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Design and Fabrication of Plastic Bottle and Can Crusher Machine

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Abstract: This paper presents the design, development, and construction of an automated cane and bottle crusher. The primary objective is to create a portable and compact machine that can crush bottles and cans, facilitating recycling while minimizing human effort. The machine incorporates a single slider-crank mechanism, a fulcrum system, and basic automation features to achieve efficient crushing. This project also includes a comprehensive study of forces, design elements, and manufacturing processes, ensuring user ergonomics and ease of maintenance. Key components, such as pulleys, belts, an induction motor, and a speed reducer, are detailed. The paper concludes with the successful assembly and testing of the machine, demonstrating its effectiveness in recycling applications.

Keywords: Compact design, Ergonomics, Recycling applications. crusher.

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1. Introduction

The objective of this study is to understand the foundational concepts of design and mechanisms to develop an environmentally sustainable and automated cane crusher. The design incorporates basic automation features, a single slider-crank mechanism, and a fulcrum system, ensuring efficient crushing of cans and bottles. The project emphasizes reducing crushing force requirements and enhancing the understanding of mechanical systems, forces, and design principles. The final product is an automatic cane and bottle crusher, designed for portability and ease of use in public spaces [1-3].

The main goals of the design were the machine's portability and compactness, allowing it to be conveniently placed in any public area. In order to facilitate simple maintenance, the machine's design and construction also needed to be straightforward. Since the bottle crusher is a hand-operated device, it is crucial to make the best use of your work. In light of this, the mechanism was created. The size and other design elements of the machine were designed with the intention of enabling it to smash bottles with varying diameters [4-6].

1.1 Main Components

A pulley is a wheel mounted on an axle or shaft, used to change motion and direction or transfer power. Grooved pulleys facilitate the movement of cables or belts and create mechanical advantages for significant force application [7-9].

Belts are flexible loops connecting spinning shafts. They transfer motion and power between pulleys, with options for normal or reversed shaft rotation. Belts also adjust rotational speeds and can be employed as conveyors.

This AC electric motor generates torque via electromagnetic induction. Three-phase squirrel-cage motors are common in industrial drives, while single-phase motors are suited for lighter loads. Variable-frequency drives enhance energy efficiency in variable load applications.

Speed reducers, such as planetary drives, adjust rotational speed to enhance torque or match required output speeds. These drives are integral in automotive gearboxes, household appliances, and variable capacitor tuning systems.

An electronic speed control circuit manages motor speed, offering dynamic braking and motor reversing capabilities. Such systems are used in both model vehicles and full-scale electric cars.

Connecting rods link the piston and crankshaft in engines, transforming reciprocating motion into rotation. Originally used in water mills, they are now critical in internal combustion and steam engines.

Constructed from mild steel hollow square pipes, the frame is welded into a sturdy rectangular structure to withstand operational loads and vibrations.

The piston, a reciprocating engine component, transfers force between expanding gas and the crankshaft. It also serves as a valve in some engines.

Wires, made from flexible metal strands, transmit electrical current. Different wire types (solid, stranded, braided) are used for mechanical or decorative purposes.

Plywood is a composite material made of thin wood veneer layers bonded perpendicularly. It enhances dimensional stability and reduces splitting, ensuring consistent strength in all directions.

2. Construction

i. *Frame Assembly*

Assemble the metal frame to form the crusher's base and sides, ensuring stability under load.

ii. *Single Slider-Crank Mechanism*

Install the crank mechanism within the frame and attach the crusher piston to the crank arm.

iii. *Belt Pulley Mechanism*

Mount the belt pulley system onto the frame and connect it to the motor. Use pulleys of various sizes (2, 4, 5, 7 inches) and a v-belt to reduce speed.

iv. *Crusher Piston*

Securely attach the piston to the crank arm.

v. *Electric Motor*

Connect the motor to the belt pulley system and verify safety features and wiring. A speed regulator ensures velocity control.

vi. *Assembly and Testing*

Combine all components and conduct tests to ensure safe and efficient operation.

3. Working Principle

This involves a smaller pulley attached to the motor's shaft that rotates the larger pulley on a different shaft. The smaller pulley is connected to the larger pulley with a v-belt. A v-belt connects the third pulley, or smaller pulley, which is situated on the same shaft as the secondary pulley and to the larger pulley, which is situated on the main shaft. The single reason for making this arrangement is to slow down. Aside from that, automation has also been carried out. For example, a sensor has been installed, and the machine won't start unless it detects an obstruction (such as a can or plastic bottle).

