

# DESIGN & IMPLEMENTATION OF A CAN CRUSHER

Thesis

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A Thesis Submitted to the  
Department of Mechanical Engineering,  
Sonargaon University

in partial fulfillment of the requirement for the Degree of  
BACHELOR OF SCIENCE  
in  
Mechanical Engineering



Submitted to the  
SONARGAON UNIVERSITY  
SPRING 2026

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## NOTATION

- $A$  = Cross-sectional area ( $\text{mm}^2$ )
- $d$  = Diameter of crankshaft (mm)
- $\eta$  = Mechanical efficiency
- $F$  = Linear crushing force at the slider (N)
- $L$  = Length of connecting rod (mm)
- $N$  = Motor speed (rpm)
- $\Omega$  = Angular velocity of crank (rad/s)
- $P$  = Mechanical power output (W)
- $\pi$  = Mathematical constant ( $\approx 3.1416$ )
- $r$  = Crank radius (m)
- $S$  = Slider stroke length (mm)
- $T$  = Motor output torque ( $\text{N}\cdot\text{m}$ )
- $T_d$  = Design torque including safety factor ( $\text{N}\cdot\text{m}$ )
- $t$  = Time per crushing cycle (s)
- $\tau_{\{\max\}}$  = Maximum torsional shear stress (MPa)
- $\tau_{\{\text{allow}\}}$  = Allowable shear stress (MPa)
- $\theta$  = Crank angle (degree or radian)
- $v$  = Linear velocity of the slider (m/s)
- $v_{\{\max\}}$  = Maximum linear velocity of the slider (m/s)

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## ABSTRACT

Post-consumer aluminum waste has significantly increased due to the growing use of aluminum beverage cans, posing problems for recycling, storage, and transportation. Effective volume reduction at the source is crucial to enhancing recycling and waste handling efficiency because empty aluminum cans take up a lot of space because of their cylindrical shape. The design, construction, and analysis of a fully motorized aluminum can crusher created especially for crushing 250 ml aluminum beverage cans are presented in this project. The suggested system converts rotary motion into linear reciprocating motion for controlled axial crushing using a crank and connecting rod (slider–crank) mechanism and a 12 V DC windshield wiper motor as the prime mover.

In order to ensure safe and reliable crushing through buckling and progressive folding of the can walls, the machine is built with a stroke length of 150 mm and runs at a low speed of 35 rpm. To assess the kinematic behavior, torque-to-force transmission, power requirement, and structural adequacy of important components, design calculations were performed. The analysis verified that the chosen motor torque of 4.12 N·m offers enough crushing force for efficient aluminum can volume reduction while using minimal power. With the proper safety margins, the crank shaft, connecting rod, and frame were made to withstand the applied loads.

By effectively reducing the volume of aluminum cans, the developed can crusher enhances storage efficiency and makes recycling and transportation easier. For small-scale recycling facilities, educational institutions, and community-based waste management programs, the system provides an affordable, energy-efficient, and simple-to-fabricate solution. This project offers a scalable basis for upcoming improvements in sustainable waste management technologies and illustrates the practical application of mechanical design principles.

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of the Study

In the modern world, aluminum cans have become one of the most widely used packaging materials, particularly in the beverage industry for soft drinks, energy drinks, and carbonated beverages. Among them, 250 ml aluminum cans are especially popular due to their lightweight nature, durability, corrosion resistance, and ease of transportation. However, the rapid growth in consumption of canned beverages has led to a significant increase in post-consumer aluminum waste, creating serious challenges for environmental sustainability and solid waste management systems. After use, a large number of aluminum cans are often disposed of without being properly recycled. Due to their cylindrical shape, empty cans occupy a considerable amount of space in waste bins, landfills, and storage areas. This inefficient use of space increases collection frequency, transportation cost, and handling complexity. In developing countries, where waste management infrastructure is often limited, this problem becomes even more critical, contributing to environmental pollution and urban cleanliness issues.

Aluminum is a highly recyclable material, and recycling aluminum requires significantly less energy compared to producing aluminum from raw bauxite ore. However, effective recycling largely depends on proper segregation, storage, and transportation of used cans. Without size reduction, the recycling process becomes less efficient and more expensive. Therefore, reducing the volume of used aluminum cans at the source plays a vital role in improving recycling efficiency and reducing environmental impact. A can crusher machine is a practical solution to this problem, as it compresses aluminum cans into a smaller and more manageable form. By crushing the cans, the volume of waste can be reduced substantially, allowing more cans to be stored and transported in a given space. This not only simplifies recycling operations but also lowers transportation and storage costs.

In recent years, there has been growing interest in low-cost, energy-efficient, and easy-to-fabricate can crusher machines or community-level applications. Manual and semi-automatic can crushers are especially attractive due to their simple construction, low maintenance requirements, and reduced power consumption. Integrating basic mechanical mechanisms with readily available components, such as a wiper motor and connecting rod mechanism, offers an effective approach to developing a compact and economical can crusher suitable for crushing 250 ml aluminum cans.

## **1.2 Problem Statement**

In developing countries such as Bangladesh, effective solid waste management remains a major challenge due to limited infrastructure, financial constraints, and lack of appropriate low-cost technologies. Most commercially available industrial can crushers are designed for large-scale operations and are expensive, bulky, and technologically complex, making them impractical for small or medium-scale use. As a result, many recycling activities still rely on manual handling or basic tools, which are inefficient and time-consuming. Fully manual can crushers require significant human effort to generate the necessary crushing force, leading to operator fatigue, low productivity, and inconsistent crushing performance. This reduces the overall efficiency of waste volume reduction and discourages regular use, especially in environments where a large number of aluminum cans need to be processed daily.

On the other hand, fully automated or hydraulic can crushers, although highly effective, demand higher power consumption, advanced control systems, and increased maintenance costs. These factors limit their feasibility in low-resource settings, educational laboratories, and small recycling facilities. Therefore, there is a clear gap between simple manual can crushers and high-end industrial crushing systems. To address this gap, there is a strong need for a cost-effective, semi-automated solution that can improve crushing efficiency while maintaining simplicity and reliability. Integrating a manual can crusher mechanism with a readily available wiper motor through a connecting rod and crank mechanism offers a practical approach. This system can significantly reduce human effort, provide consistent crushing force, and operate with low electrical power consumption. Designing such a machine specifically for crushing 250 ml aluminum cans can contribute to efficient waste

volume reduction, improved recycling practices, and the development of sustainable, locally manufacturable engineering solutions.

### **1.3 Aim and Objectives of the Project**

The primary aim of this project is to design and fabricate a manual can crusher machine that is capable of effectively crushing 250 ml aluminum cans by utilizing a connecting rod and crank mechanism driven by a wiper motor. The project focuses on developing a simple, low-cost, and reliable system that can reduce human effort while maintaining efficient crushing performance suitable for small-scale recycling and educational purposes. This aim is driven by the need to bridge the gap between fully manual can crushers, which require excessive physical effort, and industrial-grade crushers, which are expensive and complex. By integrating a commonly available wiper motor with a mechanically efficient linkage system, the proposed machine seeks to achieve consistent crushing force with minimal power consumption and straightforward operation.

To accomplish the overall aim of the project, the following specific objectives have been identified:

- To study the physical and mechanical properties of 250 ml aluminum cans and determine the amount of force required to crush them effectively without excessive energy loss.
- To select a suitable wiper motor based on torque, speed, power rating, availability, and cost, ensuring that it can meet the operational requirements of the can crusher.
- To design and analyze the connecting rod and crank mechanism that converts the rotary motion of the wiper motor into the required linear crushing motion.
- To design a strong yet simple machine frame using low-cost and locally available materials, ensuring structural stability and ease of fabrication.
- To evaluate the performance, efficiency, and safety of the developed can crusher through practical testing and analysis.

