1. Introduction

The consumption of natural resources is at an increasing rate today, even as consumer demands for material from the crust of the earth are constantly increasing. In this context, it is imperative to ensure as to how to utilize all these resources more effectively for Sustainable Product Development (SDP) and for cost effective manufacturing. During the last few decades, awareness about environmental protection has also grown to a great extent (Ishii, 1998). Moreover, continuous changes are happening today for the better with pressure from legislation & environmental awareness among consumers and these exist particularly in Big to Small and Medium Enterprises (SMEs).

To reduce the waste, the U.S. Environmental Protection Agency (EPA) has recommended for adoption of a reduce-reuse-recycle hierarchy and resorting to combustion only as a last option (U.S. EPA, 2008). It is also observed that 67.5 % of the municipal waste in the US went directly to landfills or incineration facilities in 2006 (U.S. EPA, 2007). Therefore, it is encouraging to have a market for remanufacturing. According to Hauser and Lund (2008), 9000 firms in U.S. claim themselves as remanufacturers. Many industries in this sector include remanufacturing automotive parts, clutches, cranes & forklifts, furniture, medical equipment, pallets, personal computers, photocopiers, telephones, television, tires and toner cartridge etc. Original Equipment Manufacturers (OEMs) and/or independent manufacturers (Ferguson, 2009; Amezquita and Bras, 1996) put these products in the market. Due to the huge importance of manufacturing in industries, many researchers are also beginning to bring many innovative ideas into the market.
1.1 Importance of Remanufacturing

The activities in the remanufacturing sector were boosted up during the Second World War. The industry sector that has the most experience in the remanufacturing area is the automotive industry. However, the concept of remanufacturing has become popular in the recent decades due to huge demand of remanufactured products like computers, toner cartridges, household appliances, machinery and mobile phones. Remanufacturing industries do have a huge turnover in United States, the turnover of the industry being estimated at $40.5 billion in 2003. In the United Kingdom also, the turnover of the remanufacturing industry was seen estimated to be £5 billion in 2004. Remanufacturing is intended for a great business prospect all over the world. In the USA, it is a key business in the automotive industry, which sells roughly 60 million remanufactured automotive products every year (Seitz, 2007).

1.2 The Concept of 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 the one has (Debo et al., 2005 ; Ijomah, 2009). In the remanufacturing process, the product goes through a number of specific operations. After receiving the End-of-Life (EOL) products, companies sort the products in different groups for dissembling cleaning, heating, machining and fabrication operations conducting it step by step. All operated components are reassembled for testing and finally products are ready for packaging. Study of Product Life Cycle (PLC) of an existing product is very much necessary for successful launching of a remanufactured product (Vasudevan et al., 2011).
A lot of research has been conducted on remanufacturing as a whole, such as the study of “The impact of remanufacturing on the economy” by Ferrer and Ayres (2000). The study identifies that remanufacturing promotes a higher demand for labour as well as finished products using fewer resources than manufacturing. Remanufacturing is often described as “the ultimate form of recycling. This is because it adds value to waste products by returning them to working order compared to the process of recycling which breaks down the EOL product to its raw material value.” (Steinhilper, 1998). According to Hauser et al. (2008), “Remanufacturing is the process of restoring a non-functional, discarded, or traded-in product to like-new condition. The key term in this definition is like-new. From the viewpoint of the producers, this represents the remanufacturers’ intent, their claim for the product, and their ability to live up to that claim. From the customers’ viewpoint, the like-new term represents the customers’ expectation for the product sold as remanufactured. Both in performance and appearance, the product must meet at least the specifications of the product when it was new. It may also incorporate upgrades to reflect improvements that have occurred since the product was originally made.”

In Japan, as in other countries, the remanufactured auto parts primarily include engines, turbo chargers, alternators, starters, compressors, transmissions, and steering units (Matsumoto, 2009; Ogush and Kandlikar, 2005). The case study of Shin-Etsu Denso, one of the largest auto parts remanufacturers in Japan shows the importance of assuring collection of used products, efficient remanufacturing processes and demand for remanufactured products. This company remanufactures alternators & starters and ships amounting to 100,000 of each annually. To collect used products, the company supplies car maintenance shops with
remanufactured products in exchange with used products. In addition, the company continually purchases and stocks used products from car dismantling companies. It stocks about 300,000 used products, which are essential for its business (Matsumoto and Umeda, 2011).

