

CONCEPTUAL DESIGN OF GLASS RECYCLING MACHINE

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## **ABSTRACT**

The thesis present about the development of a glass recycling machine. The objectives of this project are to study about the methodology of developing a glass recycling machine by using manufacturing approaches such as design of drawing and simulation of glass recycling machine. This project is using SolidWork 2007 in order in designing the drawing and simulation testing. The materials chosen to develop the glass recycling machine is AISI 1020 with its yield strength  $295 \times 10^6 \text{ N/m}^2$ . The machine simulation is using von Mises measurement in order to determine the strength of machine. The design of drawing is made after completing the simulation analysis. As the conclusion, the machine need to be designed in drawing and simulation analysis could helps in order to further the study until prototyped and published to the public.

## **ABSTRAK**

Tesis ini berkisar tentang pembangunan sebuah mesin kitar semula untuk kaca. Objektif projek ini adalah untuk mempelajari tentang kaedah-kaedah pembangunan sebuah mesin kitar semula kaca dengan menggunakan pendekatan-pendekatan pembuatan seperti merekabentuk lukisan dan simulasi untuk mesin kitar semula kaca. Projek ini menggunakan perisian SolidWork 2007 dalam merekabentuk lukisan dan analisis simulasi. Bahan yang dipilih untuk membangunkan mesin kitar semula kaca ini ialah AISI 1020 dengan kekuatan ialah  $295 \times 106 \text{ N/m}^2$ . Simulasi mesin melibatkan pengukuran von Mises dalam menentukan kekuatan mesin. Rekabentuk lukisan telah dibuat dan selepas itu, analisis simulasi dijalankan terhadap mesin kitar semula kaca. Sebagai penutup, mesin ini perlu direkabentuk dalam lukisan dan analisis simulasi dijalankan bagi meneruskan pembelajaran sehingga diprototaip dan diterbitkan kepada orang awam.

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**LIST OF SYMBOLS**

%	percent
Kg/ Tonnes	kilogram per tonnes
KJ/t – kilojoules	per metric tonnes
Kg	kilogram
N/m <sup>2</sup>	Newton per meter square
N	Newton
Pa	Pascal
MPa	Mega Pascal (10 <sup>6</sup> )
GPa	Giga Pascal (10 <sup>9</sup> )
MN/m <sup>2</sup>	Mega Newton per meter square

**LIST OF ABBREVIATIONS**

CO <sub>2</sub>	carbon dioxide
UK	United Kingdom
MPK	Majlis Perbandaran Kuantan
RM	Ringgit Malaysia
DVD	Digital Versatile/Video Disc
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
PBT	Plate bottom thicknesses
C	Carbon
Mn	Mangan
P	Phosphorous
S	Silicon

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 INTRODUCTION**

This chapter is describing on the background of the project, the objectives of the project, the scope of the project and the problem statement of the project due to the development of glass recycling machine.

The development of the glass recycling machine is due to the worldwide necessity especially for environment. Besides that, it is to fulfill the needs of committee in order to head to the practice of Green Earth.

#### **1.2 BACKGROUND OF PROJECT**

Recycling is processing of used material into new products to prevent wastes and reduce the consumption of raw material to invent products. It is also come with many benefits such as reduce air pollution, water pollution, reduce energy usage, and lower the greenhouse gas emission. In the context of recycling, glass is one of the materials that can be recycled efficiently because 100% of glass can be recycled without any effects to its purity and quality.

As overview in non manufacturing field, this project is about developing a glass recycling machine to encourage the consumer to recycle used up glass bottle. This project wills also helps municipal council to have a systematic management of glass that recycled with this machine developed and placed in many locations and give motivation to consumer and retailer to recycle the glass.

### **1.3 OBJECTIVE**

The objective of this project is to develop a conceptual design of glass recycling machine due to specifications that must be have at a recycling machine.

### **1.4 PROJECT SCOPE**

The scope of this project is to develop a glass recycling machine in order to encourage the consumer to recycle the glass bottles. The glass is most less material that is recycled compared to plastic and paper. The glass recycling machine development is specifically referred to mechanical properties such as the type of materials for the body of machine and the strength and sustainability of the machine.

### **1.5 PROBLEM STATEMENT**

There are some problem statements that need to be considered in developing glass recycling machine. First, there is less awareness toward recycling the used materials such as plastic, paper and glass. Unfortunately, glass is most less material that is recycled between those types of used up materials.

