Assessing Automotive Parts for Remanufacturing

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Abstract

There is a continuous flow of new products put on the market by original equipment manufacturers (OEMs). In order to retain value that is put into them during manufacturing these products can be remanufactured for economic, environmental and social reasons. This has been the case for many decades in industrial sectors, for example, the automotive industry. However, the automotive industry is currently changing much in recent years due to trends of electrification and servitization.

Stable technology, high after-use value and replaceable parts are typical attributes of a product suitable for remanufacturing. In addition, if products are servitized e.g. through leasing or sharing there are additional economic reasons to remanufacture. However, all products and parts are not suitable for remanufacturing while other products and parts are more suitable for remanufacturing. In a remanufacturing of electric vehicles, the need to define a set of parts suitable for remanufacturing becomes crucial.

The aim of this paper is to explore new ways of understanding which parts that should be selected for remanufacturing in the future automotive aftermarket. The research methodology used to meet the aim of this paper is literature search and case studies at electric vehicle manufacturers and remanufacturers based in Europe. During the case study data was collected through observations, semi-structured interviews and disassembly activities along the product value chain of electric vehicles including manufacturers, dismantlers and remanufacturers.

To define a set of parts for remanufacturing an assessment of the price and quantity of sold parts in an aftermarket, costs for remanufacturing process as well as the interdependency of the parts based on a product structure was accomplished. The results show that there are attributes deriving from the categories of economics, technology, and environment. This means in general terms that the remanufacturing is profitable, technologically possible and sound from an environmental perspective. For the different product parts these attributes were differently strong and motivating the initiation to remanufacture.

Keywords: Remanufacturing, Electric vehicles, Product attributes, Design for Remanufacturing, Circular Economy
1. Introduction

Within the automotive industry product remanufacturing has been an important factor for the aftermarket of passenger cars. In a survey of European remanufacturers by Parker et al (2015) the automotive industry came out as the second largest industry for remanufacturing when estimating the companies’ yearly turnover (Table 1).

Table 1. Industrial sectors performing remanufacturing in Europe (Parker et al, 2015)

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Turnover (£bn)</th>
<th>Firms ('000)</th>
<th>Employm’t ('000)</th>
<th>Core² ('000)</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace</td>
<td>12.4</td>
<td>1,000</td>
<td>71</td>
<td>5,160</td>
<td>11.5%</td>
</tr>
<tr>
<td>Automotive</td>
<td>7.4</td>
<td>2,363</td>
<td>43</td>
<td>27,286</td>
<td>1.1%</td>
</tr>
<tr>
<td>EEE</td>
<td>3.1</td>
<td>2,502</td>
<td>28</td>
<td>87,925</td>
<td>1.1%</td>
</tr>
<tr>
<td>Furniture</td>
<td>0.3</td>
<td>147</td>
<td>4</td>
<td>2,173</td>
<td>0.4%</td>
</tr>
<tr>
<td>HDOR</td>
<td>4.1</td>
<td>581</td>
<td>31</td>
<td>7,390</td>
<td>2.9%</td>
</tr>
<tr>
<td>Machinery</td>
<td>1.0</td>
<td>513</td>
<td>6</td>
<td>1,010</td>
<td>0.7%</td>
</tr>
<tr>
<td>Marine</td>
<td>0.1</td>
<td>7</td>
<td>1</td>
<td>83</td>
<td>0.3%</td>
</tr>
<tr>
<td>Medical equipment</td>
<td>1.0</td>
<td>60</td>
<td>7</td>
<td>1,005</td>
<td>2.8%</td>
</tr>
<tr>
<td>Rail</td>
<td>0.3</td>
<td>30</td>
<td>3</td>
<td>374</td>
<td>1.1%</td>
</tr>
<tr>
<td>Total</td>
<td>29.8</td>
<td>7,204</td>
<td>192</td>
<td>132,405</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

There are many reasons to why remanufacturing occurs often in the automotive industry. One main reason is that car owner (drivers) often chooses to use remanufactured parts instead of new spare part during their planned mileage services at the car workshops. It is also common to use remanufactured spare parts when repairing crashed cars then temporarily owned by insurance companies in order to achieve an affordable car repair. It is common that the customers get a warranty and around 50% discount on the spare parts if they choose the remanufactured parts instead of new spare parts.

