Remanufacturing: A Case study in Mercedes-Benz Bus Factory

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Abstract

There are economic and environmental motivations for organizations to value their end-of-life products. For that reason, there are alternative methods like recycling, direct reuse, repair, refurbishing, and remanufacturing. Among these only in remanufacturing used products are brought at least to the original equipment manufacturer performance specification. Worn-out parts are removed and replaced. It conserves the product identity and seeks to bring the product back into like-new condition. This paper presents remanufacturing activities of Mercedes. It explains the details of engine remanufacturing in bus factory of Mercedes-Benz in Istanbul/Turkey based on information obtained from Mercedes websites and interviews presented in media. In terms of environmental protection, the factory is an exemplary facility with the technology used, special measures taken, treatment plants, and alternative energy solutions.

Keywords
Remanufacturing, Mercedes, engine, product recovery, product return.

1. Introduction
Today organizations can produce products with less cost in shorter time with the highly developed technology. New products are introduced to market and popularity of old products rapidly disappears. Customers are willing to find verity of products with affordable prices. This makes organizations to produce products with shorter lifetime and results in increased end of life products and waste disposal rates. Green production and resource efficient systems are major issues today (Corum 2016). Organizations look for alternative ways to value end-of-life products not only for economic benefits, but also due to new regulations and a growing environmental awareness in the business world (Ozcan and Corum 2021). Product recovery is considered as one of the highest priorities on the agenda of most organizations (Corum et al 2014).

There are five product recovery options (Thieery et al. 1995): Repairing, refurbishing, remanufacturing, cannibalization, and recycling. In repairing, damaged parts are replaced or upgraded to working order (Tang and Naim 2004). It is the correction of specified faults in a product. The quality of the repaired product is inferior to those of remanufactured and reconditioned alternatives (King et al. 2006). The purpose of refurbishing is to bring used products up to specified quality. Quality standards are less rigorous than those for new products. Recycling is the series of activities by which discarded materials are collected, sorted, processed, and used in the production of new products (King et al. 2006). In remanufacturing worn out parts are removed and replaced. The quality standard is “as good as new” (Tang and Naim 2004). It is the only process where used products are brought at least to the original equipment manufacturer performance specification (King et al. 2006). It conserves the product identity and seeks to bring the product back into an as new condition by carrying out the necessary disassembly, overhaul, and replacement operations (Oh and Hwang 2006). In cannibalization, only a small proportion is being reused. The purpose of cannibalization is to recover a limited set of reusable parts from used products or components. These parts are reused in repair, refurbishing, or remanufacturing of other products and components (Thieery et al. 1995). Reconditioning involves less work content than remanufacturing, but more than repairing. All major components that have failed or that are on the point of failure will be rebuilt or replaced (King et al. 2006).

There is a major distinction between material recovery (recycling) and added value recovery (repair, remanufacturing) (Kenné et al. 2012). See Table 1 for different characteristics, and main differences between the product recovery options mentioned above.

Table 1 Comparison between product recovery options (Thieery et al. 1995)

	Level of Disassembly	**Quality Requirements**	**Resulting Product**
Repair	To product level	Restore product to working order	Some parts fixed or replaced by spares
Refurbishing	To module level	Inspect all critical modules and upgrade to specified quality level	Some modules repaired/replaced; potential upgrade
Remanufacturing	To part level	Inspect all modules and parts and upgrade to as new	Used and new modules/parts combined into new product; potential upgrade
Cannibalization	Selective retrieval of parts	Depends on process in which parts are reused	Some parts reused; remaining product recycled/disposed
Recycling	To material level	High for production of original parts; less for other parts	Materials reused to produce new parts

In the past there were limited regulations and public concern about the end-of-life products. Organizations did not feel any obligation for the consequences of the products after they sold. Remanufacturing has been receiving growing attention not only because of value recovery from the used products but also regulations, consumer awareness and environmentally consciousness. The remanufacturing process could present both environmental and social benefits, as well as economic benefits to its implementers (Duberg et al 2020).

This paper contains remanufacturing activities of Mercedes. It explains the details of engine remanufacturing. It presents the reasons for starting remanufacturing engine in Istanbul/Turkey and the advantages it provides. The paper is prepared based on information obtained from Mercedes websites and interviews presented in media.