Besides that, there is no machine to collect the glass in Malaysia. Although there are some machines that are used outside the country to recycling the used materials but it is not implemented yet in Malaysia. It is must be considering the cost of machine that must be imported from outside inventors.

Hence, the development of glass recycling machine is in right track and it should be executed in Malaysia as soon as possible to increase the awareness of importance of recycling materials especially glass..

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter is about the review of literature about the glass recycling, definition of machine, glass manufacturing, local municipal council data and feasibility study.

The literature review is important to gain basic knowledge about the already exist of glass recycling machine. Furthermore, literature review will help to generate the ideas in developing a glass recycling machine that can gives benefit to the public.

#### **2.2 GLASS RECYCLING**

Glass constitutes a significant part of solid waste produced in the society. Glass is primarily used for bottles or other containers for storing consumables and for drinking glass or windows. Compared to many other types of waste, glass is unique because it can be 100% recycled. Furthermore, manufacturing new glass products from recycled glass requires only 40% of the energy necessary to make glass from virgin raw materials. In practical terms, every recycled bottle saves an equivalent amount of energy as is required to run a television set for 1.5 hours.

Finally, every piece of glass deposited takes up valuable landfill space. Therefore, glass recycling saves energy and raw materials, reduces manufacturing cost of new products and prolongs the lifespan of landfills. (MPK, 2009). This statement describes about the specifications of glass and the benefits of glass recycling. The energy to produce new product is less when used glass which recycled as the material and the cost of manufacturing the product also reduced.

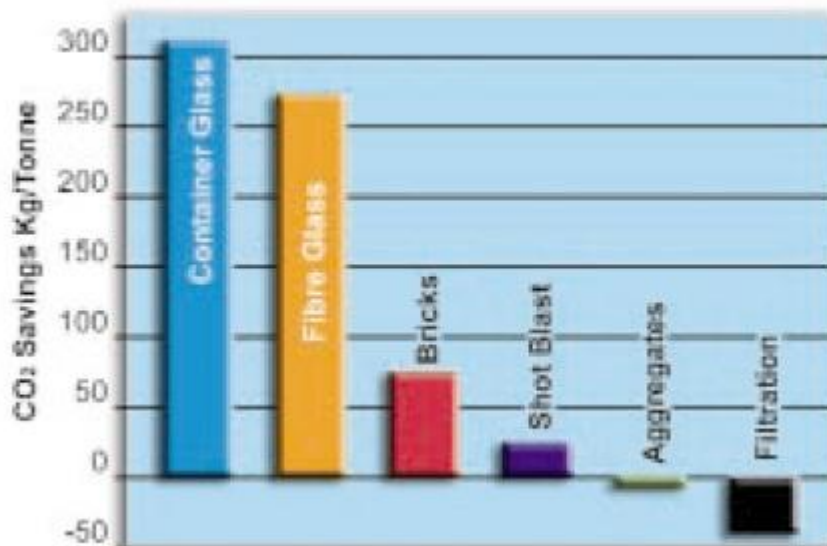
It can be proved by Scotland (2003), he said in his book, *Glass Recycling Handbook* that recycling is more sustainable as it requires less energy and fewer raw materials in new glass manufacturing than using virgin materials. One estimate is that a tonne of glass cullet saves energy equivalent to 135 litres of oil and 1.2 tonnes of primary raw materials<sup>1</sup>. Another estimate<sup>2</sup> gives a highly detailed analysis of the energy consumption, concluding that energy saving varies approximately linearly from zero to 17% as the proportion of recycled glass varies from zero to 100 %.( Remade Scotland, 2003).

British is one of the developed country which look serious on glass recycling (Figure 2.1). In 1977 the glass industry launched the first glass bank in Barnsley, in the North of England. There are now more than 22,500 glass bank sites across the UK, equating to around 50,000 actual glass banks. Several glass banks are required on each site in order to collect the different colours of glass separately. In 2003, 617,000 tonnes of glass packaging was recycled back into new bottles and jars.

This represents a recycling rate of 35% of all the containers produced in the UK. Government figures from DEFRA, that include glass used in additional markets such as shot blasting, fibre glass and aggregates, show that in total 863,000 tonnes was recycled. Using recycled glass in all markets helps the environment by saving resources and reducing landfill.



