



## Design and Fabrication of Glass Crushing Machine

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February 9, 2020

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## Abstract

Glass crusher machines are designed with the aim of pulverizing glass to aid in the recycling process. Waste glass comes from various sources, in the form of glass sheets, containers, jars and bottles. Brown or transparent crushed glass is used to make the different types of glass bottles. Other forms of crushed glass are used to form asphalt paving and blocks, or mixed into secondary concrete products.

The objective is to make a glass crusher machine which is of very less cost with small size that can be owned by the small workshops and to minimize the power consumed by machine there by crushing force with modifying the design of crushing chamber, hammer blade etc. The result of glass crushing machine produces fine particles of glass which can be recycled for formation of new glass articles so that it

requires 60% less energy and its use in partial replacement of material in concrete for fine aggregate.

Keywords: recycle glass waste, concrete, hammer blade, power, crushing force, small workshops.

## 1. Introduction

The crusher is a device which is used for reduction in size ratio of particle from large particles into the small size particle. Here, the glass crusher used is of type horizontal shaft crusher which has high particle reduction size ratio due to hammer blade mechanism rotating at high speed.

In developing countries like india, the solid waste management is the measure area of consideration to government and society. Due to increase in industrialization and many technology causes increase in the quantity of waste generation time to time and human population also cause the generation of solid waste. Glass waste is also a type of solid waste which is discarded by the members of society. The standard of waste management in developing countries is at its lowest with poor documentation of waste generation rates, inefficient storage and collection system, and the under-utilization of disposal sites. Throughout history, waste has been generated by humans, in areas with low population density, waste generation may have been negligible but in areas with considerable number of person's waste cannot be neglected or over look. This has led to the formulation of various waste management policies and technology such as anaerobic digestion (biodegradable waste), crushing machine (plastic and glass waste), incinerator (paper, textile, plastic, etc.), landfill, gasification, etc.

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. Glass can be recycled endlessly with no loss in quality or purity.

There are many environmental benefits due to recycle of glass like recycling of glass bottles provides for unmatched production efficiencies, Saves raw materials as 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. For every six tons of recycled container glass used, a ton of carbon dioxide, a greenhouse gas, is reduced. A relative 10% increase in cullet reduces particulates by 8%, nitrogen oxide by 4%, and sulfur oxides by 10%. Glass recycling is a closed-loop system, creating no additional waste or by-products. Glass crushing is important because it is the preferred packaging for consumers' concerned about their health and the environment. Consumers prefer glass packaging for preserving a product's taste or flavor and maintaining the integrity or healthiness of foods and beverages. Glass is the only widely-used packaging material considered "GRAS" or "generally recognized as safe" by the U.S. Food and Drug Administration. For all above reasons, glass recycle is done by glass crushing machine. The glass crusher machine is designed in such a way that it will be used with minimum power consumption, small size with less cost and blade is designed in such a way that with lesser impact force and high speed of rotation of blade causes reduction in particle size. By designing different types of mashing so that it can crush different types of particle size based on end uses.

## 2. Materials and Methods

The selection of materials for the glass crushing machine should be such that in operating conditions, material should flow smoothly in the crushing operation and with negligible damages to the machine components. The design require selection of strong and durable material for glass crusher so that glass particle converted into fine particles. The crushing process takes place in the crushing chamber. The physical and mechanical property of glass material is used to design the hammer blade or rotor of glass crusher. The machine consists of hopper, a crushing chamber, rotating hammer blades, ball bearings, bolts and nuts, crushed product outlet bucket, electric motor and machine main frame. The machine is design to provide resistances against friction and strain on machine component. The machine is designed in such a way that it consume less power by decreasing required amount of torque with the help of decreasing the area of friction between the rotor and internal casing and also with increasing speed of rotation of hammer blade or rotor.

## 3. Design Consideration

- The glass crushing machine consist of hopper with one way type of closing made up of 4 pieces of thin metal sheet.
- The rotor of glass crusher is considered to rotate at the speed of 1440 rpm.
- The design consideration is such that it will not fail till the power supply reaches 10hp.
- The amount of torque required is calculated with the help of assumed and calculated dimensions of glass crushing machine and pressure between internal casing and rotor due to crushing of glass.