2. Background

Ebersole (1997) states that the symbol of 20th century industry was the assembly line. The symbol of 21st century industry may be the disassembly line. Xerox Co. and Eastman Kodak Co. design products to make them not only easy to put together, but easy to take apart. Xerox remanufactures about 1 million parts and 150000 office machines each year. Kodak collects 50 million single use cameras each year from 20 countries for remanufacturing, as well as reworking products ranging from microfilm machines to photographic film base.

According to Lund (1996) a remanufactured product can be sold for 45 to 60 percent of the cost of a new one. Lund and Hauser (2010) state that they know of 113 product areas in which remanufacturing occur. In the United States the major product areas based on the number and size of firms in each area are motor vehicle parts, electrical motors and generators, pumps, transformers, laser toner cartridges, industrial machinery, tires, industrial valves, and office furniture. The price of a remanufactured product normally is between 45% and 65% of the price of a comparable new product.

Kumar and Putnam (2008) state that most developed countries have environmental regulations making the responsibilities of manufacturers, generators, and users of chemicals to properly dispose of wastes. In the mid-1980s this was commonly known as ‘‘cradle-to-grave’’ resource management. Today, modern environmental management makes sustainable manufacturing practices that focus on prevention of waste and responsible care of the earth’s natural resources. The focus on recovery of resources, recycling, and reuse can be described as ‘‘cradle-to-cradle’’ resource management. See Figure 1 which presents an integrated supply chain where service, product recovery, and waste management activities are included.

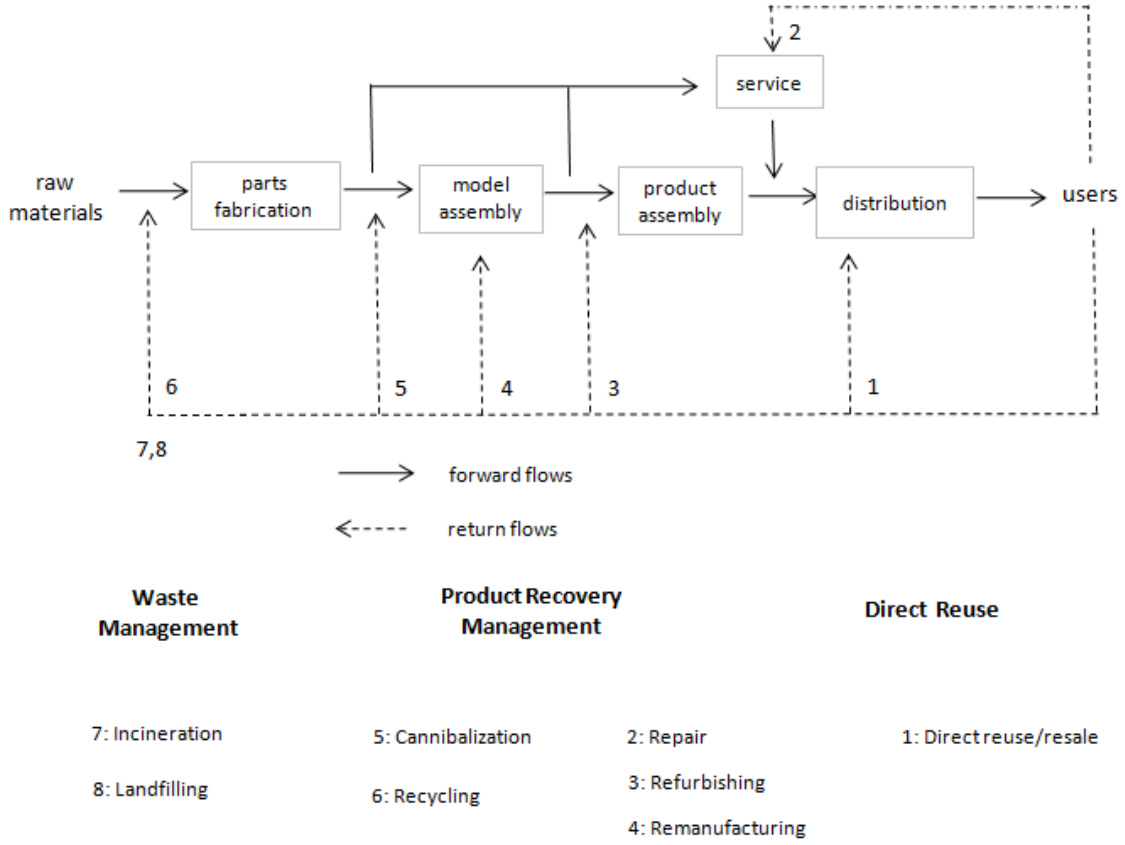

Figure 1 Integrated supply chain (Thieery et al. 1995)

