IMPACT OF RECYCLING IN A GLASS INDUSTRY: A PROJECT MANAGEMENT STUDY

Dr Padmalatha N A¹, Prabhish Shresta²

ABSTRACT

Glass is one of the most popular storage and packaging products used today. It is also, one of the easiest commodities to recycle or reuse, conserving both natural resources and landfill space. It is 100% recyclable and can be recycled perpetually. Glass is an inevitable component of the Indian economy, where it accounts for more than 21 million metric tons of consumer products each year yet there is no proper management of waste glass created by consumers. Out of the total glass produced in India only 45% is recycled which shows that there is a need for proper procurement and management of waste glass. The recycling process of glass is very simple when compared to other commodities and reduces CO₂ gas emission, saves disposal landfill; conserving valuable natural resources. This paper intends to explain the manufacturing process of the new glass using recycled glass. A full project management Gantt chart is also prepared to show the process flow with a time schedule. This paper looks at different activities required for procurement, manufacturing and cost estimation of glass recycling. Some of the major findings of the research are: The technology for recycling container glass is relatively simple and well established compared to other types of glass; recycling includes many activities, among which some of the major activities are: Collecting of waste glasses, sorting of the glasses, cullet preparation, and melting and shaping; it can be successfully carried out with a detailed project management in less than two weeks.

Key Words: Glass Recycling; Project Management; Project Cost Estimation; Project Procurement

¹. Associate Professor, BIMS, Bangalore
². Student-MBA Programme, Dayananda Sagar Institutions, Bangalore
INTRODUCTION

Glass is an important component of Indian economy, generating more than 21 million metric tons of consumer products each year. Glass production is energy intensive and accounts for 12% of the total cost of sales. As per the reports, India’s Rs. 60,000-crore packaging industry is growing at around 15%. The glass segment accounts for around 10% of the total packaging industry. The glass industry consists of following four major segments: Container glass (bottles, jars, etc.); Flat glass (windows, windshields, mirrors, etc.); Fibreglass (building insulation and textile fibers); and specialty glass (Cookware, Flat panel displays, Light bulbs, Fibre optics, medical equipment, etc.) etc.

Importance of recycling in glass industry

- **Environmental Benefits**: Recycling glass makes production efficient and provides significant environmental benefits.
- **Saves Raw Materials**: Over a ton of natural resources are conserved for every ton of glass recycled, including 1,300 pounds of sand, 410 pounds of soda ash, 380 pounds of limestone and 160 pounds of feldspar.
- **Lessens demands of energy**: Energy costs drop about 2-3% for every 10% cullet used in the manufacturing process. (The glass recycling process produces a crushed glass product called cullet. Cullet is often mixed with virgin glass materials to produce new end products. Making new glass from recycled cullet saves energy because recycled glass melts at a lower temperature than virgin raw materials. Since the materials do not need to be heated as much, less energy is required in the manufacturing process.)
- **Cuts Carbon Dioxide Emissions**: For every six tons of recycled container glass used, a ton of carbon dioxide (greenhouse gas) is reduced. A relative 10% increase in cullet reduces particulates by 8%, nitrogen oxide by 4%, and sulphur oxides by 10%.
- **Extends furnace Life**: Including cullet in the manufacturing mix makes it less corrosive and lowers the melting temperature (from 2800°F to 2600°F), prolonging furnace life.
- **No processing by-products**: Glass recycling is a closed-loop system, creating no additional waste or by-products.
Glass recycling is a process that takes unusable, end-of-life materials or products and transforms them into either the same product or a secondary product. When a material is recycled, it is used in a place of in the manufacturing process, rather than being disposed of and managed as waste. Consequently, recycling reduces greenhouse gases in two ways, depending upon the material recycled:

- Recycling offsets a portion of “upstream” greenhouse gases emitted in raw material acquisition, manufacture and transport of virgin inputs and materials.
- Recycling increases the amount of carbon stored in the forest. (When wood and paper products are recycled).

Recycling processes can be broadly classified into two different categories: Open loop and closed loop recycling. In a closed-loop recycling, end-of-life products are recycled into the same product. An example of closed-loop recycling process is recycling an aluminium can back into another aluminium can. Decisions about whether to model materials in an open-loop or closed-loop process are based on how often the material recycled and the availability of data. For materials recycled in an open loop, the products of the recycling process (secondary product) are not the same as inputs (primary product). Open-loop recycling does not account for avoided emissions from manufacturing the primary material, since recycling the already recycled material does not displace manufacturing of the secondary products. For example, personal computers are recycled by dismantling the PC and recovering and processing the raw materials it contains for use in secondary products.

