3. Theoretical Foundation

3.1 Introduction

It is widely known that the consumption of natural resources is at an increasing rate today. Moreover, the consumer demands for material from the crust of the earth are constantly increasing. Therefore, it is imperative to know as to how to utilize all these resources more effectively for sustainable product development and manufacturing (O'Brien, 1999). During the last few decades, awareness about environment protection has also grown to a great extent. Continuous changes are happening today for better with even pressure from legislation & environmental awareness among consumers and these exist in Big as well as in Small and Medium Enterprises (SMEs).

Many Industries, these days offer upgraded remanufactured version of EOL products which can compete with the new products in the market place. Remanufacturing is the process where in the industries collect the EOL products through customers or brokers and carry out operations like disassembly, cleaning, coating and replacement of worn-out parts etc., with a new one and again assemble the product for final inspection & packaging. It can be seen from the literature that many researchers view that the quality of a remanufactured product is as good as new one (Guide, 2000; Östlin et al., 2009; Hauser and Lund, 2008). Many industries offer remanufactured products at low price with same warranty as that of a new product. Due to the remarkable functional and green growth quality, many customers world over are attracted towards remanufactured products in the market (Matsumoto and Umeda, 2011). The early activities in the remanufacturing sector began to boost up during the Second World War.
Currently, the industry sector that has the most experience in the remanufacturing area is the automotive sector (Lund and Hauser, 2009). In the automotive remanufacturing market, products like alternators, breaks, clutches etc. have a huge demand (Guide and Li, 2010). Remanufacturing is an important area contributing to the green growth & sustainable product development and a significant amount of research on remanufacturing is going on all over the world. Countries like United States of America (USA), United Kingdom (UK) and Japan etc. are coming with different remanufactured products in the market. In the remanufactured products list, the remanufactured cartridge products are grabbing major share in the secondary market (Hermansson and Sundin, 2005).

Many Asian countries like India, China etc. are also doing progressive business in the cartridge remanufacturing sector. Many customers from all over the world buy the remanufactured products such as cartridge through eBay online source. For remanufacturing processes, fewer raw materials are used and hence the energy and natural resources are saved largely. Remanufacturing of automotive parts conserves 60 percent of the energy used for making the original product and reduces air pollution by avoiding re-smelting processes. According to the industry experts, for each pound of new material used in remanufacturing, 5 to 9 pounds of original materials are saved. Purchasing a remanufactured product can cost as much as 50 percent less compared to the cost of a new product, which can add up to real savings.

3.2 Important Elements of Remanufacturing

For remanufacturing industries, a closed loop supply chain management (CLSC) of EOL product is the main challenge (Brito and
Dekker., 2004; Steinhilper., 2001; Guide and Wassenhove., 2001). CLSC management is important and is an integral part of remanufacturing process (Terkar et al., 2012). Success of perfect launching of a remanufactured product mainly depends upon CLSC. Following are some important key elements in the remanufacturing sector.

3.2.1 Product Recovery Alternatives

Product recovery is possible by many ways according to the level of product. Lower level product recovery systems are often named as ‘material recycling' and higher level are named as ‘Reconditioning', ‘refurbishing' and 'remanufacturing'. In these product recovery systems, remanufacturing have shown its own importance due to its upgraded product quality with satisfied functionality (Sundin, 2004; Toffel, 2004; Ferguson and Toktay, 2006; Zuidwijk and Krikke, 2007).

In this context, it is necessary to address the definitions of recycling, reconditioning, refurbishing and remanufacturing.

When a product is reduced to its basic elements, which are reused is nothing but material recycling (Rogers et al., 1998). Recycling process return a raw material for future manufacturing. Recycling mostly applies to consumable and durable goods. In countries like India and China, material recycling is the most popular method to recover the material. In recycling process, melting and smelting part causes environmental pollution and hence many EPA are not interested in promoting recycling as a vital product recovery process.

Reuse is the added use of a component, part or product after it has been removed from a clearly defined service cycle (Keoleian et al., 1993).
Reconditioning is the process of restoring components to a functional and/or satisfactory state but not above the original specification using such methods as resurfacing, repainting etc (Amezquita, 1996).