1.3 Product Recovery Alternatives

Manufactured products can be recovered in many ways and the recovery can be executed at different levels. At the lower level, product materials are recovered and it is frequently called as “material recycling” (Blackburn et al., 2004; Sundin and Tyskeng, 2003). The higher-level product recovery is possible, where product, components or modules are reused. Higher level product recovery is called as “remanufacturing”, “reconditioning” or “refurbishment”. Remanufacturing not only encourages the multiple reuses of materials, but it also permits for the steady upgrading of product quality and functionality (Sundin, 2002; Sundin and Bras 2005; Krikke et al., 2004). The terms refurbishment and reconditioning are the product recovery options and they relate the closest to remanufacturing. The product recovery process for refurbishment and reconditioning are similar to the one for the remanufacturing process. The important difference between them is the quality level of the products after recovery (Atasu et al., 2008; Ammenberg and Sundin, 2004; Sundin and Bras, 2004).

1.4 Sustainability through Remanufacturing

Recovery of End-of-Life (EOL) products is really a big challenge for industrial firms all over the world. However, there are many product recovery systems available in the world, though many of them are not that profitable and relevant from the point of view of green growth (GG) &
Product Sustainable Development (PSD). However, remanufacturing is a vital solution to increase the Green Growth and PSD (Ferguson, 2009; ASR, 2012; Terkar et al., 2013).

Many Industries, these days are offering upgraded remanufactured version of EOL products, which can compete with the new products in the market place. Remanufacturing is the process, where in the remanufacturing industries collect the EOL products through customers or brokers, carry out the operations like disassembly, cleaning, coating and replacement of worn-out parts etc., with 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., 2007; Hauser and Lund, 2008).

Many industries offer remanufactured products with low price with same warranty as that of a new product. Due to remarkable functional and green growth quality, many customers from all over the world are attracted towards remanufactured products in the market (Matsumoto and Umeda, 2011, Ferrer and Swaminathan, 2006). The industry sector that has the most experience in the remanufacturing area is the automotive sector (Lund and Hauser, 2009; Subramanian et al., 2009). Remanufacturing is an important area contributing to the GG & PSD and a lot off contemporary research is expected in that area all over the world. Countries like USA, UK, and Japan etc. are coming with different remanufactured products in the market. In the remanufactured products list, the remanufactured cartridge products does grab a 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. In the
automotive remanufacturing market, products like alternators, breaks, clutches etc. have a huge demand (Guide and Li, 2010; Subramanian et al., 2009). Many customers from all over world frequently buy the remanufacturing products through eBay online website.

1.5 Energy and Material Conversion

Estimates in the USA indicate that over 375 million empty toner cartridges and ink cartridges are thrown as scrap every year. Most of these printer cartridges end up on landfill sites or in incinerators. 375 million cartridges amount to roughly 11 cartridges being disposed of every second. This quantum of waste can be reduced through reuse and recycling. Yet approximately 70% of all ink cartridges and 50% of all toner cartridges are still not recycled. There is also pressure from legislation & environmental awareness among consumers and these exist in many of the product segments. The plastics used in printer cartridges are made of an engineering grade polymer that have a very slow decomposing rate ranging between 450 to 1000 years depending on the cartridge type. Remanufacturing is a way to deal with this and it is the process where used product is brought back to near new product standard (Hauser and Lund, 2008).

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. Studies conducted by the Fraunhofer Institute in Stuttgart, Germany, state that the energy conserved worldwide in a year by the remanufacturing industry is equivalent to the energy contained in
10,700,000 barrels of crude oil. 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.