Many researchers refer to the definition of remanufacturing by Lund (1983): *Remanufacturing is an industrial process in which worn-out products are restored to like-new condition. Through a series of industrial processes in a factory environment, a discarded product is completely disassembled. Useable parts are cleaned, refurbished, and put into inventory. Then the new product is reassembled from the old and, where necessary, new parts to produce a fully equivalent and sometimes superior in performance and expected lifetime to the original new product*. During this process, the core (end of life product) passes through several remanufacturing operations like; inspection, disassembly, component reprocessing, reassembly, and testing to ensure it meets the desired product standards (Östlin et al. 2008). See Figure 2 for flow of typical remanufacturing unit.

Remanufacturing focuses on value-added recovery, rather than just materials recovery (recycling). Remanufacturing is distinctly different from repair operations, since products are disassembled completely, and all parts are returned to like-new condition (Guide, 2000).

Remanufacturing is also economic. The cost of remanufacturing is typically 40-60% of the cost of manufacturing a new product with only 20% of the effort (Mitra 2007). The actual process of remanufacturing is less costly than producing a new product because many parts and components can be reused instead of procuring them (Ferguson 2009).

Remanufactured products usually have shorter lead times. However, the high variability of remanufacturing operations makes the use of traditional operations management techniques difficult (Ilgın and Gupta, 2010). Labor is the major cost factor in remanufacturing. The cost of cores is an important cost factor, but generally it is lower than the cost of necessary replacement parts and other materials needed (Lund and Hauser 2010).

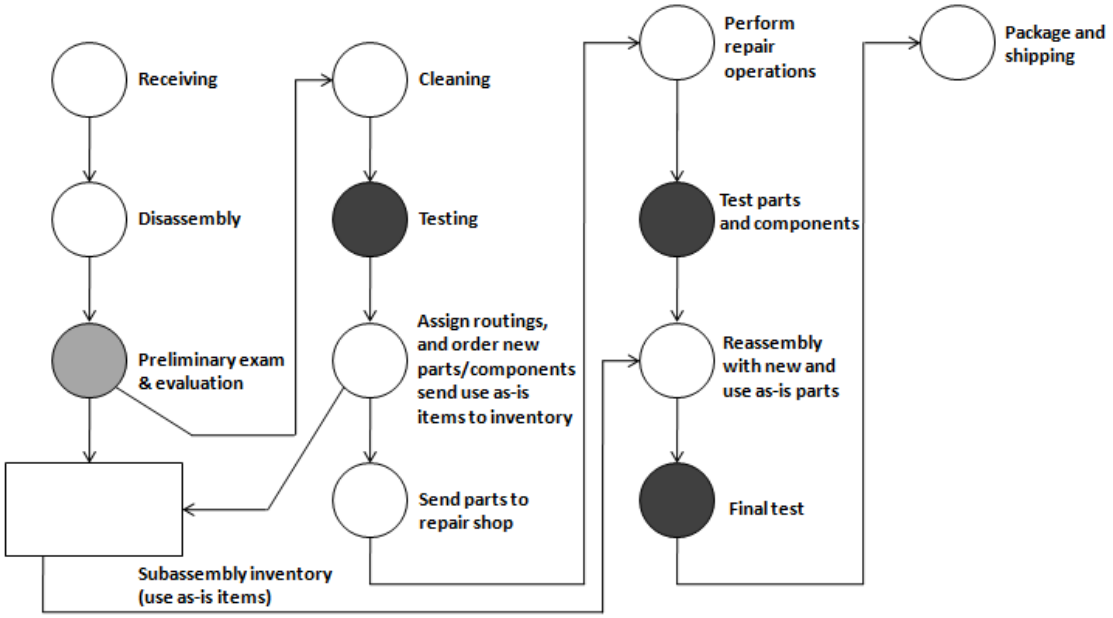

Figure 2 Flow of typical remanufacturing unit (Guide and Srivastava, 1997)

There are various motives for product remanufacturing: Increased profitability, ethical responsibility, legislation, secured spare part supply, increased market share, and brand protection (Seitz and Peattie 2004). Ferguson (2009) states that if the firm does not choose to remanufacture there is the danger of ignoring the environmentally conscious customers. There can be costly regulatory restrictions and government mandated producer disposal fees. This is already occurring in the electronics and automotive industries. One regulation is requiring a certain percentage of each automobile be recyclable (European Union End-of-Life Vehicle Directive). Another regulation impose that electronic equipment producers fund the take-back and proper disposal of their products (Waste Electrical and Electronic Equipment Directive).

