6. Remanufacturing For Profitability and Green Growth Sustainability

6.1 Introduction

Recovery of EOL products is really a big challenge for industrial firms all over the world. However, there are many product recovery systems available, many of them are not that profitable and relevant from the point of view of Green Growth Sustainability (Hart, 1997). However, remanufacturing is a vital solution to increase the green growth and sustainability of a product (Ferguson, 2009; Vasudevan et al., 2011).

In India, cartridge-remanufacturing industries are doing their business reasonably well, but other remanufacturing sectors are still in an infancy stage of growth. Cartridge remanufacturing business is estimated to be of $35 billion business all over the world and 30 percent of the business is estimated to be of cartridges and printers. In India, 30,000 enterprises are involved in cartridge remanufacturing and refilling business. Of these, only 70 remanufacturing and 300 refilling industries are doing their progressive business well. Indian cartridge industries are making business of 1300 crores and every year the industry growth is estimated at 30% (DIA, 2012). In India, customer awareness about remanufacturing product is very much the need of the hour. Government policy is also not well defined and supportive of remanufactured products. Many remanufacturing agencies and associations have requested the Indian government to review their policies about remanufactured products especially in view of sustainable product development (Jindal, 2009). The present study is therefore considered very pertinent in the context of Indian Scenario.
6.2 Remanufacturing of Cartridges

Business in the Asia pacific region is facing many challenges in regard to remanufacturing in the cartridge sector. It is necessary to study the important elements of the cartridge industries for sustainable product development. Countries like India & china are doing remarkable business in cartridge industries. Nowadays many Original Equipment Manufacturers (OEMs) have also entered into the remanufacturing sector. There is a huge competition between OEMs and Small to Medium Enterprises (SMEs) in cartridge remanufacturing sector. There are many issues and challenges for these remanufacturing industries. Collection of cores from customer is not an easy process (Lundmark et al., 2009). In Asian countries, mostly brokers supply the cores to remanufacturers. Remanufacturing cartridges provide remarkable quality to customers in lesser prices, but many customers are more attracted towards refilled cartridge products due low price as compared to new & remanufactured cartridges (Vasudevan, 2012). In India, customers are more conscious about the quality of cartridges. Many customers are not willing to pay (WTP) for remanufactured products. Awareness about remanufactured product is necessary in Indian market (Sarvary and Wassenhove, 2009; Terkar et al., 2012). Maintaining the quality of a remanufactured product to ‘as good as new’ condition is the most important challenge for remanufacturing industries.

There are some important issues, which are necessary to be discussed for the betterment of cartridge remanufacturing industries. In this chapter, the actual problems in the cartridge remanufacturing industries are discussed. On the field, there are many challenges for remanufacturing industries. Remanufacturing process is not easy for manufacturers; there are plenty of problems that arise from collection of EOL product till the
remanufacturing operation. Information about these challenges is required to be available for up growing remanufacturing industries. Collection of virgin and non-virgin cores from customers and its suitability checking for further remanufacturing is always difficult. Demand of remanufactured version of cartridges varies from nation to nation. In Asia specific region, demands of remanufactured cartridges are increasing day by day. Quality of collected cores and demand of particular cores are important. Customer demand for inkjet and toner printer cartridges often varies. Identification of customer demand about remanufactured cartridges is also a crucial issue for industries. In collected cores, many may be damaged or not in demand and hence the findings related to all these issues will guide OEMs and remanufacturing SMEs for profitable business of remanufactured cartridges.

In India, brokers play a vital role in supplying empty cores to remanufacturing industries and this is also a big business of reverse supply chain management. Many OEMs are still not very positive about the remanufactured cartridges. The findings in the article, published by Hewlett-Packard, in ‘2012 Asia Pacific Supplies Recycling (APSR)’ are considered very useful for remanufacturing sector in Asia and the research group of Info Trend as a primary research has studied these findings (Seitz and Peattie, 2004). Some important findings are explained in this chapter in an attempt to solve the cartridge remanufacturing issues.