Refurbishment is when a product is cleaned and repaired to return it to a ‘like new state’ (Rodgers et al., 1996). Closeness of refurbished process with a remanufactured product still is not clear and hence it causes a lot of confusion in the market.

The appropriate product recovery process depends upon the condition of EOL product. When the products of old version cores are not demanded in market, then recycling is the most suitable method for product recovery management (Pagell et al., 2007). Many remanufacturers think that the term reconditioning and refurbishing are very much closers to remanufacturing. The main difference between remanufacturing and reconditioning as well as refurbishing is in connection with the quality levels. According to literature, remanufacturing product quality is ‘as good as new’ counterpart product. For this dissertation work, remanufacturing has been defined as, “Remanufacturing is an industrial process wherein products, referred to as cores, are restored to useful life”. During this process, the core passes through a number of remanufacturing operations, e.g. inspection, disassembly, part reprocessing, reassembly, and testing to ensure that it meets the desired product standards (Bras and McIntosh, 1999; Sundin and Bras, 2004).

3.2.2 Remanufacture Synonyms

In international language, there are not many English words such as ‘remanufacturing’, but still they are used to describe remanufacturing.
Words like ‘inverse manufacturing’ in Japan, ‘Produkturecyling’ in Germany and ‘Renovation’ in France are used instead of remanufacturing. In Industries also there some specific synonyms used for remanufacturing. Some industries use Rebuilt as synonymous with remanufacturing for some part of motor vehicle, but not for entire vehicle. In cartridge industries also, many are using ‘Recharged’ in connection with remanufactured. In Tyre industries, Retreading or Remolding is used with remanufacturing. Overhaul terminology is used in aerospace with remanufacturing. There is a lot of confusion about remanufacturing terminology in the industries but according to the literature survey, The Remanufacturing Institute (TRI), Automotive Products Remanufacturing Association and The American Society of Mechanical Engineers have explained the remanufacturing process in detail and without any hesitation, they have agreed that the quality of remanufacturing is as good as new product.

### 3.2.3 Basic Remanufacturing Product Development

![Basic Remanufacturing Product Development Model](image)

**Figure 3.1: Basic Remanufacturing Product Development Model**

When an EOL product is collected for remanufacturing, it goes into several stages of operations for bringing it back to new conditions. Fig. 3.1. shows the steps involved in remanufacturing in the industries. After receiving the EOL products, companies sort the products in different groups for dissembling and cleaning, heating, machining and fabrication
operations, conducting it step by step (Laan and Salomon, 1997; Guide and Van Wassenhove., 2001; Östlin et al., 2008 ; Terkar et al., 2012) All operated components are reassembled for testing and finally products are ready for packaging.

3.2.4 Product Acquisition Management (PrAM)

![Figure 3.2: A framework for Reverse Supply Chain Activities](Source: Sasikumar & Kannan, 2008)

Reverse flow of used product with right quantity & good quality at right price and at right time is the most important aspect in remanufacturing industries. Frame work of a Reverse Logistic fit into remanufacturing processes (see fig. 3.2). An EOL is dissembled into parts, where in some are fitted into remanufacturing and some are fitted for recycling (Tibben-Lembke and Rogers, 2002)

3.2.5 Centralized Evaluation System

A Centralized Evaluation System is introduced between retailer & resellers and manufacturing companies. This Centralized Evaluation System helps the manufacturer for evaluation of EOL products. Customers return their EOL product to retailer & reseller and then an evaluation system is
necessary, which can make the decision about product recovery options. As shown in fig.3.3, reuse, remanufacturing, part recycling and disposal are the main product recovery options.

![Figure 3.3: Centralized Reverse Supply Chain Model](image)

In this case, retailers send all the returns to a central location, and they are not responsible for making the evaluation of a product. Centralized Evaluation System is responsible to send the EOL product to the correct place. Knowledge about market demand and core quality is very much necessary for centralized evaluation systems. In this process, time required to distribute the EOL product is more (Blackburn et al, 2004; Terkar et al., 2012).

