Shifting Remanufactured Products from Used to New

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Abstract

Humans use more resources than the earth can regenerate and the demand on materials is expected to rise further. The worldwide economy follows mainly the linear rules, in which only one life cycle of a product is considered. Remanufacturing, the reuse of products after their treatment, even if achieving a turnover of round 30 billion Euros in Europe accounts only for a small proportion of the manufacturing. In this paper the integration of remanufacturing in the production of new units is introduced in order to enable a shift of remanufactured products from used to new ones. The opportunity for this approach is explained based on the example of household appliances.

1 Introduction

Humans strive to lead a better life. The definition of a better life depends on the individual itself, their living situation and the recognized possibilities. Globalization supports not only the exchange of goods and information but also desires. The inner need to own luxury products as for example a car, a television or a smartphone can be observed all over the globe [1, 2]. A higher consumption of goods results in a higher resource consumption. In a linear economy raw materials are extracted, processed, transformed to products, used and discarded. In recent years, it has become common to collect and to return some materials to the production site [3]. Nevertheless, the majority of the economy is still linear. Circle Economy calculated the global circularity metric, which describes the proportion between the cycled materials and the material input, to be 9.1 percent in 2015 [4]. Additionally, humans worldwide use more resources than the earth can regenerate as the earth overshoot day was already on the 2nd of August [5]. Furthermore, the world population is steadily growing as well as the challenge to ensure an acceptable living standard [6]. To return the material to the production seems not to be sufficient to bridge the gap. The reuse of products is discussed and implemented in several industries as a further part of the solution. The products are treated and offered as a further purchase option often for a lower price. This additionally addresses another customer group with a lower willingness to pay and thus can lead to a further consumption and resource use [7]. Returning complete components or assemblies to a production of new units to save both material and work needed is not addressed yet.

2 Influence of the Ownership on Remanufacturing

To manufacture a product, materials, energy and work have to be added. Even if the product itself loses value over time, it still retains the material value as well as the value of production that can be used in reprocessing and thus lead to energy and material savings. The possible energy savings amount to up to 85 percent compared to the production of a new product [8], but this has to be checked for each case individually [9]. There are three main approaches to treat a product after the previous use phase: no treatment, repair and remanufacturing. The repair consists only of actions to restore the functionality of the product. In contrast to this, remanufacturing aims to achieve a product condition that is at least as good as new. According to BS8887: Part 2, remanufacturing is an industrial process of “returning a used product to at least its original performance with a warranty that is equivalent to or better than that of the newly manufactured product”. During this process the products go through the steps of inspection, disassembly, repair and replacement, cleaning and reassembly [10-12]. Remanufacturing is the highest level of treatment, since it guarantees at least the same quality, functionality, safety and warranty as a new product, even though it does not address explicitly the appearance and the perception of the product.

Several researchers have tried to explore the extent of remanufacturing in the economy. In the USA, in 2012 the United States Trade Commission introduced the report Remanufactured Goods: An Overview of the U.S. and Global industries, Markets, and Trade [13]. In 2015, the European Remanufacturing Network released a Remanufacturing Market Study [14]. In 2017, a report of VDI Centre for Resource Efficiency was published [15]. According to these data, the remanufacturing industry is worth round 30 billion Euros and employs around 190,000 people across Europe [14]. Nevertheless, it reaches only two percent of the turnover from production [15]. The share of various industrial sectors in remanufacturing is comparable in both the USA and Europe. The aviation industry with more than 12 billion Euros turnover from remanufacturing in Europe, the automotive industry with more than 7 billion Euros, and the Heavy Duty and Off-Road Equipment industry with more than 4 billion Euros turnover are the three main sectors of remanufacturing in Europe and together achieve more than 80 percent of the whole turnover [15]. In the mentioned