6.2.1 Virgin and non-Virgin Cores

There are two types of cores in the market i.e. virgin and non-virgin cores. Virgin core means the empty EOL cartridge that has not been remanufactured or refilled. Non-virgin cartridges are those, which are
previously remanufactured or refilled. For remanufacturing purpose, most of the companies in India are interested in virgin cartridges. For the brokers, segregation of virgin and non-virgin cartridges is not an easy task.

In India and China, most of the remanufacturers want to remanufacture their own cores as well as other company’s cores. From fig. 6.1, it can be seen that near about 65% of collected empty cartridges are virgin and 35% are non-virgin. In the Asia Pacific, toner cartridges are remanufactured 3-4 times and inkjet cartridges are remanufactured 1-2 times. Toner cartridges are remanufactured more number of times as compared to inkjet cartridges. In collected cores, near about 35%, cores are non-virgin and remanufacturing of these cores is not an easy task for company. Customers willing to pay towards non-virgin remanufactured cartridge are less as compared to virgin cartridges. In inkjet cartridges, remanufactured cycle is up to 1-2 times due to large amount of damaged cores and less demand of remanufactured product in the market. Profit margin of virgin and non-virgin cartridges is different. Profit margins in non-virgin cartridges are

Figure 6.1: Virgin and Non-Virgin Cartridges for Remanufacturing  
(APSR Info Trend, 2012)
always less as compared to virgin cartridges. Many remanufacturing industries are interested in virgin cartridge as a core and hence there is a very good demand for virgin cartridges and brokers always try to collect virgin EOL cartridges.

6.2.2 Collection of Empty Cartridges

Steady and consistent flow of empty cartridge is of prime and vital requirement in remanufacturing industries. Collection of cartridges from customers is not easy for brokers as well as industries and hence the role of reverse supply chain management plays a vital role (Sasikumar and Kannan, 2008; APSR, 2012). Quality check of collected empty cartridge is also necessary for profitable business. In collected empty toner and inkjet cartridges, many are not useful for remanufacturing purpose due to damage, wrong vendor type, wrong ink tank or because the cartridge model is not in demand. Near about 20% empty toner cartridges are not useful for remanufacturing purpose in the Asian market. In the collected inkjet cartridges, 40% cartridges are not useful for remanufacturing operations (See fig. 6.1). Also, huge amount of cartridges are damaged in the market and from a sustainable development point of view & green growth, this issue is very important (APSR, 2012).

For core collectors, segregation of useful and non useful cartridges is always tough and a time consuming job. Millions of cartridges are not found useful every day and land filling of such faulty cartridges is also not an easy process. Near about 20 % in toner and 40 % in inkjet cartridges are not useful for remanufacturing process at all. For GG and PSD of cartridges, reduction in faulty empty cartridges is necessary. Inkjet cartridges are less attractive for remanufacturing market due to lively clone market. Lively
clones actually cannibalize the remanufactured version of inkjet cartridges. These clones directly make an impact on sale of remanufactured products.

6.2.3 Damaged Cartridges

In collected inkjet cartridge, percentage of damaged core is more as compared to toner cartridges. Near about 40% inkjet cores are not useful for remanufacturing. In 40% unusable cartridges, 60% are damaged and 40% are not needed due to lesser market demand of inkjet cartridges and is reducing day by day, due to lively clone market. Damaged cartridge percentage is around 60% and this percentage is really challenging for remanufacturing industries (APSR, 2012).

Unusable toner cores are in less percentage as compared to inkjet cores. Near about 20% toner cores are unusable due to less demand and damages. In 20% of unusable cores, 50% are not in demand and 50% of them are damaged. On an average, near about 24 cores in 100 are damaged in inkjet cores and 10 cores in 100 are damaged in toner cores. 24 numbers is huge and it will show the impact on overall reduced profitability in remanufactured inkjet cartridges. Due to more damaged percentage of cores in inkjet printers, market demand is reduced drastically and hence good quality of new cartridges is necessary to grow the remanufacturing business. Due to quality issue, remanufacturing demand of inkjet cartridges is always less as compared to demand of toner cartridges.

