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Process Planning for Mobile Phone Remanufacturing in Indonesia Abstract. The Increased number of mobile phone users has an impact on increasing electronic waste (E-Waste) without being offset by the act of product recovery management. Remanufacturing is one way to overcome this. Remanufacturing is a process to return used products to general aesthetics and operating standards. This paper aims to design a mobile phone remanufacturing process in Indonesia. Indonesia is a developing country where the mobile usage is quite high. The mobile phones are chosen because it is one of the biggest e-waste takers of late. Several factories were visited in this study. This research uses a qualitative survey, which is carried out in mobile phone factories and service centers. From this research, a design has been made to remanufacture the process on mobile phones. The manufacturing plant verifies the design in order to obtain the input of the real constraints which will happen when the remanufacturing process is done. The steps in the process of remanufacturing are HMI & visual inspection, separation, disassembly, cleaning, inspection, sorting, reconditioning, reassembly, and final inspection. Key words: remanufacturing, mobile phone

1 Introduction Depleted natural resources, increased carbon emissions, and strict government regulations have raised concerns about how to get rid of end-of-life products, and have become stronger over the last few decades [1]. In other words, the government has done many ways to incineration in order to tackle waste, especially electronic waste. These methods include reuse, recycling, and remanufacturing. Remanufacturing is a process for returning used products to the general aesthetic and standard of operation [2]. Lund developed seven criteria. One of the criteria is remanufacturing is reasonable to be connected to technologically stable items [3]. Mobile phones are electronic products that not included to this category. Mobile phone is relatively low value product and short life cycle [4]. When the life cycle of mobile phones has ended, making mobile phone is one of the biggest contributors of e-waste. The wastes of mobile phones are hazardous and toxic, for instance Pb, Cd, Hg, As, Ni, and Cr [5]. There are numerous studies which support the remanufacturing of electronics product. Guide et al. [6] show that the remanufacturing of the short life-cycle product is not only feasible but also can be profitable with a well- managed. However, the increasing amount of waste electrical and electronic equipment (WEEE) causes remanufacturing mobile phones to be an important issue. In Indonesia, reported that 65 million people used the mobile phone in Indonesia [7]. This makes electronic waste from mobile phone in Indonesia a serious problem From the previous research, Tanoto et al. shows that mobile phones remanufacturing in Indonesia can be implemented from the perspective of technical feasibility [8]. This study aims to design a remanufacturing process for mobile phones. This study can provide an overview of the process of remanufacturing the phone to the factory, which has not done the remanufacturing process.

2 Literature review

2.1 Remanufacturing Process Remanufacturing is a part of product recovery management which consists of repair, remanufacturing, cannibalization, and recycling [9]. From those options, repairing, refurbishing, and remanufacturing have different recovery rates than

remanufacturing with the greatest recovery rate. The main purpose of the repairing process

is to return the used product to the "working order" product. The quality of this repaired products is usually lower than the quality of the new products.

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Meanwhile, the product quality of remanufacturing process is

the same or better than the quality of the new products. However, the repairment requires a portion only to disassemble and reassemble, while the remanufacturing process uses full disassemble to form part and reassemble. In contrast, the main

purpose of refurbishing is to bring the used products to certain quality.

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Refurbishing uses the disassembly of used products until they become modules. The important modules are inspected and repaired or replaced so that quality the service-life will increase. However, the service-life which remains after the refurbishing process is usually less than the average service-life of the new product. According to Steinhilper, there are five steps in remanufacturing. These steps can be seen in figure 1 [10]. Disassembly Cleaning Inspection and Sorting Reconditioning Reassembly Fig. 1. Five Steps of Remanufacturing Process. 2.2 Remanufacturing process on other products There are some electronic manufacturers which have already done remanufactured. One of them is Xerox with its copier and printer. Xerox has several production facilities in the world. In Europe, Xerox remanufacturing facilities are in Venray (NL), Mitcheldean (UK), and Dundalk (Ireland). The disassembly process is carried out based on the standard Operator Instruction Cards (OIC), so the process is easy to be tracked and to be audited as a whole for quality inspection. Full inspection is done on each existing sub-assembly. Although most components can be reused, some components will be replaced with higher and newer quality to compete with the latest standard. After that, a full test operation will be carried out with the same standards and specifications like the new product. Afterwards, these remanufactured products will be sent with the same treatment as the new products. The remanufacturing process carried out in Dundalk can be seen in figure 2 [11]. Caterpillar also processes the remanufacturing of their products [12]. After receiving the core, the first step to do is an inspection. The components which are usually remanufactured are cylinder packs, water pumps, hydraulic components, and other engines' components. Afterward, the component will be dismantled. This process carried out to the nuts and bolts. The part which has been dismantled will be cleaned using an environmentally friendly process. After cleaning, an inspection will be carried out on the quality using the Caterpillar Remanufacture Criteria. Each part which is repaired in this remanufacturing process has the right specifications to ensure that this remanufactured product has the same quality, reliability, and durability as the new items. Furthermore, the remanufactured product will be rebuilt from the previously repaired part. Tests are done to ensure that this remanufactured product can run properly. After the series of testing, the remanufactured products will be repainted and is ready for sale. Delphi Technologies also remanufactured their turbocharger [13]. The first step is to disassemble to the part level. Even though some parts of the disposal can function well, it is believed that it will reduce the performance of the turbocharger if it is reused. The discarded parts which will be sent to recycle and the replacement parts will be done before reassembly. The next is cleaning in this step the dismantled parts will be cleaned using chemicals to ensure that the dismantled parts have the same conditions like the new parts. Then, every existed part is inspected to ensure that the parts meet the specified parameters. If there are parts that do not