Achieving these objectives will result in a functional prototype that demonstrates the practical application of mechanical design principles, motion conversion mechanisms, and sustainable engineering practices for waste volume reduction.

## **1.4 Scope of the Project**

The scope of this project is primarily focused on educational applications and small-scale recycling operations. The proposed can crusher machine is designed to serve as a practical and demonstrative model that applies fundamental mechanical engineering principles, such as motion conversion, force transmission, and machine design. It is not intended to replace heavy-duty industrial can crushing machines, but rather to provide an effective solution for limited-volume crushing with low power consumption and simple operation. The project specifically concentrates on crushing 250 ml aluminum beverage cans, which are among the most commonly used can sizes in domestic and commercial environments. The design parameters, force calculations, and component selection are optimized for this particular can size and material. Crushing of steel cans, thicker containers, or large-volume industrial waste is beyond the scope of this project.

Additionally, the machine is developed using a wiper motor and a connecting rod–crank mechanism to achieve semi-automated operation while maintaining mechanical simplicity. Advanced automation features such as programmable control systems, sensors, hydraulic or pneumatic actuation, and continuous-feed mechanisms are intentionally excluded to keep the system affordable, easy to fabricate, and suitable for low-resource settings. However, the proposed design allows flexibility for future improvements. With appropriate modifications, the machine can be adapted to crush cans of different sizes, incorporate higher-capacity motors, or be upgraded into a fully automated system. Therefore, this project provides a scalable foundation for further research, design optimization, and industrial development in the field of sustainable waste management.

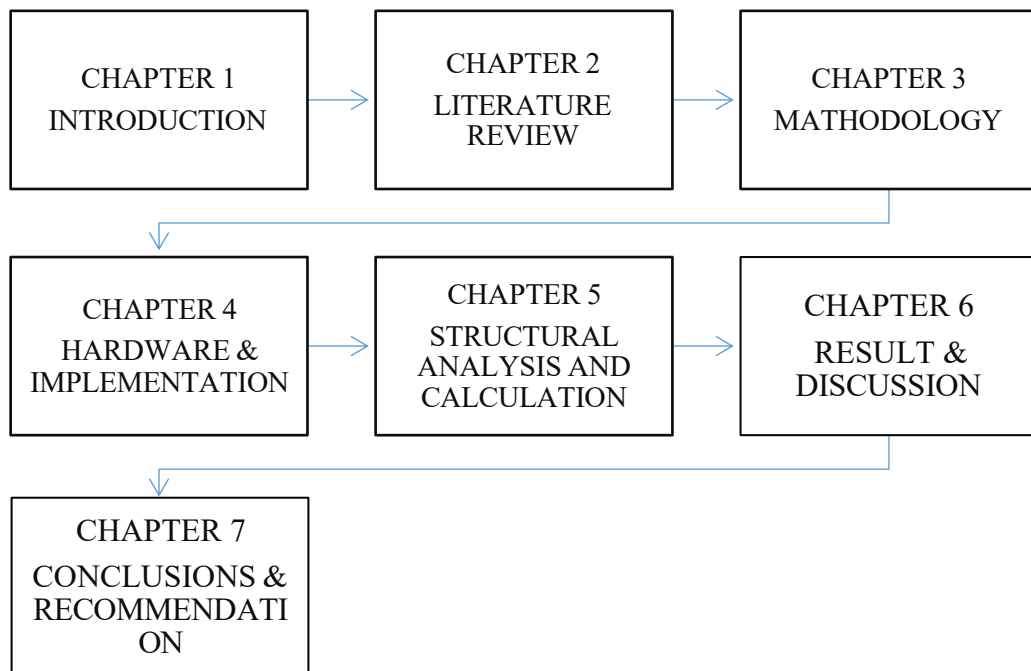
## **1.5 Significance of the Project**

The significance of this project lies in its contribution to sustainable waste management and practical engineering education. By presenting the design and fabrication of a simple, cost-effective, and environmentally friendly can crusher machine, the project addresses an important issue related to the reduction of aluminum waste volume. Crushing aluminum cans before disposal or recycling significantly reduces storage space requirements, transportation costs, and handling difficulties, thereby improving the overall efficiency of recycling processes. From an environmental perspective, the project promotes recycling-

friendly practices by encouraging volume reduction at the source. Since aluminum is a highly recyclable material that requires considerably less energy to recycle than to produce from raw materials, improving its recyclability has a positive impact on energy conservation and environmental protection. The proposed can crusher provides a practical tool that can be used in small recycling centers, educational institutions, and community-based waste management systems.

From an academic and educational standpoint, this project holds substantial value for mechanical engineering students. It provides hands-on experience in mechanical design, force analysis, motor selection, and mechanism synthesis, particularly the application of the connecting rod and crank mechanism. Students gain practical insight into how theoretical concepts learned in subjects such as mechanics, machine design, and manufacturing processes can be applied to solve real-world engineering problems. Furthermore, the use of a commonly available wiper motor demonstrates how low-cost and locally sourced components can be effectively utilized in engineering design.

### 1.5 Outline of the Thesis



**Fig. 1.1** Outline Diagram of the Thesis

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Aluminum beverage cans are widely used because they are lightweight, corrosion-resistant, and highly recyclable. However, after consumption, empty cans occupy a large volume due to their cylindrical geometry, which increases storage demands and transportation cost in solid-waste handling and recycling chains. Volume reduction at the source is therefore a common pre-processing step that improves handling efficiency and supports more effective recycling operations. In small-scale settings, a compact can crusher can reduce manual handling effort while providing a repeatable compaction process. This project focuses on crushing 250 ml aluminum cans using a fully motorized electro-mechanical system based on a 12 V wiper motor and a crank-and-connecting-rod (slider-crank) mechanism. The literature reviewed in this chapter is used to justify the selected actuation method and key design parameters such as stroke length and crushing plate geometry.

#### 2.2 Mechanics of Aluminum Can Crushing

An aluminum beverage can behaves as a thin-walled cylindrical shell. Under axial compressive loading, they can typically collapse through buckling and progressive folding, producing a large reduction in height and enclosed volume. Studies on axial loading of beverage cans report that buckling behavior is sensitive to geometric imperfections (e.g., dents), boundary conditions, and loading alignment, which can change the collapse mode and the peak force required for crushing [1]-[3].

Because buckling is strongly affected by alignment, practical can crusher designs commonly include a stable support surface for the can, guided linear motion of the crushing plate, and sufficient structural rigidity to prevent unwanted lateral motion during loading.

These factors improve repeatability and reduce the likelihood of jamming or uneven crushing.

### 2.3 Classification of Can Crusher Systems (Actuation-Based)

Can crusher machines are frequently classified by their actuation method: manual, motorized, electro-mechanical, and fluid-powered (hydraulic or pneumatic). Manual crushers typically use lever or toggle linkages to amplify human force. Hydraulic and pneumatic crushers can generate very high forces but require pumps or compressors and additional control components, which increases cost and maintenance. For small-scale recycling and low-resource environments, motorized electro-mechanical crushers provide a practical balance between cost, simplicity, and productivity [4].