Therefore, how the companies can reduce the damaged cartridge percentage is the major issue. Proper design of new cartridges is necessary to reduce the percentage of damaged cores. This issue is important and necessary to be addressed for profitable remanufacturing markets as well as for GG & PSD.
6.2.4 Damaged Components

It is very interesting to study the remanufacturing process and part replacement percentage of cores. In India, virgin cartridges are replacing more parts in the remanufacturing process.

![Component Replacement in Virgin Toner Cartridges](image)

Figure 6.2: Component Replacement in Virgin Toner Cartridges (APSR Info Trend, 2012)

Fig. 6.2 shows that the blades and drums are replaced by new parts in remanufacturing process of virgin cartridges. 70% blades and 80% drums are replaced in the remanufacturing process of virgin cores. The percentage of replacement of part is very high and hence the redesign of new cartridges in view of remanufacturing operations is necessary. Primary Charge Roller (PCR) part is not often replaced in virgin cartridge remanufacturing. Only 25% PCR are replaced by new PCR during remanufacturing (APSR, 2012).

Whereas, in non-virgin cartridges, remanufacturing blades and drums replacement percentage is about 30% but PCR replacement is 50% (see fig.
In India and China, not more parts are replaced in the remanufacturing process as compared to UK and USA.

![Component Replacement in Non-Virgin Toner Cartridges](image)

**Figure 6.3: Component Replacement in Non-Virgin Toner Cartridges (APSR Info Trend, 2012)**

In virgin cartridges, percentages of replacement of parts by new parts are more as compared to non-virgin cartridges and hence the question arises as to why the part replacement in virgin cartridges is more than non-virgin cartridges? OPC drum replacement is about 80% and in non-virgin cartridges, it is near about 30%. This issue is important for researchers to explore to increase the overall profitability of organization. PCR replacement is less in the virgin cartridges, but in non-virgin cartridges, it is increasing up to 50%. The remanufacturing cartridges will be more profitable, if number of parts are replaced in the virgin cartridges and reduced up to certain level.

### 6.2.5 Brokers and own collections

In the Asia Pacific, most of the remanufacturing industries depend upon brokers for collection of EOL cartridges. In some regions of Asia, reverse
supply chain management of cores is very strong, but in countries like India, the process mostly depends upon brokers in the market. Over all, trends in Asia Pacific indicate that 50% of brokers and 50% of OEMs are collecting the cores from customers (APSR, 2012). Many remanufacturers collect empty cartridges from channels like customers, schools, offices, resellers etc. Brokers create huge competition for collection of empty cartridges in the market.

6.3 Refilling Vs Remanufacturing

There are two methods of refurbishing the printer cartridge. Cartridge can simply be refilled or remanufactured. Understanding the difference between these two is essential.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Refill Process</th>
<th>Approximate Time in Minutes</th>
<th>Operation Time in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cartridge is electrically tested in a generic tester</td>
<td>0.5</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>Old ink is removed by spinning the cartridge</td>
<td>3.0</td>
<td>28%</td>
</tr>
<tr>
<td>3</td>
<td>Print head is cleaned using an ultrasonic cleaner</td>
<td>0.10</td>
<td>1%</td>
</tr>
<tr>
<td>4</td>
<td>Generic ink is injected into the cartridge</td>
<td>4.0</td>
<td>38%</td>
</tr>
<tr>
<td>5</td>
<td>Cartridge is print tested on a generic tester</td>
<td>1.0</td>
<td>9%</td>
</tr>
<tr>
<td>6</td>
<td>Packaging</td>
<td>2.0</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Total time required for refill of the ink printer cartridge</td>
<td>10.60</td>
<td>100%</td>
</tr>
</tbody>
</table>

