **1.2 Project objectives**

Every project must have their own objective to achieve their target.

For this project, the objectives are:

1. To evaluate the end-of-life of the product design by using a bicycle as a case study.

## **1.3 Project scopes**

One of the most important things in the project is the scopes. The scopes for this project are:

1. Literatures reviews studies of the “3Rs” – remanufacture, recycle, and reuse.
2. The study is limited to the Reuse, Remanufacture and Recycle application only.
3. Pugh method is selected as a tool to select the design alternatives.
4. The bicycle is selected as a case study.
5. Comparison with DFA is based on the quantity of parts and the assembly time.

## **1.4 Project background**

For this project, the bicycle is using as a case study to evaluate the end –of-life of the product design. A bicycle consists of many parts. The part is manufactured from many materials like steel, alloy and rubber. The flow of this project is starting by sketching and then draws the bicycle using the solid work software. Disassembly method.

After that, analysis results in a recommendation of the following recovery process for the bicycle. Identify what the component of the bicycle can be remanufacture, recycle and reuse. From that the component, generate the new alternative. By using DFA software, compare the design based on the quantity of parts and the assembly time. The design is between the old and the new bicycle.

### **1.5 Problem Statements**

1. To determine what the component from the body part or bicycle can be recycle, reuse and remanufacture.
2. To evaluate the end-of –life of the product design by using a bicycle as a case study.

### **1.6 Expected output**

To Design method that consider 3R and disassembly.

### **1.7 Significant of research**

This significant of this study is to aim to promote the consideration for eco design at the early phase of the design process and development.



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

In this chapter, all the important informations related to this project are stated. The sources of this information are from journals, books and web site.

#### **2.2 Remanufacturing**

The purpose of a remanufacturing is being brought the machine back to an as new condition with the same level of control and electrics. This involves restoring a machine its "as good as when it was new" condition by replacing all bearing and seals and inspection of all components. Major defective parts are reviewed with the customer and replaced at additional cost to restore the machine to its original mechanical specifications and operating condition. Remanufacturing represents the combination of the three Rs in to single an activity. It is the process of making renovated products or disassemblies with some components or subassemblies that have previously bee used. It requires the disassembly of the used item, selection of parts that can be reused, inspection and renovation of critical components, and reassembly into a final product.

In principle, many products may be remanufactured, with different levels of success. One cannot dissociate recycling from remanufacturing. A successful remanufacturing operation is always coupled with recycling. Successful remanufacturing has some of the requirements as recycling, such as an efficient collection system. Moreover, complex products must be easy to disassemble to be profitably remanufactured (Penev and de Ron, 1994).

The profitability of remanufacturing depends on the economics of external process such as collection, transportation, inventory, scheduling and capacity decision have significant impact on the remanufacturing plant performance. It contributes on two fronts:

1. It develops economic measures of recyclability, disassemblability and reusability.
2. It provides a framework for determining the disassembly and recovery process of a generic product.

The design measures are the building blocks of the proposed framework. They can be useful in the comparison of the recovery potential of competing designs. In addition, it identifies assemblies that should be renovating for straight reuse, disassembled for parts' reuse or recycled for material recovery (Brennan et al, 1994).

When the widget is design, the assembly process is optimized with the choice of connectors that minimizes assembly time and cost. In many case,the connection is easily reversed:

- Design for remanufacturing
- Design for disassembly may coincide.

If the connection between two components cannot be undone without damage, the remanufacturer faces one of these options:

- **Consider the two components as one:** they are jointly inspected and if the assembly is worth reusing, it is recovered for reassembly. Otherwise, it is disposed of or recycled.
- **Recover the more valuable component:** the connection and the less valuable component are destroyed. Inevitably, the number of recoveries under this situation is limited, because the component tends to deteriorate with each separation procedure.

### **The remanufacturable widget**

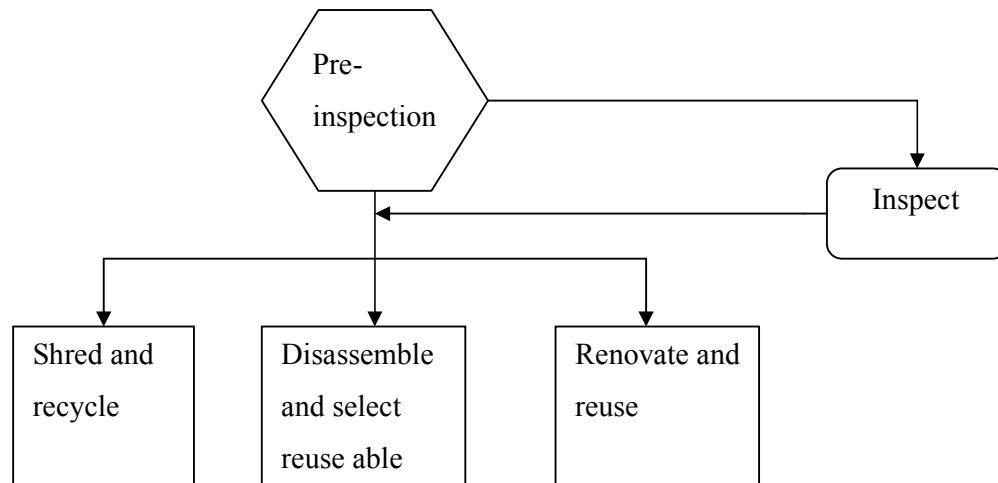
In order to evaluate the remanufacturing potential of a product, it is imperative to understand how it was originally manufactured. Without loss of generality, the widget is the assembly of several modules, including;

- A casing or a frame
- Functional modules functional connectors
- Structural connectors

Within the widget, each module has a similar architecture, including a number of assemblies, functional connectors and structural connectors.

