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Product Design Deliberations for Circular SCM to Promote Green SCM

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Abstract: Ensuring the supply of right product (or service) to right time, to right people, with optimized manner is fundamental expectation from any Supply Chain Management (SCM). However, unfortunately, the world's resources are diminishing to cater to the need of SCM, also at another side the challenges of waste disposal is an irony. Green and Circular SCM is apparent elucidation on these issues.

In this paper, an attempt is made to highlight an innovative enhancement in Circular SCM (Reverse Logistics) model that ultimately support Green SCM. This paper proposes to focus on two aspects that make circular supply chain effective:

1. Provision of features for easy decomposition of used product during design phase of product, and
2. Establishing and maintaining the integrated channels for used product components.

Keywords: Circular SCM, Green SCM, Product Recycling, Reverse Logistics

Introduction

The rapid economic growth, changes in technology, globalization and specifically, increase in population created upsurge in the amount of resources consumption that contribute adversely to the environment issues and causing shortage of assets. Hence, t becomes essential to balance between economic and environment performance [1].

As a concern to environmental sustainability, most of the organizations are forced to go green in their business operations along with their customers and suppliers.

Scope and Objectives

In a traditional (i.e. linear) SCM, the material flows sequentially from input raw-resources to manufacturing process, followed by consumption (and use) of product to waste creation. Disposition of this huge increasing amount of waste created becoming big and growing problem to entire world.

Obviously, many attempts are being made to dispose the used products as waste; however comparing to the rate of increase in the amount of waste, these attempts are falling very short. On another side, the resources of raw material are shanking day-by-day.

The scope of this paper is restricted to provide the concept for items that consist of engineering goods made up of assemblies with different types of materials in it. Used product can

be decomposed and recycled. This includes consideration of the product life cycle stages, design features, flow channels and recycling activity.

The objective of this paper is to propose a concept that during product and system design the thought should be given formaximum possible components' reuse from waste of same product. For this purpose` study and monitoring of major stages of the circular SCM are deliberated.

This paper attempts to highlight the changes that can be made in the product at the manufacture stage itself by addressing the issue from a design and reused product component perspective so as to eliminate the root cause.

According to the American Marketing Association, green marketing is the marketing of products that are presumed to be environmentally safe. Thus, green marketing incorporates a broad range of activities:

a) Product modifications

b) Changes in the production process

c) Packaging changes

d) Changes in the advertising and promotion strategies

This paper is primarily focusing on the first three activities which are related to the design and packaging of the product.

Literature Review

Terms like 'Being Green' and 'Eco-friendly' have become buzz words on commercials and product packaging; however, the term 'Eco-friendly' has been used vaguely for many products and practices; its true meaning is in danger of being lost. Understanding true 'Eco-friendly' can help usimplement practices that will lead to healthier living for us, the planet and its inhabitants.

Eco-friendly literally means Earth-Friendly or not harmful to the environment, and most commonly refers to products that contribute to green living or practices that help conserve resources like water and energy. Eco-friendly products also prevent pollution to air, water and land.

Product Qualifications: Truly Eco-friendly products keep both environmental and human safety in mind, often the product is non-toxic.

Other attributes include the use of sustainably grown or raised ingredients, produced in ways that do not deplete the ecosystem. Organic ingredients or materials are grown without toxic pesticides or herbicides and products with 'made from recycled materials' contain glass, wood, metal or plastic reclaimed from waste products. In addition, 'biodegradable' products break down through natural decomposition, which is less taxing on landfills and the ecosystem as a whole.

A green product can generally be defined as a product that, from raw material extraction and processing to use and end-of-life disposal, lessens its impact on the environment as thoroughly as possible.

Green certification for products in India has been initiated by CII (Confederation of Indian Industry) in collaboration with UL (Underwriter's Laboratory). The certification adopts a holistic approach in assessing products that include design, raw materials, manufacturing process and performance during use, recycle and reuse at the end of the product life [4].

Any product designed goes through a process of concept to reality. The same can be pictorially given as,

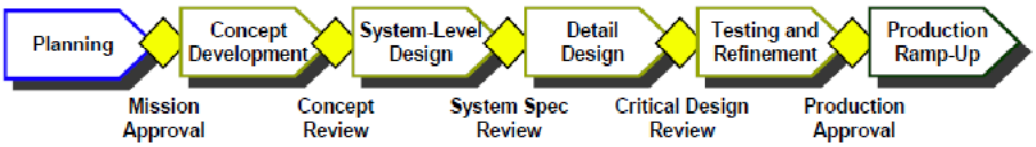

Fig. 1: Product Design Process

Planning stage is often referred to as Phase Zero, since it precedes the project approval and launch of the actual product development process. Output: Target market, business goals, key assumptions and constraints [3].

