Chapter-1

Introduction
1. Introduction

1.1 About Remanufacturing

The awareness over the environmental problems associated with the manufacturing industry continues to grow worldwide. This has created tremendous pressure on reuse, remanufacturing and recycling of the discarded product. In present economic situation, organizations and the government alike are under tremendous pressure to preserve our natural resources. In fact, many corporate units have seriously initiated the product recovery management in their business plans. Product recovery activities are considered to be more economically attractive than disposing off used products (Seitz et al., 2004). Among such activities, remanufacturing is a more efficient means of material recirculation than recycling. It extends the life of the product and prevents the environment from being polluted through land filling, incineration and disposal.

The process of remanufacturing was initiated at an industrial level during World War I for tank remanufacturing. It gained momentum after World War II when it was commercially used for car remanufacturing in United Kingdom (UK). Today remanufacturing is practiced in various industrial sectors and considered as very effective means of product recovery option for sustainable development. Remanufacturing is an option which provides the effective way to utilize and retain the value as well as extends the life of the product. Remanufacturing retains more of the energy associated with the original conversion of raw materials to finished products (Nasr et al., 2006). It consumes only 20 to 40% of energy as compared to a new product. A Study of automotive components has shown that approximately 85% of the energy expanded in their manufacture was preserved in the remanufactured product (Henstock., 1998). A remanufactured product costs only 40 to 60% of that of a new one (Guide Jr. et al., 1997). The profit from remanufacturing activities is almost around 20%, although for automotive sector it may go up to 30 ± 10% (Mukherjee et al., 2008). In some cases remanufactured product can be twice as profitable as compared to the new product (Doppelt et el., 2001). The annual energy savings from remanufacturing in US alone may be estimated to be equivalent to electricity generated by 5 nuclear power plants or 85 million barrels of oil (APRA., 2006). Remanufacturing also
saves excess of 0.8 mn tonnes of CO₂ emission per annum (OHL., 2004). Remanufacturing result in significant reduction in environmental pollution by avoiding incineration and land filling of used products (Steinhilper., 2006) which indirectly preserves our ecosystem. The raw material saved by remanufacturing worldwide in a year would fill 155,000 railroads cars forming a train 1,100 miles long (TRI., 2006). Environmental conscious customers get attracted towards reused products which results in sales growth (Guide et al., 2000). Furthermore, remanufacture can also increase the quality of life by contributing to environmental preservation and driving the market for skilled labour (Gray et al., 2006). These benefits potentially place remanufacturing as a major contributor to sustainable prosperity. The major motivational factors behind remanufacturing are take-back obligations, disposal bans, economic benefits, creation of stock of components/parts from disassembly and demand for spare parts during post product life cycle period.

Remanufacturing is currently practiced in numerous industry sectors, namely the automotive and aerospace sectors. Companies like Xerox, IBM Europe, Fuji film, Kodak, Caterpillar, Flextronics, BMW, Volkswagen, Ford Motors, Pedco Remanufacturers (US) are actively engaged in remanufacturing activities for more than a decade. On the other hand Honda, Goldman Sachs, Continental Airlines are some companies which have initiated remanufacturing activities recently. Caterpillar, Xerox and Flextronics are leading global remanufacturers; however majority of remanufacturing is carried out by much smaller organizations (Gray et al., 2006). Xerox’s estimated remanufactured output accounts for 25% of its total production and material saving from land filling accounts around 25,000 tonnes while the total cost saving is around $ 200 mn. Xerox core competency lies in its revenue generation stream from its product which is extended till its 7th life cycle (Gray et al., 2006).

Remanufacturing business in US is worth $ 53 billion while it is worth £ 5 billion in UK. An estimated 480,000 are employed in the US remanufacturing sector. The remanufacturing sector in UK reportedly employs 50,000 people (Gray et al., 2006). In the automotive sector, the remanufacturing business estimates around $ 85 – 100 billion worldwide as per US Automotive Parts Rebuilders Association and in US it worth $ 35 – 40
billion. Fuji film and Kodak used to purchase their cameras back as they have initiated the concept of design-for-the-environment in their cameras and reuse 86% (by weight) of all the used cameras (Guide et al., 2000). The main motivating factor is to build green corporate image and thus to attract the environmentally conscious customers. Furthermore, the product recovery programs of few companies established their brand image as a global leader in this niche category. Caterpillar comes first in this category whose global remanufacturing business is one of the largest in the world in terms of volume. It recycles more than 50,000 tonnes of product every year. Caterpillar’s annual revenue generation from remanufacturing business is over $1 billion and is growing reputedly at 20% per year (Gray et al., 2006). These examples clearly reveal that remanufacturing is gaining momentum in western world and the economic benefits associated with it drive several manufacturers to increase their revenue turnover by adopting it as additional profitable business activities in their existing domain.