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industries, the manufactured products can be acquired through high initial investment and therefore a longer use through maintenance is intended. Further, there are legislative regulations, such as e.g. the requirements for maintenance in the aviation industry that enforce a regular treatment and enable a continuous availability of old parts.
The availability of cores as well as the reverse logistic are mentioned as one of the most important challenges of remanufacturing [16].The occurrence of the end of life due to a functionality failure or the general dissatisfaction with the product cannot be predicted precisely and depend amongst others on the usage intensity, the quality of the product and the willingness to purchase a new product by the user. The ownership of a product determines to some extent the unit responsible for the return. If ownership is with the user and no other requirements must be met, the date and the end of life strategy are assigned to them. If ownership remains with a party responsible for the end of life treatment, due to a business model providing a service of usability and not the ownership itself, a so-called Product- Service- System, the return date can be defined in advance. A common example is a leasing contract on a car, where the exact date and the condition of the product at the return are predetermined [17]. The challenge of the reverse logistic to handle the uncertainty of date and quantity of the return can be reduced and the product can be supplied to the process. The Figure 1 illustrates four exemplary ownership models under consideration of remanufacturing.

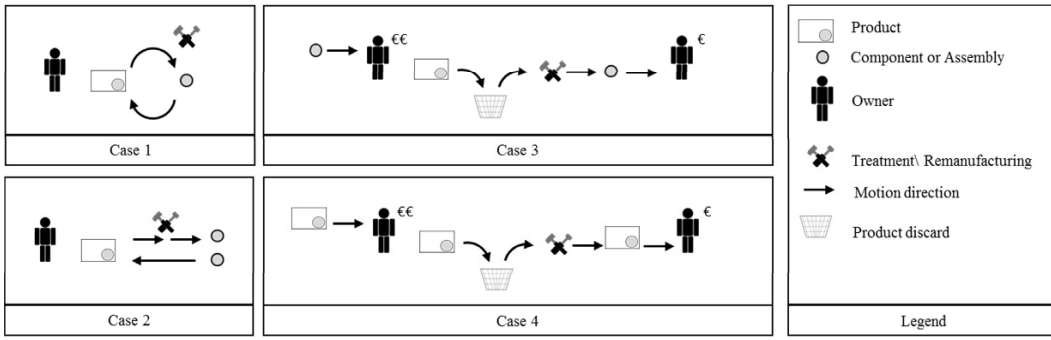

Figure 1. Ownership during remanufacturing

In case 1 the ownership remains with the customer all the time. A customer owns a product as well as all included assemblies and components. If an assembly has to be changed, this assembly can be removed, treated and reinstalled. In practice, automotive gears are remanufactured after a request of the owner and reinstalled in the same product. There is a direct connection to the owner and the observed errors can be queried. The spare part is usually adapted to a specific car model and can be exchanged only by an equivalent part.
In case 2 the ownership of the product remains with the customer, but the ownership of the assembly changes. A customer owns the product as well as all included assemblies and components. If an assembly has to be changed, another, already treated assembly is installed. The removed assembly is treated and stocked by the remanufacturer. Alternators are the most common examples, as they are installed in several car models and are available in large quantities. The exchange can be done as promptly as when using a new spare part.
In case 3 the ownership of the product remains with the customer, but the ownership of the assembly changes. A customer owns a product as well as all included assemblies and components. If an assembly has to be changed, a new assembly is installed. The removed assembly is discarded by the first owner and is bought by a remanufacturing company. It is treated and sold to another customer requiring a more favourable price-performance ratio.
Case 4 is similar to case 3 with the difference that ownership refers to the whole product. An ascending trend of this can be observed for electronic devices, such as tablets or laptops, which no longer meet the requirements of the first user but have a performance sufficient for other customer groups.
The described cases are applied in different industry sectors and business models and address a customer group with a lower willingness to pay [18-21]. Remanufactured products are perceived as used products, the customer therefore attributes a higher failure risk to them [20-22]. In several cases, where the product is used directly by the customer, as for example clothes or smartphones, additional information stating that the product was treated can lead to a worse perception of the product. To analyse the influence of information provided on the perception of used products, Ackermann et al. conducted a study in which the attitudes towards new, briefly worn and worn plus certified as equal to new pairs of pants were elaborated. The results of the study show that the respondents have worse feelings about the worn and certified as equal to new pair of pants than the just worn ones [22].
Using a different method of remanufacturing and simultaneously providing less information to the customer may shift remanufactured products from used to new ones without changing the customer attitude and therefore address the same customer group as for new products and with the same willingness to pay. In this paper a further model for remanufacturing is introduced and illustrated in Figure 2. In the introduced case, the customer acts according to the principles of the linear economy, i.e. buy, use, discard. The discarded product is not landfilled or recycled but is disassembled, and the assemblies and components are remanufactured. The remanufactured parts are not used as spare