In concept development stage, needs of the target market are identified, alternative products concepts are generated and evaluated, and one more concept is selected for further development and testing.

The system level design would include the definition of the product architecture and the decomposition of the product into sub-systems and components. The final assembly scheme for the production system is usually defined during this phase.

Detailed design is more about the manufacturing functions and includes complete product specifications such as tolerances, materials, geometry, etc. Specifications of the purchased parts, process plans and assembly plans of the product defined and tooling is also defined. Additionally, the recycling aspect is also considered.

Testing and refinement stage would involve construction and evaluation of several preproduction versions of the product for finalization.

After the testing and refinement, the product is made using the intended production system. Purpose is to train the work force and weed out any remaining problems in the production processes. The transition from ramp-up to normal production is gradual.

Hypothesis

Comprehensive approach of enhancing every stage of circular SCM or reverse logistics contribute towards effective Green SCM.

Research Methodology

The paper is conceptual in nature and is based on personal experience, interviews and study of past research conducted. A mixed approach was used in this paper. The respondents were drawn from industry professionals in the field of product development, manufacturing and supply chain. Feedback of academicians in the domain of supply chain were also taken.

Traditional SCM

Generally, the sequential flow of material from source to the processing and from there to the point of use or consumption is recognized as Supply Chain Management (SCM). Enough study, efforts and funds were used for optimizing these activities to make them more efficient and effective (i.e. maximizing the output/ productivity for available input resources.

Bower sox *et al.* (2014) while explaining the SCM in terms of 'responsiveness' suggested 'Anticipatory Business Model' and 'Responsive Business Model' as follows.

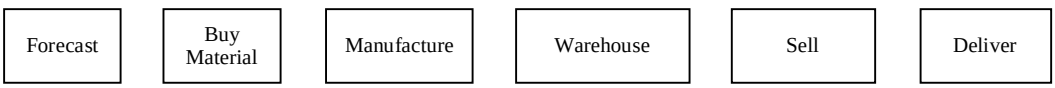

Fig. 2: Anticipatory Business Model

Loosely linked firms do not have information about 'purchase behaviour' because they do not share or integrate their business plans. Hence, their business operations were driven by forecasts. As manufactures produced products based upon market forecast, the wholesalers, distributors and retailers purchase inventory based on their unique forecasts and promotional plans. Since the entire model is based on forecast, depending upon the accuracy of forecast there is a risk of resulting unplanned inventory.

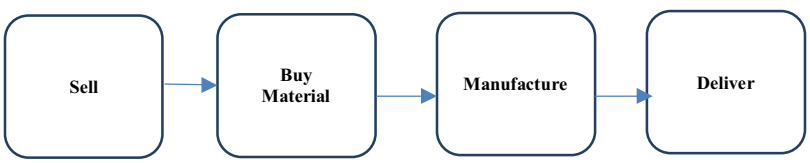

Fig. 3: Responsive Business Model

The responsive business model seeks to reduce or eliminate forecast reliance by integrating the planning activities with rapid exchange of information between supply chain participants. This minimizes or eliminates the risk related to forecast reliance.

Green SCM

According to Srivastava [2], GSCM can be defined as 'integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.'

The social and regulatory pressures for going green are increasing day-by-day andit becomes essential for any organization to establish the equilibrium between

- Financial pay-off
- Operational pay- off
- Environmental pay-off

Environmental attitude (EA) is a key predictor of GSCM activity and those organizations that have progressive attitude are also operationally very active.

The global environmental standards such as ISO 14001 facilitates role in the environmental activities between customers and suppliers. However, the specific factors such as minimizing the waste, decreasing the consumption of hazards and toxic materials in manufacturing processes, according to government regulations, statutes and reverse logistics are the drivers to think for circular SCM.

Circular SCM

Today's manufacturers have grown exceptionally capable of being able to produce record-breaking volumes of products without any recycling or reuse capabilities when unlimited resources were available. But in today's scenario, the recycling and reuse of scrapped products is vital. Circular SCM is also known as Close-Loop Supply Chain, the major activities with flows are as shown below:

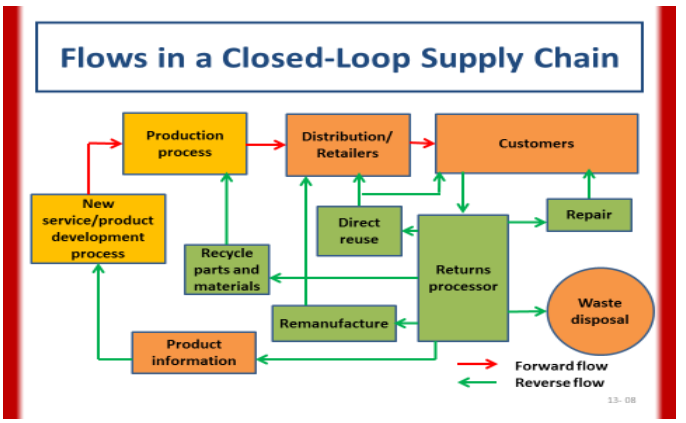

Fig. 4: The Closed-loop Supply Chain

In the Closed-loop Supply Chain ideally known as a zero-waste supply chain that completely reuses, recycles, or composts all materials. However, the term can also be used to refer to corporate take-back programs, where companies that produce thegoods are also responsible for its disposal.

