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Pedal-Powered Hacksaw: An Innovative Approach to Energy-Free Cutting Systems

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Peer Review Information	Abstract
<i>Submission: 11 Feb 2025</i> <i>Revision: 20 Mar 2025</i> <i>Acceptance: 22 April 2025</i> Keywords <i>Pedal-Operated Hacksaw</i> <i>Mechanical Cutting</i> <i>Energy-Efficient Design</i>	The pedal-operated hacksaw is an innovative, eco-friendly, and cost-effective mechanical system designed for cutting materials without the need for electrical power. This project aims to develop a manually operated hacksaw that converts human pedalling motion into a reciprocating sawing action. The system consists of a chain drive mechanism, a flywheel, a crankshaft, and a connecting rod that transmits motion to the hacksaw blade. By utilizing pedal power, this mechanism provides an energy-efficient alternative to traditional motorized saws, making it ideal for small-scale industries, workshops, and rural areas where electricity is limited or expensive. The design and fabrication process involve selecting appropriate materials, designing the transmission system, and assembling the components to ensure smooth operation and efficient cutting. This project highlights the advantages of low-cost fabrication, minimal maintenance, and environmental sustainability while offering an ergonomic and effective solution for cutting metal, wood, and plastic. The results demonstrate that a pedal-operated hacksaw can be a viable alternative to conventional power tools, promoting both energy conservation and physical fitness.

INTRODUCTION

A **pedal-powered hacksaw** is a manually operated mechanical device designed to cut materials like metal, wood, and plastic using human pedaling effort. It is an innovative and eco-friendly alternative to conventional electric saws, making it an ideal tool for rural areas, workshops, and educational projects.

The basic working principle involves converting rotary motion from pedaling into a reciprocating motion that moves a hacksaw blade back and forth, enabling efficient cutting. The system typically consists of a bicycle-like pedal mechanism, a flywheel, a crankshaft, and a frame that holds the workpiece securely in place.

RELATED WORK

Several research studies, projects, and prototypes have been developed around pedal-powered hacksaws, primarily focusing on sustainable energy solutions, cost reduction, and efficiency improvements. Here are some notable areas of related work:

1. Research and Academic Studies

- **Energy-Efficient Cutting Tools:** Researchers have explored the use of pedal-powered hacksaws as an alternative to electric saws, particularly in rural areas. Studies have analyzed the efficiency of different crank mechanisms

(such as Scotch Yoke, Crank-Slider, and Cam Mechanisms) in optimizing power transmission.

- **Human-Powered Machines:** Pedal power has been extensively studied in various applications such as water pumps, grain grinders, and washing machines. These studies highlight how mechanical energy from pedaling can be effectively converted into useful work.

2. DIY and Engineering Projects

- **Mechanical Engineering Student Projects:** Many university students have built pedal-powered hacksaws as part of their final-year projects. These projects often aim to enhance cutting speed, reduce operator fatigue, and increase stability.
- **Innovations in Design:** Some projects integrate flywheels or gear systems to store energy and improve cutting efficiency. Others explore multi-purpose pedal-powered machines that combine a hacksaw with a grinding or drilling attachment.

3. Applications in Real-World Scenarios

- **Rural and Off-Grid Solutions:** Pedal-powered hacksaws have been implemented in areas with limited electricity access, allowing small-scale workers to cut materials efficiently without relying on external power sources.
- **Low-Cost Manufacturing:** Some initiatives promote the use of pedal-powered tools in developing countries, providing an affordable alternative for artisans and craftsmen.

4. Comparison with Other Cutting Methods

- **Manual Hacksaws vs. Pedal-Powered Hacksaws:** Studies show that a pedal-powered hacksaw significantly reduces effort and increases cutting speed compared to a traditional handheld hacksaw.
- **Pedal Power vs. Motorized Hacksaws:** While motorized hacksaws are faster, pedal-powered versions are more sustainable, requiring no electricity and having lower operational costs.