parts but as parts for a production of new units. The new product contains new and remanufactured components. The proportion of the remanufactured components differs in each end product. The main difference to the current remanufacturing approach is that additionally to the functionality aspect visual aspects are addressed, as the produced product shows no signs of usage. For this approach the knowledge about the location and availability of cores is crucial. Therefore, ownership of the product and thus the possibility of deciding when a product is to be taken back should remain with the manufacturer. From an ecological point of view, this approach shows the advantage that no new customer group is addressed and therefore no additional resource consumption is expected.

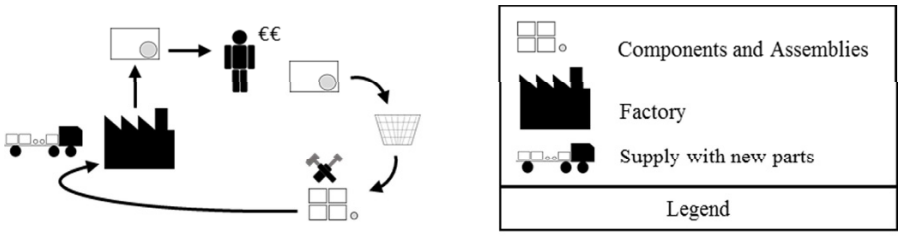

Figure 2. Integration of remanufacturing in a new production

3 The Potential of Household Appliances for Remanufacturing

Domestic appliances have become an integral part of European households. More than 95 percent of all households in Germany have e.g. a washing machine. According to the findings of Stamminger and Goerdeler 4.5 washes per week are made on average in a German household [24]. The additional effort of handwashing is no longer considered acceptable.

The average life span of a washing machine is difficult to determine. An online survey shows that the majority of washing machines are used longer than ten years [25]. If the long failure-free life time of washing machines is considered, it seems that there is no potential for remanufacturing in this sector. During such a long life span, several new models with additional features appear on the market. The cost for a single spare part amounts to a significant portion of the cost of a new washing machine. It often seems uneconomical to repair these devices after the warranty has expired, which is why a new product is bought. On the other hand, it is common to repair used washing machines in small repair shops where the spare parts are extracted from other used machines and to sell them for a small portion of the cost of a new one. An industrial process with high quality requirements would cost more money and shrink the price difference.

If a closer look at the construction of a washing machine is taken, two groups of components can be differentiated: Components that can be seen by the customer, such as the drum or the housing, and components within the machine, such as the pump. Prior research conducted by the author at the spare parts dealers has revealed that some components of the second group used by a major German household appliances manufacturer are installed in different models of a washing machine for more than twenty years. If the usage phase of a washing machine of ten years is sought, remanufactured components could be supplied to the production after half of the production timespan. Additionally, components taken from broken machines due to transportation damages or warranty claims could be used earlier.

The German washing machine market is saturated. Therefore, there is no need to attract a new customer group with a lower willingness to pay. Conventionally remanufactured washing machines would compete with low cost washing machines. Integrating remanufacturing in the production of new machines, however, would address the same customer group and reduce resource consumption without awaking the perception of a higher functionality risk.

Even if the market is saturated, there is a high demand for washing machines. It is assumed that an average household remains for 60 years, i.e. the time span between the start of independent living at 20 years and death at the age of 80. These figures represent a rough orientation rather than statistical data. With the average life time of a washing machine estimated at 15 years, four washing machines are needed for one household. With approximately 40 million households, 2.7 million washing machines are needed each year. This assumption corresponds with the market data. In 2011, 2.9 million washing machines were sold in Germany [26]. A further advantage for the market and a disadvantage for the environment is the fact that the relative cost of durable goods in Europe is sinking. For example, the necessary worktime for a washing machine, i.e. the time a worker with an average salary has to work to earn enough money to buy a product at an average price, amounted to 225 hours in 1960. In 2007, an average washing machine was achievable after 36 hours [28]. This can foster the willingness to buy new products instead of using them as long as they work without a defect. Using remanufactured components and assemblies would lessen the environmental impact of this approach without limiting the customer.