This means that the aftermarket and use of remanufactured parts is a well-established system including many actors. In addition, the car workshop (garages) are also suggesting to have even more remanufactured parts to offer to their customers (car owners) as also illustrated by Steinhilper (2012) in Figure 1.

Fig 1. Investigation of demand of spare parts from car workshop (garages) in Germany (Steinhilper, 2012).
As new technologies and customer needs are continuously being developed also the automotive aftermarket is also changing. Currently, the automotive sector are under a big change due to the rapid technology development trends within electrification and digitalization but also due to the trends of servitization.

1.1. Electrification of passenger cars

Almost all major car manufacturers are developing electric vehicles (EV) with battery electric drive trains. As reported by Casper and Sundin (2020) these are examples of electrification targets from car manufacturers:

– **Daimler** plans to electrify its entire portfolio by 2022 (Daimler, 2020)
– **Ford** will have seven electrified and custom plug-in hybrids in the future (Ford, 2020)
– **Jaguar Land Rover** plans to electrify its entire line-up by 2020 (Reuters, 2020)
– **General Motors** plans to go for an all-electric vehicle by 2023 (GM Media Online, 2020)
– **Mazda, Denso, and Toyota** are jointly developing technologies for electric vehicles (Pressroom Toyota, 2020)
– **Renault, Nissan, and Mitsubishi** are developing pure electric cars and plan to release 12 EVs by 2022 (Electrek, 2020a)
– **Volkswagen** (including brands like Audi and Porsche) plans to offer an electric and hybrid version of 300 vehicles by 2030 (Electrek, 2020b)
– **Volvo Cars** plans to electrify its entire vehicle line-up by 2019 and have five EVs by 2020 (Volvo Car USA, 2020) and plans to develop its own electric motors and control systems for its future EVs (NyTeknik, 2020)

In the same paper by Casper and Sundin (2020) the differences of the power train of a passenger car were presented (see Figure 2) and also how the remanufacturing processes of the new power train change in comparison the remanufacturing of power train parts used in a car with an internal combustion engine (ICE),
The changes in drive train components from cars using an internal combustion engine to cars with battery electric motor means e.g. that there are less parts that can be remanufactured and new kind of knowledge is needed to be able to perform remanufacturing.

1.2 Servicification of passenger cars

A second trend, maybe not so strong yet, is the servicization of cars. This means that cars are being shared to a higher degree between different users. Within the automotive industry the servicization is commonly called car sharing to share the use of a car (see e.g. Shaheen & Chan (2016) and Cohen & Kietzmann (2014)). Car sharing service examples are Zipcar, BlaBlaCar, and M which are differently connected to car manufacturers (see e.g. M (2021)). Data connectivity and shared mobility services will according to McKinsey & Co. stand for $1.5 trillion in revenues by 2030 (Mohr et al, 2016). Form a more technical perspective the
servitization of cars mean that the utilization of cars becomes higher and the cars put on milage much faster than ordinary sold cars.

1.3 Aim
Following these trends in automotive aftermarket industry it is interesting to find out more about how these trends are affecting the remanufacturing operations e.g. what parts that needs to be remanufactured in the future. Therefore, the aim of this paper is to explore new ways of understanding which parts that should be selected for remanufacturing in the future automotive aftermarket.

2. Current ways to select car parts for remanufacturing
According to Steinhilper and Weiland (2015) spare parts are provided for the automotive aftermarket mainly from four sources in different times of the economic life cycle of cars starting with new spare parts, remanufactured parts, copied parts, and reused parts at the end (see Figure 3).