1.2 Remanufacturing process

A product performs various roles during its life time before being considered as insignificant. These outdated products will be then either being considered for reprocessing or be dumped in landfills. Reprocessing basically includes the processes of refurbishing, remanufacturing, repair etc. where some sorts of maintenance are done to enhance the functional life of the product. There are numerous terminology associated with end-of-life processes which always creates confusion such as remanufacture, recycling, refurbishment, repair etc. Various sources describe the lack of precision in the terminology associated with the reprocessing of material and products (Parkinson, 2001). Uncertainty over the definition of remanufacture creates confusion, which restricts the progress towards the increase of remanufacture processes. Certain preconception of some historical practices which are loosely related with remanufacturing misleads its genuine definition. The practice of poorly re-treading car tyres, which originated in the first part of the 20th century, compared with modern practices, is a classical example of how an industry has to fight against preconceptions. The main aim of this section is to make clear distinction between these terminologies.
• **Repair:** Under this option the disordered product is brought into the working condition by some sorts of fixation or replacement of the defective parts. The quality of the repaired product is generally inferior to the new one. The degree of disassembly and assembly are limited to certain level. Repair is generally performed at the customer’s location or at manufacturer-controlled repair centre.

• **Refurbishment:** The main purpose of refurbishment is to bring the discarded product to a certain level of quality which is generally lower than the new product. Here, the used products are disassembled to the level of modules and the fixation of defective parts is done. Then approved modules are reassembled into refurbished products. Technological upgradation of the modules is also done, if required.

• **Remanufacturing:** Remanufacturing is an industrial process in which worn-out products are restored to a like new condition. Through a series of industrial processes in a factory environment, a discarded product is completely disassembled. Usable parts are cleaned, refurbished and put into inventory. Then the new product is reassembled from both old and, where necessary, new parts to produce a unit fully equivalent and sometimes superior to the original new product.

• **Recycling:** In recycling process the product identity and functionality are not restored at all. It is basically done to recover material from used products. These recovered materials are then used for manufacture of the same or different parts.

Among the four processes of product recovery options mentioned above, the primary focus of this research is on remanufacturing. Remanufacturing as a product recovery operation is extensive and includes product disassembly, cleaning and identification of parts, parts recovery and product re-assembly (*Seitz et al., 2007*).
The process of remanufacturing basically consists of the following steps.

- **Disassembly**: Disassembly process for remanufacturing requires non-destructive operation. So major concern is given to the selection of tools for disassembly. Permanent fastener and corrosion/rust are the most important issues, as they make the disassembly operation slow and expensive. Furthermore corrosion/rust affects the recovery rate negatively. Once the parts are disassembled they are sorted and kept in respective bins. Sorting basically requires identification of similar parts and clustering them accordingly. Disassembly equipment includes electric and pneumatic power tools and general workshop tools especially hammer mallets and drifts, wrenches, jigs and holding fixtures, bearing presses and drills.

- **Cleaning**: Cleaning process should require that all the contamination to be removed viz. degreasing, derusting and removal of surface coatings such as paint. Numerous methods are adopted to clean the parts such as petrol cleaning, water jet cleaning, ultrasonic cleaning, sand blasting etc. Shot blasting methods have the additional advantage that they improve the surface hardness of a component and increase its wera and fatigue resistance.

- **Inspection**: Inspection is one of the critical steps in determining the condition of the component. Inspection is an important stage that decides the reusability of the parts and whether it can be reconditioned. Recovered part should have residual life of at least equivalent to its design life and should fit, function and fulfil the reliability criteria and safety requirements as per specifications. Visual inspection is widely
used along with non destructive testing techniques such as dye penetrant, magnetic particle, eddy current and ultrasonic methods.

- **Reconditioning**: Reconditioning process includes various manufacturing operations like milling, turning, grinding, heat treatment, welding etc to bring the used components into working condition. The parts which cannot be repaired are replaced by new ones to make the component as sound as or even better than earlier. An example of this would be the reboring of the engine and regrinding of the crankshaft.

- **Reassembly**: Reassembly operation is almost the same as that of assembly process except the components/parts used are carried out with combination of recovered parts, new parts and some mandatory parts. The tools used are the same which were used for assembly operations of new product. The production line are likely to be lowered in the remanufacturing, as reassembly takes place on small batch assembly lines.

- **Testing**: Testing of remanufactured product is likely to be similar to that used on newly manufactured products. Remanufacturer uses 100 percent inspection testing of the remanufactured finished goods, which may be higher than a new manufacturer who may sample a percentage of the products for testing.