### 3.2.6 Decentralized Reverse Supply Chain

In a decentralized reverse supply chain, customers return EOL products through retailer and reseller. In this process, retailer and reseller do not directly return the product to the centralized evaluation and test facility system. In this system, reseller and retailer are important decision-making authorities for supplying an EOL product to reuse disposal & test and repair
facility center (Blackburn et al., 2004; Terkar et al., 2012). Here test and repair facility center takes the decision about product recovery by remanufacturing and recycling method. In this system, the time consumed to return the product from consumer to manufacturer is less (See the Fig 3.4).

![Diagram](image)

Figure 3.4: Decentralization Reverse Supply Chain Model

3.3 Remanufacturing Challenges

3.3.1 Cost of EOL Product

Cost involved in the return of an EOL product to a remanufacturer is the largest cost involved in the remanufacturing process. To reduce this cost, remanufacturer offers incentives to consumers to return the EOL product by offering a discount on new product in return for old. An EOL product goes through many tests before remanufacturing and the cost associated for these tests are high. Sometimes, if the product is not suitable for remanufacturing, then recycling or landfill will remain the next option. Proper design of a product in view of remanufacturing is necessary (Ferrer and Ketzenberg, 2004; Golany et al., 2001; Terkar et al., 2013)
3.3.2 Opinion on Quality

From a customer perspective, a remanufactured product and a low-end product are different. Even if function wise both products are of same quality, the customer is not fully positive about a remanufactured product. Customer’s willingness to pay towards a remanufactured product is necessary to be understood. Many customers do not want the tag of a remanufactured product, especially for high-end products (Terkar and Vasudevan, 2011).

3.3.3 Supply Limitation

Remanufacturing supply mostly depends upon the product life cycle of old products. Return flow of used product is a necessary element for successfully remanufacturing the products. Used product availability and time required to return the product are necessary to increase the profitability of the company (Guide et al., 2005; Vasudevan et al., 2012). OEMs can predict the market of low-end products. However, prediction about the return of used product is very difficult. Hence return-flow supply of used product always becomes a challenge for remanufacturing industries. It totally depends upon the customer’s intensity of use.

3.3.4 Competition

Producing of a low-end product is directly under the control of an OEM. Remanufacturing of products is not directly controlled by OEM. If OEMs are not remanufacturing the product, then other competitors will remanufacture the product to grab the market share. On behalf of OEMs, many third party industries make remanufactured products. Poor quality of a remanufactured product may cause damaging of the brand (Atasu et al., 2010; Vasudevan et al., 2012; Östlin et al., 2009). OEMs can produce the
remanufactured product at a low cost so that it can directly compete with low-end product manufacturers.

3.3.5 Change of Technology

Demand of a remanufactured product also depends upon pace of change in technology. Acceptance of a remanufactured product by consumer depends upon the need and price of the product. Nowadays, PLC is becoming shorter and shorter with the reduction of price. Early launching of a remanufactured product will result in more profit in the market. New technology will replace old technology product and a remanufactured product. Hence, the pace of change of technology will decide the market of remanufactured products (Vasudevan et al., 2012).

3.4 Core Quality and Operations

When core quality is high, cost for remanufacturing operation is not motivating enough for a remanufacturing operation (Aras et al., 2004). In this situation, the sound option is to reuse the product (see fig. 3.5). Later, when the quality of core keeps decreasing, the benefit for remanufacturing becomes greater and is logically motivated from a profit perspective. After certain level, the quality of the returning core becomes so low that the cost for remanufacturing becomes too high according to the potential market price (Östlin et al, 2009; Golany et al., 2001). In these situations, it may be motivating to recycle the product.
3.4.1 Measurement of Key Parameters Core

The motive of the repair process is mainly to extend the product life for a low cost option. In normal circumstances when the product is broken down, the most frequent recovery option is to repair the product. Table 3.1 explains the advantages of remanufacturing over the repair, reconditioning and refurbishing processes.