Remanufacturing has also been shown to be environmentally preferable in comparison with other end-of-life treatments, because the geometrical form of the product is retained and its associated economic and environmental values preserved (Östlin et al. 2008). Ferguson (2009) states that the Xerox Corporation started remanufacturing early. In 1991, company obtained savings of around $200 million by remanufacturing copiers returned at the expiration of their lease contracts. Kodak has created a fully integrated manufacturing-remanufacturing strategy around its reusable funsaver camera line. Caterpillar established a remanufacturing division that markets both equipment and parts, even including parts from other manufacturers. In 2007, this division had over $2 billion in sales and was the fastest growing division out of all of Caterpillar's divisions. In 2007, IBM collected over one million units of used information technology (IT) equipment that were converted to billions of dollars in revenues on the secondhand equipment, parts, and materials markets.

One of the most widely reported remanufacturing systems is belonging to Xerox Corporation (Kerr and Ryan 2001). Company has been recovering used equipment since the 1960s but developed a more formal remanufacturing system in the late-1980s. Today, Xerox has remanufacturing programs for used photocopiers and print and toner cartridges, from all around the world. It has remanufacturing facilities in United States of America, United Kingdom, Netherlands, Australia, Mexico, Brazil, and Japan. By remanufacturing, Xerox has saved millions of dollars in raw material and waste disposal costs. With remanufacturing, Xerox had an environmentally conscious company image. Product recovery and remanufacturing are core part of the Xerox business model. Integration of remanufacturing into the company's overall business strategy brought significant environmental and financial benefits to the company (Atasu et al. 2010).

The imaging and printer group at Hewlett Packard (HP) has various contracts with third party remanufacturers and logistics providers to recover some of the costs. HP does product recovery primarily to avoid polluting the environment with used products and to have an environmentally conscious image (Atasu et al. 2010). In the Renault trucks company remanufacturing is quicker than rebuilding. With the cost savings over purchasing a new part, this made remanufacturing even more attractive (Bourgeosi 2004). Robert Bosch Tool, North America offers remanufactured versions of its Bosch and Skil product lines. The company remanufactures for a variety of reasons including cost. Remanufacturing is also a way to reach customers who would not buy expensive new products. By this way, company can compete with inexpensive imports. Bosch managers consider remanufacturing to be a core part of the business (Atasu et al. 2010).

Guide (2000) identified seven complicated characteristics of remanufacturing: (1) Uncertainty in the timing and the quantity of returns, (2) balancing returns with demands, (3) disassembly, (4) uncertainty in materials recovered, (5) reverse logistics, (6) materials matching requirements, and (7) routing uncertainty and processing time uncertainty. These characteristics make resource planning, scheduling, shop floor control, and material management more difficult than in traditional manufacturing environments.

3. Mercedes Reman Engines

For Mercedes remanufacturing means to recondition used Mercedes-Benz genuine parts from all three divisions of passenger cars, vans, and trucks, in such a way that they are as good as a new part regarding their function, safety and quality. Specially trained professionals examine each individual part and decide whether it can be used or not (daimler.com).

Remanufacturing of automotive parts begins with an inoperative, failed, or worn-out part. This part is disassembled so that the subsystems and components can be cleaned, tested, repaired, reworked and/or replaced. These components are then restored to a “like-new” specification, reassembled, and tested to a quality of level with same warranty as parts that are brand new (mbbloomfield.com).

Mercedes has remanufactured parts of engine, transmission, clutch, propeller shaft, moving parts such as starters, but also electronic components such as engine control units. For example: When Mercedes-Benz needs a repair, customers buy a remanufactured transmission rather than a new one. The part price has two components: One part for the remanufactured transmission and a smaller part as a deposit. If customers return the old, used part to Mercedes, the deposit is refunded to them. The deposit is a financial incentive for customers, to collect old parts. The remanufacturing system is a closed circuit. A remanufactured part combines the aspect of sustainability with an attractive price and high quality. This is also well received by the customers (daimler.com).