Because of the additional energy savings when recycled glass is used to make new bottles and jars this is by far the most environmentally beneficial use for recycled glass. (British Glass)



**Figure 2.1:** CO<sup>2</sup> Savings Kg/ Tonnes

In the UK glass industry, approximately 3.7 million tonnes of glass produce each year. These glass produce can be divide into four main categories that is container glass, fibre glass, flat glass and domestic glass. The main sources of this glass are come from manufacture of containers for food and drink, glazing for the automotive and the construction industries. All of this sources accounted for about 90% from all glass produce in the UK in 2006. Lately glass processing plants have appeared and been develop over recent years, demand for recycle glass from industry and aggregates business has increased.

Furthermore, there are many advantages of recycling the glass especially glass bottles. It is involve environment, social and economic advantages. First, it is conserving valuable natural resources and raw materials used in industry. By making products from recycled materials instead of virgin materials, we conserve land and reduce the need to drill for oil and dig for minerals.

Next, it can generate civic pride and environmental awareness. Then, it saving energy reduces acid rain, global warming and air pollution.

Making products from recycled ingredients often uses much less energy than producing the same product from raw materials. Furthermore, it saves landfill space. When the materials that you recycle are used to make new products, they don't go into landfills, so landfill space is conserved. (Clean Up Australia Limited)

In economic perspective, the recycled glass has been a “Green Business” for Tim Whaley whose recycles ordinary everyday household glass bottles and jars and porcelain that those typically destined for landfills and, applying the same process used to create artistic marble installations by binding hard aggregate with a color pigmented epoxy resin, converts these throwaway items into unique countertops, flooring, decorative tables and landscape mulch. (Figure 2.2) (Tim Whaley)