### 1.6 Importance of Closed-Loop Supply Chains in Remanufacturing

Closed-Loop Supply Chains (CLSC) is a process wherein the EOL product is taken back from customers for reusing, refurbishing, remanufacturing or recycling activity. For the last 15 years, closed loop supply chains have gained significant attention in industry and academia. According to Guide, Harrison & Wassenhove (2009), closed-loop supply chain management is the design, control and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time. Closed-loop supply chains have immense economic potential. According to Lund (1996), the manufacturing sector in the USA is presently bigger than the U.S. domestic steel industry in terms of sales and employment with annual sales in excess of $53 billion. Large retailers have product return policies with 10% or more discounts on purchasing of a new product. The total value of returns can easily run in the hundreds of millions of dollars for a single retailer. According to Stock, Speh & Shear (2002) the annual costs of commercial returns is in excess of $100 billion. According to Guide and Wassenhove (2006), computer network equipment manufacturers have estimated that more than $700 million of wholly operational recovered products are being destroyed. Personal computers have short life cycles and it depreciates to 1% of their value per week and has high return rates (Guide and Wassenhove, 2006). These types of products represent a huge challenge for
value recovery. A slow-moving reverse supply chain that takes 10 weeks to put the returned product back in the market translates to depreciation of 10% of the total value in that product. This far exceeds many profit margins on consumer electronics and hence a computer manufacturer is well advised to develop competencies in fast recovery systems.

1.7 Motivation for this Study

Manufacturing is a set of activities leading to the transformation of materials into physical products needed by end users or intermediaries using productivity-enhancing tools, machines and methods. The traditional definition of manufacturing focuses only on the act of production: starting from raw materials, conversion through a number of stages and ending with assembly and testing. A more comprehensive definition includes all activities in product life, starting from customer inputs for concept design and ending with product disposal (including repair and recycling).

From the viewpoint of a Remanufacturer, cost, quality and market demand are the main important factors and from a customer's point of view, quality and price are the motivating factors to buy the remanufactured products (Nasr et al., 1998). If the cost of a remanufactured product is less than that of a new product with high margin, then it will be a huge motivating factor for remanufacturers (Atasu, et al., 2010; Lund and Hauser, 2009, Terkar et al., 2012). In this research study, few case studies are conducted in order to find the cost saving percentage of a remanufactured product over a new product and the same is explained in Chapter 5. Many companies prove that the cost associated with remanufacturing product is less as compared to new products so that companies could earn more profit margins (Guide and Li, 2010). It is also necessary to study the cost associated with remanufacturing operations
and its impact on overall turnover and profit of an organization. Nowadays, many OEMs are entering into the remanufacturing business and are gaining huge amount of profits. Before last decade, many OEMs hesitated to enter into the remanufacturing sector due to the fear of cannibalization of existing new product due to sale of same version of remanufactured products (Vasudevan et al., 2012; Terkar et al., 2012; Guide and Li, 2010; Debo, 2005).

Many remanufacturing SMEs have entered into remanufacturing and refilling business and thus cannibalized huge amount of sale of OEMs. Most of the SMEs in remanufacturing and refilling sector are not too much quality conscious, but still they are doing good business due to low price. In India, many customers do not believe in the quality of remanufactured products and they feel that the remanufacturing quality is not as good as the quality of new product and hence they are inclined towards new products. Awareness about remanufactured product among customers is very much necessary in the Indian market (Terkar et al., 2012; Ferguson, 2009; Atasu et al., 2010).

OEMs have also entered into the remanufacturing business and they are very much quality conscious about products. If OEMs would not have entered into the remanufacturing sector, then there was a strong possibility of huge product cannibalization due to other competitors in the market. In the beginning, OEMs started the remanufacturing business to avoid the excessive cannibalization of new products. Now, they have realized that the remanufacturing business is an important profit-making segment (Matsumoto and Umeda, 2011). OEMs are still slightly hesitant to launch the remanufactured products in the markets. Many top ranking OEMs are missing the opportunity of capturing the secondary market of
remanufacturing. However, many remanufacturing industries collect their cores and make quality-remanufactured products in the market. Demands of remanufactured products are increasing day by day and these remanufacturing industries are grabbing the wide market share of OEMs (Matsumoto and Umeda, 2011).