### **The disassembly and the recovery routine**

Consider a disassembly line of used widget. At any given station, the operator receives a component from upstream to be disassembled. The operation generates a number of subassemblies to be routinely processed. The line designer has to determine the routine to be followed by each item obtained from the disassembly operation in that station, with minimal ambiguity.



**Figure 2.1: Decision making process in a remanufacturing station**

Fig 1 shows the decision process faced by the operator with each of the subassemblies.

- 1) Send to a shredder for recycling.
- 2) Disassemble further to obtain selected subcomponents.
- 3) Renovate for direct reuse.
- 4) Inspect further to identify which of the three previous alternatives is the most appropriate.

### **2.2.1 Benefit of the remanufacturing**

- 1) Does not require the same material as inputs as original manufacturing.
- 2) The reduction of solid waste that is produce by the disposal of decommissioned equipment and their spare parts inventories.
- 3) Accomplish saving the energy required to produced a new product
- 4) Can make contribution to material conservation, capital saving, energy conservation, and environment protection (Johson and Wang, 1995).

## **2.3 Recycling**

Recycling is the material recovery process and disassembly is not yet a recovery process. Indeed, disassembly as such does not recover either the material or the value added to the disassembled item, but rather it defers the recovery decision to a lower assembly level.

### **Why recycling**

Recycling is one way we can all help to ensure the environmentally sustainable future for ourselves and generations to come. However, when the parts are recycled, one cannot recover the finished material suitable for the production of the same part again. For example, recycling the body of an automobile will provide scrap steel valued at much less than the sheet metal required stamping new automobile parts. This scrap steel needs to undergo a series of costly processes before it becomes sheet metal again. At this point, it is worthwhile to build a common vocabulary of product recovery. Strictly speaking, there are two recovery approaches for any product or component: they are material recovery and value recovery (Ferrer 1997).

#### **2.3.1 Material recovery**

The process of recovering the material value in the product. It is destructive process with complete loss of all function and all information embodied in the part (Ferrer, 1997).

### **2.3.2 Value recovery**

The process of recovering usable components or subassemblies from the product. The material value and the value added in the production of the individual component are saved. There are several value recovery processes, including cannibalization and remanufacturing (Ferrer, 1997).

### **2.3.3 The recycling process**

Collecting and processing secondary materials, manufacturing recycled-content products, and then purchasing recycled products creates a circle or loop that ensures the overall success and value of recycling.

#### **Step 1: Collection and Processing**

Collecting recyclables varies from community to community, but there are four primary methods: curbside, drop-off centers, buy-back centers, and deposit/refund programs. Regardless of the method used to collect the recyclables, the next leg of their journey is usually the same. Recyclables are sent to a materials recovery facility to be sorted and prepared into marketable commodities for manufacturing. Recyclables are bought and sold just like any other commodity, and prices for the materials change and fluctuate with the market.

#### **Step 2: Manufacturing**

Once cleaned and separated, the recyclables are ready to undergo the second part of the recycling loop. More and more of today's products are being manufactured with total or partial recycled content. Common household items that contain recycled materials include newspapers and paper towels; aluminum, plastic, and glass soft drink containers; steel cans; and plastic laundry detergent bottles. Recycled materials also are used in innovative applications such as recovered glass

in roadway asphalt (glass halt) or recovered plastic in carpeting, park benches, and pedestrian bridges.

### Step 3: Purchasing Recycled Products

Purchasing recycled products completes the recycling loop. By "buying recycled," governments, as well as businesses and individual consumers, each play an important role in making the recycling process a success. As consumers demand more environmentally sound products, manufacturers will continue to meet that demand by producing high-quality recycled products.

## 2.4 Reusing

- 1) Reuse is using an item more than once. This includes conventional reuse where the item is used again for the same function and new-life reuse where it is used for a new function.
- 2) Reusability implies some explicit management of build, packaging, distribution, installation, configuration, deployment, maintenance and upgrade issues. If these issues are not considered, software may appear to be reusable from design point of view, but will not be reused in practice.
- 3) Reusability is often a required characteristic of platform software. Reusability brings several aspects to software developments that does not need to be considered when reusability is not required.
- 4) The ability to reuse relies in an essential way on the ability to build larger things from smaller parts, and being able to identify commonalities among those parts.

### 2.4.1 Advantages of reuse

- Energy and raw materials savings as replacing many single use products with one reusable one reduces the number that need to be manufactured.
- Reduced disposal needs and costs.
- Refurbishment can bring sophisticated, sustainable, well paid jobs to underdeveloped economies.
- Cost savings for business and consumers as a reusable product is often cheaper than the many single use products it replaces.
- Some older items were better handcrafted and appreciate in value ( Arslan,H. 2008).

### 2.4.2 Other researchers work

**Table 2.1: Reference from the other researchers work**

Author	Year	Work
Askiner Gungor and Surendra M. Gupta	1999	<p>-Recovery process can divide in two categories:</p> <ol style="list-style-type: none"> <li>1. Recycling which aims to reclaim the material content of retired (or used) products</li> <li>2. Remanufacturing which targets to bring the parts of a product or the product as a whole to a desired level of quality to reuse resell or reassemble.</li> </ol> <p>-Disassembly is one of the most actively researched areas in the context of material and product recovery. Various practical and theoretical techniques are being developed for manual and automatic disassembly processes.</p>
Charles R. Mc Lean	1997	Study about establishing disassembly plants and developing product designs which specifically facilitate disassembly. Once disassembled, the items can be reused, recycled, or discarded.