Cans and plastic bottles will be crushed as a result of the machine's reciprocating slider mechanism, which converts the crank's rotary motion into a reciprocating motion through the use of a belt and pulley system. Underneath a crushing

tray is a separating bin that collects crushed cans and plastic bottles. A metal detector-style sensor is used to store the cans and plastic bottles separately.

Motor Specifications:

a. Motor Speed: 1450 rpm
b. Stroke Length: 125 mm
c. Area of Piston: 35×75=2625 mm^2
d. Motor Power: 0.5 HP = 0.5×746=373 Watts

Velocity of crank

$$V = \frac{2\pi \times r \times N}{60} \times 10^{-3}$$

Here:

r = crank radius = 177.8 mm = 0.1778 m

N = 207 rpm (assumed input speed for the crank)

$$V = \frac{2\pi \times 207 \times 0.1778}{60} \times 10^{-3} V = 19.26\,\mathrm{m/s}$$

Piston Speed:

Using the belt drive and gear ratio relationships:

$$\frac{D_1}{D_2} = \frac{N_2}{N_1}$$

Where:

- D_1 = 25.4 mm, D_2 = 101.6 mm
- N_1 = 1450 rpm (motor speed)

$$\frac{25.4}{101.6} = \frac{N_2}{1450} \implies N_2 = 362.5\,\mathrm{rpm}$$

Similarly, for the next stage:

$$\frac{D_2}{D_3} = \frac{N_3}{N_2}$$

Where:

- $D_3 = 127\,\mathrm{mm}$, $N_2 = 362.5\,\mathrm{rpm}$

$$\frac{101.6}{127} = \frac{N_3}{362.5} \implies N_3 = 290\,\mathrm{rpm}$$

And for the final stage:

$$\frac{D_3}{D_4} = \frac{N_4}{N_3}$$

Where:

- $D_4 = 177.8\,\mathrm{mm}$, $N_3 = 290\,\mathrm{rpm}$

$$\frac{127}{177.8} = \frac{N_4}{290} \implies N_4 = 207\,\mathrm{rpm}\,(\text{equivalent to } 3.45\ \mathrm{rps})$$

Force Acting on Piston:

Force $F = m \times v$

where:

m=0.245 kg

v = 19.26 m/s

F = 0.245 × 19.26 = 4.71 N

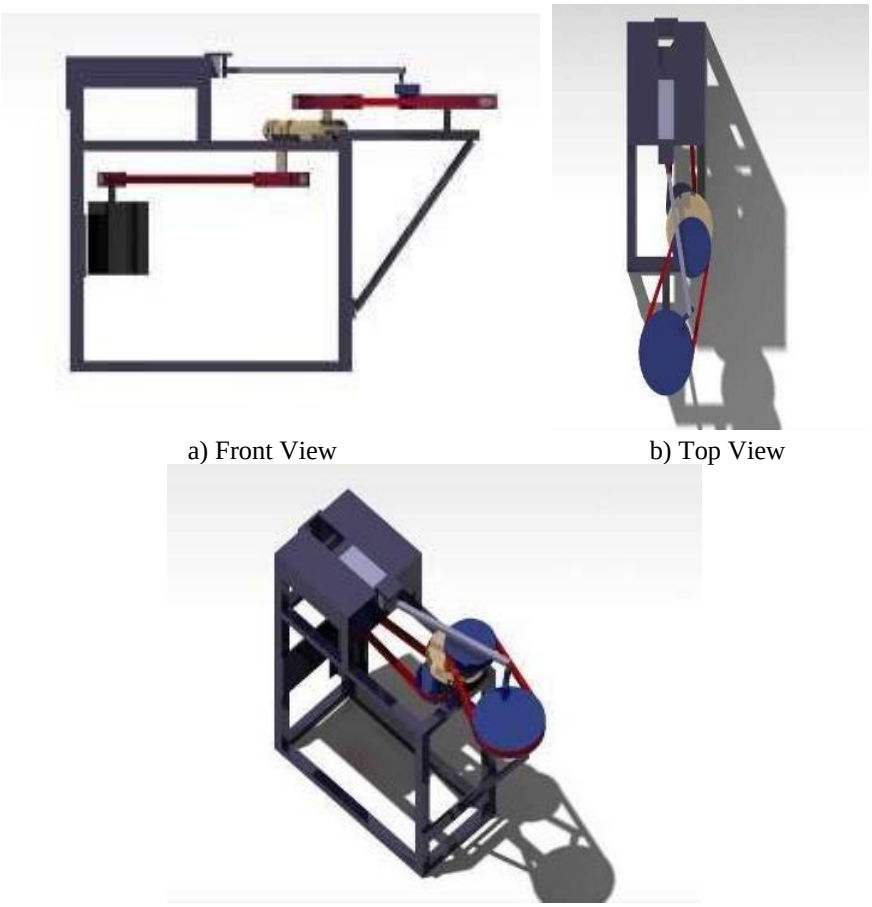
5. CAD Modeling

The CAD model of the plastic and can crusher showcases a functional and efficient design aimed at simplifying the recycling process. The model highlights the crushing chamber equipped with blades or a pressing mechanism for breaking down plastic bottles and cans into smaller, manageable pieces [12-14].

