Importance of Closed Loop Supply Chain in the Product Recovery Processes such as Remanufacturing

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ABSTRACT

Study of Closed Loop Supply Chain process is necessary for understanding the reuse, remanufacturing, recycling & disposal and other product recovery processes for perfect decision making in regard to End-of-Life products. Managing the Closed Loop Supply Chain process is not an easy task for manufacturers and hence the study of product acquisition management, reverse logistics with inspection and deposition is important. Reverse Logistic collection for End-of-Life product is described in this study through centralized and decentralized Reverse Supply Chain Models for optimum profit through proper product recovery process. Product Life Cycle is an important tool for guiding, understanding and predicting time sensitiveness and insensitiveness of products. For Closed Loop Supply Chain process, the study of Product Life Cycle and Product Cannibalization is necessary for arriving at optimum product recovery process resulting in optimum profit.

Keywords – **Closed Loop Supply Chain, Reverse Logistics, Product Life Cycle, Product Cannibalization, End-of-Life, Reverse Supply Chain Models**

I. INTRODUCTION

Over the last few decades, many industries have been paying a lot of attention to the environment concerns, regulatory impact and building up of commercial recognition [1]. A growing number of industries are starting to focus a lot on the reuses, remanufacturing and recycling & disposal of products as part of the environment management practices [2]. Product waste is becoming a big problem all over world. In order to minimize waste and to use the resources well, products can be remanufactured and its materials can be recycled to get better sustainability. In comparison to recycling materials, remanufacturing of products can retain all the value added, potentially retaining high profitability and sustainability [3], [4]. One of the concerns may be that the remanufacturing needs to recall the End-of-Life (EOL) product back to their original manufacturers, which often incur complex infrastructure and logistics.

Closed-loop supply chains (CLSC) is a process wherein the End-of-life 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 V.D.R. Guide, T. Harrison & L. Wassenhove [5] 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 R.T. Lund [6], the remanufacturing 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 J. Stock, T. Speh & H. Shear [7] the annual costs of commercial returns is in excess of $100 billion. According to V.D.R. Guide and L. N. Van Wassenhove [8], 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 [8]. 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.

II. IMPORTANCE OF CLSC PROCESS IN REMANUFACTURING

The remanufacturing system starts with the return of an end-of-life (EOL) product from customers. The process of getting the EOL products from the customer back to the manufacturers is known as Reverse Logistics (RL). According to D.S. Rogers and R.S. Tibben-Lembke [9] the Reverse Logistics is the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. From an economic recovery perspective, Reverse Logistics is important as a result of its contribution to the reduction or elimination of waste. It can exist as part of a CLSC.

Demand of a remanufactured product also depends upon pace of change in technology. Acceptance of a remanufactured product by consumer depends upon the need and price of the product [10], [11]. Nowadays, Product Life Cycle (PLC) is becoming shorter and shorter with reduction in price of products. Early launching of remanufactured product will result in more profit in the market [12], [13]. For early launching of remanufactured product, an effective CLSC process is needed. New technology will replace old technology products and remanufactured products. Hence, the pace of change of technology will decide the market of remanufactured products. Here, the role of CLSC process is very important. End-of-use returns happen when a well-designed product is replaced by a technological upgrade. End-of life returns are available when the product becomes technically obsolete or no longer contains any utility for the current user.

III. CLOSED LOOP SUPPLY CHAIN PROCESS

For the last many decades, remanufacturing of air craft and engines are in huge demand due to the extension of product life. In an air craft, there are thousands of parts which are dissembled at the remanufacturing process. Distribution of a part at a remanufacturing center for processing and reassemblies is a tedious process. Reverse Supply Chain Management has to play an important role in this situation. Reverse flow of material in shop and testing of EOL parts is a big challenge for industries. Not much attention has been paid for improving remanufacturing shop control and coordination [14]. Understanding of key parameters of CLSCs is more important for replacement of traditional operations management by advanced CLSCs process.