**Table 2.1: Actuation-Based Comparison of Can Crushers**

Actuation type	Typical features	Advantages	Limitations	Small-scale suitability
Manual (lever/toggle)	Human force amplified by linkages	Low cost; simple; easy maintenance	Operator fatigue; inconsistent output; low throughput	Medium
Motorized electro-mechanical	DC/AC motor + mechanism converts rotary to linear	Repeatable cycles; reduced effort; scalable	Requires power supply; mechanism design needed	High
Hydraulic	Cylinder + pump/valves	Very high force; industrial capacity	High cost; bulky; maintenance-heavy	Low
Pneumatic	Cylinder + compressor	Fast actuation; cleaner system	Needs compressor; pressure losses; added cost	Low-Medium

### 2.4 Motion Conversion Mechanisms Used in Can Crushers

In motorized crushers, the primary design requirement is converting the rotary motion of a motor into a controlled linear crushing stroke. Mechanisms commonly reported in the literature include lever/toggle linkages, screw drives, rack-and-pinion systems, and slider-crank mechanisms. Each option differs in manufacturability, achievable force profile, speed control, and reliability. The slider-crank mechanism is widely used in reciprocating machinery because it provides a simple and repeatable conversion of constant rotary

motion to reciprocating linear motion. Several published can crusher prototypes employ a single slider-crank mechanism because it is fabrication-friendly and suitable for low-cost designs while still providing effective volume reduction [4]-[6].

A key characteristic of slider-crank operation is that the transmitted force varies with crank angle; therefore, appropriate motor selection and structural design are required to avoid stalling during the high-resistance portion of the crush cycle.

**Table 2.2: Mechanism Comparison for Motorized Can Crushers**

Mechanism	Motion conversion	Fabrication complexity	Key strength	Key concern	Suitability for low-cost prototypes
Lever/Toggle	Rotary or manual -> linear	Low-Medium	High end-stroke advantage	Over-center risk; high joint loads	Medium
Screw drive	Rotary -> linear	Medium	High force capability	Friction and wear; slower cycles	Medium
Rack-and-pinion	Rotary -> linear	Medium-High	Smooth motion if precise	Gear machining and alignment	Medium-Low
Slider-crank	Rotary -> reciprocating linear	Low-Medium	Simple; repeatable cycles	Force varies with crank angle	High

## 2.5 Wiper Motor as a Low-Cost Prime Mover

Windshield wiper motors are commonly used in low-cost automation and student prototypes because they are widely available, robust, and typically include a gear reduction stage that produces low output speed with usable torque. Engineering references describe typical characteristics of wiper motor systems, including brushed DC operation, gearing, and integration features such as parking signals and protection considerations in the drive electronics [7], [8].

For a can crusher application, the low rotational speed of a geared wiper motor helps achieve controlled crushing (compression-dominated) rather than impact loading, which can improve safety and reduce dynamic stress on the frame and joints. Therefore, the literature supports the selection of wiper motors as economical prime movers for compact electro-mechanical crushing mechanisms.

## 2.6 Key Design Parameters Highlighted in Literature

Prior work on can crusher prototypes emphasizes several parameters that strongly influence performance: crushing plate geometry, stroke length, cycle speed, guidance/alignment, and frame rigidity [4]-[6]. These parameters determine crushing repeatability, volume reduction efficiency, and mechanical reliability.

Crushing plate geometry affects the contact condition between the plate and the can. A flat crushing plate is a common practical choice because it is easy to fabricate and provides a uniform contact surface for axial compression, which supports repeatable buckling and folding behavior. Stroke length must be sufficient to achieve the desired compaction while allowing a complete return stroke for loading the next can. Finally, controlled speed is preferred to minimize vibration and reduce peak dynamic loads on linkages and welded structures.

## 2.7 Present Work: Design Datasheet and Alignment with Literature.

Based on the reviewed literature, the present work adopts a low-cost motorized electro-mechanical approach using a slider-crank mechanism driven by a wiper motor. The selected specifications are summarized in Table 2.3 and are consistent with commonly reported prototype design principles: simple mechanism, controlled speed, and fabrication-friendly construction.

**Table 2.3: Present Work Design Datasheet (Project Inputs)**

Item	Specification (Present Work)
Target can type	250 ml aluminum beverage can
Actuator	Wiper motor
Motor voltage	12 V DC
Motor speed	35 rpm
Operation mode	Fully motorized
Motion conversion mechanism	Crankshaft + connecting rod (slider-crank)
Stroke length	150 mm
Crushing plate type	Flat plate

## **2.8 Research Gap and Justification of the Present Work**

The reviewed studies indicate that a clear gap exists between simple manual can crusher and industrial hydraulic or pneumatic crushers. Manual designs are affordable but require significant human effort and provide inconsistent output, while industrial systems are costly, bulky, and maintenance-intensive. Consequently, small recycling centers and educational laboratories benefit from a compact motorized solution that is affordable, energy-efficient, and locally manufactured.

A wiper-motor-driven slider-crank crusher addresses this gap by providing repeatable motion with reduced human effort while maintaining simple fabrication. Controlled operation at low speed (35 rpm) and an adequate stroke length (150 mm) support consistent crushing and safe operation. These considerations motivate the design approach adopted in this project.

## **2.9 Summary**

This literature review shows that (i) aluminum cans generally collapse under axial loading by buckling and progressive folding, and performance is sensitive to alignment and imperfections [1]-[3]; (ii) motorized electro-mechanical crushers are well suited for small-scale applications because they improve repeatability and reduce manual effort; (iii) the slider-crank mechanism offers an effective balance of simplicity, manufacturability, and repeatable cycles for prototype crushers [4]-[6]; and (iv) wiper motors are practical low-cost prime movers due to gear reduction and robust construction [7], [8]. The present work therefore, adopts a 12 V, 35 rpm wiper motor with a crank-and-connecting-rod mechanism, a 150 mm stroke, and a flat crushing plate to support reliable crushing of 250 ml aluminum cans.