Willingness to Pay (WTP) on the part of customer, expectation of quality of remanufactured product and product cannibalization issues are necessary to be examined in detail. WTP towards the remanufactured product as well as new product is also an important factor to be studied. Many customers are more conscious about the quality and hence they are willing to purchase only new products (Sarvary and Wassenhove, 2009; Terkar et al., 2011). Quality of remanufactured product and customers’ WTP are important elements in the market and correlation between these two is necessary to be explored. If the customers feel that, the quality of remanufactured product is really the same as new one, then WTP is increased towards remanufactured products. Hence, we need to look at whether there is any correlation between WTP and quality.

Product cannibalization is a big issue in the markets and it is necessary to find certain facts about it. Why the OEMs in India have a fear of the product cannibalization due to remanufactured products? WTP towards remanufacturing and new product is therefore an important factor while considering the issue (Guide and Li., 2010; Ovchinnikov et al., 2013). The correlation between WTP and the product cannibalization issue is also very important. In Indian market, many OEMs have fear of cannibalization of their new product due to entry of remanufactured version. Demand of remanufactured product totally depends upon the rate of change of technology. Due to change of technology, demand for old technology
products decreases continuously and hence remanufactured version of such a product is also not in much demand. Categorization of products into time-sensitive and time-insensitive products is essential to predict the market demand (Ostlin et al., 2009; Sasikumar and Kannan, 2008; Terkar et al., 2012). In computer and mobile instruments sectors, products are time-sensitive due to rapid change in technology and hence, the prediction of market demand is not easy in such sectors (Vasudevan et al., 2012). Time-insensitive products are useful to be considered in remanufacturing and many customers are taking these advantages in automotive manufacturing sectors (Matsumoto and Umeda, 2011). Cartridge products are also time-sensitive products and yet they are very popular in the remanufacturing sector due short life of product. Customers are always attracted towards new technology upgraded products; hence, the new products have their own strong customer segments.

1.8 Problem Identification

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., 2009, Lund and Hauser, 2009). Many Original Equipment Manufacturers (OEMs) have tremendous fear about cannibalization of existing new products due to the sale of new launched and remanufactured counterpart products. Concept of product cannibalization has not still fully understood by many OEMs. Study of product cannibalization due to remanufactured product is necessary to be studied (Guide and Li, 2010). Sale of remanufacturing will displace the sale of new product causing the cannibalization. Not much detailed study has been conducted so far in the field of product cannibalization (Atasu et al., 2010, Gupta, 2011). Most of the literature has been written on new product
launching and cannibalization of old products (Guide and Li, 2010). Demand for remanufactured product depends upon the pace of change of technology. Prediction of market demand of remanufactured product with reference to change of technology is necessary even in SMEs (Vasudevan et al., 2012). Product cannibalization and its impact on remanufacturing market are necessary to be studied (Swartz, 2011).

Many times, remanufacturing companies buy excessive EOL products, which cause heavy loss to companies. Importance of time value in the inventory control management is valuable for getting optimum profit through product recovery management (Matsumoto and Umeda, 2011, Guide, 2000, Toktay et al., 2000). The time delays in remanufacturing process reduce the value of products and hence the study of time sensitive products and time insensitive products are necessary. Personal Computer (PC) Monitors are time sensitive products and hence these types of products have limited time value for remanufactured products (Vasudevan et al., 2012). The value of time insensitive product decreases slowly as time passes and the value of time sensitive product decreases with high rate as the time passes. For prediction of remanufactured product demand, it is necessary to know the time sensitive and time insensitive product for optimum profit making in product recovery management. In the remanufacturing sector, success of a remanufactured product mainly depends upon time sensitiveness (Guide, 2000; Sasikumar and Kannan, 2008). Product cannibalization due to time sensitive and insensitive remanufactured products is necessary to be addressed.

Product cannibalization due to sale of a remanufactured product is a very important live problem felt by OEMs. Many SMEs sell the remanufactured product significantly at a lower price as compared to its
new counterpart product and hence many OEMs are of the opinion that remanufactured product displaces the sale of new counterpart product. Many upper management of OEMs feel that remanufacturing the product will cannibalize the new product, which will result in reduction of market share (Guide and Li, 2010). A Remanufacturing manager has to give answer to such questions frequently. Many managers do not think about launching of remanufactured products. They feel that only new products will make more profits in the market, which is not completely true (Guide et al., 2003).

