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Hammer Mill Machine for Glass Waste Crushing

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Abstract. A hammer mill is a machine that grinds both grains and stones into fine particles called flour. The working principle of the hammer mill is that the impact process is carried out by dynamic blades repeatedly so that it breaks into small particles. The hammer mill consists of dynamic blades mounted on a rotating shaft under which there is a screen that controls the maximum particle size to exit the grinding chamber from within the hammer mill. The hammer mill machine tool made has the following specifications: Height 67 cm, width 20 cm, length 78 cm, using a 1 HP electric motor as the driving force. The hammer (beater) is made of stirrup with a thickness of 6 mm, the hammer length is 60 mm and the width is 30 mm. There are 3 sides of the hammer where the hammer blades are attached, where each side has 8 hammer blades.

Keywords: Hammer Mill, Blade, Rotating Shaft, Grains, Grinding Chamber

1. INTRODUCTION

Glass is a material that cannot be biologically decomposed by soil. It is one of the materials that plays an important role in human life. However, glass can also have negative impacts if the leftover or used glass is not properly handled. This leftover material is referred to as glass waste. The negative impact of glass waste is that it can damage the environment and pose a danger to humans [1]. As we know, Indonesia generates a significant amount of glass bottle waste and broken industrial glass every day. Glass waste is commonly found in industrial areas where glass is used either as a raw material or as a supporting material in production. Components of glass waste typically found in landfills include bottles, broken glassware, light bulbs, clear (float) glass, tinted glass, and mirror glass [1]. This is closely related to the large volume of waste collected by waste collectors [2].

Due to its extensive use in various human needs, glass production is demanded in large quantities. This high volume of production has an environmental impact, as glass is non-corrosive and not biodegradable. Used glass that can no longer be reused becomes waste that cannot naturally decompose by organic matter. Therefore, various alternative treatments are needed to ensure that glass waste can either be safely returned to the environment or be recycled into useful products.

Several researchers have already carried out glass waste processing by designing hammer mill machines for crushing glass waste. The working principle of the glass crusher machine is to crush the glass waste into fragments using a hammer mill system.

Based on previous studies, the author intends to assemble and install a hammer mill machine capable of crushing glass into the desired size and producing optimal output results.

2. LITERATURE REVIEW (OPTIONAL BUT COMMON)

Design and development (Rancang bangun) is a process to define something to be done by using various techniques and involves descriptions of the architecture, component details, and limitations that will be encountered during the implementation process. There are also definitions of design and development according to experts.

Currently, waste problems—both organic and inorganic—have become a national issue that negatively impacts social life, the economy, health, and the environment. Glass constitutes a major component of household and industrial waste due to its heavy and dense nature. The glass components commonly found in public waste sites mostly consist of bottles, broken glassware, light bulbs, and other items. Unused glass can be recycled, and machining processes are one way to convert used glass into glass fragments [3].

Glass waste is debris mostly produced by society, especially in large cities. The volume of glass waste increases daily due to human activities that produce glass. Most of this glass waste is discarded in open fields and can be recycled naturally. Therefore, innovations must be made to minimize glass waste, one of which is by utilizing existing glass waste to be processed into a composite material [4].

A hammer mill is a size reduction tool that uses impact force. The hammer blades are driven by a motor at high speed, and the hammers strike the material against the hammer mill walls. The advantages of using a hammer mill are its simple construction, varied output particle sizes, and relatively low operating and maintenance costs. However, the disadvantages include a relatively high installation cost and the requirement of considerable power for initial or coarse grinding [5].

Design of a Glass Waste Grinding Machine with a Roll System, Capacity of 60 kg/hour. The results of this research show that the machine operates using a double roll system and employs S40C type pipes with a flat surface [6].

Design of a Glass Waste Crushing Machine with Pulley Transmission. This machine uses a V-belt type A with a belt length of 1500 mm, a belt width of 13 mm, and a cross-sectional area of 0.81 cm^2, with a shaft center distance of 48.8 cm [7].