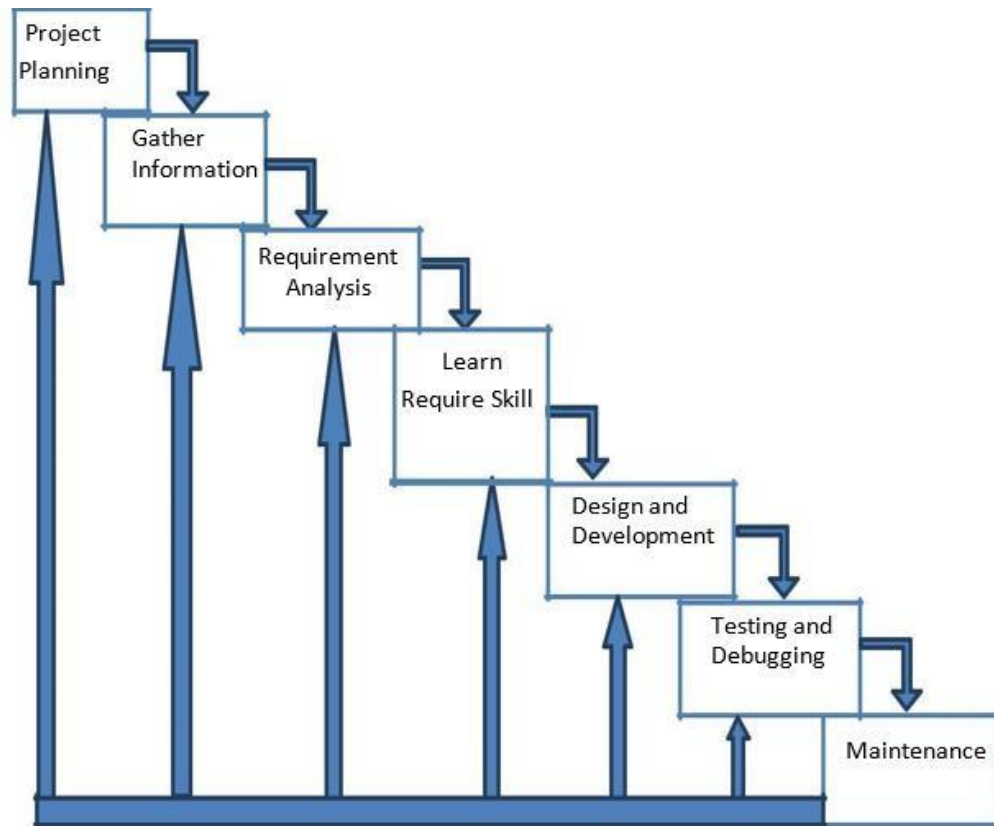
# CHAPTER 3

## METHODOLOGY

### 3.1 Introduction

The methodology is the general research strategy that outlines the way in which research is to be undertaken and among other things, identifies the methods to be used in it. These methods, described in the methodology. Methodology does not define specific methods, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective. When proper to a study of methodology, such processes constitute a constructive generic framework and may therefore be broken down into sub-processes, combined, or their sequence changed. A paradigm is similar to a methodology in that it is also a constructive framework. In theoretical work, the development of paradigms satisfies most or all of the criteria for methodology. An algorithm, like a paradigm, is also a type of constructive framework, meaning that the construction is a logical, rather than a physical, array of connected elements.

Any description of a means of calculation of a specific result is always a description of a method and never a description of a methodology. It is thus important to avoid using methodology as a synonym for method or body of methods. Doing this shifts it away from its true epistemological meaning and reduces it to being the procedure itself, or the set of tools, or the instruments that should have been its outcome. A methodology is the design process for carrying out research or the development of a procedure and is not in itself an instrument, or method, or procedure for doing things. Methodology and method are not interchangeable. In recent years, however, there has been a tendency to use methodology as a “pretentious substitute for the word method. Using methodology as a synonym for method or set of methods leads to confusion and misinterpretation and undermines the proper analysis that should go into designing research.



**Fig. 3.1** Diagram of Methodology

### **3.2 Justification of Methodology**

We have divided this work into some parts. To solve any kind of problem or error it should arrange the whole work in the segment so that it can provide its validity. We have collected all possible requirements which are very well documented there are no ambiguous requirements. All requirements are clear and fixed.

### **3.3 Description of Methodology**

Full work has been divided into some parts. The work is done part by part. Research methodology is the specific procedures or techniques used to identify, select, process, and analyze information about a topic. In a research paper, the methodology section allows the reader to critically evaluate a study's overall validity and reliability.

### **3.4 Project Planning**

Project planning is a discipline for stating how to complete a thesis within a certain timeframe, usually with defined stages, and with designated resources. First of all, we found some problems in our industry. Then find this problem and think to solve it by some smart way within a certain timeframe. We discussed with our team members and teachers. In order to overcome this problem, Authors has taken plan a smart system which can use in industry for regular task. So, we ensure that robotics arm is the best one. For this thesis, we divided the whole subject in three parts. At first, industrial robotics arm is designed by Solidworks. Then analysis this design and find weak zone of the arm. Finally, it is fixed by design calculation. For better torque, we use bevel gear and worm gear combination. It easily changes the direction of rotation.

### **3.5 Gather Information**

Most industrial utilize six axes, which give them the ability to perform a wide variety of industrial tasks compared to fewer axes. Six axes allow to move in the x, y, and z planes, as well as position itself using roll, pitch, and yaw movements. After finding problem we gathered some information about this problem that how to solve it in smartly. We read some research paper about this problem. We search in internet to find the solutions. Some information gathers from industry. We collect stepper motor of various types of torque. And also collect some bevel gear and worm gear to calculate the torque.

### **3.6 Requirement Analysis**

Requirements analysis encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product or project. After gathering the information, we are thinking about requirement to make this project successful. Three sensors have been utilized in the proposed system. We collect some requirement data from industry. It helps us in calculation time. Then final model will be analyzed for getting idea about its total workspace consumption during its working in actual form.

### **3.7 Learn Required Skill**

For completing the project, we had to know about Solidworks part design and also know how to assembly this part. We learn mass properties of the object and also learn simulation to simulate all the parts for checking any error.

### **3.8 Necessary Skill Study**

To complete this thesis authors had to learn many things related to design and some gear calculation. Authors also get idea on dynamic and kinematic torque calculation. And also known design analysis software such as Solidworks, CAD Drawing, Fusion 360 etc.

### **3.9 Design and Development**

System design is the process of defining the components, modules, interfaces, and data for a system to satisfy specified requirements. System development is the process of creating or altering systems, along with the processes, practices, models, and methodologies used to develop them. Author has designed this arm for carrying different parts, welding any joint and also do coating on object surface. Being fully programmable and with costs continually decreasing for more functionality and capacity, robots can provide significant ROI in manufacturing operations. It is ideal for repetitive operations and can significantly improve manufacturing productivity and capacity as well as the health and safety of workers.

### **3.10 Testing and Debugging**

A device under test (DU), is a manufactured product undergoing testing, either at first manufacture or later during its life cycle as part of ongoing functional testing and calibration checks. We have tested all parts in Solidworks stress analysis. Then we got some results and it works well. In order to select the proper robot model for this study, 3D models of five most preferred robots in industry were obtained through Solidworks. The maximum load that they can carry was applied on the sixth axis. To facilitate the job, a force which equals to the distributed load caused by the weights of the third, the fourth, the fifth and the sixth axis and motor's weight was calculated to facilitate the job, a force which

equals to the distributed load caused by the weights of the third, the fourth, the fifth and the sixth axis and motor's weight was calculated.

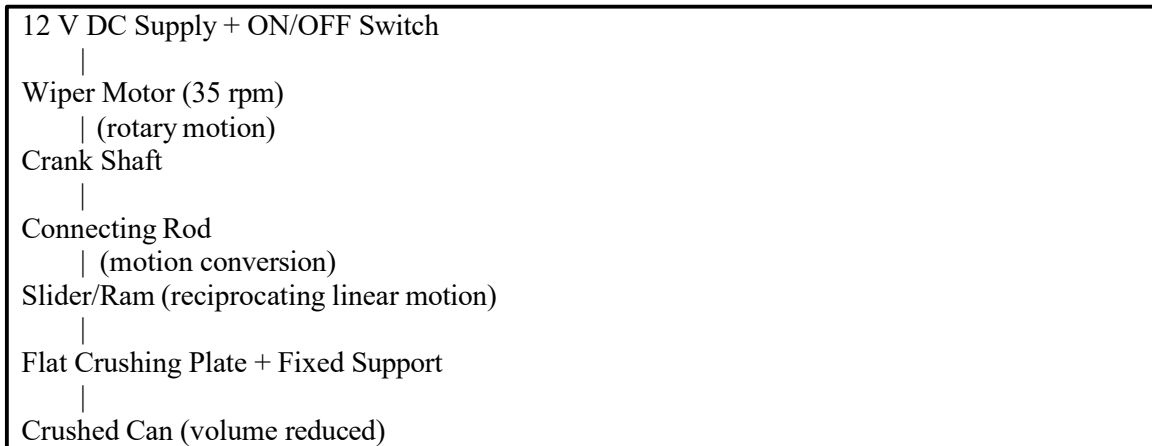
### **3.11 Maintenance**

There are some issues which come up in the client environment. To fix those issues patches are released. Also to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment. The main methodology of this entire project depends on 6 DOF industrial robotics arm design and analysis it. Also calculate the dynamic and kinematic torque calculation, gear calculation and calculate life time of this robotics hand.