<table>
<thead>
<tr>
<th>Operations</th>
<th>Product Performance</th>
<th>Labor Content</th>
<th>Warranty</th>
<th>Cost</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair</td>
<td>Less</td>
<td>Less</td>
<td>Less</td>
<td>Less</td>
<td>Less</td>
</tr>
<tr>
<td>Reconditioning</td>
<td>Medium</td>
<td>Medium</td>
<td>Less</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Refurbishing</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Remanufacturing</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Product performance of a remanufactured product is always high as compared to other material recovery operations. Remanufacturing operation is more costly as compared to repair and reconditioning, but
profit margin is high as compared to other operations (Östlin et al., 2008, Guide et al., 2003).

3.5 Demand and Supply of a Remanufactured Product

Market demand of a remanufactured product and availability of used products are two important factors, which decide the remanufacturing strategies. Fig 3.6 shows four quadrants in which ‘No Action’ quadrant shows insufficient market demand and sufficient supply of remanufacturable products.

![Figure 3.6: Product Remanufacturing Matrix](image)

The “Watch” quadrant shows sufficient market demand, but an insufficient supply of remanufactured products available. The situation should be carefully watched, since this is a potentially profitable market and third-party remanufacturers will be attracted. The “Remanufacture” quadrant is where there are both market demand and sufficient quantities of remanufactured products available (Atasu et al., 2010; Terkar et al., 2011). Remanufacturing them should be initiated as soon as possible. The
final quadrant, “Recycle” is when there are sufficient supplies of remanufactured products, but no market demand. The best choice in this situation is to obtain some revenue via materials recycling.

### 3.6 Remanufacturing Decision

Table 3.2, shows very important decisive conditions by which a company can decide whether they can go for remanufacturing or not. The decision to stop remanufacturing a product is a function of many factors, including the presence of third-party remanufacturing, age of the technology, the availability of replacement parts & components and a need to retire legacy systems (Atasu et al., 2010).

<table>
<thead>
<tr>
<th>Remanufacturing Costs</th>
<th>Supply of EOL Products</th>
<th>Consumer Segment</th>
<th>Remanufacturing Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>v</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>x</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>v</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>v</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>x</td>
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<td>High</td>
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<td>High</td>
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<td>High</td>
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<td>Low</td>
<td>x</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>High</td>
<td>v</td>
</tr>
</tbody>
</table>

From Table 3.2, it can be seen that remanufacturing cost, supply of used product & size of functionality-oriented customer segment are decisive parameters for remanufacturing (Ferguson and Toktay., 2006). If
remanufacturing costs are high, the functionality-oriented segment is large with sufficient quantities of used products available, and then company can think about remanufacturing (Guide et al., 2005; Terkar et al., 2011). In this case, products will lie in ‘Remanufacture’ quadrant. If the remanufacturing costs are low, remanufacturing is profitable in three scenarios. However, if the supply of used products is limited and there is a large functionality-oriented segment, remanufactured products should not be offered, for example as in the ‘No Action’ quadrant in fig 3.6.

3.7 Product Life Cycle of a Remanufactured Product

The actual process of remanufacturing is almost always less expensive than producing a brand new unit of the product because many parts and components can be reused, thus avoiding the need to procure them from supplier (Hermansson and Sundin, 2005). Remanufacturing of used product is important to extend the product life cycle in the decline phase. There are many potential financial benefits to extending product life cycle besides the pure profit margin obtained by selling the remanufactured product (Guide, 2000). Many OEMs were initially ignoring the remanufacturing of used products resulting in SMEs entering into remanufacturing which has caused huge cannibalization (Vasudevan et al., 2012). Now many OEMs are entering into remanufacturing area, as secondary market is grapping the market share widely (Guide and Li, 2010).

Study of Product Life Cycle (PLC) of an existing product is very much necessary for successful launching of a remanufactured product. Perfect Launching of a remanufactured product is necessary for deriving maximum share in the market (Vasudevan et al., 2011). Demand of remanufactured product depends upon the product life cycle of an existing product.
Predicting the demand of remanufactured product and its perfect launching is not an easy task for the company (Östlin et al., 2009). Study of disposal rate of existing product is also another crucial issue for remanufacturing industries. It is also interesting to study the product cannibalization due to entry of remanufactured products (Hermansson and Sundin, 2005).