PROPOSED METHODOLOGY

The methodology for developing a **pedal-operated hacksaw** involves several key steps, including design, material selection, fabrication, and testing. The project follows a structured approach to ensure efficiency, durability, and ease of operation.

1. Problem Identification and Objectives

- Identify the need for an alternative cutting method that is **cost-effective, energy-efficient, and eco-friendly**.
- Define the objectives, such as reducing human effort compared to manual sawing, improving cutting efficiency, and ensuring ease of use.

2. Design and Working Principle

- **Conceptual Design:** Sketch different design ideas and select the best mechanism (Scotch Yoke, Crank-Slider, or Cam Mechanism).
- **Mechanical Working Principle:**
 - **Pedaling Mechanism:** Converts human effort into rotary motion.
 - **Crankshaft System:** Converts rotary motion into a reciprocating motion.
 - **Hacksaw Blade Movement:** Moves back and forth for cutting.
 - **Workpiece Holder:** A vice or clamp holds the material firmly in place.

3. Material Selection

- **Frame:** Mild steel or aluminium (for durability and lightweight construction).
- **Pedal Mechanism:** Bicycle pedals and crankshaft system.
- **Cutting Tool:** High-carbon steel hacksaw blade.
- **Linkage System:** Connecting rods for smooth transmission of motion.
- **Base & Stand:** A rigid structure to maintain stability during operation.

4. Fabrication Process

1. **Frame Construction:** Welding and assembling the frame to support the system.
2. **Pedal and Crankshaft Installation:** Mounting the bicycle pedal system and connecting it to the crank.
3. **Sawing Mechanism Assembly:** Attaching the hacksaw blade to the crank-slider or Scotch yoke mechanism.
4. **Work Holding Mechanism:** Fixing a vice or clamp to hold the workpiece securely.
5. **Testing and Adjustments:** Ensuring proper alignment of components for smooth operation.

5. Testing and Performance Analysis

- **Cutting Efficiency:** Measure cutting time for different materials.
- **Force Required:** Evaluate the ease of operation compared to manual sawing.
- **Durability and Stability:** Test for vibrations, wear, and overall robustness.
- **User Comfort and Ergonomics:** Assess pedaling effort and adjust seat height if needed.

ASSEMBLY OF PEDAL-POWERED HACKSAW MACHINE

The assembly of a **pedal-powered hacksaw machine** involves integrating various mechanical components to ensure smooth operation and efficient cutting. Below are the step-by-step procedures for assembling the machine.

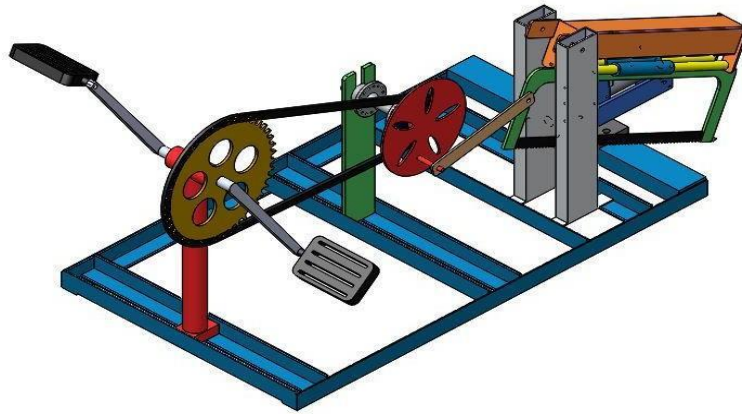


Fig. 1 Cad model of pedal powered hacksaw machine

1. Components Required

Main Structural Components:

- **Frame:** Mild steel or aluminium structure for stability.
- **Base Plate:** Provides a stable foundation for mounting all components.