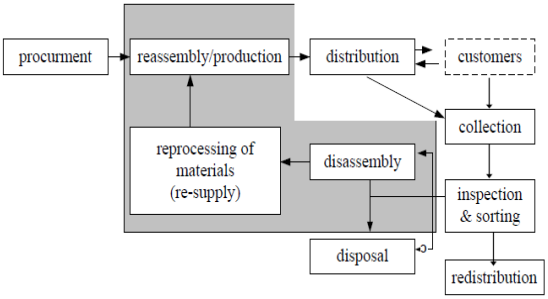

Figure.1. Closed Loop Supply Chain Model for remanufacturing [16]

For researchers, profit maximization and cost maximization are important parameters for investigation. In Europe, Companies like Xerox have decided to go beyond legislation. They have introduced remanufactured copiers as a part of 'Green' line strategies [15]. Citing Xerox, a group at Erasmus University has realized that the remanufacturing is not only about minimization of cost but rather a more fundamental business. Assembly, reprocessing of materials and reassembly are the three important phases of a remanufacturing process. Fig. 1 shows the closed loop supply chain management process for a remanufactured product.

3.1 Sources of Product Acquisition

Closed Loop Supply Chain management process starts from product acquisition [17]. This is the process of retrieving used products and components from user [18]. Mainly, there are three main sources of product acquisition. First important source is forward supply chain used for defective or damaged part pushed upstream through the same chain. Second source is existing reverse supply chain, used to acquire the used product for reuse, remanufacturing and recycling process. Third source is waste streams used for product land-filled process. Product acquisition is the important process for profitable CLSC process. The product return should be well managed in terms of quality, quantity and timings.

3.2 Product Acquisition Management

Reverse Logistic activity is basically divided in to five types of waste treatment, namely reverse distribution of product, return of unsold goods, damaged good, product recalls and waste management [19]. H. Dyckhoff, R. Lackes & J. Reese [20] has explained the RL activity as shown in fig. 2. Closed Loop Supply Chain management process starts from reuse option.

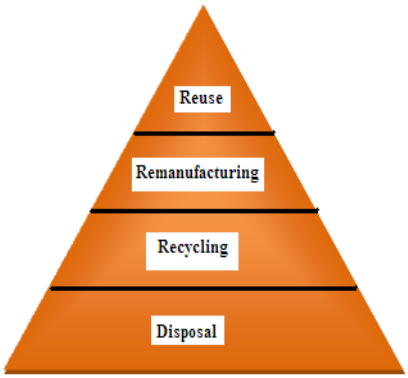

Figure. 2. Hierarchy of Reverse Logistics Activities [20]

Disposal of product is the last option in Reverse Logistic (RL) process. For product reuse, remanufacturing and recycling activity, RL plays an important role. RL consists of transportation, warehousing, distribution and inventory management with common goal of cost minimization and value maximization.

3.3 Inspection and Disposition

Customers return the used products for a variety of different reasons. However, all those reasons would not be as obvious to the distributers or remanufacturers who receive the returned goods. Hence, it is important to inspect the used product for the right decision of disposition. This activities including disassembly, inspection, testing, sorting and rating of the products for selection is appropriate for product recovery options. All the returned products are split into different groups of distinct recovery. Proper disposition alternatives are important for cost saving for logistics. Due to proper disposition, products can be distributed early in the market. Table 1, describes the four product recovery strategies and detailed disposal options.

Table 1 Product Recovery Strategies [20]

Product Recovery Strategies	Detailed Disposal Options
Direct Reuse	**Direct Reuse** **Resale**
Product Upgrade	**Repair** **Refurbishing** **Remanufacturing**
Material Recovery	**Recycling**
Waste Management	**Incineration** **Land-filling**

After inspection process, companies take the decision about disposal option. Valuable components or EOL product as a whole are repaired, refurbished or remanufactured for resale. For remanufacturing purpose, reassembly of product and conditioning is an important activity.