**Manufacturing of glass using recycled glass**

Glass is made from its raw materials in a carefully structured two-step process, and is then molded into different forms as required, into either Sheet/Flat glass bottles. Glass mainly consists of silica, obtained from pure sands. The sand is first washed to remove the unwanted impurities before it is mixed with other materials which control the color and other properties and melted. The manufacturing process includes the following three steps:

**Batch Mixing:** Cullet is one of the important raw materials which is prepared by collecting used glass from homes, businesses and recycling sites and sent to material recycling facility and then sorted
into different colors. The separated glass is then crushed to form a product called ‘cullet’ which is then sent for separation of other metals, and light contaminants. The clean cullet is then crushed further and melted in a furnace at 1500 degree Celsius. As glass is fed continuously into the furnaces, each furnace has to be dedicated to producing glass of a particular recipe, and it takes 12-48 hours and a number of steps to alter the mix in order to produce a different type of glass of an acceptable standard.

**Batch melting:** The ingredient mixture is fed continuously into the furnace which is fed by natural gas, and boosted by electricity when necessary. The glass is initially heated to 1400°C, then raised to 1540°C, at which temperature the mixture melts. When no more gases are evolved the liquid is ready to be formed into the desired product.

**Shaping and Molding of the glass:**

**Shaping Flat glass:** The cooled, molten glass from the furnace is flowed into an extension of the tank known as the drawing canal, where it is cooled to 1000°C before being drawn up into a tower. On the top floor of the factory the glass is monitored to ensure its constant thickness, and then scored and snapped off by the break-off machine. The individual sheets weigh 22 kg, and are lifted by rubber suction pads and placed on a conveyor belt where they are cooled, and have their rough edged snapped off before being transported for storage.

**Molding Container Glass:** Molten glass is removed from the furnace through forehearts (heated channels) where the glass is cooled to between 1100 and 1500°C, the exact temperature varying depending on the product to be formed. These are molded in “sections” within the machine, held in the air for a short time to cool and transported to the annealing lehrs. The annealing lehrs are a further stage in the cooling process, and after going through these, the bottles are coated with a shiny, slippery spray-on coating.

The purpose of the project management practices for glass recycling helps to improve the opportunities in order to increase efficiency. As established by various researchers, “Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. It is accomplished through the use of the processes such as initiating, planning, executing, controlling, and closing.” The project team manages the project work, and the work typically involves:
• Managing the competing demands for scope, time, cost, risk and quality
• Managing stakeholders with differing needs and expectations
• Identifying requirements and procurement needs.

It is important to note that any of the processes within project management are iterative in nature. This is in part due to the existence of and the necessity for progressive elaboration in a project throughout the project life cycle i.e. the more you know about your project, the better you are able to manage it. The project planning activities and goals include defining:

• The specific work to be performed and goals that define and bind the project
• An estimate to be documented for planning, tracking, and controlling the project.
• Commitments that are planned, documented, and agreed to by affected groups.
• Project alternatives, assumptions and constraints.

**REVIEW OF LITERATURE**

The project management book (PMBOK, 2012) describes knowledge areas and practices in terms of component processes. The nine knowledge areas which have been described in detail are: integration management, scope management, time management, procurement management, cost management, human resource management, communication management, Quality management and Risk management. The article contains a detailed discussion of skills, tools and techniques of project activities to meet the requirements.

The research by Friends of earth, 2008, mentions different frequency and practices to collect waste materials. In order to collect these materials in an efficient manner, local authorities must be provided information about the practices of recycling, and the government should give councils clear guidance as to what the best practices are. Some of the more interesting recommendations of the research for the collection are: usage of source separated collection systems; investment in providing a good customer care service for households so that they are encouraged to take part in the scheme and recycle as much of their waste as possible; and investment in reaching properties such as high rise, high density and remote rural homes and increase the number of materials collected; and
introduce separate weekly food waste collections.

The focus of the research on British Glass (www.britishglass.org) is to explore a relationship in terms of efficiency using daily primary energy which in turn uses virgin feed and recycled glass entering the furnace. The study has developed a methodology for calculating CO₂ emission for various recycling options. Using multiple regression analysis, the research clearly shows greatest CO₂ savings result when recycled glass is used as feedback for manufacturing a new glass. From the report, it is clear that the greatest environmental benefits would be reaped if glass was used as a feed stock in new glass manufacturing.

According to the consortium of automotive recycling(1999), it is estimated with a degree of certainty that at least two million tons of glass waste is created every year, which includes waste arising from in service, packaging as bottles and jars, glass arising from pubs, clubs, restaurants, as well as other commercial services etc. The article elaborates on the advantages of recycling glass in terms of economic and environmental facts. Some of the benefits mentioned are: glass can be recycled indefinitely without the quality significantly deteriorating, huge energy savings; for every

tone of recycled glass used the equivalent of 130 litres of oil are saved, it reduces operating waste disposal costs by reducing both the weight and volume of waste requiring storage, transportation and disposal.