Mechanical Components:

- **Pedal Mechanism:** Bicycle pedals and crank system for power generation.
- **Flywheel (Optional):** Helps maintain consistent motion and reduces pedaling effort.
- **Crank and Slider Mechanism:** Reciprocating motion refers to rotary motion.
- **Hacksaw Blade:** The cutting tool attached to the slider mechanism.

Supporting Components:

- **Vice or Clamp:** Holds the workpiece securely.
- **Bearings and Shafts:** Ensure smooth movement of rotating parts.
- **Bolts, Nuts, and Fasteners:** For securing components.

2. Assembly Procedure

Step 1: Frame Construction

- Cut and weld the **metal frame** to form the structure.
- Ensure proper alignment and stability.

Step 2: Installing the Pedal Mechanism

- Mount the **bicycle pedal system** onto the frame.
- Connect the **pedal crankshaft** with bearings for smooth rotation.

Step 3: Attaching the Flywheel (Optional)

- If a **flywheel** is used, attach it to the crankshaft to maintain momentum.

Step 4: Connecting the Crank and Slider Mechanism

- Fix the **crank** onto the shaft connected to the pedals.
- Attach the **slider or Scotch yoke mechanism** to convert rotary motion into linear motion.
- Ensure that the slider moves smoothly back and forth.

Step 5: Mounting the Hacksaw Blade

- Secure the **hacksaw blade** onto the slider mechanism.
- Ensure that the blade moves freely and maintains proper tension.

Step 6: Installing the Workpiece Holder (Vice or Clamp)

- Fix the **vice** or clamp onto the base to hold the material during cutting.
- Adjust the position for different sizes of materials.

Step 7: Final Adjustments and Testing

- Check for **proper alignment** of all components.
- Ensure **smooth movement** of the hacksaw blade.
- Test the system by pedaling and making trial cuts on different materials.
- Adjust the **blade tension** and **pedal effort** as needed.

3. Safety Considerations

- Ensure all moving parts are **securely fastened**.
- Provide **protective covers** for rotating parts if necessary.
- Wear **safety gloves and goggles** while operating.

4. Expected Performance

- **Smooth and efficient cutting** with minimal effort.
- **Energy-saving operation** compared to manual sawing.
- **Durable and maintenance-friendly design.**

RESULTS AND OPTIMIZATION

- Compare results with conventional cutting methods.
- Identify potential improvements, such as using a **flywheel for energy storage** or adding a **gear system** to reduce effort.
- Make modifications for better efficiency and ease of use.

CONCLUSION AND FUTURE ENHANCEMENTS

- Summarize the benefits of a pedal-powered hacksaw, such as energy savings, sustainability, and cost-effectiveness.
- Suggest future upgrades, like integrating a **multi-functional tool setup** (e.g., grinder, drill).

References

1. Research Papers & Journals

- Google Scholar – Search for "Pedal Powered Hacksaw Machine" or related topics.
- International Journal of Mechanical Engineering & Technology (IJMET) – Many research papers discuss human-powered mechanical systems.
- International Research Journal of Engineering and Technology (IRJET) – Often publishes student and academic research on mechanical innovations.
- IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) – Covers pedal-operated machines and sustainable mechanical designs.

2. Project Reports & Theses

- National Institute of Technology (NITs) and IITs project repositories – Many universities publish their students' mechanical project reports online.
- Academia.edu & ResearchGate.net – Platforms where students and professionals share project reports and papers.

3. Books & Technical References

- Machine Design by R.S. Khurmi & J.K. Gupta – Useful for understanding crank-slider and Scotch yoke mechanisms.
- Theory of Machines by S.S. Rattan – Explains motion conversion principles used in pedal-powered hacksaws.
- Design of Machine Elements by V.B. Bhandari – Helps in material selection and component design.

4. Online Resources & DIY Projects

- Instructables.com – DIY guides on pedal-powered machines.
- YouTube Tutorials – Search for "*Pedal-powered hacksaw project*" for step-by-step video demonstrations.
- ScienceDirect & SpringerLink – Engineering articles on human-powered tools.