Proposed design Deliberation for Reverse Logistics (Recycle of Components)

Logistics is the process that links supply chain participants into integrated operations [5]. Reverse supply chain refers to the movement of goods from customer-to-vendor. It is the process of planning, implementing and controlling the efficient and effective inbound flow and storage of secondary goods and related information for the purpose of recovering value or proper disposal.

Recycling and reuse of scrapped products is vital but not a new concept.

Reclaiming raw material from existing waste (specifically from the same scrapped product by tracking its life cycle stages, without mixing with other waste) and special design provisions for accommodating this scrap material as raw material with minimum possible processing is the central theme of the paper. For example, some people are offering the scrapped products such as used bulbs/ tubes, old discarded car batteries with much discounted prices. This list can be extended to e-waste such as old computer equipment's such as used monitors, printers and hard drives that can fetch great value when they carefully classified (rather not mixed), recycled and reused properly.

In fact, considering the business objectives such as constant growth and sustainability with constraints such as limited and diminishing resources, tracking the product life-cycle path (for not mixing the waste) and accepting the own product scrap as input raw material without much effort becomes vital.

On this background, two modifications in conventional reverse logistics or circular SCM is suggested as follows:

1. Not to mix the product scrap with other product scrap (by keeping track of product life-cycle path) and
2. Provision in the design to adopt own product scrap as input raw material with little or no processing

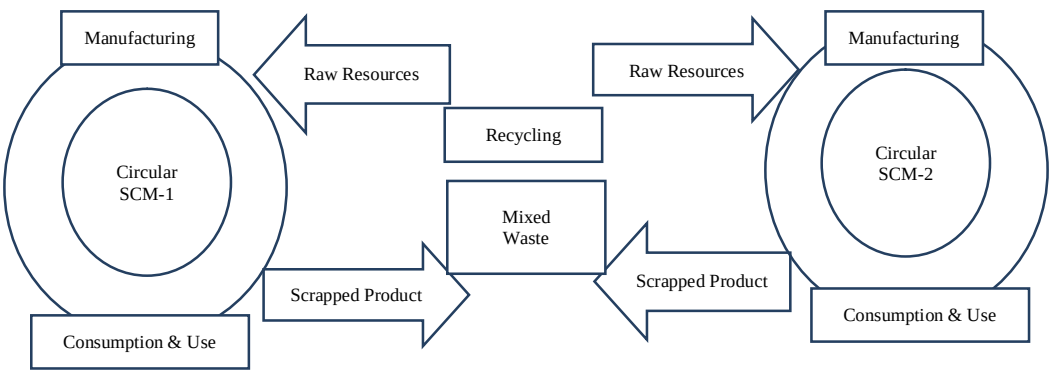

Fig. 5: Conventional Reverse Logistics/ Circular SCM, with Mixing of Product Scrap

As shown in Figure 5, in conventional reverse logistics the raw resources are being obtained from common/ mixed waste or garbage. There are no specific design provisions to adopt/ modify the waste. Recycling efforts includes separation/ classification of waste and then supply it to manufacturing as raw resources.

Here the recycling yield is very less as waste consists of mixture of various product scrap. Hence, recycling is not effective.

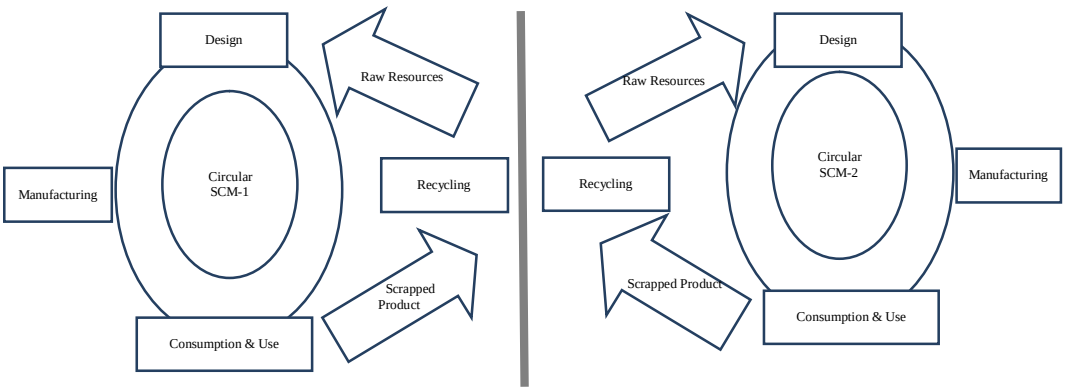

Fig. 6: Proposed Reverse Logistics/ Circular SCM, with Suggestions

In order to make the recycling and thereby the reverse logistics effective the product scraps are maintained separately (without mixing together). The channels of used product components are being maintained.