In addition, there are still markets with a high demand for low cost washing machines. In Vietnam in 2012, only 22.7 percent of all households owned a washing machine. The demand for them is increasing, as is the number of households [27]. To meet the demand, products based on older technology can be produced locally and therefore extend the time a component is used and increase the ability of integration remanufacturing into a production of new units.

4 Conclusion

This paper describes a new model for product reuse, where parts are remanufactured and used in the production of new products. It addresses the challenge of customer perception regarding remanufactured products. Several researchers have examined the willingness to pay for remanufactured products. In all studies, the achieved price was less than for new products [18-21]. Customers perceive remanufactured products as used ones entailing lower benefits and higher risks [21, 22]. The paper describes the opportunity to overcome this challenge by providing less information and addressing the visual appeal in the treatment process. The approach is explained based on the example of a washing machine. The bought product is always a new one, as it consists of approved assemblies and goes through the standard production process. It also guarantees the predetermined functionalities, appearance and warranty. If no further information is provided, customers do not experience any further difference. This idea can be compared to the use of recycled materials in production. In general, customers cannot determine the proportion of recycled materials. Only in exceptional cases, such as in the case of children's toys, is information provided stating that the product consists only of new materials.

To implement this model, a consideration of the legal situation is necessary. There is no legal definition of used products. For example, the Higher Regional Court of Hamm (Oberlandesgericht Hamm) has decided that a product is considered a used product (Gebrauchtware), if it has been used under normal conditions and is therefore associated with a higher risk of defects [29]. Used products are allowed to have a reduced warranty, which influences the customer perception. Remanufactured products have been used under normal conditions, but have no higher risk of defects than new products and come with at least the same warranty as a new one. However, they still cannot be described as new products. In this context, a Dutch court has ruled that remanufactured products cannot be used as exchange products as part of the warranty, because they are not an equivalent substitute for a new product [30].

5 Zusammenfassung

Der Mensch verbraucht bereits jetzt mehr Ressourcen, als die Erde regenerieren kann. Zusätzlich wird der Bedarf an Rohstoffen weiter steigen. Die Weltwirtschaft folgt hauptsächlich den linearen Regeln, bei denen nur ein Lebenszyklus eines Produktes berücksichtigt wird. Remanufacturing, die Wiederverwendung von Produkten, mit einem Umsatz von rund 30 Milliarden Euro in Europa macht lediglich einen kleinen Teil des Umsatzes der gesamten Produktion aus. In diesem Beitrag wird die Integration von Remanufacturing in die Produktion von neuen Gütern vorgestellt, um eine Verlagerung von wiederaufbereiteten Produkten von Gebrauchtware zu Neuware zu ermöglichen. Die Chancen dieses Ansatzes werden am Beispiel von Haushaltsgeräten erläutert.

6 References

[1] Pkw-Bestand in weltweiten ländern in den Jahren 2005 bis 2015 (in 1.000 Pkw); https://de.statista.com/statistik/daten/studie/415061/umfrage/pkw-bestand-in-weltweiten-laendern/ ; last access: 18.05.18

[2] Business Wire; Absatz von Smartphones weltweit in den Jahren 2009 bis 2017 (in Millionen Stück). https://de.statista.com/statistik/daten/studie/173049/umfrage/weltweiter-absatz-von-smartphones-seit-2009/ last access: 18.05.18

[3] Statistisches Bundesamt; Umwelt-Abfallbilanz 2015 (Abfallaufkommen/-verbleib, Abfallintensität, Abfallaufkommen nach Wirtschaftszweigen); 2017

[4] de Wit, M. et al.; The Circularity Gap report. An analysis of the circular state of the global economy; January 2018

[5] Umweltbundesamt; Abfallaufkommen; https://www.umweltbundesamt.de/daten/ressourcen-abfall/abfallaufkommen#textpart-2; last access 14.03.2018

[6] United Nations; World population projectes to reach 9.8 billion in 2050, and 11.2 billion in 2100; published: 21.06.2017; https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html; last access 24.04.2017

[7] Nijland, H. et al.; Mobility and environmental impacts of car sharing in the Netherlands; In:Environmental Innovation and Societal Transitions Vol. 23, p. 84-91, 2017

[8] Steinhilper, R.; Remanufacturing: The Ultimate Form of Recycling. Stuttgart, Germany: Fraunhofer IRB Verlag, 1998.