3.4 Measurement of Key Parameters

The motive of the repair process is mainly to extend the product life for a low cost. Under normal circumstances when the product is broken down, the most frequent recovery option is to repair the product. Table 2, explains the advantages of remanufacturing over the repair, reconditioning and refurbishing process. Product performance of remanufactured products is always as high as compared to other material recovery operations. Remanufacturing operation is more costly as compared to repair and reconditioning, but profit margin is also high as compared to other operations.

Table 2 Production Operations and Key Parameters

Operations	Product Performance	Labor Content	Warranty
Repair	Less	Less	Less
Reconditioning	Medium	Medium	Less
Refurbishing	Medium	Medium	Medium
Remanufacturing	High	High	High

3.5 Core Quality and Operations

When the core quality is high, cost for remanufacturing operation is not a motivating factor for remanufacturing operations. In this situation, the sound option is to reuse the product (see fig. 3). Later, when the quality of core decreases, the benefit for remanufacturing becomes greater and is logically motivated from a profit perspective. After a certain level, the quality of the returning core becomes so low that the cost for remanufacturing becomes too high according to the potential market price. In these situations, it can be motivated to recycle the product.

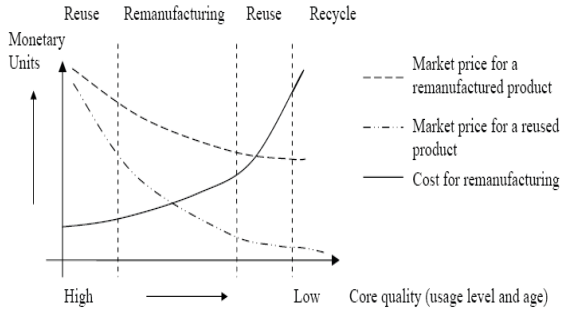

Figure. 3. Core Quality and Product Recovery [22]

IV. REVERSE LOGISTIC COLLECTION MODELS

There are basically three methods for collection of EOL products for the purpose of remanufacturing. Here, mainly the remanufacturer, retailer, third party and consumers are involved in reverse logistic collections [2].

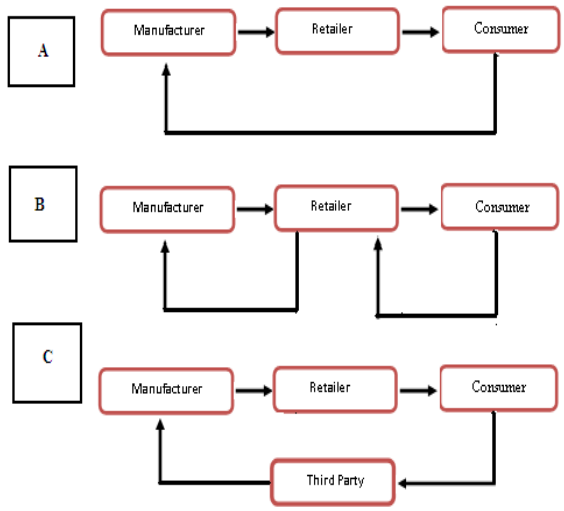

Figure 4. Reverse Logistic Collection Methods [2]

In Fig.4 Section A, B and C shows reverse logistic collection methods. Section 'A' shows that the consumer directly returns the used product to a manufacturer. Here, the retailer is not involved in the reverse logistic collections. Many remanufacturing companies like Xerox, Canon and Hewlett Packard do collect EOL products directly from customers. Section 'B' explains the involvement of retailers in the collection of EOL products from consumers. Here, retailers supply the EOL product to the manufacturer. Consumer always feels comfortable to return EOL product to the retailers [24]. Single use of Kodak Camera, television and refrigerators are returned from consumer to retailer. This method is usually adopted by most of the remanufacturers. Section C, Shows that the third party collects the EOL products from consumer on behalf of the manufacturer. In this case, the retailer is not involved in reverse logistic operation. Cars, Automobile parts etc. are collected by third party and a third party agency supplies the same to manufacturing units [24].