A review of extant literature reveals that no research has been done to address these issues in remanufacturing. Therefore, a research work exploring the linkages among product cannibalization issue and other aspects in remanufacturing has the potential to make significant contributions to academic literature and industry practices. This study makes an attempt to extend the current literature in this direction.

1.9 Importance and Objective of the Study

Remanufacturing is important for Green Growth and sustainability and hence the awareness of remanufactured products and its benefits to consumers as well as remanufacturing industries are necessary to be studied (Terkar et al., 2013). Indian Government has also failed to promote the remanufacturing sector in India. Remanufacturing industry is still in infancy stage in the Indian market and hence very few industries are doing good business in the market. Many academicians, industries as well as consumers (Guide and Li, 2010) do not still know the concept of a remanufactured product. Remanufacturing saves a huge amount of material, energy and it leads to truly sustainable development.
Environmental agencies are also promoting remanufactured products for Green Growth Sustainability (GGS). Quality of remanufactured product is as good as new product and the price is also significantly less as compared to new product, hence business in countries like United States of America (USA) and United Kingdom (UK) are growing very rapidly in this sector (Ijomah et al, 1999; Terkar et al., 2013).

Main purpose of this study is to address the challenges and benefits due to remanufactured products to create awareness in the consumers, industries and dealers etc. for GGS. Many OEMs fear and are hesitant to produce the remanufactured products due to fear of cannibalization of new existing products. Many experts from remanufacturing sectors also feel that the remanufacturing product will cannibalize the sale of its new counterpart products. This issue is very serious and hence the study related to cannibalization issue is necessary and as such this important issue has not been investigated fully. The solution to this problem will help the OEMs and remanufacturing industries to promote the idea of remanufactured products confidently.

As the competition increases in the manufacturing arena, especially in view of sustainable development, the time is ripe to investigate more closely the remanufacturing concept and address the product cannibalization issue & other aspects involved in Remanufacturing. Interestingly, while there are a few studies that have looked into remanufacturing, none of the studies have touched upon the cannibalization issue in remanufacturing directly. This research bridges this gap in extant literature by exploring the product cannibalization issue while also addressing issues such as cost of remanufactured products and customers’ willingness to pay etc.
1.10 Research Objectives and Hypotheses

Primary objective of this research is to explore the benefits and importance of remanufactured products in the market and also to investigate the product cannibalization issue as well as consumers’ willingness to pay due to the entry of remanufactured products in comparison with the existing counterpart new product.

The research objective has a wide scope and would require to be studied and investigated along with the allied research questions. To arrive at the research objectives, this dissertation addresses eleven hypotheses. By studying these research hypotheses, the research objective is expected to be addressed and they are described in the following paragraphs.

Remanufacturing area is not widely studied by researchers and it is always difficult to find the answers of such research questions (Geyer et al., 2007). Product cannibalization issue has also been studied mostly in Product Life Cycle Management area. Before studying the cannibalization issue, it is therefore necessary to study the motivating factor for remanufacturers to produce the remanufactured product (Guide and Li, 2010). There are several important factors, which are deciding factors as to whether or not to remanufacture a given product. Hence first hypothesis \((H_{01})\) is,

\[ H_{01}: \text{Profit Potential of the remanufactured product is the deciding factor whether or not to remanufacture a given EOL product.} \]

Cannibalization due to remanufactured product is one of the main the focuses of this research. Before studying the product cannibalization issue due to the sale of remanufactured products on its counterpart new products (Golany et al., 2001, Guide et al., 2003), it is necessary to
understand quality difference between the new and remanufactured product in view of experts and hence the second hypothesis \((H_{02})\) formulated is.

\textbf{\(H_{02}\): Quality of remanufactured product is ‘as good as new counterpart product’}. 

Cost of remanufactured product as compared to new counterpart product is necessary to be studied. In a country like India, this aspect has not been much explored and there are only remanufactured cartridges which are having huge market currently. Therefore, the study of basic elements and challenges are necessary to understand the growth of this sector in India and across the world (Gager, 2011; FTB, 2011; Jindal, 2009). It is necessary to study the cost saved due to remanufactured product as compared to new counterpart product and hence the third hypothesis \((H_{03})\) formulated is.

