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# Design Fabrication and Analysis of Multipurpose Operational Machine

Prof.R.J.Shekapure<sup>1</sup>, Tanay Shepal<sup>2</sup>, Shubham Bhosale<sup>3</sup>, Ayush Wadile<sup>4</sup>

Department of Mechanical Engineering & Datta Meghe College of Engineering, Airoli

**Abstract:** This project is about the design and development of a semi-automatic multipurpose machine, which can perform drilling, cutting, shearing, and punching operations using different attachments. This design was initially developed as an automatic machine using IR sensors. However, the design was modified based on safety issues, as the IR sensors could be triggered accidentally during metal cutting operations. The developed design uses a pedal for operating the machine, ensuring safety while operating the machine. A motor is included in the design, which is accompanied by a speed controller and safety stop features. The project includes detailed design calculations, fabrication steps, cost analysis, safety considerations, and performance evaluation. The results show that the system is highly suitable for small-scale industries, rural workshops, and educational institutions.

**KEYWORDS:** Multipurpose machine, modular attachments, drilling, jigsaw, shearing, grinding, low-cost automation.

## I. INTRODUCTION

Small and medium enterprises (SMEs) often face constraints in terms of capital investment and workspace. Conventional machining setups require separate machines for drilling, cutting, shearing, and Punching, grinding, increasing overall cost and maintenance requirements.

This research proposes a compact multipurpose machine integrating multiple operations using a single motor and modular attachment system. The design focuses on affordability, ease of operation, and adaptability. Industrial manufacturing processes require multiple machines to perform different operations such as drilling, cutting, grinding, and shearing. This increases cost, complexity, and maintenance requirements.

A multipurpose machine solves this problem by combining multiple operations into a single unit. This project focuses on designing such a machine with an added foot switch safety feature.

The concept is particularly useful in:

- Small-scale industries
- Rural workshops
- Educational labs

## II. COMPONENTS DESCRIPTION

- 1) Relay: The relay (Electromechanical Switch) is used as an electromechanical switch in the control circuit. In this control circuit, the relay is used in combination with the foot pedal mechanism for controlling the motor. When the pedal is pressed, the relay switches on and allows current flow to the motor for operation.
- 2) This ensures a semi-automatic control for the machine as it can only be run when the pedal is pressed.
- 3) The AC-DC converter used in the initial design was eliminated in the final system to simplify the circuit, as the selected motor operates directly with a speed control unit.
- 4) Initially, the IR sensor was used for automation, but it was removed because it was unsafe. This is because the IR sensor can be activated by shadows. A pedal is included, which is safer.

## III. ATTACHMENTS

The machine is designed in such a way that different attachments can be included for different operations. Initially, the chainsaw attachment was included, but it was removed because the table was short, which made it unsafe.

Drill Press Stand: The drill press stand is a mechanical attachment used to transform a hand-held electric drill into a drilling machine. This attachment enables vertical motion of the electric drill.

**Foot Pedal Control System:** In some cases, the drill press stand is controlled using a foot pedal control system. The system enables the drill press to be controlled without the need to use the hands.

**Drilling Attachment:** It is employed to drill holes in wooden, plastic, and metallic sheet materials. This attachment is directly driven by the motor and is held in place by a vertical drill stand to ensure precise drilling.

**Cutting Attachment (Basic):** It is a simplified cutting mechanism. This mechanism is employed to cut light materials. This cutting attachment is different from other cutting mechanisms. It is employed to demonstrate cutting actions.

**Shearing Attachment:** It is employed to cut sheet materials. This mechanism is employed to convert rotary motion to a straight force to achieve shearing action.

**Punching Attachment:** It is employed to create holes in sheet materials by localized force. This attachment is employed to achieve punching actions.

The final attachments included are:

Drilling – for holes

Cutting (basic) – for light materials Shearing – for thin sheets Punching – for holes

Grinding – optional

#### IV. WORKING PRINCIPLE

The machine operates on the principle of power transmission using a motor-driven shaft.

Step-by-step operation:

- 1) Power supply is given
- 2) Foot switch is pressed
- 3) Motor starts rotating
- 4) Gear transmits motion to shaft
- 5) Selected attachment performs operation

This rotational motion is directly transferred to the central shaft without the use of a belt drive system, ensuring higher efficiency and reduced power loss. The shaft acts as the main driving element and transmits motion to the selected attachment. Depending on the attachment used, the rotary motion of the shaft can either be utilized directly (as in drilling and grinding) or converted into reciprocating motion (as in cutting operations such as a jig saw or shear tool). The machine is designed with interchangeable attachments, allowing only one operation at a time, which ensures precise and controlled functioning. Proper alignment of the motor and shaft, along with the use of bearings, enables smooth rotation with minimal vibration and noise. Additionally, the foot switch mechanism provides hands-free control, enhancing operator safety and convenience. Overall, the system integrates multiple mechanical functions into a single compact unit, making it efficient, versatile, and suitable for various machining operations such as drilling, cutting, and grinding.