4.1 Centralized Evaluation and Test

A Centralized Evaluation System is introduced between retailer & resellers and manufacturing companies. This Centralized Evaluation System helps manufacturer for evaluation of EOL products. Customers return their EOL product to retailer & reseller and then an evaluation system is necessary, which can make the decision about product recovery options. As shown in fig. 5, reuse, remanufacturing, part recycling and disposal are the main product recovery options.

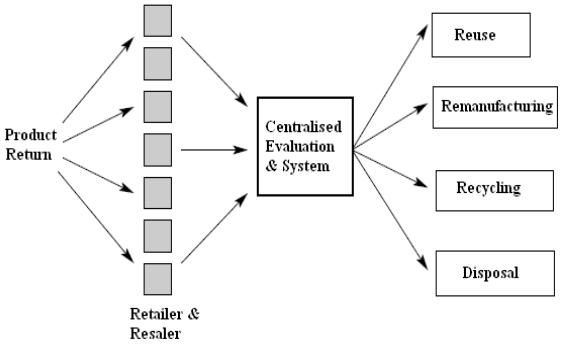

Figure .5. Centralized Reverse Supply Chain Model

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

4.2 Decentralized Reverse Supply Chain

In decentralized reverse supply chain, customers return EOL products through retailer and reseller. In this process, retailer and reseller do not directly return the product to the centralized evaluation and test facility system. In this system, reseller and retailer are important decision making authority for supplying EOL product to reuse, disposal & test and repair facility center. Here test and repair facility center takes the decision about product recovery by remanufacturing and recycling method. In this system, the time consumed to return the product from consumer to manufacturer is less. See the Fig 6.

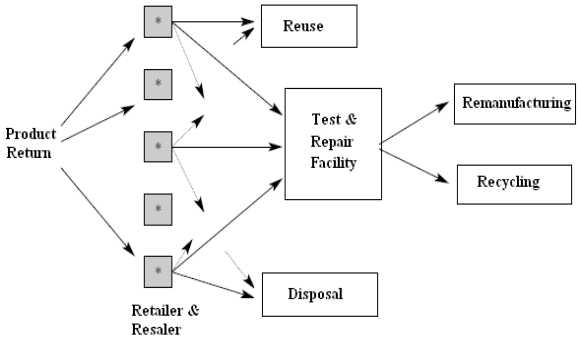

Figure. 6. Decentralization Reverse Supply Chain Model

V. PRODUCT LIFE CYCLE AND CLOSED LOOP SUPPLY CHAIN

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

5.1 Cannibalization and remanufacturing Opportunity

A report by Electronics Waste Management group in the United States published in 2011 shows the sale data of PC CRT monitors and PC Flat monitors in the USA for the last 31 years. Based on this data, the Product life cycle of PC CRT monitors and PC Flat monitors is plotted and is as shown in fig. 7.

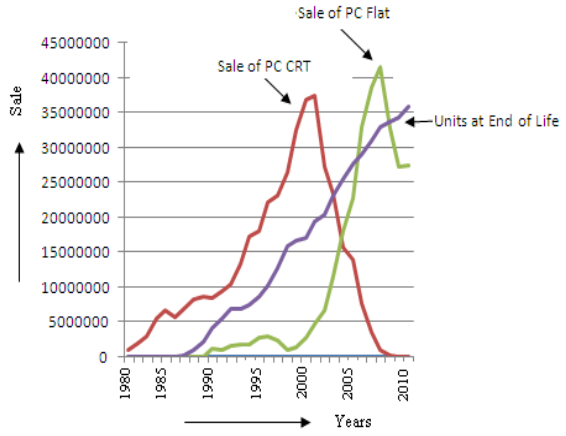

Figure.7. Product Cannibalization and Remanufacturing opportunity [24]