\textbf{\(H_{03}\): Cost incurred for a remanufactured product is less than cost incurred for a new counterpart product.}

For product cannibalization issue, the cost and price saving due to a remanufactured product is necessary to be studied. If the cost & price of a remanufactured product is less than the new counterpart product, then it is necessary to know the willingness to pay in view of remanufacturing experts (Atasu et al., 2010, Vasudevan et al., 2012, Terkar et al., 2013). Hypothesis \(H_{04}\) has been formulated to know the willingness to pay towards a remanufactured product and this hypothesis is useful to know the status of remanufactured product in the market. Therefore, the fourth hypothesis \((H_{04})\) formulated is.
$H_{04}$: Consumers Willingness to pay (WTP) towards remanufactured product is less as compared to its new counterpart.

To find the product cannibalization issue, it is very important to know the willingness to pay towards remanufactured product as compared to new counterpart product (Vorasayan and Ryan., 2006; Volckner., 2005). Consumer’s willingness to pay is mostly related with quality and price of remanufactured product (Mason and Milne., 1994) and hence it is necessary to study the quality of remanufactured products and its affect on the willingness of customers’ to pay. Therefore, the next hypothesis ($H_{05}$) formulated is.

$H_{05}$: Quality of a remanufactured product and customers’ willingness to pay are related to each other.

Price saving due to remanufacturing is an important parameter to also understand the customers’ willingness to pay towards a remanufactured product (Atasu et al., 2008, Assmus and Wiese., 1995). It is interesting to study the opinion of remanufacturing experts about these two parameters and hence the hypothesis $H_{06}$ is formulated to check the correlation between price saving due to remanufacturing and customer’s willingness to pay.

$H_{06}$: Price saving due to remanufactured product as compared to its new counterpart product and customers’ willingness to pay are related to each other.

On the online website eBay, many remanufactured and its new counterpart products are kept for auction. Bids received to new product in the presence or absence of remanufactured product is necessary (Guide
and Li., 2010). In auction, many bidders repeatedly put the bids to win the auction. Numbers of bids are always equal or greater than the number of bidders (Crampton., 1998; Bajari and Hortacsu., 2003; McTigue., 2000; Roth and Ockenfels, 2002). How many people participated in auction process of product in the presence and absence of remanufactured product? Is the presence of a remanufactured product a cause to reduce the bid? In this context, these are few important questions, and it is interesting to find the presence of how the remanufactured product reduces the bids/bidders of new product or not. Therefore the next Hypothesis \( H_{07} \) is.

\[ H_{07}: \text{Existence of remanufactured product will reduce the end bids/bidders of new counterpart product.} \]

Customer’s willingness to pay towards a remanufactured product is an important element to study the product cannibalization issue (Copulsky., 1976; Guide and Li., 2010). This research is primarily focused on to explore the product cannibalization issue due to sale of a remanufactured product. Therefore, based on previous hypothesis, the next and a key hypothesis \( (H_{08}) \) is formulated as:

\[ H_{08}: \text{Existence of remanufactured product will cannibalize the sale of its new counterpart product.} \]

As per the survey of available literature, many industrial experts are of the opinion that the remanufactured product would cannibalize the sale of new product (Guide and Li., 2010; Atasu, 2010; Majumder and Groenevelt., 2001). In India also, many OEMs are not in favor of remanufacturing production due to the cannibalization issue (Jindal., 2009; Gager., 2011; Terkar et al 2013). Therefore, addressing the hypothesis \( H_{08} \) is important to
the industries. Whether, the product cannibalization occurs or not is the main objective of this research, but it is also important to check the validity of the answer to the hypothesis and hence, it is necessary to check the correlation between product cannibalization due to sale of remanufactured product and customers’ willingness to pay. Therefore, the next hypothesis \(H_{09}\) formed is.

\[H_{09}: \text{Product Cannibalization of new product due to the sale of counterpart remanufactured product and customer’s willingness to pay are related to each other.}\]