3. RESEARCH METHODOLOGY

The design and installation process was carried out at Mechanical Workshop #2 of Jambi Polytechnic. The implementation stages began with collecting a series of data related to the hammer mill. The design of the glass waste crusher hammer mill was determined by referring to various hammer mill design images found on the internet. Tools and materials required for the construction of the hammer mill machine were identified. Measurements of the materials to be used in the machine's construction were also conducted. The following stage involved the assembly and installation of the hammer mill machine. After assembly, the hammer mill was tested to observe its working process and performance. The preparation of tools included hand grinder (Gerinda bosch GWS 0604), hand drill, welding machine, coarse grinding stone, fine grinding stone, measuring tape, set square, drill bits, protractor. The materials used included freon cylinder, hollow steel, round steel, electrodes, fixed coupling, reinforcing steel (rebar), fixed bearings, electric motor 1 Hp, 1400 Rpm.

4. RESULTS

The results of the glass waste crusher hammer mill design carried out by the author are as follows.

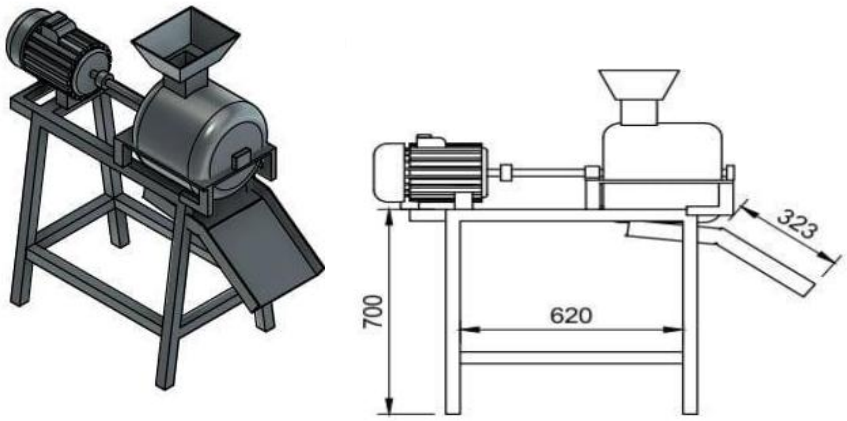

Figure 1. Design Layout

Based on the assembly results conducted by the author on the glass waste crusher hammer mill machine, the frame and hammers possess sufficient strength to support all the loads applied to the hammer mill. The following are images of the frame and hammers of the glass waste crusher hammer mill machine.

Figure 2. Frame and hammers of the glass waste crusher hammer mill machine.

Figure 3. The Results of Testing

5. DISCUSSION

The fabrication of the hammer mill machine frame includes the processes of marking, cutting, and welding, which illustrate the sequence of activities involved in assembling a machine. In the fabrication of the hammer mill machine frame for glass waste crushing, the author carried out an assembly process on the hammer mill machine. During the assembly process, the author performed several steps or stages as follows:

1. Preparing Tools and Materials
   Before starting a task, workers should prepare the tools and materials to be used. This aims to facilitate the assembly process of the hammer mill machine.
2. Studying the Design Drawing
   Before carrying out the work, the author studies the design drawing in advance to avoid mistakes during the work process and to prevent errors in measuring and cutting the materials.
3. Parts of the Hammer Mill Machine Assembly:
   a. Fabrication of the lower frame
   In this process, the author constructs the lower frame to determine the width of the bottom section.

Figure 4. Fabrication of the lower frame

b. Fabrication of the lower frame inclination

In this process, the author fabricates the inclination of the lower frame using a square protractor. The side angle is 15 degrees, and the inner angle is 30 degrees.

Figure 5. Fabrication of the lower frame inclination

c. Fabrication of the upper frame

The fabrication of the upper frame uses hollow steel, which serves as a support for the electric motor, bearings, and the freon cylinder. Its purpose is to connect the lower frame to the upper frame.