meet the parameters, they will be discarded from the system and recycled. The parts which meet the specified parameters will be merged with the new parts so that the reassembly process can run. After they are assembled, each turbocharger will undergo several industry standard tests to ensure it will work based on the standards. After each turbocharger passes the specified parameters, the remanufactured turbocharger can be sold.

Core Disassembly
Sorting
Cleaning
Remanufacture
Parts
Frame
Add new parts
Sub-assembly
Remanufactured product
Testing
Configure
System
Whole Machine
Assembly
Assemble
Frame
Add new parts

Fig. 2. Xerox Remanufacturing Process Flow Chart in Dundalk

3 Methods Conducting interviews and studying the production process of mobile phones at mobile phone manufacturer in Indonesia are done to obtain the data. We visited three factories, such as Huawei, Advance and Polytron. The interview took place in some city in Indonesia during November 2017 until July 2018. The interviewees are the owner, plant manager, mechanical design manager and team, and electrical design manager and team. The interview was organized in a semi structured questions, face to face, and recorded. We also visited some services centres to supplement the previous research data [10]. After getting the data, remanufactured mobile process planning can be designed. This process is affiliated with the Steinhilper stage. The process plan will be consulted with expert the factory to minimize the technical problems so as to enable it to be implemented.

4 Results and Discussions

4.1 Results of factory visits

Through the result of factory visits, we find that there is no factory that produces a whole mobile phone but limited to assembly process. Among the three factories, there is a factory whose production processes are more intact. The factory does not only assemble, but also performs mechanical and electrical design process. We call the brand "A" for the secrecy. According to the interview result, there are two types of mobile phones which is considered suitable for remanufacturing process, high-end and featured phone.. High-end mobile phones are possible to be remanufactured because the specifications are almost the same with the new mobile phones. This is because the consumers still demand the specifications. Featured phone is suitable to be remanufactured especially when there is a specification upgrade process on the mobile phone. Upgrading (specification) process of mobile phones is difficult because the design of the mobile phone must be prepared since the beginning., Human Machine Interface becomes the most favourite upgrade because the consumers can perceives directly. Reworking mobile phones is not the same like reworking heavy equipment or other products. In infeasible components are replaced to rework the mobile phone. Even though the PCBA can be reworked, it can only replace the damaged connectors. So, it includes the replacement as well. Planning the remanufacturing process will only be carried out to modular level instead of the part level. It is because many electronic components are supplied to the mobile manufacturer in the form of modules, such as cameras, LCDs and more. Most of the modules are supplied from overseas manufacturers. The domestic industry has not been able to produce it. In addition, the costs will be enormous to dismantle and to repair it. For example, the process and the equipment to disassemble LCD Module (LCM) are not easy, so it will be very expensive to fix.

4.2 Step of mobile phones remanufacturing

The stages of the remanufacturing process design can be seen in Figure 3.

Core HMI & Visual Inspection
Separation
Disassembly
Cleaning
Refurbish
Part Harvesting
Remanufactured product
Waste Reuse
Recycle
Final Inspection
Reassembly
Reconditioning
Sorting
Inspection

Fig. 3. Steps of Mobile Phone Remanufacturing Process.

4.2.1 Human machine interface (HMI) & visual inspection

Checking mobile phones's HMI and physical conditions is carried out on this stage. HMI can be checked manually or using engineering mode. Engineering mode is an built-in software from the manufacturer which can be used to determine the condition or the performance of the features in the mobile phone. Meanwhile, the physical condition of the mobile phone is checked whether there is damage in the form of scratches, dent, or chipped paint..

4.2.2 Separation

The separation will be classified into 3 options. There are remanufacture (go to next step), part harvesting, and waste. This classification is based on several factors, such as the visual (physical) condition, the cost of the repairment, the complexity of the improvements, the availability of the components, and the time.