The remanufactured engines are called “reman engine”. Mercedes-Benz Türk started to sell reman engines in 2014 at an affordable price and it was demanded by customers. Remanufacturing operations were carried out worldwide at the Mercedes-Benz Mannheim Engine Remanufacturing Plant. Since the round-trip process of an engine collected in Turkey takes about 3-4 months and is costly, it was decided to carry out the remanufacturing at the Engine Renewal Center within the Mercedes-Benz Türk Bus Factory in Istanbul. Detailed analyzes were made and the needs were determined. The processes in the German factory were applied exactly. The team went through training in Germany. Necessary equipment was provided. In addition, teams from Germany came, examined, and approved the processes. The second remanufacturing facility within Mercedes started operating in April 2017. On average, around 1500 engines are remanufactured in Mercedes-Benz Turkey per year.

Reman engine is not different from a new engine in terms of quality and durability. It has the same performance, quality, and Mercedes-Benz guarantee as new engine, supporting environmentally friendly production. With this process, Mercedes extends the life of the vehicle and offers new engine quality at high performance and reasonable prices. Remanufacturing application makes a great contribution to customer’s budget. Instead of buying a new engine, customers get a reman engine with a Mercedes-Benz warranty for 1/3 price. Customers cannot distinguish the performance of the Reman engine from the new engine. Reman engines are offered with original spare parts and labor warranty of 1 year without the km limit.

The prerequisite for customers to benefit from these advantages is the complete return of the damaged engine on the vehicle to Mercedes-Benz Türk. Delivering the used or damaged engine to the Mercedes-Benz Turkish dealer, the

vehicle owner can receive the Reman engine without losing time. Reman engine is mounted within 24 hours following the order, allowing the vehicle to be moved. Customers do not have to wait while their old engine is remanufactured.

There are several drivers behind Mercedes-Benz implementing remanufacturing in their production plant in Turkey. The main driver is to increase sales offering less price and high customer satisfaction. In Turkey, there is a very competitive spare parts market. Remanufacturing can offer customers Mercedes-produced certified engine at a lower price while maintaining the high-quality standards. The reuse of parts through various processes is an increasing trend in the world. The reman engine service has advantages in terms of efficiency and cost for both the environment and the customer. There was a growing demand for this service in Turkey.

Mercedes-Benz's Reman engine production is completed in 5 stages: (1) Engine parts are disassembled, (2) all parts are cleaned, (3) parts are tested and parts that do not meet the standards are replaced with new ones, (4) reman parts are moved to assembly line and assembled with other original spare parts, (5) reman engines are tested.

According to the experience of the remanufacturing staff in Mercedes-Benz Turkey, the most time-consuming and error prone step in the remanufacturing process is the inspection. Each part is individually disassembled and analyzed. All parts are tested for quality in new vehicle production and non-conforming parts are scrapped and instead of them original spare parts are used. When the processes are finished, the reman engine is painted with special paint and delivered to the customers.

Workers involved in remanufacturing need to have more skillset as compared to workers involved in regular processes. In regular manufacturing, workers are responsible for the supply of parts and assembly. In remanufacturing, disassembly and inspection are added. The main driver behind remanufacturing is to supply cheaper engines, improve customer loyalty, and high profitability. The production time and inventory holding cost is higher in remanufacturing. However, material cost is significantly lower in remanufacturing.

4. Conclusion

Today product recovery is important for the organizations. There are many motivations behind: Value recovery from used products, new regulations, globally increasing environmental awareness of customers, and to have an environmentally friendly company image. Different material recovery options exist but remanufacturing is the only process where the quality standard becomes as good as a new product.

Mercedes-Benz have been using remanufacturing techniques in Germany for a long time. Products are produced for ease of disassembly. Cores are collected from the Mercedes-Benz dealers and stored in the factory. Customer can buy remanufactured engines from the dealers. Reman parts lower costs with Mercedes-Benz quality. They are remanufactured to the highest quality standards as original Mercedes-Benz parts and then verified within internal assessment facilities. By remanufacturing in its production plant in Istanbul/Turkey, Mercedes started to produce engines at a more affordable price. In this way, it delivers high quality engines to more customers at low prices.

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Biography

Adnan Corum is a faculty member at Bahcesehir University, department of industrial engineering in Istanbul/Turkey. He is delivering courses on operations management, production planning and control, ERP systems, process management, mathematical programming, and engineering economy in both undergraduate and graduate levels. He has publications on remanufacturing systems, financial decision making, and ERP systems.