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Material Crusher Machine: A Review

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Abstract: Material crushers are essential machines used in construction, mining, and quarry industries to reduce large rocks into smaller aggregates. This paper presents the design and fabrication of a small-scale material crusher model intended for laboratory and small industrial applications. The study discusses the working mechanism, major components, and design considerations such as material strength, flywheel energy storage, and crushing mechanism. Computer Aided Design (CAD) tools are used to develop the model and visualize component assembly. The fabricated machine is designed to be efficient, durable, and economical. The proposed design demonstrates that how Mechanical principles can be applied to develop a reliable Crushing Machine capable of handling moderate crushing loads while maintaining operational simplicity and safety.
Keywords: Material Crusher, Mechanical Design, CAD Modeling, Crushing Mechanism, Fabrication, Aggregate Production

I. INTRODUCTION

A Material Crusher is a Mechanical device used to break large rocks into smaller fragments such as gravel, sand, or rock dust.
These machines are widely used in construction, road building, mining, and quarrying industries. Aggregates produced from crushed stones are essential raw materials for concrete, asphalt, and other building works.
The increasing demand for infrastructure development has led to the need for efficient and cost-effective crushing equipment. Designing a Material Crusher requires knowledge of machine design, material properties, and mechanical motion. In most cases, crushers work on compression or impact principles to break stones into smaller pieces.
The aim of this project is to design and fabricate a simple and effective Material Crusher model that demonstrates the crushing mechanism while maintaining durability and operational efficiency.

II. OBJECTIVES OF MATERIAL CRUSHING

1) Size Reduction – Convert large rocks into smaller and uniform aggregates.
2) Material Liberation – Separate valuable minerals from waste rock in mining operations.
3) Preparation for Further Processing – Produce material suitable for grinding, screening, or chemical processing.
4) Recycling – Convert construction waste such as concrete or asphalt into reusable aggregates.
5) Efficiency and Safety – Improve handling, transportation, and storage of crushed materials.

III. LITERATURE SURVEY

The design and development of material crushers have been extensively studied in the fields of mechanical and mining engineering, with a focus on improving efficiency, durability, and cost-effectiveness.
According to R. S. Khurmi and J. K. Gupta, [1] fundamental principles of machine design such as stress analysis, shaft design, and power transmission play a crucial role in developing reliable crushing machines. Their work provides a strong theoretical foundation for designing components like flywheels, bearings, and frames.
Shigley’s Mechanical Engineering Design,[3] emphasizes the importance of fatigue analysis and material selection in machines subjected to cyclic loading, such as crushers. The study highlights that improper material selection can lead to premature failure of components like the eccentric shaft and jaw plates.
Research by Norton on machine design, [4] integration explains how combining kinematics and dynamics improves the performance of mechanisms such as toggle systems used in jaw crushers. His work supports the optimization of motion transfer in crushing mechanisms.
Bansal, [2] discusses the role of strength of materials in determining stress, strain, and deformation in structural components. This is particularly important in crusher frames, which must withstand high compressive forces during operation.

In the field of mineral processing, Wills (Mineral Processing Technology), [8] provides detailed insights into size reduction techniques, including crushing and grinding operations. The study explains different types of crushers and their industrial applications, emphasizing efficiency and particle size distribution.

Further, Napier-Munn, [9] highlights the importance of comminution circuits and energy consumption in crushing operations. His research indicates that energy efficiency is a critical factor in crusher design and performance evaluation.

Several recent studies, including those published in the International Journal of Engineering Research and Technology (IJERT),[10] focus on the design and fabrication of low-cost rock crushing machines using locally available materials. These studies demonstrate that small-scale crushers can achieve acceptable performance while significantly reducing manufacturing costs.

Other research works analyze the performance of double roll crushers and jaw crushers, [7] focusing on parameters such as crushing force, capacity, and wear resistance. These studies also utilize CAD tools like SolidWorks and ANSYS for simulation and stress analysis, enabling optimization before fabrication.

Overall, the literature indicates that modern crusher design integrates mechanical design principles, material science, and computational tools , [6] to achieve efficient and durable machines. However, there is still scope for improvement in terms of automation, wear resistance, and energy efficiency, especially for small-scale and portable crushers.

IV. MAIN COMPONENTS OF MATERIAL CRUSHER

1) Frame – The main structural body that supports all components and withstands crushing forces.
2) Fixed Jaw Plate – A stationary plate that forms one side of the crushing chamber.
3) Movable Jaw Plate – A moving plate that compresses stones against the fixed jaw.
4) Toggle Plate – A linkage mechanism that transfers motion from the eccentric shaft to the movable jaw.
5) Eccentric Shaft – Rotating shaft that produces oscillating motion required for crushing.
6) Flywheel – Stores rotational energy and ensures smooth operation of the machine.
7) Hopper – A funnel-shaped component used to feed stones into the crusher.
8) Electric Motor – Provides the driving power to rotate the eccentric shaft through belt and pulley mechanisms.

V. CAD DESIGN AND DESIGN CALCULATIONS

Computer Aided Design (CAD) software is used to design individual components and assemble the complete Material Crusher model.