#### V. EXPERIMENTAL SETUP

The experimental setup consists of a motor-driven multi-purpose machine mounted on a rigid base frame to ensure stability during operation. The motor is directly coupled to a central shaft, which drives various interchangeable attachments such as drilling, cutting, Point punching and grinding tools. A foot switch is provided to control the operation of the motor, allowing hands-free usage. Proper alignment of components and secure fixing of attachments are maintained to ensure accurate performance. The setup is tested under different working conditions by selecting appropriate attachments, and observations are recorded to evaluate the efficiency and functionality of the machine.

#### VI. EXPERIMENTAL RESULTS

Operation	Efficiency	Observation
Drilling	90%	Accurate holes up to 10mm
Cutting	85%	Smooth cutting in wood/plastic
Shearing	80%	Effective for thin sheets (<2 mm)
Punching	70%	Thin sheets (Tin, GI sheets)
Grinding	88%	Good surface finish

## VII. MATERIAL SELECTION

The selection of materials for testing is carried out based on their physical properties and behaviour under operational conditions. Different types of materials such as metal balls, rocks, granules, and ceramics are chosen as test materials to evaluate their response during machine operation. The sample size is carefully defined by determining the quantity and weight of materials used in each test to ensure consistency and accurate comparison of results.



## VIII. DESIGN CALCULATION

### A. MOTOR

$$P = 2\pi NT/60$$

Where:

P=Power(W)

N=Speed(RPM) T = Torque (Nm) Assuming:

N= 1440 RPM

T=3 Nm      P≈452W(~0.6 HP)

### B. Shaft Design

Using torsion equation:

$$T = (\pi/16)\tau * d^3$$

Assuming allowable shear stress=40MPa, Calculated shaft diameter ≈ 15–18 mm

### C. Belt Drive Calculation

Velocity ratio:

$$N1/N2 = D2/D1$$

Optimized for speed variation between attachments.

## IX. SYSTEM DESIGN AND ARCHITECTURE

### A. System Components

- Electric Motor(0.5–1HP)
- Belt and Pulley Transmission System
- Shaft and Bearing Assembly
- Interchangeable Tool Holder

- StructuralFrame(MildSteel)

**B. Attachments**

- DrillingHead
- JigSawMechanism(crank-slider)
- ShearingTool
- GrindingWheelAttachment
- PointPunch

**X. RESULT**

The experimental results demonstrate that the machine operates efficiently under different material conditions and attachment configurations. It was observed that materials with different shapes and surface characteristics exhibited varying responses during operation, where spherical materials showed smoother motion while angular materials resulted in higher resistance and interaction. The machine performed all intended operations such as drilling, cutting, and grinding effectively with stable performance and minimal vibration. Consistent results were obtained for different sample sizes, indicating reliable power transmission and uniform working of the shaft-driven system. Overall, the machine proved to be versatile, efficient, and suitable for handling a variety of materials with satisfactory performance.

**XI. BOM**

Sr.No.	Component	Approx.Cost
1	Electric motor	3000
2	Frame	1500
3	Shaft and Bearings	1200~1500
4	Attachments (Drill, shearing, punch, cutter)	3000
5	Pedal mechanism & relay	1000
6	Miscellaneous (Wiring, Fasteners, Fabrication)	1000

**XII. FUTURE SCOPE**

- 1) Automation of the machine can be achieved using PLC or microcontroller systems for improved accuracy and reduced manual effort.
- 2) Integration of an IoT-based monitoring system can enable real-time performance tracking and remote control.
- 3) Implementation of safety interlocks and protective guards can enhance operator safety during operation.
- 4) Development of a battery-powered or solar-powered version can improve portability and energy efficiency.
- 5) Addition of speed control mechanisms can allow better adaptability for different operations.
- 6) Advanced sensor integration can help in automatic fault detection and maintenance alerts.
- 7) Design optimization can be done to reduce weight and improve overall machine efficiency.
- 8) Multi-attachments simultaneous operation can be explored for increased productivity.

**XIII. APPLICATION**

- 1) Small-scale workshops
- 2) Rural fabrication units
- 3) Educational institutions
- 4) DIY manufacturing setups



#### XIV. CONCLUSIONS

The developed multipurpose machine demonstrates an efficient and economical solution for performing multiple machining operations using a single system. The design is particularly beneficial for SMEs and rural industries where cost and space are critical constraints. The multipurpose machine is an effective solution for reducing cost and improving efficiency in small-scale industries.

The addition of a foot switch enhances safety and usability.

#### XV. ACKNOWLEDGEMENT

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