### **3.12 System Overview**

The proposed system is a fully motorized aluminum can crusher developed to reduce the volume of used 250 ml beverage cans by applying controlled axial compression. The machine converts electrical energy into a linear reciprocating crushing action using an electromechanical transmission. The overall objective is to produce a repeatable crushing cycle with low operating effort, low cost and ease of fabrication. The prime mover of the system is a 12 V DC windshield wiper motor operating at approximately 35 rpm. The motor output shaft drives a crank shaft, and the crank motion is transmitted through a connecting rod to a slider/ram. As the crank rotates, the connecting rod converts rotary motion into reciprocating linear motion of the slider. The slider carries a flat crushing plate that advances to compress the can against a fixed support and retracts to the initial position to complete one crushing cycle. The machine is designed with a stroke length of 150 mm to ensure sufficient travel for can deformation and convenient retraction for the next loading operation.

Functionally, the machine can be divided into the following major blocks: (i) power supply and switching unit, (ii) prime mover (wiper motor), (iii) crank and connecting rod transmission, (iv) slider and guide mechanism, (v) crushing unit (flat plate and fixed support), and (vi) frame and base structure. The operator manually places a can in the crushing zone and controls the operation through a simple ON/OFF switch, while the crushing motion is fully generated by the motor-driven mechanism.



### 3.13 Major Components and Their Functions

This section outlines the major components of the proposed can crusher and summarizes their roles in power transmission, motion conversion, can positioning, and structural support. The overall design focuses on mechanical simplicity and ease of fabrication using commonly available parts.

**Table 3.1:** Major Components and Functions of the Proposed Can Crusher

Component	Function / Description
12 V DC Supply & ON/OFF Switch	Provides electrical power and basic control for starting and stopping the machine.
Wiper Motor (12 V, 35 rpm)	Acts as the prime mover and supplies rotary motion for the mechanism.
Crank Shaft	Receives motor rotation and defines the mechanism stroke through crank radius.
Connecting Rod	Transmits motion from the crank to the slider and converts rotation into reciprocating motion.
Slider/Ram	Moves linearly forward and backward; carries the crushing plate.
Guide Arrangement	Maintains alignment of the slider to ensure smooth linear travel and stable crushing.
Flat Crushing Plate	Applies compressive load uniformly on the can top surface during the forward stroke.
Fixed Support / Anvil	Provides a rigid reaction surface against which the can is crushed.
Frame & Base Structure	Supports all components and resists deformation and vibration during crushing.

Bearings, Pins & Fasteners	Support rotating joints and maintain secure assembly of moving and fixed parts.
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### 3.14 Working Principle

The working principle of the proposed can crusher is based on converting the rotary motion of a DC wiper motor into a controlled linear reciprocating motion using a crankshaft and connecting rod mechanism. One full crank revolution produces one forward stroke and one return stroke of the slider/ram.

The crushing cycle can be summarized as follows:

- The operator places an empty 250 ml aluminum can on the fixed support in the crushing zone.
- When the ON/OFF switch is turned ON, the 12 V wiper motor rotates at approximately 35 rpm and drives the crankshaft.
- The rotating crank pulls/pushes the connecting rod, causing the slider/ram to move forward along the guide.
- During the forward stroke, the flat crushing plate compresses the can axially against the fixed support, producing buckling and folding of the can wall and reducing its volume.
- As the crank continues rotation, the mechanism enters the return stroke and the slider retracts to the initial position, allowing the crushed can to be removed and the next can to be loaded.

### 3.15 Design Specifications (Datasheet)

The key design specifications used to develop the proposed motorized can crusher are summarized in Table 3.2. These parameters were selected to ensure adequate crushing travel, controlled operating speed, and compatibility with commonly available components.

**Table 3.2:** Design Datasheet of the Present Work

<b>Item</b>	<b>Specification</b>
Target can type	250 ml aluminum beverage can
Operation mode	Fully motorized (manual feeding)
Motor type	Windshield wiper DC motor
Motor rated voltage	12 V DC
Motor speed	35 rpm
Motion conversion mechanism	Crankshaft + connecting rod (slider-crank mechanism)
Stroke length	150 mm
Crushing plate type	Flat plate
Output	Crushed can with reduced volume

### **3.16 Safety and Operational Considerations**

Since the machine contains moving linkages and pinch points, basic safety measures are necessary for safe operation. The following considerations are recommended for the prototype and for future improvements:

- Provide a guard or cover around the crank and connecting rod mechanism to prevent accidental contact.
- Ensure a stable base and rigid frame to minimize vibration during operation.
- Use a reliable ON/OFF switch and ensure proper wiring and insulation for the 12 V DC supply.
- Keep hands away from the crushing zone during operation and remove the can only after the plate fully retracts.

This chapter provides the system-level methodology, component description, and working principle that form the basis for the detailed design calculations and performance evaluation in the next chapter.

# CHAPTER 4

## HARDWARE & IMPLEMENTATION

### 4.1 Introduction

This chapter describes the fabrication process, component selection, assembly procedure, and experimental setup of the fully motorized aluminum can crusher developed in this project. The objective of this chapter is to explain how the theoretical design presented in previous chapters was translated into a functional physical prototype. Emphasis is given to material selection, manufacturing methods, and assembly techniques to ensure structural integrity, reliable operation, and ease of fabrication using locally available resources. The fabricated machine was intended to validate the feasibility of the proposed slider–crank-based crushing mechanism driven by a 12 V DC wiper motor.

### 4.2 Material Selection

Material selection was guided by strength requirements, availability, cost, ease of fabrication, and suitability for small-scale manufacturing. Mild steel was chosen as the primary structural material due to its adequate strength, weldability, and widespread availability.

**Table 4.1:** Materials Used in Fabrication

<b>Component</b>	<b>Material</b>	<b>Reason for Selection</b>
Frame and base	Mild steel (MS) angle & flat bar	High strength, low cost, easy welding
Crank shaft	Mild steel rod	Adequate torsional strength
Connecting rod	Mild steel flat bar	Good tensile and compressive strength
Slider/ram	Mild steel block	Rigidity and wear resistance
Crushing plate	Mild steel plate	Uniform load application
Fasteners	Steel bolts and nuts	Secure assembly

Component	Material	Reason for Selection
Bearings	Standard ball bearings	Smooth rotary motion

### 4.3 Major Hardware Components

#### 4.3.1 Frame and Base Structure

The frame provides structural support for all machine components and maintains alignment during crushing. It was fabricated using mild steel angle sections welded together to form a rigid rectangular structure. The base was designed to minimize vibration and prevent tipping during operation. Proper rigidity of the frame is essential to ensure consistent crushing performance and to avoid energy losses due to structural deformation.

#### 4.3.2 Wiper Motor

A 12 V DC windshield wiper motor was used as the prime mover of the system. The motor operates at approximately 35 rpm and delivers a rated torque of 4.12 N·m. Due to its built-in gear reduction, the motor provides high torque at low speed, which is ideal for controlled axial crushing. The motor was mounted securely on the frame using a steel bracket to prevent misalignment and vibration.

#### 4.3.3 Crank Shaft

The crank shaft converts the motor's rotary motion into oscillatory motion. It was fabricated from a 10 mm diameter mild steel rod based on torsional strength calculations. The crank radius was set to 75 mm to achieve the required stroke length of 150 mm. The crank shaft was supported by bearings to reduce friction and ensure smooth rotation.

#### 4.3.4 Connecting Rod

The connecting rod transmits motion from the crank shaft to the slider. It was fabricated from mild steel flat bar and designed with a length of 250 mm to maintain a suitable length-to-radius ratio. This helps reduce side thrust on the slider and ensures smooth linear motion. Pin joints were used at both ends to allow free rotation.