The CAD model helps visualize the arrangement of the frame, jaw plates, shaft, and flywheel. It also assists in checking alignment, clearances, and structural stability.

Stress analysis can be performed on critical components to ensure that they can withstand crushing loads. The design process allows optimization of dimensions, material selection, and component strength before actual fabrication.

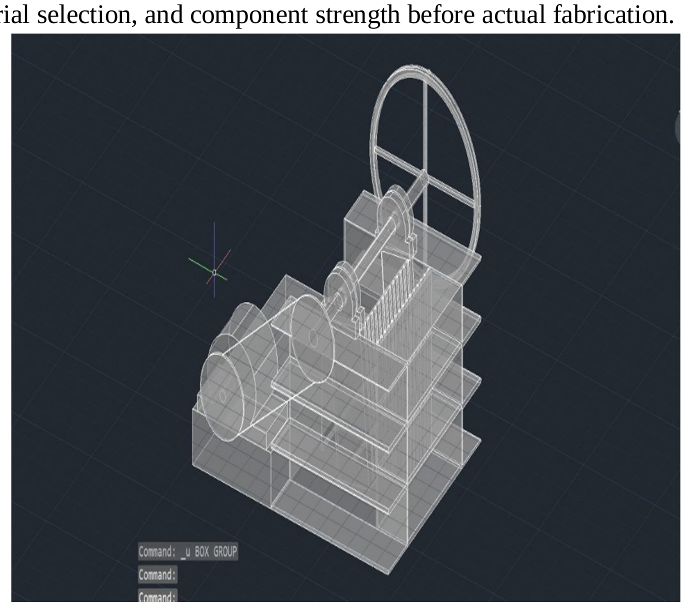


Fig. 1: Right hand Side view of Crushing Machine

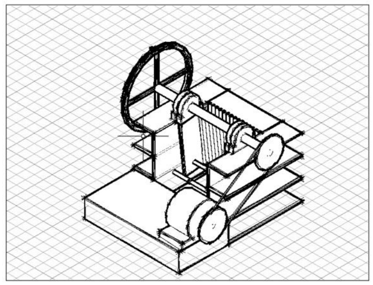


Fig. 2: Left hand side view of Crushing Machine

VI. DESIGN CALCULATIONS

Basic mechanical calculations are required during the design stage. Flywheel energy is calculated to maintain uniform speed during crushing cycles. Stress calculations are performed to determine the strength required for shafts and structural members. These calculations ensure that the machine operates safely without failure while maintaining the desired crushing capacity.

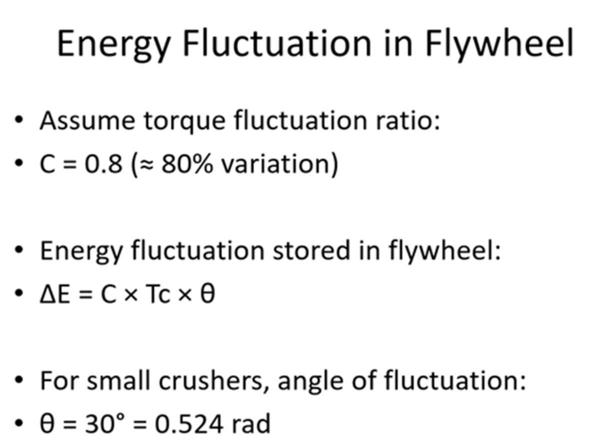
Main Component Dimensions

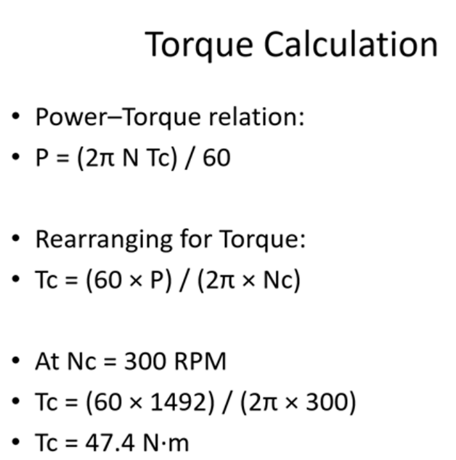
- Base Frame: 900 mm × 500 mm × 450 mm
- Hopper Size: 300 mm × 250 mm (top), 120 mm × 100 mm (bottom)
- Fixed Jaw Plate: 200 mm × 120 mm × 15 mm
- Moving Jaw Plate: 200 mm × 120 mm × 15 mm
- Jaw Opening: 120 mm (feed), 20–30 mm (discharge)

Mechanical Parts Specifications

- Main Shaft: 35 mm diameter, 450 mm length
- Flywheel: 300 mm diameter, 25 mm thickness
- Eccentric Shaft Offset: 5 mm
- Bearings: UCP 207 Pillow Block (35 mm bore)
- Motor: 2 HP, 1440 RPM
- Motor Pulley: 80 mm
- Crusher Pulley: 250 mm
- Overall Machine Size: 1000 mm × 600 mm × 700 mm