**STATEMENT OF THE PROBLEM**

The costs of recycling are estimated by the difference between the costs of collection and sorting and the value of materials in the end market. By recycling, landfill costs can be saved which are made up of the financial costs of landfill and externalities. Benefits include, ‘direct consumer benefits’, which are a measure of the extent of people’s personal preferences to recycle rather than create waste. Considering these factors, it is found that it is important to recycle and manage the recycling process.

**OBJECTIVES OF THE STUDY**

The research focuses on the impact of recycling in the glass industry. The research focuses on procurement operation, cost factors and time management due to adaptation of recycled glass as the raw material for further production. The study identifies the cost factors related to manufacturing of glass and the factors affecting the procurement operations.
develops the time line chart for manufacturing container and flat glass using recycling operation.

PROPOSITION OF THE STUDY
As established by numerous researches, usage of various tools and techniques helps to manage the process of recycling of the glass better. Hence, the following propositions were formulated for the above study:

Proposition: Usage of project management tools enhances glass recycling.

MAJOR FINDINGS OF THE STUDY

✔ Cost Estimation: The following categories of costs should be considered when evaluating glass recycling system.

Capital Costs: As with any commodity of manufacturing process, capital cost consists of the fixed cost of purchasing equipment and the costs of mechanical and electrical installation. The equipment lists are: Glass hopper; Initial Belt Conveyor; Primary Crusher; Rotary Dryer; Belt Conveyor with magnetic head pulley; Impactor or Hammermill; Belt conveyor with magnetic Head Pulley & Dust collection Hood; Motor Control center with frequency controller on impactor & Field conveyors; Sizing apparatus; Bighouse; Bag packer with Beam Balance; and Electrical & Mechanical installation.

Production Costs: This includes the costs of labor, building and equipment rental, utilities, Gasoline, oil, maintenance and supplies, and the cost of dust and debris disposal. In case of glass recycling, continuous labor is required to perform maintenance tasks and replacement parts, lineup feedstock, change the dust collector barrel, move bulk bags of product, and weigh the product.

Selling, general and administrative Costs: Selling, general, and administrative costs include management, office expenses, insurance, taxes, and commissions.

✔ Procurement Management of Glass:
Glass waste includes household, businesses and industries waste generated in municipal or notified areas including treated biomedical wastes. It consists of household waste, waste from hotels and restaurants, construction and demolition debris, sanitation, residue and waste from streets.

Collection: Glass containers are collected from consumers through three primary channels: deposit programs, programs involving drop-off or buy-back centers, and curbside pickup. No estimates of the quantity of waste glass and cullet obtained
from each of these sources exist in the Indian market. Many of the deposit programs include wine and liquor bottles, and juice bottles. Reliable data on the amount of glass recycled by each method are not available, but it is believed that deposit programs probably provided the largest fraction of container cullet.

For the cullet market, the demand function expresses the relationship between a given price of cullet and the quantity that consumers of cullet will purchase at that price. The cullet market is typical in that some consumers are willing to buy some scrap at a relatively higher price; however, if scrap suppliers wish to increase sales, they must lower the price to increase the quantity demanded.

**The major factors affecting demand for cullet are:**

- The container industry remains the major end user of postconsumer cullet.
- The major concerns of glass container makers in using cullet are contamination in the cullet and guaranteeing a reliable cullet supply.
- The container industry uses the available cullet because of benefits such as reduced energy use and concern over public image.
- Non-container glass industries face barriers to increasing cullet use; the barriers may be based on technical issues or on the cost of learning how to use cullet in their industries.

**Container cullet dominates the cullet market:** Because of the short-term use of glass containers, as well as the manner in which recycling programs have been set up, container cullet has been collected more successfully from residential and commercial consumers than any other type of cullet. And because it is easier for glass manufacturers to use cullet originating from only their own industry, i.e. cullet that generally already conforms to production requirements, most of the container cullet is purchased by the container industry for use in new containers.

Because of their low numbers and ease of recycling, the container companies effectively set cullet prices. In many cases, this cullet is not worth the same as fibre glass insulation to other cullet users. Thus, although alternative use of cullet is growing because of the general increase in cullet supply, alternative users still represent a very small portion of the post-consumer cullet market compared to the container producers. However, in some cases, where alternative users can purchase cullet in the
area around manufacturing plants, suppliers find it more profitable to sell cheaply to the nearby alternative users than to pay transportation costs to higher-paying container plants that are farther away.