From the customer point of view, price and quality of cartridge will play an important role before a buying decision is made. Here a clear-cut comparison between refill and remanufacturing did by a Cartridge company; World Pasadena is examined (see the Table 6.1 & 6.2).
Table 6.2: Remanufacturing Process & Operation Time

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Remanufacturing Process</th>
<th>Approximate Time in Minutes</th>
<th>Operation Time in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cartridge is electrically tested in a generic tester</td>
<td>0.5</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>The print head of the cartridge is soaked in a special ink dissolving solution</td>
<td>0.5</td>
<td>0.03</td>
</tr>
<tr>
<td>3</td>
<td>Old ink is removed by spinning the cartridge</td>
<td>15</td>
<td>1.0%</td>
</tr>
<tr>
<td>4</td>
<td>Print head is further cleaned using a specially designed water atomizing gun</td>
<td>02</td>
<td>0.10%</td>
</tr>
<tr>
<td>5</td>
<td>Cartridge goes through multiple cycles of vacuum boiling, spinning and atomizing to fully clean out and rejuvenate the cartridge</td>
<td>240</td>
<td>14%</td>
</tr>
<tr>
<td>6</td>
<td>Cartridge is completely dried</td>
<td>1440</td>
<td>81.5%</td>
</tr>
<tr>
<td>7</td>
<td>Ink specially designed for the cartridge which matches original ink as close as possible is injected into the cartridge</td>
<td>03</td>
<td>0.2%</td>
</tr>
<tr>
<td>8</td>
<td>Cartridge is allowed to rest and acclimate after the refill process</td>
<td>60</td>
<td>3%</td>
</tr>
<tr>
<td>9</td>
<td>Cartridge is print tested in the printer for which it was designed for</td>
<td>01</td>
<td>0.06</td>
</tr>
<tr>
<td>10</td>
<td>Packaging</td>
<td>02</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Total time required for remanufacture of the ink printer cartridge: 1766 minutes (100%)

Table 6.1 Shows the refill process and operation time required for ink printer cartridge. Within 10 to 12 minutes of time, refilling process can be done. Due to less operation time, labor & material cost reduces. As shown in Table 6.2, remanufacturing process and operation time are explained in detail. Remanufacturing of cartridge took around 30 hrs for operations. Cost associated with remanufacturing product is high as compared to refilling process. Remanufacturing process required more operations as compared to refilling process.
In remanufacturing operation process, cartridge drying process took maximum operation time. Near about 81.5 % operation time is consumed in cartridge drying process. Cartridge goes through multiple cycles of vacuum boiling, spinning and atomizing. To fully clean out and rejuvenate requires 240 minutes and cartridge acclimate after refill process takes around 60 minutes. Labor and material cost associated with remanufacturing process is high as compared to refilling process.

Now customers have three choices in buying the cartridge. Customer can buy refilled or remanufactured or can buy new cartridge itself. Price of refilled cartridge is less as compared to remanufactured or new cartridge. However, quality of refilled cartridge is very low as compared to remanufactured or new one. Quality of remanufactured cartridge is same as new one and hence customers give more preference to buying remanufactured cartridge. Price of remanufactured cartridge is 70 % as compared to newly manufactured cartridge by OEM.

6.4 Profitability Issues in Remanufacturing

To achieve more profitability in the business of remanufactured cartridges, study of core quality and its demand in the market is important. Virgin cores are more profitable and the willingness to pay towards it is also high in quality conscious customers. Cost reduction in the remanufactured product is possible by reducing percentage of damaged cartridges and it will show the positive effect on demand of remanufactured products. It is found that toner cartridges are more sustainable as compared to inkjet cartridges. Toner cartridges can be remanufactured multiple times and demand for toner cartridges also depends upon quality of cores used in remanufacturing.
Reranufacturing industries nowadays are competing with OEMs and are trying to grab maximum market share. Remanufacturing industries mainly concentrate on two main factors i.e. price and quality of remanufactured products. Remanufacturers set competitive price as compared to new product price. Many customers are attracted towards the remanufacturing product due to low price and better quality. Remanufacturing is the real step towards Green Growth and Product Sustainable Development, which are more necessary to protect the environment. Many OEMs have also entered into remanufacturing business to compete with existing players. A decade ago, it was found that many OEMs were entering into business to avoid excessive cannibalization of their existing products, but now many OEMs are making good business through remanufactured products to grab the potentially huge secondary market.