Sale of PC CRT monitors were in the growing phase between years 1990 to 2000. During these years the opportunity of remanufacturing is more for the companies. Maturity phase of PC CRT monitors is very small. After launching of PC Flat Monitors in 1988; it started cannibalization of CRT PC monitors and the rate of cannibalization has increased between the years 2000 to 2011. Here the decline phase of PC CRT monitors is observed as being quite healthy. Around 2009, the sale of PC CRT monitors was totally replaced by Flat PC monitors and the demand of remanufactured PC CRT monitors was also replaced by remanufactured Flat PC monitors. It is seen that the demand of remanufactured product depends upon the product cannibalization of existing product. Product life cycle of remanufactured product depends upon the product life cycle of existing product [24]. Quantity of End-of-Life (EOL) product also shows the opportunity for remanufactured product in the market. In this example, the role of CLSC is very crucial. The reseller and retailer had huge responsibility to collect EOL monitors at the right time as per the demand of remanufacturing market. The product life cycle can guide CLSC process about prediction of remanufactured products. Demand of a remanufactured product also depends upon the pace of change in technology. Acceptance of remanufactured product by consumer depends upon the need and price of the product. Nowadays, PLC is becoming shorter with reduction in price. Early launching of remanufactured products can result in more profit in the market. New technology is replacing old technology products and remanufactured products. Hence, the pace of change of technology will also decide the market of remanufactured products.

5.2 Time sensitive and Timing insensitive products

Importance of time value in the reverse supply chain is valuable for getting optimum profit through product recovery management. The time delays in CLSC process reduce the value of products and hence the study of time sensitive products and time insensitive products are necessary in CLSC processes. In Fig. 7, PC Monitors are time sensitive products and hence these types of products have limited time value for remanufacturing products.

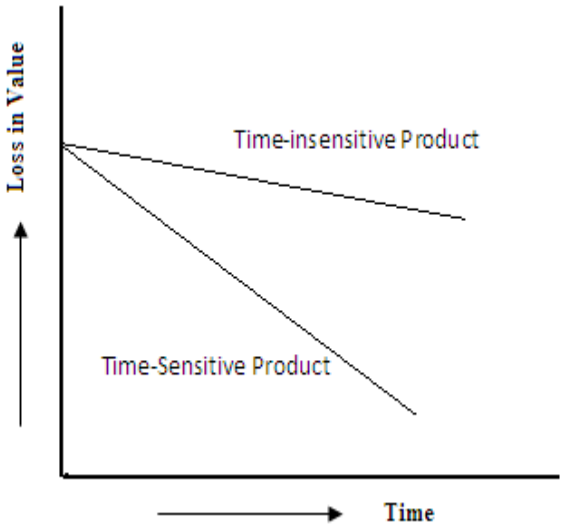

Fig 8 Time Sensitive and Insensitive Product [23]

As shown in Fig 8, 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 CLSC, it is necessary to know the time sensitive and time insensitive product for optimum profit making in product recovery management. In remanufacturing sector, success of remanufacturing product mainly depends upon time sensitiveness. The product life cycle management is very important for checking and evaluating time sensitive and insensitive products.

VI. CONCLUSION

This study is expected to guide the industries as well as academic researchers in understanding the Closed Loop Supply Chain Process and its decisive strategies for reuse, remanufacturing and recycling & disposal product recovery options. In CLSC process, the product acquisition management, inspection and disposition of EOL products and core quality & operations are important elements for deriving optimum benefits using various product recovery systems. In Reverse Logistic Collection System, centralized and decentralized Reverse Supply Chain models and its applications are described. Importance of product life cycle management and cannibalization process has also been explained with the help of a case study of PC Monitors. In the remanufacturing sector, understanding time sensitiveness and insensitiveness are both necessary for identification of the exact product recovery process.

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