![Figure 3. Markets and market actors for automotive spare parts (Steinhilper and Weiland (2015)).](image)

Since automotive parts has been remanufactured for many years the market actors are used to set up new remanufacturing of new parts. For a contracted remanufacturer one starts to calculate the market for remanufactured parts by finding out answers to the following questions:

1) What is the spare part demand? (estimate the yearly demand of parts)
2) How often does the part break down? (measure the failure rate)
3) How to supply from new spare parts and from reman spare parts? (finds core suppliers)

From a car manufacturers point of view starting up remanufacturing (or contract someone to do it for you) if there is:

1) a big demand on the market,
2) the car parts have a high value, and
3) the car parts are easily available to get hold on.
These kinds of attributes are not easy to establish from the start of new car manufacturing but it is rather learned during the first years of manufacturing. In addition, the car parts are usually not designed for remanufacturing which also can be challenging for the remanufacturing companies. From a technical standpoint Steinhilper and Weiland (2015) have proposed to position any product types (not only automotive parts) according to their technological attractiveness for remanufacturing based on the dimensions of; a) product usage time per life cycle, b) technical effort for the implementation of the remanufacturing process steps, and c) regeneration rate. This is illustrated in Figure 4 below.

![Assessment of the Technological Remanufacturing Attractiveness](image)

**Fig 4.** An example of how to assess the technological remanufacturing attractiveness of products (Steinhilper and Weiland, 2015)

This general way of estimating the technological attractiveness is of course applicable on automotive parts as well and can give remanufacturing companies a hint of what kind of attributes to look for when planning their future remanufacturing operations. However, one can note that it is the economic attributes that is first mentioned by manufacturers and remanufacturers and secondly the environmental attributes and not the technological factors.

Within a research project industrial and academic partners tried to set up what car parts that are attractive for remanufacturing for electric vehicles. The attributes were placed in the categories economic, technology and environment as shown in Table 2.

**Table 2.** Car part attributes useful when identifying part for future electric vehicle.

<table>
<thead>
<tr>
<th>Economy</th>
<th>Technology</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Remanufacturability:</td>
<td>Material scarcity</td>
</tr>
<tr>
<td>Price/Value</td>
<td>- Accessibility</td>
<td>Material and weight</td>
</tr>
<tr>
<td>Economic lifetime</td>
<td>- Disassemblability</td>
<td>Resource efficiency</td>
</tr>
<tr>
<td>Remanufacturing volumes</td>
<td>- Testability</td>
<td>Climate impact</td>
</tr>
<tr>
<td>Collaboration with:</td>
<td>- Robustness</td>
<td>Transport possibilities</td>
</tr>
<tr>
<td>- Part supplier (OEM)</td>
<td>- Affinity/Originality</td>
<td></td>
</tr>
<tr>
<td>- Insurance company</td>
<td>- Backward compatibility</td>
<td></td>
</tr>
<tr>
<td>Core collection costs</td>
<td>High quality/Technical lifetime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access to spare parts</td>
<td></td>
</tr>
</tbody>
</table>

These car parts attributes are what we identified to be the attributes that affects the possibilities for having a potentially successful remanufacturing process.
3. Discussion and conclusion

As cars are being developed according to new technology trends the remanufacturing of car parts also needs to follow these trends. Since the automotive industry right now are going through a larger shift of technology as well as their way of being sold and used traditional ways of choosing parts for remanufacturing will be challenged. Most likely there will be and must be closer focus on creating aftermarket solutions to fulfill the remanufacturing, reusing, repairing or refurbishing possibilities already in the developing design phases. The trends of pointed out earlier in the automotive industry gives more incentives to start using design for remanufacturing guidelines of car parts to be able to have the cars running many more miles per years than today.

Within this research there are a set of product attributes that affects the possibilities for remanufacturing. These attributes are good remanufacturing companies to know in advance either if they are original, contracted or independent remanufacturers.

Future research includes to study more which of these attributes that are of most importance and if there are other factors that affect them if the trend of servitization is further increased.

Methods

The data was collected through literature studies and interviews and workshops with car manufacturers, car part remanufacturers and company experts within automotive aftermarket industry.

Authors' contributions

ES initiated the manuscript idea and writing. ES also collected data for the study in collaboration with research project partners. JKP and RC contributed with text parts of data for the manuscript and with valuable improvement comments of the paper.

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