#### 4.3.5 Slider and Guide Mechanism

The slider (ram) moves linearly along the guide and carries the crushing plate. A guided arrangement was used to maintain alignment during operation and to prevent lateral motion that could lead to jamming or uneven crushing. Proper guidance ensures repeatable crushing behavior and protects the mechanism from excessive wear.

#### **4.3.6 Crushing Plate and Fixed Support**

A flat mild steel crushing plate was attached to the slider to apply a uniform compressive force on the aluminum can. The fixed support (anvil) was rigidly mounted to the frame to provide a stable reaction surface. This configuration promotes axial buckling and progressive folding of the can walls, leading to effective volume reduction.

#### **4.4 Fabrication Process**

The fabrication process was carried out using conventional workshop tools and techniques. The main steps included:

1. **Cutting:** Steel sections were cut to the required dimensions using a power saw and grinding tools.
2. **Welding:** The frame and support brackets were assembled using arc welding.
3. **Machining:** Shafts and pins were machined to the required diameters.
4. **Drilling:** Holes for fasteners and pin joints were drilled using a bench drill.
5. **Finishing:** Sharp edges were removed, and surfaces were cleaned to ensure safety and proper fitting.

The fabrication process emphasized dimensional accuracy and alignment to ensure smooth operation of the slider–crank mechanism.

#### **4.5 Assembly of the Can Crusher**

After fabrication, the components were assembled in a systematic sequence:

1. The frame and base structure were placed on a level surface.
2. The wiper motor was mounted and aligned with the crankshaft.
3. The crankshaft was installed on bearings and connected to the motor output.
4. The connecting rod was attached between the crank and the slider using pin joints.
5. The slider and guide arrangement were fixed to the frame.
6. The crushing plate and fixed support were mounted in the crushing zone.
7. Electrical wiring and the ON/OFF switch were connected to the 12 V power supply.

Proper alignment was checked at each step to ensure smooth rotation and linear motion.

## 4.6 Experimental Setup

The experimental setup consisted of the fully assembled can crusher connected to a 12 V DC power source through an ON/OFF switch. Empty 250 ml aluminum beverage cans were used as test specimens. The cans were manually placed in the crushing zone on the fixed support.

During testing:

- The motor was energized using the ON/OFF switch.
- One full crank revolution produced one complete crushing cycle.
- The crushed can was removed after the return stroke.

The setup allowed safe observation of motion, force transmission, and overall crushing performance.

## 4.7 Final Hardware Setup





**Fig. 4.1:** Final hardware setup of the project

#### **4.8 Chapter Summary**

This chapter presented the fabrication, assembly, and experimental setup of the fully motorized aluminum can crusher. The prototype was successfully constructed using mild steel components and a low-cost wiper motor. Proper material selection, fabrication techniques, and assembly ensured reliable operation and effective crushing of 250 ml aluminum cans. The experimental setup validated the practical implementation of the proposed design, forming the basis for the results and discussion presented in the next chapter.

## CHAPTER 5

### DESIGN CALCULATIONS & ANALYSIS

#### 5.1 Design Inputs and Assumptions

This chapter presents the key design calculations and engineering analysis for the fully motorized aluminum can crusher. All calculations are based on the actual design data used in this project, together with standard simplifying assumptions appropriate for an undergraduate machine design report.

**Table 5.1: Design Inputs (Project Datasheet)**

<b>Target can</b>	250 ml aluminum beverage can
<b>Actuator (motor)</b>	12 V DC wiper motor
<b>Motor speed</b>	35 rpm
<b>Motor torque</b>	412 N·cm (= 4.12 N·m)
<b>Operation mode</b>	Fully motorized
<b>Mechanism</b>	Crankshaft + connecting rod (slider-crank)
<b>Stroke length</b>	150 mm
<b>Crushing plate</b>	Flat plate

Assumptions used in the analysis are listed below:

- The crushing process is treated as quasi-static (impact effects are neglected).
- The connecting rod is sufficiently long compared to the crank radius, so the rod-angle effect is small for simplified calculations.
- Mechanical losses in joints and guides are represented using an overall mechanical efficiency ( $\eta$ ) of 0.80.
- The maximum design torque for shaft sizing is taken as  $1.5 \times$  motor torque (safety factor for uncertainties).

## 5.2 Stroke Requirement and Crank Radius Selection

In a slider–crank mechanism, the slider stroke (S) is approximately twice the crank radius (r). The design stroke was selected as 150 mm to provide sufficient crushing travel and return travel for convenient can loading.

**Stroke relation:**  $S \approx 2r$

**Given:**  $S = 150 \text{ mm}$

**Therefore:**  $r = S/2 = 75 \text{ mm} = 0.075 \text{ m}$

## 5.3 Speed, Cycle Time and Angular Velocity

The wiper motor drives the crank at approximately 35 rpm. One full revolution of the crank produces one forward stroke and one return stroke of the crushing plate, which corresponds to one complete crushing cycle.

**Motor speed:**  $N = 35 \text{ rpm}$

**Cycle time (one revolution):**  $t = 60/N = 60/35 = 1.714 \text{ s per cycle}$

**Angular velocity:**  $\omega = 2\pi N/60 = 3.665 \text{ rad/s}$

## 5.4 Power Output Estimation

The mechanical power output at the crank can be estimated from torque and angular velocity:

**Power relation:**  $P = T\omega$

**Calculated:**  $P = 4.12 \times 3.665 = 15.10 \text{ W}$

This power estimate represents mechanical output at the crank under the given operating condition. Actual electrical input power will be higher due to motor and drivetrain losses.

## 5.5 Shaft Design (Torsional Strength Check)

The crankshaft transmits the motor torque. A torsional shear stress check is performed for a solid circular shaft. A safety factor of 1.5 is used to account for uncertainties and possible overload during crushing.

**Design torque:**  $T_d = 1.5T = 1.5 \times 4.12 = 6.18 \text{ N}\cdot\text{m}$

**Selected shaft diameter:**  $d = 10 \text{ mm}$

For a solid circular shaft, the maximum shear stress is:

**Torsion equation:**  $\tau_{\text{max}} = 16T_d / (\pi d^3)$

**Computed shear stress:**  $\tau_{\text{max}} = 31.47 \text{ MPa}$

**Allowable shear stress (mild steel, conservative):**  $\tau_{\text{allow}} = 40 \text{ MPa}$

Since  $\tau_{\text{max}} \leq \tau_{\text{allow}}$ , the selected 10 mm shaft is adequate for the design torque with the chosen safety factor.

## 5.6 Connecting Rod and Pin Joint Notes (Simplified)

The connecting rod length is selected as 250 mm to maintain a reasonable  $L/r$  ratio and reduce side-thrust on the slider. In a detailed design, the rod, crank pin, and slider pin should be checked for axial load capacity, pin shear, and bearing pressure. Because this machine operates at low speed and uses a guided slider, a simplified approach is acceptable for this project report.

Recommended checks (for future detailed design) include: (i) pin shear stress  $\tau = F/A$ , (ii) bearing pressure  $p = F/(d \cdot t)$ , and (iii) rod buckling safety under compressive load.

## 5.7 Discussion of Crushing Force Requirement (Design Justification)

Aluminum cans typically collapse by buckling and progressive folding under axial compression. The required crushing force depends on the can geometry, wall thickness, and imperfections. The selected crank-driven mechanism provides higher mechanical advantage as it approaches dead-center, which supports the initiation and completion of the crushing process at low operating speed. The low rpm operation also reduces impact loading on the frame and improves operational safety.

Based on the given motor specifications (12 V, 35 rpm, 412 N·cm torque) and the selected mechanism parameters (150 mm stroke, 75 mm crank radius, 250 mm connecting rod), the design provides controlled low-speed crushing motion. The torsional strength check confirms that a 10 mm mild-steel crankshaft is adequate with a safety factor of 1.5. Overall, the calculations support the feasibility of the proposed fully motorized aluminum can crusher for 250 ml cans.