3.8 Product Cannibalization

Product cannibalization occurs when a company decides to replace an existing product and introduce a new one in its position in the market (Ioannis, 2002). This is due to newly introduced technologies and it is most common in Large-Scale Industries (LSI). The theoretical roots of product cannibalization can be traced to the cross-elasticity of demand theory (Kerin et al., 1978). Product-line extensions, with the possible resulting market cannibalization, have been studied extensively in the marketing literature (Reddy et al., 1994). In product life cycle, there is negative and positive cannibalization (Ioannis, 2002). In the normal case of cannibalization, an improved version of a product replaces an existing product as the product reaches its sale peak in the market. The new product is sold at a high price to sustain the sales, as the old product approaches the end of its life cycle (Terkar et al., 2011). Nevertheless there are times when companies have introduced a new version of a product, when the existing product has only started to grow. In this way the company sustains peak sales all the time and does not wait for the existing product to enter its maturity phase.

The trick in cannibalization is to know when and why to implement it, since bad, late or early cannibalization can lead to bad result for company sales (Terkar et al., 2011; Ovchinnikov et al., 2013). Product Cannibalization
refers to reduction in sales volume, sales revenue, or market share of existing product because of the introduction of a new product and/or remanufactured product by same manufacturer or by competitors. Normally product cannibalization may be considered negative, even in the context of a carefully planned strategy. It can be efficient by eventually raising the total sales volume of a company’s product or superior consumer demands. Cannibalization is a key consideration in Product Portfolio Management (PPM). Product cannibalization is defined as the process by which a new product gains sales by diverting sales from an existing product. Cannibalization is a real threat for vast majority, prevalence of line extensions as manufacturers struggle to maximize the leverage of their brand equity (Ehrenberg, 1991).

3.8.1 Unfavorable Cannibalization

When the new product is sold at a lower price, with a resulting lower sales and profits then the old products causes unfavorable cannibalization (Frederic, 2001). Technology changes can force a product to be cannibalized by a completely new one. In some cases, loss of profit due to the cannibalization is too great. The new product may be profitable, but it may be at a greater risk than the old one. A company cannot cannibalize its market share using a failed product. These can happen in high-tech companies that do not understand enough of a new technology so as to turn it into successful and working product. As a result, an unreliable product emerges and replaces a reliable one, and that can increase service costs and as a result expected profits.

3.8.2 Offensive Cannibalization

Cannibalization favors attackers and always hurt the market leader. For companies that are trying to gain share or establish themselves into market,
cannibalization is the way to do it. Also cannibalization is a good way to define market share or size. A usual practice is the market leader to wait and do not cannibalize a product unless it has to. It is thought that a company should acquire and develop a new technology that will produce a newer and better product that an existing one and then wait (Ovchinnikov et al., 2013).

3.8.3 Defensive Cannibalization

Controlled cannibalization can be a good way to repel attackers as deforesting can repel fire. Cannibalization of a company's products before a competitor does is a defensive strategy to keep the competitor of being successful. Timing is the key in this strategy. Do it too soon and profits will drop, do it too late and market share is gone.

3.9 Concerns of Cannibalization

Cannibalization is not a major concern when remanufactured versions are just right substitute for new products. A right substitute means the finish product is the same from a new version for the consumer. This allows OMEs to use remanufactured components and parts, considerably reducing a material cost that does not require the firm to offer a lower selling price (Wang and Tseng, 2010; Xu and Zhu, 2011). Therefore, a firm in this situation can benefit from lower remanufacturing costs and higher profit margins (Debo et al, 2005). From an economic point of view, remanufacturing is attractive when the cost of remanufacturing is less than the cost of new products and larger this differential, the more attractive it becomes (Astu et al 2010 ; Linton, 2008).