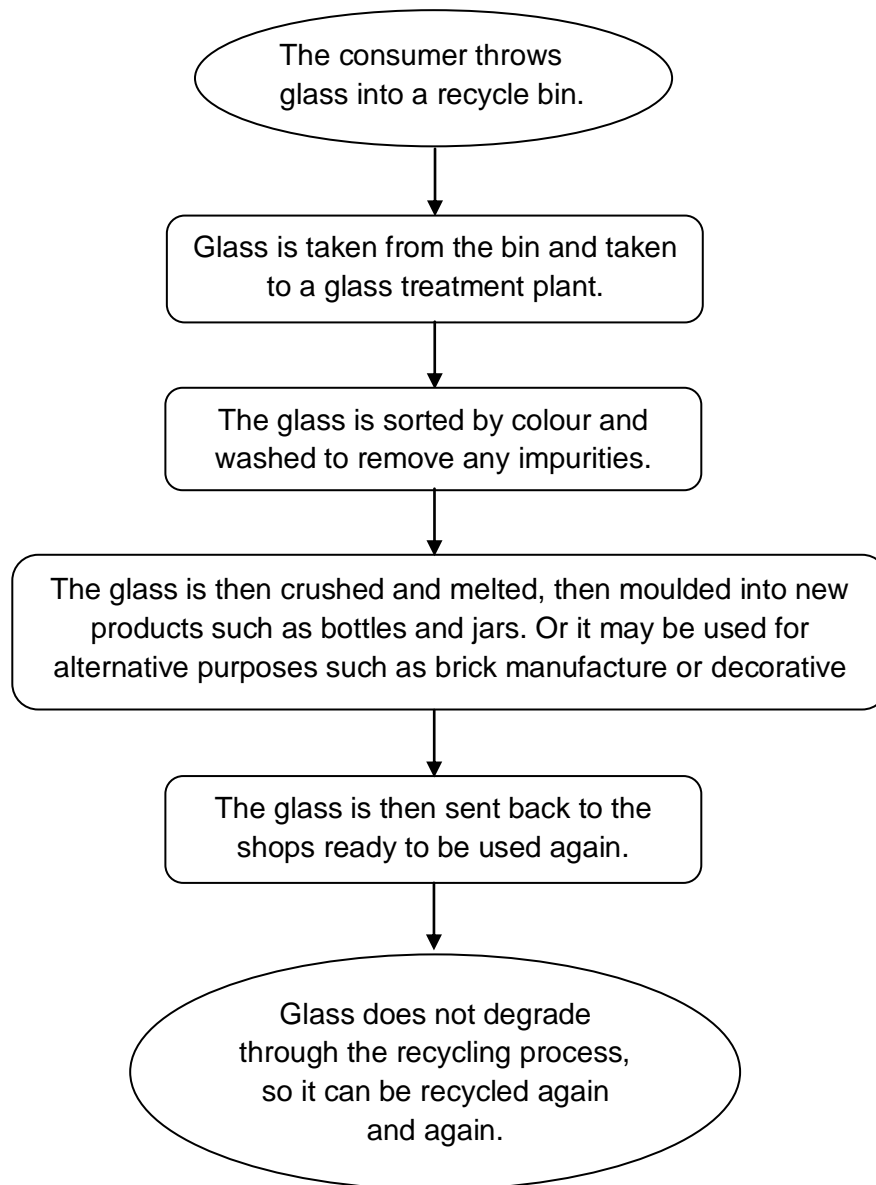


Mitchell Garman Architects, Dallas, TX; Custom Residence Stair Case; Custom GlassTREAD Design; Recycled Porcelain and Brown Glass in a Bone White Epoxy Resin Matrix. Photo by Jason Woelfel.

**Figure 2.2:** Recycled Porcelain and Brown Glass in a Bone White Epoxy Resin Matrix

From Figure 2.3, we can see flow chart of the glass recycling process that had been done in Europe. The recycle process is started when consumer throw the glass bottle into bins located near consumer location. This bins location is depend on the supply chain design by the management. Some of this supply chain contain loop retailer that sell the glass bottle and consumer, the buyer of the product. Then the glass is taken from the bin and taken to the treatment plant. Glass is taken from the bin by using transport such as lorry. The glass is pick up manually and the sorting the glass according to the glass color. This process done because when it come to the treatment, glass different color cannot be mix because of their different properties.

After the glass is being sort, it will be wash to remove any impurities. The impurity is an obstacle to the non-identify object fail the recycle process. When it had been clean and sorted, the glass is being crushed and melts. The glass is melt to form a new shape. To form the shape it then molded into new products such as bottles and jars. Beside the melt glass is being use as the glass bottle some of them is being made or used for alternative purposes such as brick manufacture or decorative. Then the finish product of the glass is ready to be brought to shop again and sold to the consumer. This recycle process of glass is can be repetitive because glass does not degradable during recycle process. So glass can be recycling again and again.



**Figure 2.3:** Flowchart for glass recycling process

### 2.3 DEFINITION OF MACHINE

What is actually the machine? Machines are widely used in world's technology. Every field of technology use machine to help about performing tasks.

According to Mallinson, G. C., Mallinson, J. B., Froschauer, L., Harris, J. A., Lewis, M. C., & Valentino, C, (1991), a machine is, in a very general sense, a combination of parts we use to overcome a resistance by transferring or transforming energy, usually that exerted by a human being. Furthermore, it can be also defined as devices that help us do work. When we do work, we use energy; energy transfers or transforms, but it does not disappear.

## **2.4 GLASS MANUFACTURING**

How is the glass being manufactured in industry? According to Bounicore, A.J. and W.T. Davis (1992), there are many types of glass that be manufactured by the industry. There are divide into two categories that are flat glass includes plate and architectural glass, automotive windscreens and mirrors. Besides that, pressed and blown glass includes containers, machine and hand-blown glassware, lamps and television tubing. In both categories a glass melt is prepared from silica sand, other raw materials such as lime, dolomite, and soda, and cullet (broken glass). The use of recycled glass is increasing and this requires extensive sorting and cleaning prior to batch treatment to remove impurities. The use of recycled glass reduces the consumption of both raw materials and energy.

For the manufacture of special and technical glass, lead oxide (up to 32 wt. %), potash, zinc oxide, and other metal oxides are added. Refining agents include arsenic trioxide, antimony oxide, nitrates, and sulfates. Metal oxides and sulfides are used as discoloring agents.

The most common furnace used to manufacture glass melt is the continuous regenerative type with either side or end ports connecting brick checkers to the inside of the melter. Checkers conserve fuel by acting as a heat exchanger--the fuel combustion products heat incoming combustion air.

The molten glass is refined (heat conditioning) and then is either pressed, blown, drawn, rolled or floated, depending on the final product. Damaged or broken product (cullet) is returned to the process.

The most important fuels for glass melting furnaces are natural gas, light and heavy fuel oil and liquefied petroleum gas. Electricity is also used (frequently installed as supplementary heating). Energy requirements range 3.7-6.0 kiloJoules per metric ton (kJ/t) glass produced.

