

## Characterization of Case Mobile Phone for Remanufacturing Purpose

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**Abstract.** Remanufacturing is a standardized industrial process by which cores are returned to same-asnew, or better, condition and performance (Ikeda, 2017). The process is in line with specific technical specifications, including engineering, quality and testing standards. The process yields fully warranted products. An industrial process is an established process, which is fully documented, and capable of fulfill the requirements established by the remanufacturer. The purpose of this study is to initial study the feasibility of remanufacturing only on the case of mobile phone as an information and consideration if the company will do remanufacturing for mobile phones. To achieve the objectives of this study conducted interviews with mobile phone manufacturers to find opinions and views about remanufacturing and conducted characterization material of case that used on mobile phones through literature and component analysis of material structure on mobile phone.

**Key Words:** *remanufacturing; case remanufacturing; characterization of case mobile phone for remanufacturing purpose*

## 1 Introduction

Along with the development of mobile phone technology is very rapidly the period 2007 to 2017 there are so many brands and types of mobile phones in the market that cause the period of mobile phone usage is getting shorter. This resulted in the number of secondhand mobile phones, either from the condition of mobile phones that have been damaged or from the previous model output that will be electronic waste. E-waste or commonly referred to as electronic waste. According to Baldé et al., (2014), e-waste in the world reaches 41.8 million tons consisting of 1 million tons of waste lamps, 3 million tons of small electronic goods waste, 6.3 million tons of electronic display, 7 million tons of temperature control waste, 11.8 million tons of large electronic equipment waste and 12.8 million tons of small electronic equipment. For mobile phone itself is in the category of small electronic goods. Therefore, one way to overcome the waste problem is by doing remanufacturing.

Remanufacturing is a process whereby cores are returned to the same conditions as new, or better, under conditions and performance (Ikeda, 2017). This process complies with technical specifications, including engine, quality and test standards. This process produces a product that is completely guaranteed as new. Remanufacturing is required to reduce the amount of waste by repairing components from damaged products that can be reused. During this time remanufacturing activities are intended for products that have a very expensive price and have a reasonable component size to do remanufacturing (Ikeda, 2017). In this thesis research, focused on feasibility study of early possibility of remanufacturing case of mobile phone. The mobile phone case meant here includes the frame and back case. This is chosen because the physical damage of a mobile phone is mostly found in the outer case due to the effects of abrasion, impact and so on. This level of disability is also affected by the strength of mobile phone case materials used. There are 3 types of materials that generally use for mobile phone case in Indonesia market, that is plastic, glass, and metal. The study consists of disability identification on a number of used mobile phone cases, studying the material and its coatings when present and the manufacturing process so as to provide an initial recommendation for possible remanufacturing process. In addition, the literature study also complements information to examine the ability to remanufacturing mobile phones, especially in Indonesia.

## 2 Research Methods

Remanufacturing has been run previously by some companies, for example the photocopier. One of the photocopy companies that already run the remanufacturing process is Xerox. Xerox

performs remanufacturing on the Xerox 5100 type that is not designed for remanufacturing and DC 265 that has been designed for remanufacturing. Generally the remanufacturing process they use can be seen in Figure 1.

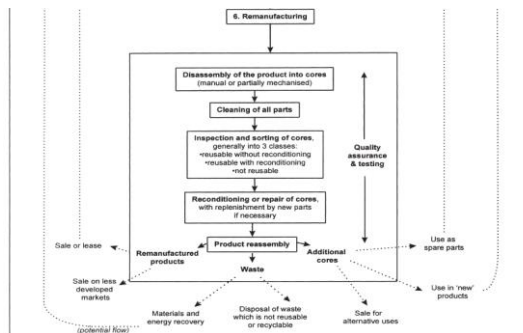


Figure 1. Remanufacturing cycle

According to Kerr and Ryan (2000), by providing customers with remanufactured products, companies can provide services to customers using lower resources so Xerox can save millions of dollars in raw materials and waste disposal costs in accordance with the results presented in Table 1.

