The Design and Fabrication of a Hydraulic-Powered Automated Can Crushing Machine

Ramonu O.J & Adiyeloja I.T

Abstract- This study focuses on the design and fabrication of a hydraulic-powered can crushing machine. The study aims to reduce the volume of aluminum cans by a great percent to create more space for cans to be transported to the recycling site. The primary objective of the machine is to save space so that more cans can be transported to the recycling site, to aid recycling. The crushing machine is designed to crush approximately 29 aluminum cans in one round. The Automatic Can Crusher comprises four integral parts namely: the frame, the hydraulic press, the crushing chamber, and the hopper. The frame is a rectangular rigid structure fabricated to give support to the machine, the frame was made of a 3mm thick angle iron, the crushing chamber comprises of a cylinder through which the piston travels and a rigid metal plate which the cans will be crushed against. The fabricated crushing machine was able to crush aluminum cans four times smaller than their actual size and allows the reuse of the crushed cans in various ways.

Keywords: Design, Fabrication, Hydraulic Actuator, Can, Crushing Machine

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1. Introduction

Studies have shown that Beverages are mostly made up of aluminum materials, this shows that aluminum cans are majorly used for the production of beverages globally. Thus, it is imperative to recycle the used aluminum for it to be reused and preservation of limited resources. Elucidating how can crushing machines save energy, and help the environment, Kshirsagar et al (2014) explain that ninety five percent less energy is required for new beverages can production and at the same time reduces global warming by 95% when compared to making the cans from scratch i.e. newly produced aluminum.

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These prompted the fabrication of can crushing machines within the past years. (Hadi et al., 2019). A can crusher is a machine that is used for crushing empty cans for recycling purposes. They are for everyday usage and are most useful in areas where a lot of cans are disposed of, especially in restaurants and shopping malls or other places where objects such as empty cans are disposed of. Can crushing machines are capable of reducing the volume of aluminum cans by a great percent? These machines' primary usage is to save space so that more cans can be transported to the recycling site, to aid recycling. They can be placed anywhere in parks, restaurants, canteens, etc. Storage space is often a problem and cans consume a lot of space, thereby increasing the total volume of trash. The transportation cost is also high for moving huge quantities of cans. Thus, this machine will help to reduce and maintain an eco-friendly environment. Can crushers will crush a large number of empty

cans in much less time. A can crusher will crush a regular 12oz can down to 1-inch size, which is four times smaller than its actual size which means that four times more cans can be stored in the same trash bin.

2. METHODOLOGY

The suitability of each material used for fabrication was duly investigated before they were selected and used. Some of the basic factors that were considered for material selection include suitability and availability of materials. The automatic can crusher comprises four integral parts namely: the frame, the hydraulic system, the crushing chamber, and the hopper.

2.1 The Frame

The frame is a rectangular rigid structure fabricated to give support to the machine, the frame was made of a 3mm thick angle iron, all the joints are permanent and were made with electric arc welding. It supports all the components of the machine. The hydraulic system's electric motor is mounted on the bracing below the face of the frame while the hydraulic press sits on the face of the frame, and the crushing chamber together with the hopper is mounted on the face of the frame.

2.2 The Crushing Chamber

The crushing chamber is the part of the machine where the crushing of the cans takes place, it is a perfect simulation of a piston-cylinder arrangement, the crushing chamber comprises of a cylinder through which the piston travels and a rigid metal plate that the cans will be crushed against and a metal plate welded to the face of the piston that has a width that is enough to accommodate four cans at once. The crushing chamber has the allowance for the action; an exit hole is present beneath the tip of the crushing chamber so that when the size of the can is reduced enough for the cans to fall, they fall through that hole into a provided basket.

2.3 The Hopper

A hopper is a funnel-shaped container from which solid materials can be emptied into a container below, but this design adopted a straight geometry to allow the proper arrangement of cans, and the component right under it is the compression chamber. The hopper is spacious enough to contain four cans side by side, and they can be crushed simultaneously.

2.4 The Hydraulic System

A Hydraulic system uses liquid fluid power to perform work. The working principle of a Hydraulic system is based on using a pressurized fluid to power an engine. The Hydraulic system is the prime mover of the designed can crushing machine. The main parts of the hydraulic system consist of the following components; reservoir, pump, valves

2.5 The Design Analysis

The volume of the hopper.

$$V = \frac{\frac{1}{3}H(A^2a - B^2b)}{(A-a)} \qquad (1)$$

Where:

A is the length of the upper rectangle

B is the breadth of the upper triangle

a is the length of the lower triangle

b is the breadth of the lower triangle.