The design phase (specifically for recycling purpose) is being introduced. It is expected that during this design phase, design will ensure tracking and monitoring the Bill of Material (BOM) wise assembly components.

For example, metallic components and glass components can be designed in such a manner that the components made up of glass can be tracked throughout its life cycle stages (Design-Manufacture-Consume/Use) independently so that only used scrap glass component will undergo recycling process, whereas metallic components need not be scrapped.

For this purpose

1. Component material-wise life-cycle path or channel need to be maintained for effective recycling
2. Product design should allow to replace only recycled items for waste reduction

Advantages of Reverse Logistics

- Allows a trader to receive products back from the consumer or send unsold merchandise back to the manufacturer to be taken apart, sorted, reassembled or recycled; minimising overall costs for an organisation.

- Reverse logistics can be valuable in increasing product lifecycles, supply chain complexity, maintainable practices and consumer preferences; which have to be improved on to maintain productivity and growth.
- Gains can include: increasing speed of production, reducing costs (transportation, administrative, and after-market maintenance, repair and replacement), retaining customers by improving service goals and meeting sustainability goals.
- More value can be extracted from used/returned goods instead of wasting manpower, time and costs of raw materials involved in the original supply chain.
- Improved customer satisfaction and loyalty by paying more attention to faulty goods, and repairs of merchandise. Reverse logistics can include gaining feedback to make improvements and to improve the understanding of real reasons for product returns.

Findings and Recommendations

To achieve the economic as well as environment efficiency together it is recommended that the process of product development should incorporate the following vitalaspects that support circular SCM

1. ***Adoption of the Reverse Logistics Concept by Designing the Supply Chain as Closed Loop System:*** Many times rather than calling as 'reverse flow' the supply of used products are treated as beginning of its raw material supply, which can give substantial amount of recycled content to produce a new product. Therefore, it is recommended to adopt the reverse logistic concept by designing the supply chain as closed loop system over conventional supply chain.
2. ***Enhancement of the Product Design with the View Making Recycling of the Product Easy and Convenient:*** It is suggested to have the provision in the product design that shall assist for separating the components form used products. While classification of components (elements) of used product, if design is conventional there are chances to spoil these items (used components). Hence, it is recommended to enhance the product design which shall cater to this need.
3. ***Establishment of Channels to Track and Keep the Own used Product Material Separately:*** Various channels are suggested to maintain for each used components. This channelled networks are further suggested to optimize for daily, monthly and annual basis. Cost and capacity of recycling units along with capability of such distribution network of new (as well as used) product determines the success of the circular supply chain.

The provision should be there in product design to classify the products from recycle of the used product perspective. For this purpose, the supply chain should be a closed loop supply chain.

A good example of a closed loop supply chain is the supply chain of Reserve Bank of India for currency. Where the new notes are issued in the circulation and soiled notes are taken back from circulation.

Case Study

A global manufacturer Johnson Controls incorporated a 'circular' or 'close-loop' supply chain for automotive battery recycling (Blanco *et al*., 2014). This process of feeding used product back as raw materials gives plenty of economic incentives to Johnson Controls. About 80 percent of the material used to make auto batteries is being used from recycled batteries.

The metals, plastics and acids are major components used to make the auto batteries which can be recycled. Johnson Controls obtained two significant benefits from recycling process of auto batteries.

1. Considerable business benefits were achieved by obtaining raw materials at a more competitive cost
2. Health and environmental risks are being minimized by channelizing and recycling of hazards material in the auto batteries

Johnson Controls observed that managing the reverse flow of a circular supply chain is different from managing the conventional supply chain which is linear.

Johnson Controls partnered with outlets such as auto repair shops and retailers who replace non-functional auto batteries. They collect, sort and send the units to recycling centres. At present about 97 percent of automotive batteries are being recycled.

The major issue that Johnson Controls facing is supply of used batteries is seasonal. Hence, balancing the demand of new batteries with supply of used batteries becomes challenging. Safety and transportation efficiency were other challenges. Johnson Controls managed these challenges by establishing the effective information network.

Finally, Johnson Controls achieved economic and environmental efficiency by application of circular supply chain with product and network design deliberations.

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