Table 1. Cost Saving

The savings achieved by remanufacturing Xerox 5100 photocopiers

	Xerox 5100 copiers (non-modular)		DC 265 copiers (modular)	
	% saving	Reduction by a factor of ...	% saving	Reduction by a factor of ...
Materials consumption (kg)	25	1.3	49	1.9
Energy consumption (MJ)	27	1.4	68	3.1
Water consumption (L)	19	1.2	38	1.6
Landfilled waste (kg)	35	1.5	47	1.9
CO <sub>2</sub> equivalents (kg)	23	1.3	65	2.9

The results of the study indicate that the product designed to be disassembled and remanufactured provides significantly greater savings than products that were not originally designed for remanufacturing.

In the case of remanufacturing for mobile phones, begins with the procurement of mobile phones with 3 types of materials for evaluation consisting of metal, glass and plastic (Table 2).

Table 2. Mobile phone used for evaluation

Brand	Type	Material
Apple	iPhone 5	Metal
Samsung	Galaxy S5	Plastic
Samsung	Galaxy S6	Glass
Xiaomi	Redmi 3	Metal

Step 2 to characterize the material from mobile phones that have been collected together with a visit to the factory producing mobile phone as a resource. Afterwards collect used mobile phones for identification of the defects experienced by the mobile phone (Table 3) and coincide with learning about remanufacturing through reading the literature.

Table 3. Mobile phone used for identification

Brand	Type	Material
Samsung	Galaxy Note 3	Plastic
Samsung	Galaxy S5	Plastic
Samsung	A5 2017	Glass
Samsung	Galaxy S7	Glass
Samsung	Galaxy S7	Glass
Samsung	Galaxy S8	Glass
Apple	iPhone 5	Metal
Apple	iPhone 5s	Metal
Apple	iPhone 6s+	Metal
Apple	iPhone 7	Metal

Next did the grouping of types of mobile phone case damage and continued by reviewing feasibility in implementing remanufacturing mobile phone, giving recommendation of process remanufacturing and ending with conclusion.

### 3 Result and Discussion

#### 3.1 Characterization of Case Mobile Phone

Material characterization is performed on back over mobile phone. To conduct a study on the structural and composition of mobile phone back cover material used SEM (Scanning Electron Microscopy) and EDX (Energy Dispersive X-Ray Analysis) evaluation. Evaluation was performed on three back cover sections of the top surface, cross section and bottom surface of the evaluated mobile phone case pieces. The material evaluated was carried out on plastics and metals. Plastic material comes from Samsung Galaxy S5 while for metal materials using iPhone 5 and Xiaomi Redmi 3.

##### 3.1.1 Plastic

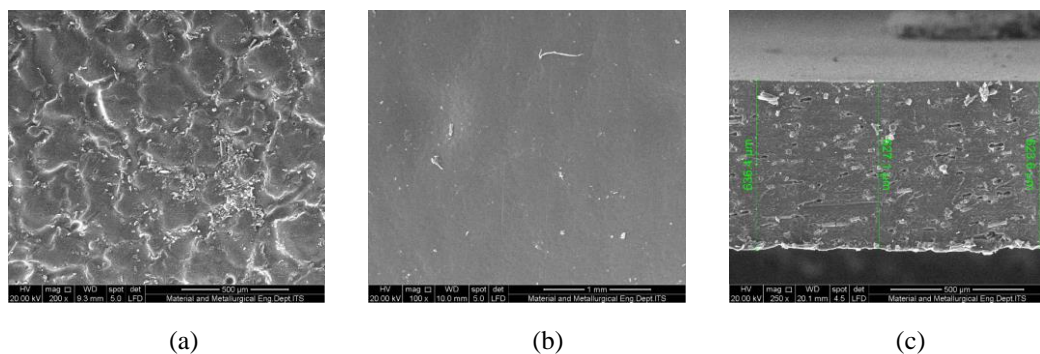


Figure 2. SEM photographs of material case Samsung Galaxy S5 from (a) top, (b) bottom dan (c) cross section

In Figure 2 the SEM results from 3 different cross sections. It can be seen from Figure 2 (c) that this case has a thickness of 636.4  $\mu\text{m}$  and uses completely plastic and no coating is found that protects the plastic material.