6.5 Fear of Cannibalization

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 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 et al., 2005). Many remanufacturing SMEs have entered into remanufacturing and refilling business and 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 remanufacturing 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 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 the 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).

6.6 New Vs Remanufactured Cartridge

Mainly cannibalization issues are related to the sale of products and therefore the issue of prices of remanufactured and new product was addressed to understand basic root of cannibalization issues. In this study, a sample of ten different models of new and remanufactured cartridges of HP, Lexmark and Brother were covered to analyze the average percentage
of price and cost saving due to remanufacturing of products. Many top branded companies like HP, Lexmark and Brother are in the business of remanufacturing of cartridge products. These companies are selling the new as well as remanufactured cartridges in the market. In Indian market, many customers prefer to purchase new cartridges instead of remanufactured ones. Willingness to pay for remanufactured cartridges is increasing day by day due to its remarkable functional quality and low price as compared to new one.

Figure 6.4: Price Reduction Due to Remanufacturing HP Cartridge
(Online www.eBay.in, 2012)

Figure 6.5: Price Reduction Due to Remanufacturing Lexmark Cartridge
(Online www.eBay.in, 2012)
Figures 6.4, 6.5 & 6.6 show the different models of cartridges with its new and remanufactured versions and their prices. Remanufactured cartridges are cheaper than new cartridges. Near about 30% to 45% price is less for a remanufactured cartridge as compared to new cartridges. Comparison between the saving percentages of prices due to remanufactured cartridges has been shown in fig.6.7. As compared to new Lexmark, HP and Brother Cartridges, remanufacturers reduced 42 % & 40% average price of new product to grab the maximum market share. 40% reduction in price is really a huge amount and customers are enjoying the benefits of remanufactured cartridges. Average remanufacturing price for Brother remanufactured version is 31 % less than the new version of Brother Cartridges.

Price saving mostly depends upon the demand of product in the market. Many remanufacturing products are actually cannibalizing the new products of OEMs and therefore nobody can stop this process and in view of this, it is necessary for OEMs to enter the remanufacturing sector for their own survival and sustainable product development.
Moreover, many industries in the SME sector are offering fewer prices for remanufactured products in the market. Due to tough competition and huge demand, companies are trying to reduce the prices of remanufactured products. Prices of remanufactured products mainly depend upon the prices of cores in the cartridges.

Here, empty core reduces the cost of remanufactured product to around 40% to 50% as compared to new products. Many OEMs and remanufacturing companies are facing the problem of damaged cartridges. If company tries to reduce the number of damaged cartridges, then they can reduce the remanufactured price to a maximum extent. Damaged cartridges add unnecessary cost for the company. Damaged parts are also a big issue in the remanufacturing sector.

6.7 Analysis of Price between New and Remanufactured Cartridge

From Fig. 6.4, 6.5 & 6.6, we can conclude that the price of remanufactured products is always attractive for customers as compared to
new product price. It is also very interesting to investigate the correlation between prices of new and remanufactured cartridges.

Table 6.3: Correlation Analysis of Prices

<table>
<thead>
<tr>
<th>Cartridge Remanufacturer</th>
<th>COC New &amp; Remanufacturing Price (R)</th>
<th>COD New &amp; Price &amp; Remanufacturing Price (R²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>0.9803</td>
<td>0.9609</td>
</tr>
<tr>
<td>LEXMARK</td>
<td>0.9344</td>
<td>0.8731</td>
</tr>
<tr>
<td>BROTHER</td>
<td>0.9785</td>
<td>0.9574</td>
</tr>
</tbody>
</table>

Table 6.3 shows the correlation between new and remanufactured product price of top brand companies like HP, Lexmark and Brother. COC (R) between the price of new product and price of remanufactured product is very strong. Price of remanufactured cartridges is mostly related to the price of new cartridge decided by top brand companies like HP, Lexmark and Brother. COD (R²) is around 90%, meaning the price of new cartridge and price of remanufactured cartridge is strongly related to each other. If the price of new cartridge reduces then price of remanufactured cartridges also reduces, in the same proportion. If the percentage of damaged core cartridge and its part is reduced, then remanufacturing SMEs can offer a very competitive price in the market.