Price of new and remanufactured product is the most important deciding factor for customers’ WTP (Guide and Li, 2010; Atasu, 2010; Mason and Milne., 1994). Product cannibalization mostly depends upon the price difference between new and a remanufactured product. It is interesting to know the industrial expert’s opinion about product cannibalization and Price saving due to remanufacturing and hence the next hypothesis \(H_{10}\) formulated is:

\[H_{10}: \text{Product Cannibalization of new product due to sale of counterpart remanufactured product and price saved due to remanufactured product are related to each other.}\]

From literature survey, it has been observed that the quality of a remanufactured product is ‘as good as’ the new product (Atasu et al., 2010; Vasudevan et al., 2012; Terkar et al., 2013; Guide and Li, 2010). Quality of a remanufactured product is responsible to increase the consumer’s willingness to pay towards the remanufactured product. Remanufacturing industrial experts’ opinion therefore needs to be analyzed. Product cannibalization issue due to the sale of remanufactured product and quality
of remanufactured products are important elements and therefore it is interesting to find the correlation between these two parameters. Hence the next hypothesis \( (H_{11}) \) formulated is,

\[ H_{11}: \text{Product Cannibalization of new product due to the sale of counterpart remanufactured product and quality of remanufactured product are related to each other.} \]

1.11 Expected Contributions of the Study

This study is expected to be of important significance to both academicians and practitioners in the areas of remanufacturing and manufacturing management. For academicians, the study contributes by providing a framework and empirical results integrating various concepts in Remanufacturing (Souza et al., 2002). As this kind of a study has not been reported in literature so far, it will add to the body of literature on remanufacturing and product cannibalization pertinent to manufacturing firms.

The hypothesized research framework in this study examines the crucial aspects involved in remanufacturing in a typical manufacturing firm. The results could prompt manufacturing firms to start looking at the idea of remanufacturing and thereby enhancing their competitive strength in the emerging highly complex market scenario worldwide.

1.12 Thesis Overview

Based on an extensive and detailed literature survey (chapter 3), the problem statement, purpose of study and research objectives are included in chapter 1. After the overview of the introductory chapter, comprising of
research objectives and hypothesis formulation, next chapter 2 explains the research methodology followed in this research work.

In Chapter 3, the theoretical foundation covering various literatures in the remanufacturing sector has been explained in detail. The extensive literature survey conducted has been useful in knowing the specific problems faced by industries in the remanufacturing area. In this chapter, importance of remanufacturing process, elements & challenges in remanufacturing, CLSC, product cannibalization and consumer's willingness to pay are explained in detail. Product cannibalization has been studied by many researchers mostly in view of launching of new product. Perfect launching of new product and its cannibalization impact is therefore necessary to be studied.

In chapter 4, a case study of air coolers has been analyzed to find out the phenomena of product cannibalization in manufacturing industries.

In chapter 5, few more case studies conducted, covering different types of manufacturing firms are included. Diesel Loco Modernization Works has been producing remanufactured locos for the last 20 years. Timken India is the leading bearing manufacturer Company in the world and produces remanufactured bearings for their clients. Ink guide manufactures Cartridges and is involved in remanufacturing. All three companies have a special department of remanufacturing and are doing profitable business with GGS.

Chapter 6 is on sustainable green growth in the cartridge sector. Importance of remanufactured cartridges, that covers cost savings, profitability and sustainability due to remanufactured cartridge have been explained in this chapter.
Chapter 7 includes the Data analyses covered in addressing the research objectives. Data were collected through a questionnaire and eBay online tool, the auction website. In this chapter Cost, Price, WTP, Product Cannibalization and challenges in remanufacturing products have been analyzed and explained in detail. The thesis layout followed is as follows.

Chapter 1: Introduction
Chapter 2: Research Methodology
Chapter 3: Theoretical Foundation
Chapter 4: Product Cannibalization due to New Product
Chapter 5: Benefits of Remanufacturing & Analysis
Chapter 6: Remanufacturing For Profitability and Green Growth Sustainability
Chapter 7: Primary and Secondary Data Analyses and Interpretation
Chapter 8: Conclusion, Limitation and Future Scope
References
Publications
Appendix

The dissertation structure is as shown in fig. 1.1

![Figure 1.1: Structure of the Dissertation](image)