### 3.1.2 iPhone 5 and Xiaomi Redmi 3

The existence of similarities in terms of materials and processes used to prepare mobile phone case on the iPhone 5 and Xiaomi Redmi 3. Figure 4.2 is a photo with a cross section of the iPhone 5 results from the SEM test.

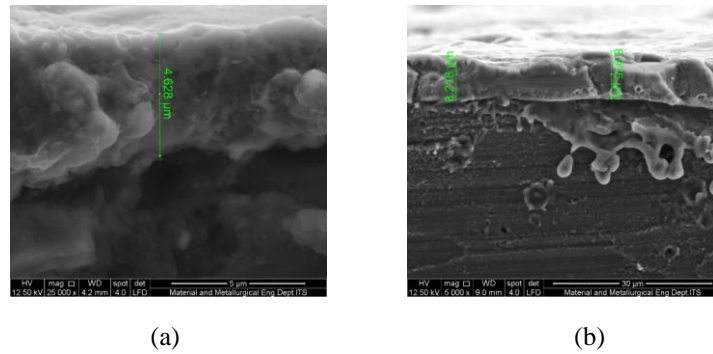


Figure 3. SEM evaluation cross-section (a) iPhone 5 and (b) Xiaomi Redmi 3

Figure 3 shows that this Xiaomi Redmi 3 has a layer on its case surface but with a size of 8.975 μm or nearly twice as thick as the layer of iPhone 5.

### 3.1.3 Glass

After characterizing glass, it appears that Gorilla Glass 5 has the highest durable level compared to the previous series described in Figure 4.

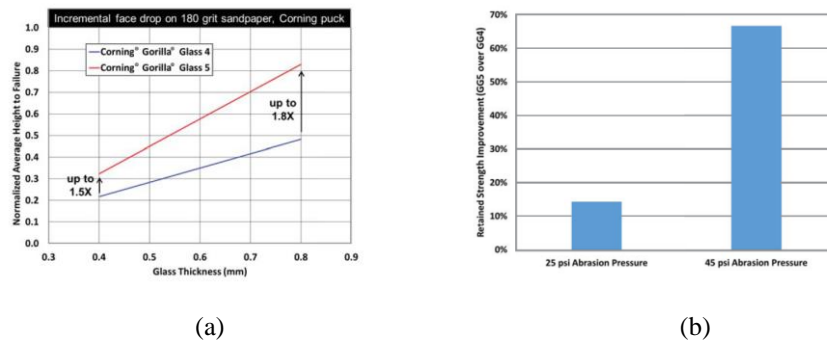


Figure 4. Glass Characterization (a) drop test and (b) scratch test

In Figure 4(a) a drop test is performed using a pendulum and an emery paper of 180. The glass attached to the pendulum will be dropped to a certain degree and hit the emery paper 180. As can be seen the damage resistance of Gorilla Glass 5 increases by 1.5x to 1.8x. The glass thickness parameters use 0.4 to 0.8 because there are differences in thickness produced by Corning for Gorilla Glass 4 and Gorilla Glass 5. As for Figure 4(b) it can be seen that Gorilla Glass 5 is able to withstand 10% more scratches for 25psi pressure and 65% more for 45psi pressure when compared to Gorilla Glass 4.

### 3.2 Identification of mobile phone

After identifying the defects of the mobile phone, the conclusions in Table 4.