Cannibalization turns into major concerns when remanufactured and new products are differentiable to the consumers. This is the case when the
firm bid a remanufactured version of a product at a different price point than a new version of that same product (Astu et al., 2010, Ovchinnikov et al., 2013). The sale of remanufactured products may then decrease the sales of new product. For many consumer goods OEMs, current generation products are returned to resellers and in an effort to recover some of the cost of consumer returns, many OEM’s turn to remanufacturing. This is especially where sales and marketing department cry wolf and claim that new product sale will be heavily cannibalized (Shu and Flowers, 1995).

Any new or remanufactured product entering a market will take market share from all the existing players and predicting this cannibalization is a critical and difficult task. Excessive use of commonality could result in products of similar nature and cause product cannibalization. It is not only important to predict the performance of a new or remanufactured product, but also the cannibalization effects of new or remanufactured products on the current portfolio. The identification and prediction of cannibalization is an integral factor for strategic new or remanufactured product introduction decisions (Peizhi et al., 2010). Very little research is available related to the pattern and magnitude of cannibalization effects.

3.10 Cannibalization and Remanufacturing Opportunity

A report of Electronics Waste Management in the United States published in 2011 shows the sale data of (Personal Computer) PC CRT monitors and PC Flat monitors in USA for the last 31 years. Product life cycle of PC CRT monitors and PC Flat monitors is shown in fig. 3.7. Sale of PC CRT monitors were in growing phase between the years 1990 to 2000. During these years, the opportunity of remanufacturing is more for the companies. Maturity phase of PC CRT monitors is very small. After launching of PC Flat
Monitors in 1988; it started cannibalization of CRT PC monitors and the rate of cannibalization has increased between the years 2000 to 2011. Here the decline phase of PC CRT monitors is observed as being quite healthy. Around 2009, sale of PC CRT monitors was totally replaced by Flat PC monitors and the demand of remanufactured PC CRT monitors was also replaced by remanufactured Flat PC monitors.

![Figure 3.7: Product Cannibalization and Remanufacturing opportunity](image)

It is seen that the demand of remanufactured product depends upon the product cannibalization of existing product. Product life cycle of remanufactured product depends upon the product life cycle of existing product. Quantity of EOL product also shows the opportunity for remanufactured product in the market.

### 3.11 Product Cannibalization Issues in Remanufacturing

Remanufacturing is the process where in a company conducts many operations on used products to bring it back to near total new conditions with same warranty as new one has (Debo et al., 2005). Sale of
remanufacturing will displace the sale of new product causing the cannibalization (Matsumoto and Umeda, 2011). Not much detailed study has been conducted so far in the field of product cannibalization and its importance. Many companies have tremendous fear about cannibalization of old products (Ogush and Kandlikar, 2005, Ovchinnikov et al., 2013). Concept of product cannibalization is still fully not understood by many OEMs. Detailed study of product cannibalization in view of product development (PD) and marketing phase is very necessary. Remanufacturing manager has to give answer to such questions frequently. Many managers do not think about launching remanufactured products. They feel that only new products will make more profits in the market, which is not completely true (Sarvary and Wassenhove, 2009).

It is difficult to ignore the importance of a remanufactured product for sustainable product development (O’Brien, 1999). Many OEMs are making good profit in remanufacturing sectors. Awareness about the remanufactured product is necessary in the consumers for sustainable development. People really don’t know the exact concept of remanufacturing. Product cannibalization will not become an issue when remanufactured product is a perfect substitute for new product. When the cost of remanufacturing product is less than cost of new product then the company can enjoy more profit through remanufactured product (Atasu et al., 2010; Ovchinnikov et al., 2013). The Kodak line single use camera is the best example of a perfect substitute for new product. ‘Xerox’ company offers remanufactured, updated new product for customers for less price (Kerr and Ryan, 2001). Here company makes more profit in remanufacturing the product. ‘Xerox’ company has handled the issue of
cannibalization of new product by remanufactured product by making more profit in the market.