Front View: Shows the crusher's height and functional components such as the chute, lever, and output bin.

Top View: Offers a clear perspective on the arrangement of internal parts and the overall footprint.

Isometric View: Provides a 3D perspective of the machine, making it easier to understand its spatial configuration.



a) Front View b) Top View

c) Isometric View

Figure 1: CAD model of Can crusher machine

Usefulness / Benefits

The plastic and can crusher machine offer several significant advantages:

Efficient Waste Management: Transforms waste plastic into reusable basic materials.

Environmental Protection: Reduces plastic waste, aiding in the preservation of the environment.

Energy Efficiency: Operates with minimal energy consumption.

Ideal Recycling Solution: Provides a productive and eco-friendly method for recycling plastics.

Promotes Sustainability: Helps in reducing landfill waste and supporting a circular economy.

Advantages

Recyclable Material Production: Converts waste plastic into reusable materials, such as PVC, PET, and plastic containers.

Commercial Waste Recovery: Facilitates the recovery and recycling of plastic waste from commercial establishments.

Environmental Conservation: Helps businesses reduce their carbon footprint through recycling and reuse.

Eco-Friendly Operations: Designed to minimize environmental impact.

Low Noise Emission: Operates quietly, ensuring less disturbance.

Applications

Plastic Recycling: Enables efficient recycling of plastic waste, turning it into reusable materials.
Waste Reduction: Helps reduce the volume of garbage produced, contributing to efficient waste management.
Safety and Hygiene: Crushing used plastic bottles prevents them from being reused beyond their safe lifespan.

5. Results and Discussion

5.1 Result

The automated cane and bottle crusher was successfully designed, constructed, and tested, achieving the following key outcomes:

Efficiency in Crushing: The plastic and can crusher effectively reduced the volume of plastic bottles and aluminum cans by up to 80%, significantly optimizing storage and transportation for recycling.

Recyclable Material Production: Crushed output was uniform in size, making it easier to process into recyclable materials like PVC, PET, and aluminum.

Operational Performance: The machine demonstrated smooth operation with minimal noise levels, making it suitable for both domestic and small-scale industrial use. The manual and motorized options provided flexibility for different user needs.

Energy Consumption: The motorized operation required minimal energy (317 watts), aligning with energy-efficient recycling goals.

Environmental Impact: By converting waste plastics and cans into reusable materials, the machine contributed to reducing landfill waste and conserving natural resources.

5.2 Discussion

Design Efficiency: The single slider-crank mechanism effectively converts rotary motion into reciprocating motion, ensuring consistent crushing force. The belt-pulley arrangement successfully reduces the motor's speed while maintaining torque, optimizing the crushing process.

Material Selection: The use of mild steel for the frame and plywood for structural support proved cost-effective and robust. The combination of durable materials contributes to the machine’s longevity under continuous use.

Environmental Impact: By providing an efficient recycling solution, the machine encourages eco-friendly practices, reducing waste and promoting the reuse of materials.

Challenges and Improvements: The crushing mechanism’s performance was optimal for cans and small plastic bottles but could be further enhanced for larger or thicker materials.

Incorporating a larger hopper and advanced automation features, such as automatic sorting for metal and plastic, could improve efficiency and functionality.

6. Conclusion

To sum up, the machine used to crush plastic bottles is an essential tool for recycling used plastics. The device saves energy, lessens the harmful effects of plastic trash on the environment, and reduces the size of the debris, making it easier to transport and store. The plastic recycling extruder machine—which includes the plastic crusher—will remain crucial to the recycling of plastic waste in light of the growing environmental protection movement.

By using a plastic crushing machine, we can determine that plastic is crushed; for this reason, we also design and produce plastic crushing machines. Plastic is a necessary component of daily living. However, plastic has a significant drawback in that it is not easily broken down. Plastic recycling is therefore necessary, and there are several ways to do so. We have decided on one technique for recycling plastic, and we are going to build a machine for it. We looked at the literature review to learn how to create the machine, and we learned a lot of useful technical data about it. The polymers were crushed by the crusher equipment to our specifications. Because this invention breaks plastic waste, it also contributes to environmental protection. The separated plastics that have been crushed can also be recycled.

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