[9] Gutowski, T. et al.; Remanufacturing and Energy Savings; In: Environmental Science and Technology; 45, p. 4540-4547, 2011

[10] Lund, R.T.; Remanufacturing: The Experience of the United States and Implications for Developing Countries. World Bank Technical Paper, Vol.31, 1985

[11] Sundin, E.:Product and Process Design for Successful remanufacturing. Dissertation. Departmnet of Mechanical Engineering, Linköping University; 2005

[12] Nasr, N. et al.; remanufacturing: a Key Enabler to Sustainable Product System; In:Proceedings of the 13th CIRP International Conference on life Cycle Engineering (LCE), p.15-18, 2006

[13] Remanufactured Goods: An Overview of the U.S. and Global Industries, Markets and Trade; Investigation number 332-525, USITC Publication 4356, United States International Commission; 2012

[14] Parker, D. et al; Remanufacturing Market Study; November 2015

[15] Lange, U.; Ressourceneffizienz durch Remanufacturing - Industrielle Aufarbeitung von Altteilen; Kurzanalyse Nr. 18, 2017

[16] Widera, H.; Geschäftsmodelle der Wiederaufbereitung für Hersteller von Originalteilen; Berichte aus dem Produktiontechnischen Zentrum Berlin; 2014

[17] Tukker, A.; Eight Types of Product-Service System: eight way to sustainability? Experiences from SUSPRONET; IN: Business Strategy and the Environment; Vol. 13, p. 246-260; 2004

[18] Agrawal, V., et al.; Remanufacturing, third-Party Competition, and Consumers‘ Perceived Value of New Products; In: Management Science 61(1):60-72. https://doi.org/10.1287/mnsc.2014.2099; 2015
[19] Rathore, P., et al.; Sustainability through remanufacturing in India: a case study on mobile handsets; In: Journal of Cleaner Production 19, p. 1709-1722, 2011
[20] van Weelden, E., et al.; Paving the way towards circular consumption: exploring consumer acceptance of refurbished mobile phones in the Dutch market; In: Journal of Cleaner Production 113, p.743-754, 2016
[21] Matsumuto, M. et al; Comparison of U.S. and Japanese Consumers' Perceptions of Remanufactured Auto Parts; In: Journal of Industrial Ecology; Valume 21 Number 4; 2016
[22] Ackerman, D., et al.; Assuring me that it is as 'Good as New' just makes me think about how someone else used it. Examining consumer reaction toward marketer provided information about secondhand goods; In: Journal of Consumer Behaviour, J. Consumer Behav., 16: 233–241 (2017)
[23] Subramanian, R.,et al.; Key Factors in the Market for Remanufactured Products; In: Manufacturing & Service Operations Management 14(2):315-326. https://doi.org/10.1287/msom.1110.0368, 2012
[24] Stamminger, R.; et al.; Waschen in Deutschland- Auswertung einer Verbraucherbefragung; In: SÖFW-Journal, 131, 11-2015, 2015
[25] https://www.waschmaschinen-test.eu/wie-hoch-ist-die-lebenserwartung-einer-waschmaschine; last access: 20.04.2018
[26] Fachgemeinschaft für effiziente Energieanwendung e.V.; http://service.hea.de/fachwissen/waschmaschinen/1-marktdaten.php; last access: 15.04.2018
[27] General Statistics Office of Viet Nam; Data results of the Viet Nam Household Living Standards Survey 2012
[28] Handelsblatt; Tabelle: Kaufkraft der Lohnminute; http://www.handelsblatt.com/politik/konjunktur/butter-zucker-tageszeitung-tabelle-kaufkraft-der-lohnminute/2937670.html; published 24.03.2008; last access 14.03.2018
[29] OLG Hamm, verdict from 16.01.2014 - 4 U 102/13; https://medien-internet-und-recht.de/volltext.php?mir_dok_id=2567
[30] reman IPad cannot settle court dispute; https://www.rematec.com/news/news-articles/reman-ipad-cannot-settle-court-dispute/; published 22.05.2017; last access: 27.04.2018