4.2.3 Disassembly

The

next step is to disassemble the mobile phone. Disassembly requires several tools such as tweezers, solder, screwdrivers, picks, headers and blowers. The sequence of disassembly processes on the mobile phones is casing, middle cover, PCBA, peripheral components, and batteries. There are several types of connections which are used in the mobile phone casing, like a snap fit, adhesive, and bolt connection. The snap fit connection can be removed by hand. After there is a space, the pick can enter and open all existing connections. A blower can open the adhesive connection. The heat will weaken the adhesive on the casing. Then, a cop or pick is used to open the case. Meanwhile, a screwdriver can unscrew the bolt connection. The next step is removing the middle frame from the mobile phone. There are mobile phones which use middle frame and do not use middle frame. The middle frame can be removed by unbolt the bolts. Meanwhile, for the non-middle frame mobile phone, the battery is directly attached to the front cover. PCBA is a major component of mobile phones. In general there are two types of PCBA. There are PCBCA which unites with the sub-board and PCBA which separates from the sub-board. The mobile phone which have separate PCBA sub-board is connected with a flat cable called FPC. FPC cable is very easy to break, so the process of disassembly must be done carefully. The process of removing PCBA, which unites with the sub-board uses heating equipment (heater / hot plate). The heat will remove the adhesive material from the PCBA. However, there are also PCBAs which can be revoked. The next process is to remove the peripheral components from a mobile phone. The peripheral components are the supporting components of the mobile phone, for example the camera, speaker, antenna, vibrator, and so on. There are two types of connection which are used for the peripheral components. There are connection which uses solder and connection which uses socket.. The process of removing the connection using solder uses solder, meanwhile the process of removing the connection using socket only needs to remove it from the socket. The last step is to remove the battery. There are 2 types of batteries, no-removable battery and removable battery. . While the removable battery is easy to release, the non-removable battery is much more complicated. It is because the adhesive layer has to be removed from the battery. A heater can remove the adhesive layer on the battery. However, temperature limit must be heeded since it can cause explosion. Certain types of mobile phones uses strip adhesive on the non-removable batteries.

4.2.4 Cleaning

After disassemble process, it needs to be cleaned up. However, there are some parts of the mobile phone which need extra care, like the camera, because it can possibly cause damage.. This step will carry out the remnants of glue which attached on the parts of the mobile phone. The sticking dust on the components of the old mobile phone is cleaned using a brush. The component which ever exposed to the water can also be found through this step. If the component ever exposed to the water, it will be cleaned using thinner or 90% alcohol. If fungus is found, it can be cleaned using a Special Thinner or an ultrasonic cleaner. The exposed part is placed in a container soaked by thinner. Then the container will be inserted in an ultrasonic cleaner and turned on for a certain time.

4.2.5 Inspection

This step aims to check the components of the mobile phone. There are three types of testing to be carried out, namely reliability inspection, performance inspection, and safety inspection. The reliability test includes various tests covering the reliability of the mobile phone. However not all reliability test can be applied to the remanufacturing process of the mobile phones. This is because some tests considers destructive. Performance inspection includes features which are owned by the mobile phones. This performance aims to ensure that every component in the mobile phone can function properly. Safety inspection covers the level of security on mobile phones when the users use it. For the remanufacturing process, the safety test that can be done is minimal because most of the safety tests are destructive.

4.2.6 Sorting

This step aims to classify the mobile phones into several groups. There are mobile phones which are recommended for remanufacturing and are not recommended for reconditioning. Mobile phones which are not recommended for the remanufacturing process will be classified into based on the recycling processes which are refurbish, recycle, and reuse.

4.2.7 Reconditioning

Every damaged component will be replaced immediately at this stage. The replacement of the components which are

considered “must-be-replaced”™ according to the inspection process has been carried out.

4.2.8 Reassembly

After replacing the parts reused and unused parts, the next process to do is reassembly. This step aims to rebuild the mobile phone which has been disassembled. This reassembly process is almost the same as the process of disassembly, but it is done in reverse direction.

4.2.9 Final Inspection

The last step is to ensure the function of the mobile phone features, whether it works well or not. The feature examination includes signal, Wi-Fi, Bluetooth, microphone, speaker, receiver, front camera, rear camera, autofocus camera, video, camera flash, battery charging, LCD backlight, proximity, USB, home key, volume key, screen lock key, and vibration.

5 Conclusion

This study aims to produce a design for the process of remanufacturing on mobile phones. The step of the remanufacturing process of mobile phones which have been made are HMI & visual inspection, separating, disassembly, cleaning, inspection, sorting, reconditioning, reassembly, and final inspection. This step is useful to provide the insight for those who want to remanufacture so that those who want to do remanufacturing can know the steps that must exist in the process of remanufacturing mobile phones. This step is also useful to give an overview to consumers who want to buy a mobile phone for remanufacturing products, because some consumers do not believe in this remote processing process. So that with these steps consumers can find out the procedures performed when the mobile phone remanufacturing process takes place.

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