1.3 **Automobile Remanufacturing worldwide**

The automotive industry is one of the leading sector which practices remanufacturing globally. Automotive components that are currently remanufactured include clutches, brake shoes, engine block, starters, alternators, water pumps and carburetors (Lund et al., 1998). The remanufacturing of automotive products in current state accounts for two third of all remanufacturing business (Steinhilper et al., 2001). There are around 150 engine remanufacturers and 1000 automotive parts remanufacturers in US alone (Henstock., 1998). In automotive industry, the increased usage of electronics in auto
components has resulted in increased product recovery value (Subramonium et al., 2009). In USA, 95% of cars and trucks that are retired each year go to the recycler, and for each of those cars, 75% by weight is recovered for reuse (Steinhilper et al., 2001). In the European union (EU) countries, the European union End-of-life vehicles (ELVs) directive has passed laws to the member countries to reuse and recover 85% by weight of the average vehicle by the year 2006, and this percentage will increase to 95% by the year 2015 (Gerrard et al., 2007). This shows that the product recovery percentage in automobile is highest among other component/article.

Companies like Perkins Engine (UK) and Caterpillar are the major global automotive remanufacturers. In some cases remanufacturing engine is the only possibility to provide a replacement in a short timeframe (Seitz et al., 2007). Perkins Engine remanufactures diesel engines and transmissions for armored fighting vehicles, mobile diesel generator sets, naval and marine propulsion engines and generator sets, construction equipments. Caterpillars’ global remanufacturing business is currently one of the largest in the world in volume terms and recycles more than 50,000 tonnes of product each year (Lund et al., 1998). It remanufactured engine for Ford’s Truck and its annual revenue generation is over $1 billion which grows continually at 20% per year (Gray et al., 2006). Companies like Volvo, BMW and Volkswagen are continuously advancing towards developing new innovative methods in automobile remanufacturing. For example- Volvo’s cars exchange system is the system in which Volvo remanufactured used parts (obtained from dealers) to the same quality as new parts. Over 2000 different components, from gearboxes to consoles, are remanufactured in this manner and sold to consumers with full warranty (Volvo report., 2004). BMW remanufactures 15000 engines each year at its Landshut plant. The BMW7 series contains an on-board computer which constantly monitors component wear and alerts the driver when action is required. It is also working on recycling of pyrotechnic components (such as airbags and belt tensioners) in addition to new, automatic sorting techniques for plastics, metals and shredder residues (BMW report., 2003). Volkswagen has designed a new separation and recycling process, known as VW-Sicon process (Volkswagen report., 2004). To increase the recyclability/remanufacturing of
the cars, the three big auto makers in the U.S. have joined together to form the Vehicle Recycling Development Centre (VRCD). At the VRCD, they are trying to find out the options how to build vehicles to be disassembled more easily. They are investigating one of the newest trends in engineering, Design for Disassembly (DFD).

1.4 Remanufacturing business in India

In India, remanufacturing business is mostly practiced as disorganized sector. The growth of remanufacturing business has tremendous potential if we consider the huge population base of India. Companies like Xerox India Ltd (Rampur, UP); United Van Der Horst Ltd (Mumbai); Soft-AID Computers Pvt. Ltd (Mumbai); Kores Printer Technology Ltd; Transdot Electronics Pvt Ltd; Timkin India Ltd; Printech Solutions (Bangalore); BBA Remanufacturing (India, Kolkata); Unisert Machines (India) Pvt. Ltd (Noida, UP) are actively engaged in remanufacturing business in India. In Indian automobile sector, Maruti Suzuki provides options to sell and purchase of used car under True Value car exchange (a venture of Maruti Suzuki India Ltd). True Value Category cars are refurbished in state of art workshops using Maruti Genuine Parts and by skilled technicians. These cars are then sold through Maruti True Value outlets.

A promising automotive industry started in India in the year 1940s. However, for the next 50 years, the growth of the industry was controlled by the Socialist and the bureaucratic policies. Following economic liberalization since 1991, and the gradual easing of restrictions on industry, India has seen a dynamic 17% annual growth in automobile production and 30% annual growth in exports of automotive components and automobiles. The Indian automobile industry is the ten largest in the world. At the same time the two-wheeler industry in the country ranks second globally while the commercial vehicles industry is the fourth largest in the world.

Currently, the Indian automobile annual production rate is more than 2 million units. Recently India has overtaken China in global auto exports of compact car. Total turnover of
the Indian automobile industry is expected to grow from USD 34 Billion in 2006 to USD 122 Billion in 2016. It has been estimated that this figure will soon touch 10 million units per year (India business Directory, 2009 & Automotive industry in India, 2009).