### 3.1 Design Calculation

The estimation of shaft diameter, torque required ,power, area used for crushing are selected with calculation as shown below,

1]. selection of motor:-

a) Force acting on hammer blade:-

Normal force acting on blade while crushing glass particles is given by,

$$F_n = P_b * A$$

where ,  $P_b$  = working pressure of glass , N/mm<sup>2</sup>

$$= 25 \text{psi} = 0.17225 \text{MPa}$$

$A$  = Area at which crushing takes place, mm<sup>2</sup>

$$\Rightarrow F_n = 0.17225 * 130 * 5 \\ F_n = 111.9625 \text{N}$$

Frictional force:-

$$F_u = \mu * F_n$$

$$F_u = 0.2 * 111.9625$$

$$F_u = 22.392 \text{N}$$

For 4 blades,

$$F = 4 * F_u$$

$$F = 89.568 \text{N}$$

2] Design of shaft:-

Shaft is subjected to both twisting moment and bending moment.

a) The diameter of shaft may be obtained by using torsion equation,

$$\frac{T}{J} = \frac{\tau}{r}$$

where,  $T$  = Torque on shaft , Nmm  
 $J$  = Polar Moment of Inertia of shaft about rotational axis, mm<sup>4</sup>  
 $= \frac{3.142 \cdot d^4}{32}$   
 $r$  = Distance from neutral axis to the outer most fiber, mm  
 $r = d/2$   
 $d$  = diameter of shaft, mm

Therefore,

$$T = \frac{3.142 \cdot d^4}{32} \cdot \frac{d}{2}$$

$$\tau_s = 16T / (3.142 \cdot d^3)$$

b) The diameter of shaft may be obtained by using bending equation,

$$M = \frac{\sigma b}{I} Y$$

where,  $M$  = bending moment of shaft , Nmm  
 $I$  = Moment of Inertia of cross-sectional area of shaft, mm<sup>4</sup>  
 $\sigma$  = bending stress, N/mm<sup>2</sup>  
 $y$  = distance of N.A to overmost fibre, mm  
 $y = d/2$  and  $I = \frac{3.142 \cdot d^4}{64}$

$$\text{Therefore, } M = \frac{\sigma b \cdot I}{d/2}$$

According to maximum shear stress theory or Guest's theory,

$$\tau_{\max} = [\sigma^2 + 4\tau_s^2]^{0.5}$$

$$\tau_{\max} = \left[ \left\{ \frac{32 \cdot M}{3.142 \cdot d^3} \right\}^2 + 4 \left\{ \frac{16 \cdot T}{3.142 \cdot d^3} \right\}^2 \right]^{0.5}$$

$$\tau_{\max} = \frac{32}{3.142 \cdot d^3} \cdot \sqrt{M^2 + T^2} \cdot 0.5$$

Consider , shaft material as C40 which has tensile stress ,  $\sigma_t = 650 \text{ N/mm}^2$

Maximum shear stress,  $\tau_{\max} = \frac{0.577 \cdot \sigma_b}{\text{fos}}$

consider , fos = 6

$$\tau_{\max} = \frac{0.577 \cdot 650}{6}$$

$$\tau_{\max} = 62.5 \text{ N/mm}^2$$

Bending Moment of shaft is given as,

$$M = Fr \cdot x$$

Where ,  $Fr = ((F_n)^2 + (F_t)^2)^{0.5}$

$$Fr = ((4 \cdot 112)^2 + (108)^2)^{0.5}$$

$$Fr = 460.83 \text{ N}$$

$$M = 460.83 \cdot 0.09 \cdot 10^3$$

$$M = 41.47 \cdot 10^3 \text{ N mm}$$

We know that , torque required ,  $T = 13.97 \text{ N m}$

$$T = 13.97 \cdot 10^3 \text{ N mm}$$

Putting all the values in eq iii,

$$62.5 = \frac{32 * ((41.47 * 10^3)^2 * (41 * 10^3)^2)^{0.5}}{3.142 * d^3}$$

$$D = 22.29 \text{ mm}$$

Hence we will select the diameter of shaft greater than 22.9 mm

**Considering industrial recommendation & based on application , we have selected 35 mm shaft diameter.**

DESIGN OF BEARING:-

From PSG 4.14, FOR SHAFT OF DIAMETER , D = 35

Selecting Deep groove ball bearing ,6307(SKF)

D=80mm

D<sub>1min</sub> =44mm

D<sub>2max</sub> = 71mm

B=21mm

Probability of survival = 90%

R=2.5 mm

Co=1760kgf

Dynamic capacity , c = 2600kgf

3.1 Equivalent Load acting on bearing

Radial load , Fr = Wself + Fr

where , Wself = mg

$$= 10 * 9.81 \text{ N}$$

Resulting radial load

$$Fr = 98.1 + 460.83$$

$$Fr = 558.93 \text{ N}$$

Axial load , Fa = 0N

From PSG 4.4,

Hence,  $\frac{Fa}{Fr} < e$ ,

y=0 & x=1

V=1 \*(outer race is fixed)

S = 2(1.6 to 4)

Equivalent load , P= (x\*V\*Fr+y\*Fa)\*S

$$= (1 * 1 * 558.93 + 0) * 2$$

$$P = 1117.86 \text{ N}$$

$$P = 111.783 \text{ kgf}$$

3.2. To determine the rated life :-

$$C = \frac{L_{10}^{1/k}}{L_{10}} * p$$

$$L_{mr} = 12.582 * 10^9$$

3.3] Conversion of life from revolutions to hours:-

$$L_{hrs} = \frac{L_{mr}}{N * 60}$$

$$= \frac{12.582 * 10^9}{720 * 60}$$

$$L_{hrs} = 2.9125 * 10^5 \text{ hrs}$$

considering ,8hrs working for this bearing in a day

$$L_{hrs} = 36406.25 \text{ Days}$$

$$= 36406 \text{ Days}$$

## 4. Conclusion

- This machine is less expensive as compared to the industrial machines.
- Glass which creates storage and landfill problems can be utilized as primary material which saves the energy.
- Different sizes of glass particles can be used for building and road construction and also for aesthetics purpose.
- Can be used in hotels, restaurants and bars etc.