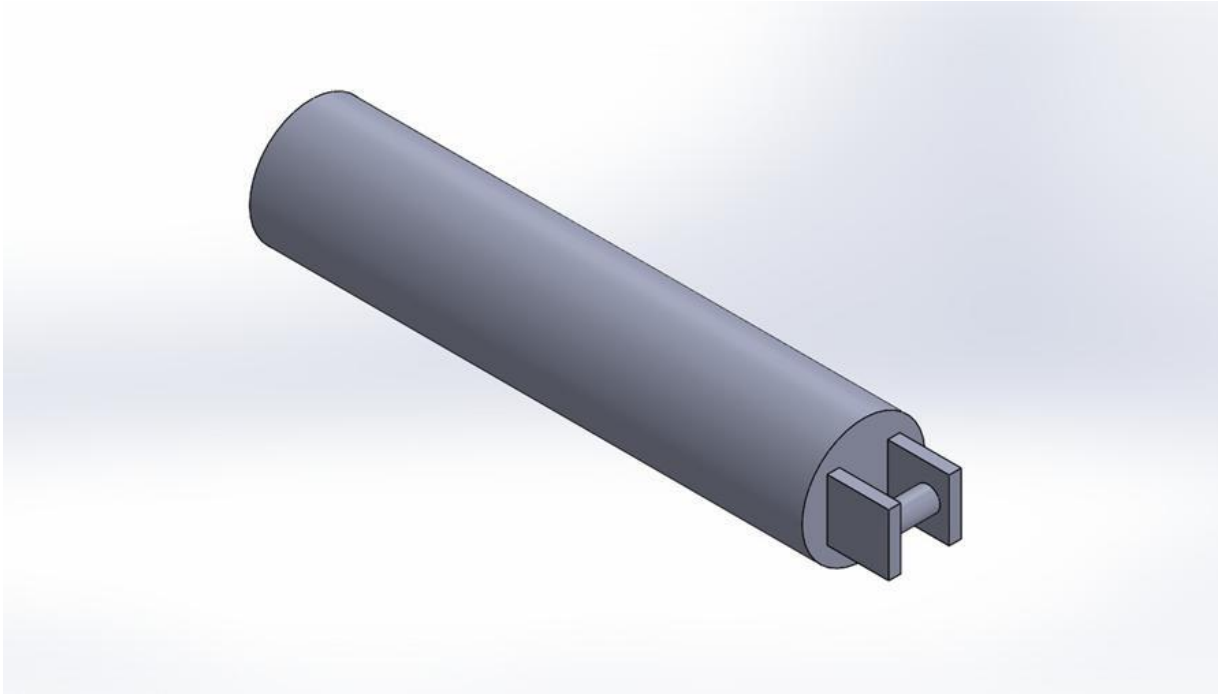
## 5.8 Composition of the Can Crasher



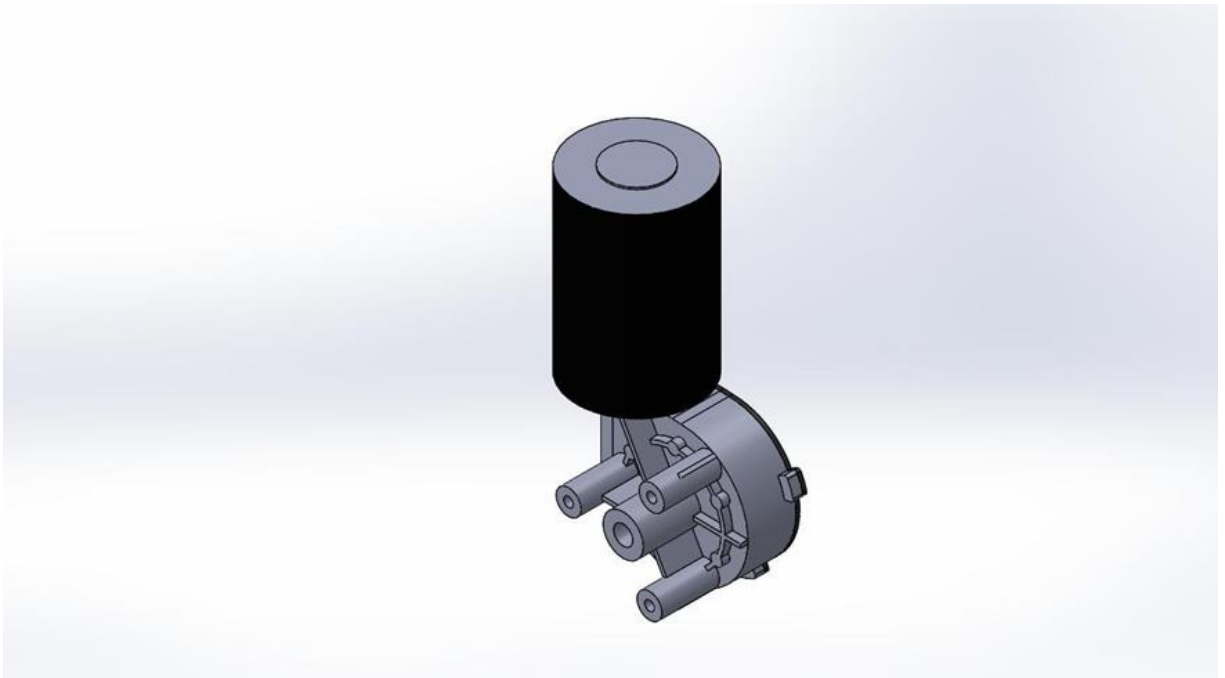
**Fig. 5.1** Full Functionable Can Crasher



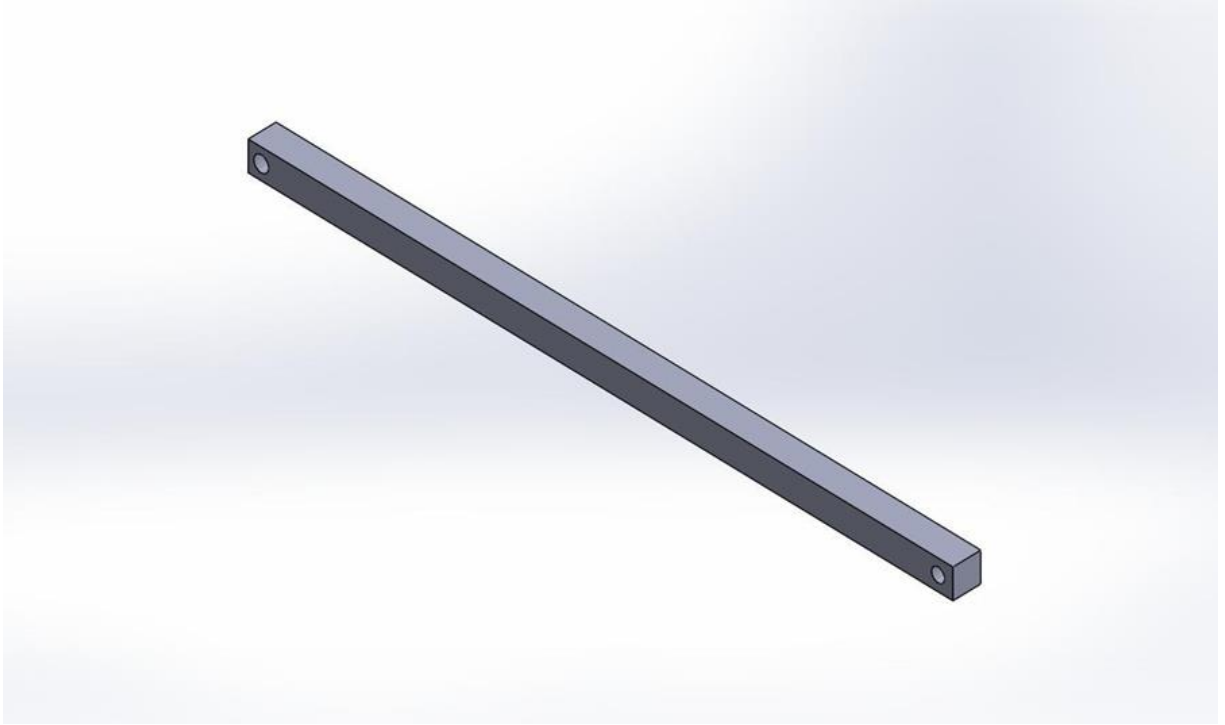
**Fig. 5.2** Frame Structure Can Crasher