3.12 Cannibalization and Product Return Life Cycle

When the supply of used products is little and these products turn up late in the product life cycle, remanufactured product sales will be limited since both supply and demand are constrained. The best situation for profitable remanufacturing is when there is adequate supply of used products throughout the product life cycle and the functionality-oriented segment is large. This is exactly the situation at many consumer goods OEMs, where commercial product returns are a stable percentage of new product sales for the majority of the new product life cycle. As can be seen in Figure 3.8, product returns volumes for inkjet printer are a predictable percentage of new product sales time-lagged by 2-3 months from the initial product introduction. In this case, many remanufactured products can be sold at a high price, and thus at high margins (see fig. 3.8).

![Figure 3.8: Product Return Life Cycle for an ink jet printer](image)

Recent studies have shown that remanufacturers earn an average profit margin of around 20 percent. Late in the product life cycle, however, product returns often surge, creating excessive returns relative to demand.
Companies such as HP and Bosch Tool have shown the importance of managers recognizing the changing dynamics of profitable product recovery. As the new product is replaced by remanufactured product, it causes cannibalization, which helps industries to grab maximum share in the market.

3.13 WTP towards Remanufactured Product

Willingness to Pay (WTP) of consumers for remanufactured and new product is the necessary input to know the consumers’ behavior. Many researchers used the sell data of product to analyze cannibalization issues and many are using auction data too (Keskinocak and Tayur, 2001). Willingness to pay is the maximum amount of money consumer want to pay for a given quantity of products (Kalish and Nelson, 1991). Through online auction, it is possible to calculate consumers’ WTP for remanufactured as well as new products (Hoffman et al., 1993; Noussair., 2004; Guide and Li., 2010).

Remanufacturers always claim that the quality and functionality of a remanufactured product is same as good as new products have (Lund, 1984) and hence, it is necessary to observe the consumer behavior in the market about remanufactured products. Are the consumer agreed quality and functionality of a remanufactured product is same as good as new one? Many customers are very much quality conscious and willing to buy only new products. WTP between new and remanufactured product is necessary to find and sort out the cannibalization issue (Atasu et al., 2008).

3.14 Auction for Investigation of Product Cannibalization Issue

Literature survey suggests that the remanufactured products cannibalize the sale of new counterpart product (Mason and Milne, 1994;
Aaker and Keller, 1990; Buday, 1989). Auction of remanufactured and new counterpart product can give valuable information to analyze the cannibalization issue. Guide and Li (2010) suggested two methods to measure the product cannibalization. Through the first method, it is interesting to see the number of bids received to new product with and without the presence of a remanufactured product. The number of bidders indicate the number of competitors participated in the bidding process, which shows the intensity of competition (Guide and Li., 2010, Roth and Ockenfels, 2002). When the number of bids received to new product in the presence of a remanufactured product is less, than it indicates that cannibalization exists due to the existence of remanufactured product.

Second method is based on end bid value i.e. winning bid value, which is a useful input to measure product cannibalization. Winning bid of new product with and without remanufactured counterpart product is interesting to see. Economic theory shows that the presence of product drops the sale of other product (Tirole, 1988), hence here also it is interesting to observe the impact of remanufactured products end bid price on new counterpart product (Guide and Li., 2010). If the existence of a remanufactured product shows the impact of reducing of end bid price of new product then it indicates that cannibalization is exists.

In short, remanufacturing of used products indicates its huge impact in product cannibalization. Initially many OEMs hesitated to enter into remanufacturing market. SMEs earned tremendous profit through remanufacturing product, grabbing major market share in the market. In Product Life Cycle, remanufacturing plays a vital role in product petrification. It results in huge profit to industries in product decline phase also. Product remanufacturing matrix is a useful technique for decision
making in remanufacturing. The decision for remanufacturing mostly depends upon demands for a remanufactured product and supply of reused product. Automobile, printing and photocopier industries have good market for remanufactured products. Product Return Life Cycle of an inkjet printer in the study shows the impact of remanufacturing product on the old printer. Remanufacturing is particularly useful for OMEs in increasing their market share and reducing of waste for environmental protection. Not much of widely covered literature is available on the product cannibalization issue. Very few researchers studied the cannibalization issue between new and remanufactured product. Guide and Li (2010) collected data through online auction to study the product cannibalization issue between new and remanufactured counterpart product.