## 5. Future Scope and Application

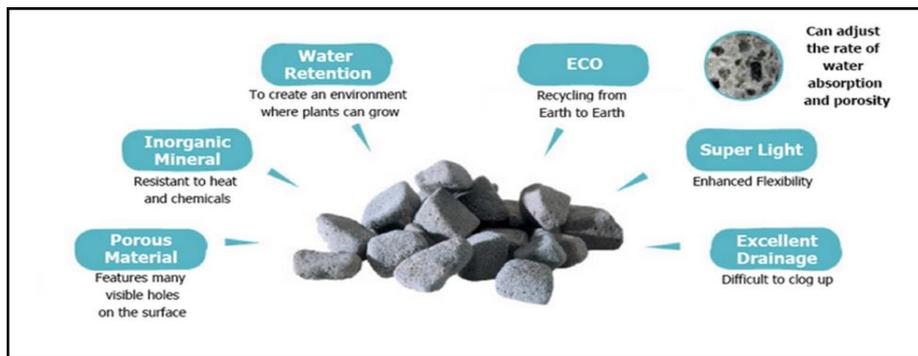


Fig1. Aerosol

- Glass will be crushed in coarse particles but the machine has a mesh so the process continues until the coarse converts into fine particles.
- Production technology of porous materials like “Super sol” or “artificial pumice” from fine glass powder made from waste by baking and foaming the powder.
- Application of glass recycle materials for rain water reservoir.
- Aggregate for light weight civil engineering projects.
- Agriculture, and waste water treatment.
- Drainage Fills.
- Road repairing and Embankments/
- Glass Fiber reinforced Concrete (GRC / GFRC) is used for construction of buildings using the powder made from glass powder.
- Soil improvement for cultivation.

## 6. References

- [1]. Design and evaluate of a small hammer mill, Mohamed T. H., H. A. RADWAN, A. O. ELASHHAB and M. Y. ADLY, Agric. Eng. Research Institute, ARC, Dokki, Giza, Egypt.
- [2]. K.E. Vijaya. Design and Analysis of Rotor Shaft Assembly of Hammer Mill Crusher. International Journal of Engineering and Management Research, Volume-3, Issue-2, April 2013, ISSN No.: 2250-0758, pp.22-30.
- [3]. R.S.Khurmi and J.K. Gupta. Machine Design, Eurasia Publishing House (pvt) Ltd, New Delhi, pp. 731-739, 2013.
- [4]. Design of Hammer Mill for Crushing of Glass Waste Ejiroghene Kelly Orhororo<sup>1</sup>, Oghenekevwe Oghoghorie<sup>2</sup> <sup>1</sup>Faculty of Engineering, Delta State Polytechnic, Otefe-Oghara, Nigeria. <sup>2</sup>Faculty of Engineering, University of Benin, Nigeria.
- [5]. Christian Meyer Department of Civil Engineering and Engineering Mechanics Columbia University, New York, NY, "Recycled Glass – From Waste Material to Valuable Resource" Int. Symposium on Recycling and Reuse of Glass Cullet 19-20 March, 2001, University of Dundee, Scotland.
- [6]. Najib N. Gerges, Camille A. Issa, Samer A. Fawaz, Jacques Jabbour, Johnny Jreige, and Aiman Yacoub, "Recycled Glass Concrete: Coarse and Fine Aggregates" EJERS, European Journal of Engineering Research and Science Vol. 3, No. 1, January 2018.
- [7]. L. Barbieri, A. Corradi and I. Lancellotti, "Glass Matrix Composites from Solid Waste Materials", Journal of the European Ceramic Society, vol. 21.4, (2001), pp. 453-460.
- [8]. T. U. Ganiron Jr, "Scrap Waste Tire as an Additive in Asphalt Pavement for Road Construction", International Journal of Advances in Applied Sciences, vol. 1.2, (2012), pp. 31-37.
- [9]. A. Luz and S. Ribeiro, "Use of Glass Waste as a Raw Material in Porcelain Stoneware Tile Mixtures", Ceramics International, vol. 33.5, (2007), pp. 761-762.
- [10]. Tan, K. H., and Du, H., "Towards a Sustainable Concrete: 'Sandless' Concrete," Science and Engineering of Composite Materials, V. 18, No. 1-2, 2011, pp. 99-107.