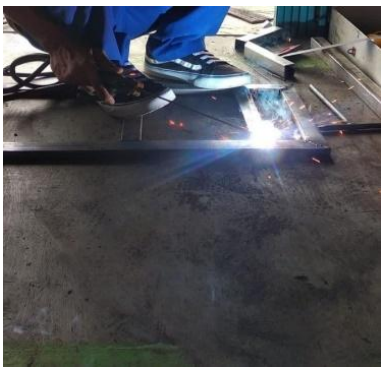

Figure 6. Fabrication of the upper frame

d. Fabrication of the hammer

In this process, the author fabricates the hammer using a 3 mm thick iron plate, with a length of 60 mm and a width of 30 mm. The purpose is to crush glass waste into small fragments.

Figure 7. Fabrication of the hammer

e. Fabrication of the hammer rod shape

In this process, the author shapes the hammer rod with the purpose of reducing the weight load on the hammer.

Figure 8. Fabrication of the hammer rod shape

f. Fabrication of the hammer holes

In this process, the author makes the hammer holes using a 10.5 mm drill bit. The purpose is to allow the hammer to hang on the reinforcing steel.

Figure 9. Hammer hole fabrication

g. Fabrication of the iron plate ring separator

In this process, the author makes a circle with a diameter of 15 cm. The purpose is to serve as a separator for the hammer and to determine the hammer's position.

Figure 10. Fabrication of the iron plate separator circle

h. Fabrication of the reinforcing steel length

In this process, the author determines the length of the reinforcing steel. The purpose is to ensure that the reinforcing steel used is not excessively long.

Figure 11. Fabrication of the reinforcing steel length

i. Fabrication of the shaft

In this process, the author reduces the shaft from 30 mm to 20 mm. The purpose is to allow the shaft to fit into the bearing.

Figure 12. Fabrication of the shaft

k. Fabrication of the shaft end for the cylinder wall section

In this process, the author makes the shaft end of the cylinder wall with the purpose of allowing the shaft to fit into the bearing located on the cylinder wall.

Figure 14. Fabrication of the shaft end for the cylinder wall sectio

l. Fabrication of the hammer frame

In this process, the author fabricates the hammer frame. The purpose is to arrange the layout of the hammers.

Figure 15. Fabrication of the hammer frame

m. Fabrication of the hammer layout

In this process, the author arranges the layout of the hammers. The purpose is to ensure that the hammers are not placed too closely together, allowing sufficient clearance so that they do not collide with each other.

Figure 16. Fabrication of the hammer layout

n. Fabrication of the hammer reinforcing steel lock

In this process, the author designs the hammer locking to prevent the rebar from shifting its position.

Figure 17. Fabrication of the hammer reinforcing steel lock

o. Fabrication of the glass hole size on the cylinder

In this process, the author designs the hole size on the tube to ensure that the crushed glass waste exits the tube in accordance with the desired specifications.

Figure 18. Fabrication of the glass hole size on the cylinder

p. Fabrication of the input hopper for raw materials

In this process, the author designs the hopper as the initial entry point for materials into the hammer section, aiming to ensure smoother feeding and to prevent the crushed glass fragments from being ejected back out.

Figure 19. Fabrication of the input hopper for raw materials

q. Fabrication of the fixed coupling hole

Creating a coupling hole aims to allow the shaft to fit into the fixed coupling part

Figure 20. Fabrication of the fixed coupling hole

r. Fabrication of the shaft locking hole

In this process, the author makes a shaft locking hole. The purpose is to ensure that the shaft in the fixed coupling can rotate according to the rotation transmitted from the coupling

Figure 21. Fabrication of the shaft locking hole

s. Fabrication of the component layout holes

In this process, the author creates positioning holes for the electric motor and fixed coupling components to ensure that the components stay properly aligned and do not move from their position.

Figure 22. Fixed coupling components

The results of the design and performance testing show that the crushed glass waste can be processed into fine granules, which can subsequently be utilized for further processing into functional finished products

6. CONCLUSION

Regarding to observations and performance testing, the following conclusions can be drawn the process of assembling and installing the glass waste hammer mill with an electric motor drive, supplied by 220V/50Hz power and operating at a speed of 1400 rpm. To understand the machine's performance and the operating procedure of the equipment, from the initial crushing process to obtaining the final result in the form of small granules.

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