H is the height of the hopper

A = 0.4318m

B = 0.4318m

a = 0.2032m

b = 0.2032m

H = 0.3048m

$$V = \frac{\frac{1}{3}H(0.4318^2 \text{ x } 0.4318 - 0.2032^2 \text{ x } 0.2032)}{(0.4318 - 0.2032)}$$

V = 0.0267m³   Volume of hopper

Volume of the crushing chamber;

The Volume of the crushing chamber is expressed thus,

0.602m x 0.2 x 0.2 = 0.02408m³

The crushing begins from about half the length of the crusher onwards.

0.301m x 0.2 x0.2 = 0.01204m³

1 can equals 0.00033m³ in volume

The crushing chamber will accommodate 36 cans (approx.)

The cans are loosely arranged such that there is always a clearance of about 20%.

This implies that the crushing chamber will accommodate 29 cans for crushing at the same time.

According to an experiment performed by the Hydraulic Press Channel, it takes 170pounds of mass under gravity to crush one can at a right angle.

170 pounds equal 77.11kg.

Since F = mg, it will take (77.11 x 9.81)N = 756.45N to crush one can.

It will take (29 x 756.45) N = 21937.05N of force to crush 29 cans at once.

$$P = \frac{force \text{ x } distance}{time} \qquad (2)$$

It takes approximately 5 seconds for the press to travel through the crusher, meanwhile, it takes four such movements back and forth to completely impact the contents of the crushing chamber which equals 29 cans, which equals 20sec.

Distance traveled by the press is 0.301m, since the crushing begins at half the length of the crushing chamber.

$$P = \frac{35099.28 \text{ x } 0.301}{20} \qquad = 528.24W$$

The power required for crushing is 528.24W.

2.6 Fabrication Procedure

The frame was fabricated with a 3mm thick angle iron; the frame is rectangular in shape having length, breadth and height of 1550mm, 480mm and 800mm respectively. The electric motor powering the hydraulic press was bolted on the bracing metal right under the face of the frame, and the main hydraulic press was fastened to the face of the frame. The hydraulic press sits on the frame while the crushing chamber and the hopper are also mounted on another side of the frame. The hydraulic press is one of the vital component parts of the machine, as it supplies the force required for the crushing. A rigid flat bar is attached to the free end of the piston, so that when it moves forward, it crushes the cans in the crushing chamber against another rigid metal wall put in place for this purpose. The crushing chamber is the part of the machine where the crushing is done, it is essentially a cuboid of a 602mm long, having breadth and height of 200mm and 200mm respectively, and a crusher which is essentially a squared 5mm thick mild steel of 185mm is bolted to the face of the actuator. To fabricate the hopper, a 2mm thick metal sheet was cut and welded such that a pyramid shape was formed. The length and breadth of the upper section is 480mm and 400mm respectively while the length and breadth of the lower section is 202.5mm and 200mm respectively. The height of the hopper is 390mm.
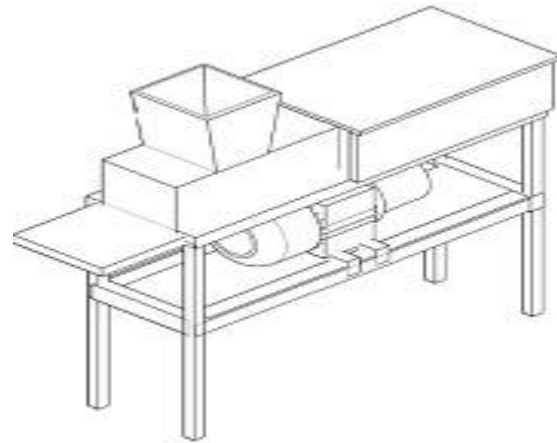

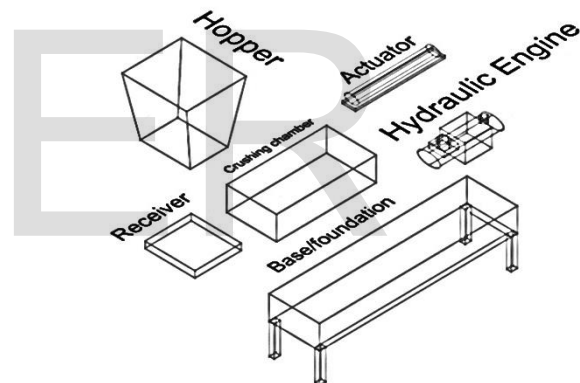Fig.1 Isometric view of the Can Crushing Machine

Fig.2: Exploded view of the Can Crushing Machine

Plate 1: The Fabricated Can Crushing Machine

3. Results and Discussion

A hydraulic powered automated can crushing machine has been designed, fabricated, and tested. The result obtained from the performance evaluation test carried out indicated a 75% reduction in the volume of the cans crushed.

4. Conclusion

The fabricated crushing machine was able to crush aluminum cans four times smaller than their actual size and allows the reuse of the crushed cans in various ways. The fabricated hydraulic-powered can crushing machine can be used in the rural and urban communities for effective crushing of aluminum cans for recycling purposes.

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