Flywheel Calculation – Given Data
Motor Power (P) = 2 HP = 1492 W
Motor Speed (Nm) = 1440 RPM
Crusher Speed after reduction (Nc) = 250 – 300 RPM
Required: Torque on crusher shaft and energy fluctuation in flywheel
Torque Calculation
Power–Torque relation:
$P = (2\pi N T_c) / 60$
Rearranging for Torque:
$T_c = (60 \times P) / (2\pi \times N_c)$
At Nc = 300 RPM
$T_c = (60 \times 1492) / (2\pi \times 300)$
$T_c = 47.4$ N·m
Energy Fluctuation in Flywheel, Assume torque fluctuation ratio:
C = 0.8 (≈ 80% variation)
Energy fluctuation stored in flywheel:
$\Delta E = C \times T_c \times \theta$
For small crushers, angle of fluctuation:
$\theta = 30° = 0.524$ rad





VII. CONCLUSION

The design and fabrication of a Material Crusher demonstrate the application of mechanical engineering principles in developing industrial machines.

1) The proposed crusher model provides an efficient solution for reducing large stones into smaller aggregates.
2) Proper design, material selection, and fabrication techniques ensure reliability and durability of the machine.
3) Future improvements may include automation and improved wear-resistant materials to increase productivity and operational life.

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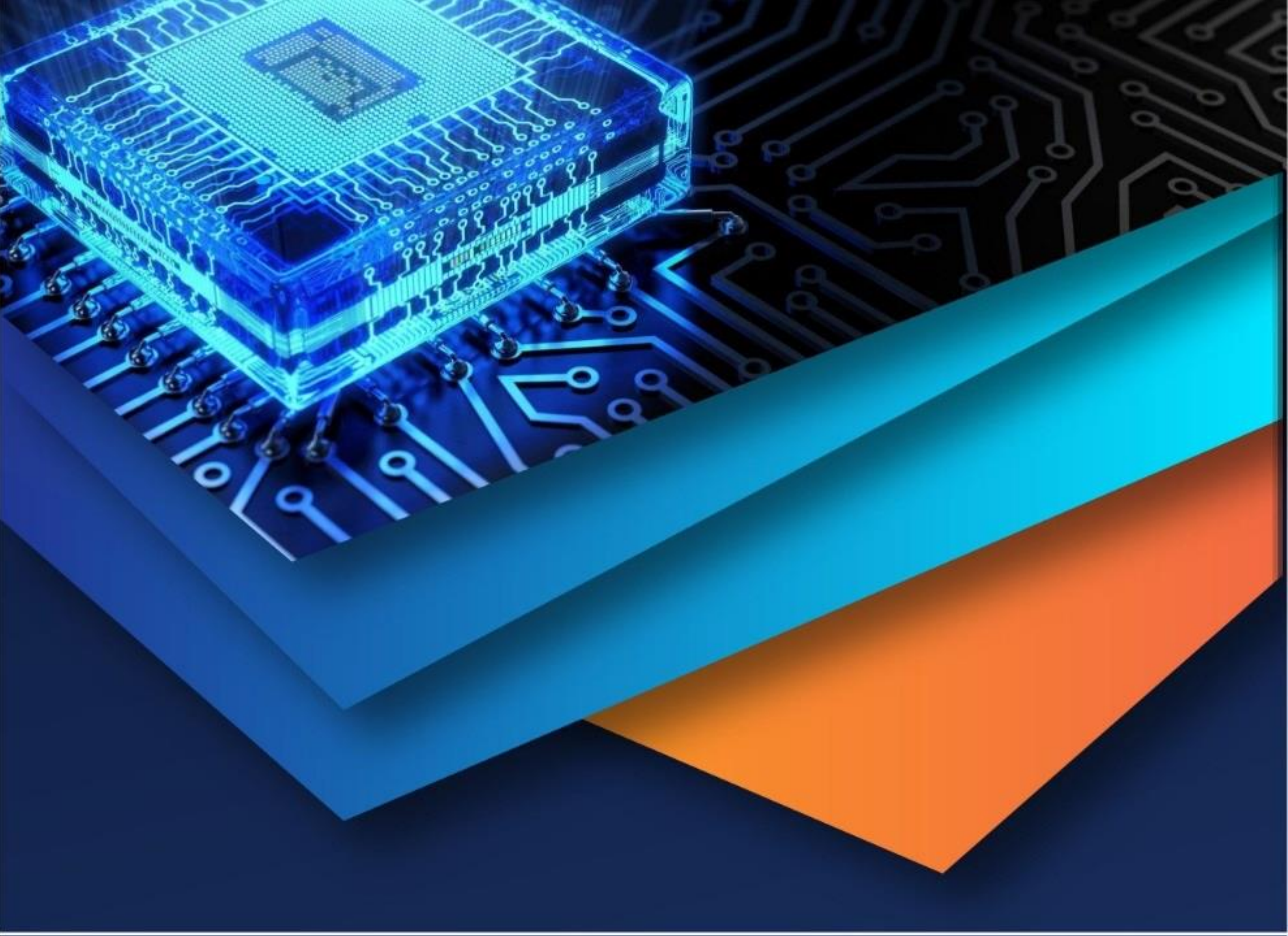

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