## 2.5 LOCAL MUNICIPAL COUNCIL DATA

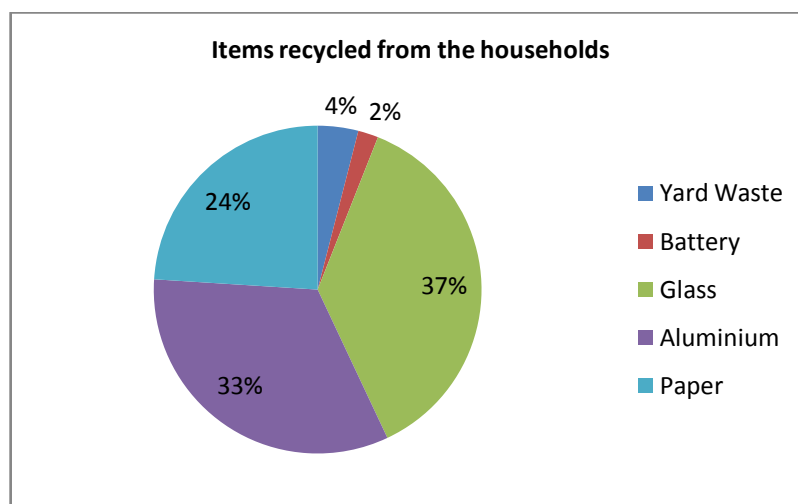
Why glass is chosen as main item in this project and not other recyclable materials such as plastic and paper? For further information, consumer of recyclable materials chose to recycle paper and plastic rather than glass. The glass is less recycled although the consumption of glass is high such as in Kuantan. Majlis Perbandaran Kuantan (MPK) is a municipal council in Kuantan, Pahang Darul Makmur. MPK has started the glass recycle campaign in 2009 and there are some data distributions about the recycle along the campaign. Furthermore, survey has been made by MPK to school, pubs and restaurants.



**Figure 2.4:** Total Glass Collected (1 May 09 – 30 April 10)

Based on Figure 2.3, it shows the volume of glass recycled in Kuantan in range of May 2009 until April 2010.

The figure shows that in May '09, the amount of glass collected is highest that is about 2500 kg and the lowest amount of glass collected is in Jan '10 that is less than 1500 kg. The overall amount of glass collected is 20 tonnes and average about 1.7 tonnes per month. This campaign is to give awareness to consumer about glass recycling and if there is no campaign from MPK, the glass will be thrown out to landfill and can cause pollution to environment.



**Figure 2.5:** Items recycled from the households

Figure 2.4 shows the items recycled from the households in Kuantan. Containers for sauces and bottled drinks were among the items most frequently recycled. The most recycled item was glass and followed by aluminum, paper, batteries and yard waste. This condition happened because of the campaign that held by MPK and the volume of items recycled can be determined as the benchmark for future improvement in recycling especially for glass. (MPK, 2009)

The project which consists of 3 objectives that are develop the glass collection machine, reward system and supply chain of recycling could helps the municipal council to collect and recycle the glass more systematic.

Nowadays, the municipal council in Kuantan which is MPK done the collection and recycling the glass manually. They go to the school, pubs, and restaurants and then collect the glass bottle for free because the price of bottle collection is only about RM 0.10 per kilogram. MPK obliged to bear high cost of this collection session but MPK which is service-oriented sector did it for the sake of cleanliness and environment of Kuantan. (MPK, 2009)

## **2.6 FEASIBILITY STUDY**

The feasibility study in order to develop a glass recycling machine is taken from vending machine and reverse vending machine specifications and mechanisms. Vending machine is a machine that dispenses small articles such as food, drinks, or cigarettes when a coin, bill, or token is inserted. Furthermore, it is also can be defined as an automated machine which dispenses drinks, snacks, videos, DVDs and other merchandise to consumers upon payment transacted without assistance of a cashier. Vending machines are a permitted accessory use when located inside a principal establishment or on the sidewalk adjacent to the exterior wall of the establishment. Vending machines in other locations are regulated as accessory structures.

On the other hand, a reverse vending machine is a device that accepts used or empty beverage containers and returns money to the user which is reverse of the usage of vending machine. The machines are popular in places that have mandatory recycling laws or container deposit legislation. In some places, bottlers paid funds into a centralized pool to be dispersed to people who recycled the containers. Any excess funds were to be used for general environmental cleanup. The other definition of reverse vending machine is an automated mechanical device that accepts at least one or more types of empty beverage containers including aluminum cans, glass and plastic bottles, and issues a cash refund or a redeemable credit slip.