Type	Scratch		Eroded		Peeling Paint		Deformation		Bend		Crack	
	Case	Frame	Case	Frame	Case	Frame	Case	Frame	Case	Frame	Case	Frame
Galaxy Note 3 (P)	-	-	-	-	v	v	-	-	-	-	-	-
Galaxy S5 (P)	-	v	-	-	-	-	-	v	-	-	-	-
iPhone 5 (M)	v	v	v	v	-	-	-	-	-	-	-	-
iPhone 5s (M)	-	-	v	v	-	-	v	v	v	v	v	v
A5 2017 (G)	-	v	-	-	-	-	-	v	-	-	-	-
iPhone 6s+ (M)	-	-	-	-	-	-	v	v	-	-	-	-
Galaxy S7 (G)	-	-	-	-	-	-	-	v	-	-	-	-

Table 4. Summary

After identifying the mobile phone according to table 4, the majority of mobile phone defects with daily use lie in the framework of the mobile phone. Can also be seen disability that allows to be repaired only on mobile phone that experience defect of scratch or paint peel only because if defect already about the material of its parent / core can not be repaired again. With this category of disability then the Samsung Galaxy Note 3 mobile phone, Galaxy S7 and Galaxy S8 that allows to be remanufacturing materials for reasons of disability.

### 3.3 Recondition

Table 5 represents the possibility of repair for each damage.

Table 5. Recondition

Damage	Repair Possibility	Product	Number
Scratches and peeling paint	Eliminate the coating first either in the form of color paint or protective coating. After that do the re-dye according to the initial color and end with the drying process.	Galaxy S5	1,2,3
		A5 2017	1,2
		Galaxy S7 (gold)	1
		iPhone 5	1
		Galaxy Note 3	1,2,3,4
		iPhone 7	1
Eroded	Can not be repaired so change must be done	iPhone 5	2,3,4,5
		iPhone 5 s	2
Indentation of deformation and bend indentation	Use vacuum or emphasis	Galaxy S5	4
		iPhone 5s	1,3
		A5 2017	3
		iPhone 6s+	1,2
		Galaxy S7	1
		iPhone 7	2
Indentation crack	Can not be repaired so change must be done	iPhone 5s	4

As in Table 5, any of the defects in the mobile phone found not all can be repaired because the defect experienced by the mobile phone has reached its parent material so it must be done substitution. Appropriate that has been written in table 4, which entered the category can be remanufacturing is Samsung Galaxy Note 3, Galaxy S7 and Galaxy S8 however. considering that the material used by Samsung Galaxy Note 3 is plastic, it must reconsider the cost and time spent to do the repair because the back cover with plastic material has a cheap price if it will buy new. In defects in the form of scratches allow to be repaired by means of re-polished but must be in accordance with the tolerance limit of the OEM (Original Equipment Manufacturer) if not possible to be replaced with a new one. For the repair of flawed paint defects in the mobile phone with the coloring process using anodizing and painting have different ways. In the anodizing process, the material must be removed initially before anodizing anodizing can be done again and for painting is only required to remove the paint using chemical liquids and then repainted. As for indentation deformation and bent indentation can be repaired by using vacuum or pressure given so that

mobile phone case can return to its original shape if still included in limit of OEM tolerance (Original Equipment Manufacturer).

#### 4 Conclusion

In carrying out its special remanufacturing for mobile phone case it is necessary to study its characterization in terms of material structure and processes experienced from mobile phones during production. Any mobile phone that uses aluminium or mobile phone mobile phone that uses plastic materials, the content of its elements and dimensions will vary for each brand depending on the needs and costs. As for mobile phones that use the majority of glass materials will have similarities in the constituent elements but differ in dimensions. Almost all existing mobile phone brands work with Corning in case making. The majority of mobile phones have been identified, the defect occurs in the mobile phone frame with the shape of scratches, peeling paint, eroded, deformation indentation, bent indentation and crack indentation. As for the other disability is a special case that rarely happens. For the majority of mobile phone samples tested, mobile phone cases are not suitable for remanufacturing and after analysing in terms of materials, difficulty and cost, mobile phones are more suitable for refurbishes already executed in Malaysia by way of direct sale in accordance with the level of defects or recycle as run by Apple for its mobile phone compared to remanufacturing.

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