6.8 Actual Price Saving Percentage due to Remanufacturing

From data shown in the fig. 6.4, 6.5 & 6.6, calculation for nearby value of price saving due to remanufacturing is necessary. For sample size 10, T-test is considered most relevant. See the tables 6.4, 6.5 & 6.6, Case I and Case II were studied because null hypothesis has been rejected in Case I.
Maximum price saving due to remanufacturing value is the average of two top readings of price saving due to remanufacturing.

**Table 6.4: Price Saving Percentage in HP Toner Cartridge**

<table>
<thead>
<tr>
<th>Average Price saving Due to Remanufacturing in HP Toner Cartridge ($\bar{x}$)</th>
<th>Expected Price Saving Due to Remanufacturing in HP Toner Cartridge ($\mu$)</th>
<th>Maximum Price Saving Due to Remanufacturing in HP Toner Cartridge ($\mu_1$)</th>
<th>Standard Deviation ($S$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>44.56%</td>
<td>47.35%</td>
<td>6.10%</td>
</tr>
</tbody>
</table>

Case I, T-test, Level of Significance ($\alpha$) =0.01, $\mu_1$=49%, Population Distribution (N) =10, T = -3.86 is less than -2.821 so Null Hypothesis ($\mu_1$) = 49% rejected and Alternative Hypothesis ($\mu_1$) <49% accepted.

Case II, T-test, Level of Significance ($\alpha$) =0.01, $\mu$ =44.56, Population Distribution (N) =10, T = -2.36 is greater than -2.821 so Null Hypothesis ($\mu$) = 44.56% are accepted.

**Table 6.5: Price Saving Percentage in Lexmark Toner Cartridge**

<table>
<thead>
<tr>
<th>Average Price saving Due to Remanufacturing in Lexmark Toner Cartridge ($\bar{x}$)</th>
<th>Expected Price Saving Due to Remanufacturing in Lexmark Toner Cartridge ($\mu$)</th>
<th>Maximum Price Saving Due to Remanufacturing in Lexmark Toner Cartridge ($\mu_1$)</th>
<th>Standard Deviation ($S$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.49%</td>
<td>49.42 %</td>
<td>54.4 %</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

Case I, T-test, Level of Significance ($\alpha$) =0.01, $\mu_1$=54.4 %, Population Distribution (N) =10, T = -3.3037 is smaller than -2.821 so Null Hypothesis ($\mu_1$) = 54.4 % is rejected and Alternative Hypothesis ($\mu_1$) <54.4% accepted

Case II, T-test, Level of Significance ($\alpha$) =0.01, $\mu$ =49.42 %, Population Distribution (N) =10, T = -1.9223 is greater than -2.821 so Null Hypothesis ($\mu$) = 49.42% is accepted.

**Table 6.6: Price Saving Percentage in Brother Toner Cartridge**

<table>
<thead>
<tr>
<th>Average Price saving Due to Remanufacturing in Brother Toner Cartridge ($\bar{x}$)</th>
<th>Expected Price Saving Due to Remanufacturing in Brother Toner Cartridge ($\mu$)</th>
<th>Maximum Price Saving Due to Remanufacturing in Brother Toner Cartridge ($\mu_1$)</th>
<th>Standard Deviation ($S$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.93%</td>
<td>35.6 %</td>
<td>41.7 %</td>
<td>6.88</td>
</tr>
</tbody>
</table>