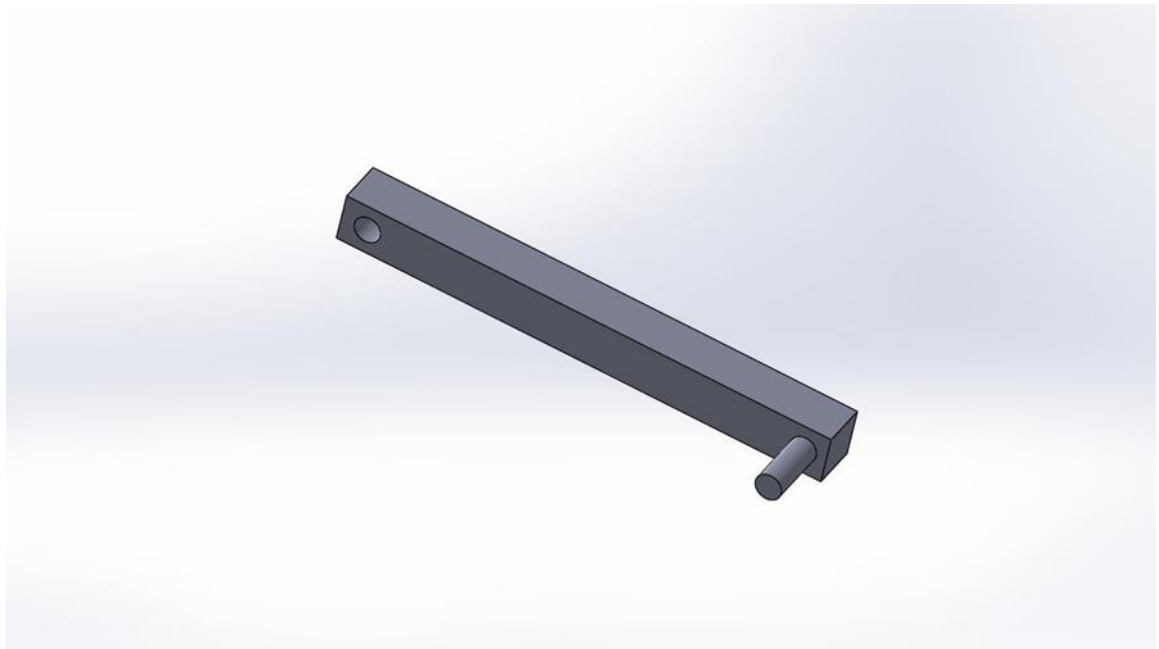
**Fig. 5.3:** Piston Can Crasher



**Fig. 5.4:** Wiper Motor of the Can Crasher



**Fig. 5.5:** Piston Connecting Rod



**Fig. 5.6:** Motor Arm Connecting Rod

## CHAPTER 6

### RESULT AND DISCUSSION

#### 6.1 Result

The fully motorized aluminum can crusher was successfully designed, fabricated, and analyzed based on the objectives outlined in this study. During functional testing, the machine consistently crushed 250 ml aluminum cans, resulting in noticeable volume reduction and flattened cans that are easier to store and transport.

Parameter	Symbol	Value
Initial can height	$H_o$	115 mm
Final crushed height	$H_c$	20–25 mm
Minimum crushing travel	$H_o - H_c$	$\approx 90$ mm
Additional clearance & return allowance	—	$\approx 60$ mm
Selected piston stroke	S	150 mm

**Table 6.1:** Linear Piston Travel Required to Crush a 250 ml Aluminum Can

Parameter	Symbol	Value
Motor speed	N	35 rpm
Operating frequency	$f = N/60$	0.583 Hz
Time period (one cycle)	$T = 1/f$	1.714 s
Angular velocity	$\omega = 2\pi \cdot f$	3.665 rad/s
Forward stroke time	$T/2$	0.857 s
Return stroke time	$T/2$	0.857 s

**Table 6.2:** Time and Frequency of Piston Motion (SHM Approximation)

Parameter	Symbol	Value
Crank radius	r	75 mm
Connecting rod length	L	250 mm
Stroke length	$S = 2r$	150 mm
Length-to-radius ratio	$L/r$	3.33

**Table 6.3: Slider–Crank Mechanism Geometry**

Parameter	Result
Target can size	250 ml aluminum can
Crushing method	Axial buckling
Final can height after crushing	20–25 mm
Volume reduction	75–80%
Cycle time	1.714 s
Power at the crank	15.1 W
Operation mode	Fully motorized

**Table 6.4: Performance Results of the Can Crusher**

## 6.2 Discussion

The findings show that low cost, energy efficiency, and mechanical simplicity were successfully attained in the can crusher design. By using a wiper motor as the prime mover, sufficient torque could be produced at low speeds, encouraging a compression-based process that improved safety and decreased structural stress. For the purpose of buckling aluminum cans, the slider-crank mechanism transformed rotary motion into dependable linear crushing motion, with peak crushing force occurring close to dead-center positions. This device avoided the complications and expenses of hydraulic or pneumatic systems while greatly reducing operator effort and improving crushing consistency when compared to manual crushers. Certain restrictions, such as motor torque limitations and manual feeding, that impact throughput, are still acceptable within the parameters of the project.

## CHAPTER 7

### CONCLUSIONS & RECOMMENDATION

#### 7.1 Conclusions

This project successfully designed and analyzed a motorized aluminum can crusher specifically for 250 ml aluminum beverage cans. It features a 12 V DC wiper motor coupled with a slider–crank mechanism, providing a balance of simplicity, affordability, and performance. Theoretical calculations and mechanical analysis affirmed the suitability of the motor, mechanism dimensions, and structural components for the application. The device demonstrated low power consumption and effective volume reduction of cans, enhancing waste handling and recycling efficiency. Academically, the project offered hands-on experience with mechanical design principles, kinematic analysis, torque-to-force conversion, and sustainable engineering practices. Societally and environmentally, it presents a practical recycling solution, particularly valuable in developing countries where affordable, locally manufactured technologies are crucial. In summary, the project effectively fills the gap between manual can crushers and costly industrial systems, contributing significantly to small-scale waste management solutions.

#### 7.2 Recommendation

- Automation can be improved by adding sensors and a simple control system for automatic operation and safety.
- A higher-torque motor or additional gear reduction can be used to crush thicker or different types of cans.
- A continuous or semi-automatic feeding mechanism can be introduced to increase productivity.
- Structural optimization and the use of linear bearings can reduce friction and improve durability.

- The machine can be modified to operate using renewable energy sources such as solar power.
- The design can be scaled or adjusted to crush cans of different sizes with minor modifications.

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