**Consistency of Supply:** Glass making is a continuous, closely-monitored process. The ingredients of glass – lime, soda, glass sand, and any cullet used in the process- are fed continuously into furnace. The materials are melted in the furnace, and the product is removed from the furnace continuously. The mix of these inputs can only be changed slowly, and the transition glass produced during the changeover is unusable except as in-house cullet to be blended back into the process.

Because of the nature of the process, the ratio of cullet to virgin materials used must be changed gradually during glass making. As a result, glass container manufacturers find that a major problem is guaranteeing a consistent supply of cullet. One strategy the container makers use to guarantee supply is to deal, when possible, with large intermediaries who can provide a greater volume of cullet with greater reliability than small, individual communities or cullet processors can.

**GANTT chart for manufacturing of glass using waste glass:**

In the Gantt chart below, x-axis shows the time length of the activities and Y-axis shows the different activities in the project. The major activities are denoted on the black bar and the sub activities are denoted on the shaded bar. The milestone from each major activity is denoted by the diamond sign after each activity.

![Gantt Chart for Recycling Container Glass](source: Authors)
Chart-2: Gantt Chart for Recycling Flat Glass

Source: Authors
As indicated in chart-2, the activity begins and continues for 10 days and in case of flat glass, whereas in the case of container glass it goes on for 11 days (Chart-1).

- **Collection of used glass:** Waste glass is collected from household, business and industries in a weekly basis and is further ready for further processing.

- **Sorting:** Involves the following activities: Sorting according to color, Separation of metals and separation of other impurities is conducted in one day. However, time estimated is on single batch processing quantity.

- **Preparation of Cullet:** The pure glass is put into a cullet crusher, which turns glass into tiny pieces. This activity usually takes half a day to complete. After the completion of this activity, a ready to melt batch of glass is produced.

- **In the Furnace:**
  - Weighing: The cullet is weighed according to the required quantity and quantity of the final glass. This activity takes a little more than 2-3 hours.
  - Mixing with other ingredients: The right quantity of the cullet is then mixed with other ingredients of the glass (major and minor). This activity takes less than an hour.
  - Pouring into furnace: The mixed glass is then poured into the furnace for further processing.
  - Melting: The cullet is heated upto 1700°C for 8 hours to get a fresh and ready-to-shape glass.
  - Completion of the above activities will take one day.

- **Shaping:** This activity is completed within 48 hours.

- As indicated in Gantt chart, the activity goes on till ten days in case of flat glass. In case of container glass, the manufacturing process extends to eleven days.
SUMMARY OF FINDINGS
It is estimated that approximately 45% of glass is recycled in India. Recycling of the glass in glass industry accounted for many results among which cost reduction in manufacturing and reduction in carbon dioxide and other greenhouse gas emissions were included.

The support of manufacturers to recycling differs. Among the different types of glasses, container glass is recycled using cullet. And among the various kinds of container glass; beer, cold drinks, locally brewed liquor containers were collected more whereas containers from cosmetics products, foreign juice and liquor containers, laboratory equipment were not collected from the source of waste generation. Beer and soft drink container accounted for virtually 100% of recycled glass.

The technology for recycling container glass is relatively simple and well established. Recycling includes many activities, among which some of the major activities are found out to be: Collecting of waste glasses; Sorting of the glasses; Cullet preparation; and Melting and shaping. This can be successfully carried out with detailed project management in less than two weeks. Mechanisms for recovering glass from municipal solid waste stream takes most of the effort, time and resources.

CONCLUSION
With the rapid increase in the demand of packaged food and beverages and increase in infrastructure, demand for glasses has been increasing drastically. With the extensive demand for glass, manufacturers are continuously producing more and more glass. The use of recycled glass in aggregate is an excellent initiative to promote sustainable practice. Despite some minor difficulties with stockpiling and crushing, the product is feasibly replaced by virgin aggregate. The environmental impact due to the reduction carbon emissions and the extension of life of both landfills and quarries makes the initiative of recycling worthy.

SUGGESTION
Since glass recycling requires continuous supply of raw materials, data on the quantities of cullet supplied through each of the programmes needs to be recorded systematically. Along with municipal collection, post consumer glass waste can be collected through several different channels, including deposit-refund laws, curbside collection programs, drop-off centers, and
buy-back centers. There is a need to conduct seminars regarding waste management in urban areas which will encourage consumers to segregate waste according to degradable and non-degradable nature to shave time off sorting the waste once it is collected. Beverage container deposits, buy-back or drop-off centres, and curbside collection programs are some of the programs that can be initiated by the organization agency.

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