Table 1: Indian Automobile Production Trends (No. of Vehicle)

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<tbody>
<tr>
<td>Passenger Vehicles</td>
<td>1,309,300</td>
<td>1,545,223</td>
<td>1,777,583</td>
<td>1,838,593</td>
<td>2,357,411</td>
<td>2,982,772</td>
<td>3,123,528</td>
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<tr>
<td>Commercial Vehicles</td>
<td>391,083</td>
<td>519,982</td>
<td>549,006</td>
<td>416,870</td>
<td>567,556</td>
<td>760,735</td>
<td>911,574</td>
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<tr>
<td>Three Wheelers</td>
<td>434,423</td>
<td>556,126</td>
<td>500,660</td>
<td>497,020</td>
<td>619,194</td>
<td>799,553</td>
<td>877,711</td>
</tr>
<tr>
<td>Two Wheelers</td>
<td>7,608,697</td>
<td>8,466,666</td>
<td>8,026,681</td>
<td>8,419,792</td>
<td>10,512,903</td>
<td>13,349,349</td>
<td>15,453,619</td>
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<tr>
<td>Grand Total</td>
<td>9,743,503</td>
<td>11,087,997</td>
<td>10,853,930</td>
<td>11,172,275</td>
<td>14,057,064</td>
<td>17,892,409</td>
<td>20,366,432</td>
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</tbody>
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( Source: Society of Indian Automobile Manufacturers, March 2013 )

The passenger car penetration is 12 for every thousand Indian and the sales are growing at the rate of 9% per annum. If we consider the average life cycle of a vehicle to be around 20 years, then between 2020 and 2025, 5.1 million cars would be ready for disposal after the end of their useful life. Thus approximately 3 million tones of metal would be ready for dumping. But remanufacturing option can however delay this process of land filling, hence increasing the utilization of natural resources. The basic factor for considering the demand for a car consists of rapidly growing middle class (450 million in 2007, NCAER report) and are expected to rise upto 550 million by 2025 (Mckinsey Report), market oriented stable economy, availability of trained manpower at competitive cost, fairly well-developed credit and financing facilities and local availability of almost all the raw materials at a competitive cost. The Indian customers are keen on low running cost and low cost of ownership. These are the influential purchase decisions for most of Indian customers. The projected size of Indian automotive industry in 2016 will vary in between $.122 billion to $.159 billion (Automotive Mission Plan report 2006-16).
The above data shows that Indian automobile sector has a massive potential for remanufacturing business. Also, the enormous growth in consumption and price sensitivity factor reflects possibility of enough demand for remanufactured vehicles and automotive spare parts. Moreover, remanufacturing being labour intensive business (35% of total cost), India would be a suitable destination given the availability of cheap labour.

1.5 Objective of the research

The available literature and various reports show that there are many sectors along which remanufacturing are being carried out presently. These include diesel engine, computers, mobile phones, refrigerators, tyres, batteries etc. among these automotive is the major contributor. The automotive remanufacturing business estimates around $ 85 – 100 billion worldwide which is the highest among other sectors. These statistics shows that automobile remanufacturing is a very lucrative & sustainable business option in European countries. But in many Asian countries especially, in India it is in a nascent stage. This research work is an effort to explore and analyse the perception of Indian business units related to automobile sector on factors relevant to remanufacturing business. This study will perhaps lead to identification of issues which are possibly hindering automotive sector in taking up remanufacturing as an organized business in India. Further, we also intend to identify prospective business units who may take the initiative to start automobile remanufacturing business in India. With the above backdrop, the following research objectives are proposed:

- To explore the important issues which prevent corporate houses of automobile sector from carrying out remanufacturing business in India
- To identify the prospective business units who are expected to initiate the remanufacturing business in India.
1.6 Organization of the thesis

This research project consists of six chapters. Chapter-1 introduces the general remanufacturing process with emphasis on automobile remanufacturing and its practice worldwide. The current scenario of Indian automobile sector is also described in this chapter. Chapter-2 includes the contemporary research literature on remanufacturing, particularly on automobile remanufacturing. The empirical study and the related issues have been described in detail in chapter-3. This comprises the relevant factors, steps taken for developing survey instruments etc. Chapter-4 consists of the data analysis in the empirical investigation (as mentioned in Chapter-3). The outcome of this chapter is a set of critical and important factors, which actually deters the business units of automotive sector in taking up remanufacturing business. The first objective of thesis research project has been addressed in Chapter-3 and Chapter-4. In Chapter-5, the identification of the prospective business units has been done by the application of Analytic Hierarchy Process (AHP). The discussions and conclusions have been put forth in the sixth chapter.