Case I, T-test, Level of Significance ($\alpha$) =0.01, $\mu_1$=41.7 %, Population Distribution (N) =10, T = -4.95 is less than -2.821 so Null Hypothesis ($\mu_1$) = 37.5 % is rejected and Alternative Hypothesis ($\mu_1$) <41.7% accepted

Case II, T-test, Level of Significance ($\alpha$) =0.01, $\mu$ =35.6 %, Population Distribution (N) =10, T = -2.1757 is greater than -2.821 so Null Hypothesis ($\mu$) = 35.6% is accepted.
In the case of HP, Lexmark and Brother, Case-I has been rejected and hence the alternative hypothesis is accepted and therefore it was mandatory to conduct another T-test on expected price saving due to remanufacturing. Values 56%, 49.42% & 35.6% are the average of top five values of price saving due to remanufacturing and these are expected prices saving percentage. In Case-II, null hypothesis has been accepted and Values 56%, 49.42% & 35.6% are the expected price savings due to remanufacturing. These values really attract the customers making their willingness to pay towards remanufactured products high. Null Hypothesis is accepted in Case II.

6.9 Focus on Cannibalization Issue

Due to remarkable price difference between new and remanufactured cartridges, customers are accepting remanufactured products in the market. A company, inkGuide also studied remanufacturing sale volumes and they indexed over 10,000 ink and toner cartridges from over 10 well known online ink stores. According to their findings, sale volume of remanufactured HP, Lexmark and Brother is 36 %, 25% and 26 % respectively of total sale volume of new cartridges. These sale volumes are healthy and it shows that the customers are willing to pay for remanufactured products.

It is important to know whether the remanufactured product is cannibalizing the sale of new products. If OEMs are not selling the remanufactured product, then other competitors from market will sell the remanufactured product causing the cannibalization of OEMs products. Volume of sale of remanufactured product depends upon price benefits and good functional quality as compared to new cartridges. If companies are
able to reduce the damaged percentage of cores, then they can reduce the cost of remanufactured products and put competitive price in the market. Remanufacturing market is growing fast and many OEMs have entered into this market to become more competitive.

Remanufacturing is useful both for industries and for customers and it saves a huge amount of material and energy, thereby protecting the environment for green growth development. It is one of the important steps as well, towards achieving sustainable development.

The importance of remanufacturing sector is increasing day by day in view of profitability, green growth and sustainable product development, ensuring reduction of waste for environmental protection. In Asia pacific, cartridge-remanufacturing industry is growing very fast and many OEMs are also entering into the remanufacturing business. Still, many OEMs in India are hesitant to launch remanufactured products due to the fear of new product cannibalization. Many SMEs are also remanufacturing cartridges and are competing with OEMs to cannibalize the sale. Nowadays, many OEMs are producing remanufactured cartridges and are trying to grab maximum market share.

Remanufacturing industries are facing many problems in the collection of virgin & non-virgin cartridges and faulty cartridges. The percentage of non-usable cores in the inkjet cartridge is 40% and 20% in toner cartridge. In the percentage of non-usable cartridges, maximum percentage is due to damaged cartridges. Reduction in damaged cores is the challenge for OEMs and remanufactures in their attempt to increase overall profitability. In virgin cartridge remanufacturing, percentage of replacement by new parts
is around 80% in blades and 65% in VCR. In non-virgin cartridges, percentage of replacement by new parts is also dropping.

Tables 6.4, 6.5 & 6.6 show the actual value of price saving percentage of remanufactured cartridges. It was tested to get the exact value of price percentage saving due to remanufactured cartridges. In the case of HP, Lexmark and Brother, saving of price due to remanufacturing is around 44.46%, 49.42% & 35.6%. COC between new and remanufactured cartridges is also very strong and the COD is more than 90%. Remanufacturers can thus adjust their prices in proportion to prices of new products.

OEMs are also entering the remanufacturing business to avoid excessive cannibalization of new products by other remanufacturing industries. Cartridge remanufacturing sector is growing in India and it is important for GGS. It also creates a huge secondary market to boost the economy.