

# Prototype Design and Research Collection

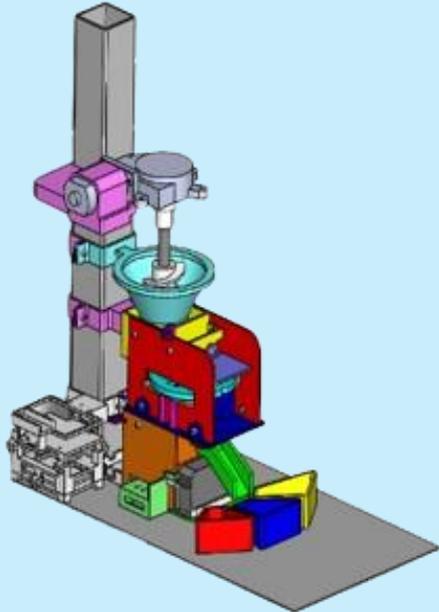
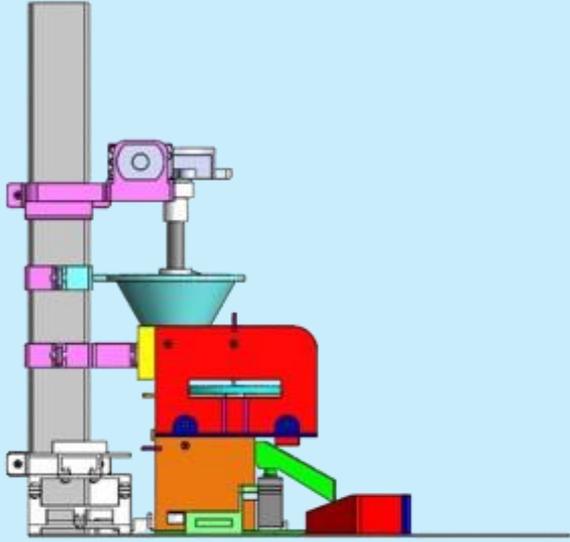
Series 1



Universiti Teknologi MARA  
Pasar Gudang Campus

# Prototype Design and Research Collection

## Series 1



**AHMAD NAJMIE RUSLI**

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# FOREWORD

This digital book on Prototype Design and Research Collection Series 1 (PDRC Series 1), is designed as a comprehensive reference for mechanical engineering students. The designs featured in this collection undergo an extensive analysis process, incorporating both prototype development and research to ensure a thorough understanding of design principles. Each project is carefully analysed before the prototype fabrication with detailed summaries of the project description and design parameters. The design and research products presented in this series cover a wide range of tools and equipment for various applications including household, workshop and entrepreneurial purposes.

This collection aims to foster innovation by offering students valuable insights into both the technical and research aspects of product design. It is hoped that this book will inspire future engineers and designers to approach product development with a deeper understanding of the design and research processes.

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## CHAPTER 16

### Designing and Fabricating Mini Lathe Machine for Low Volume Production

Nik Daniel Haziq bin Nik Azman Abadi <sup>1</sup>, Ab Aziz bin Mohd Yusof <sup>2\*</sup> and Ainaa Maya Munira Ismail <sup>3</sup>

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#### ABSTRACT

This research focuses on developing a compact and cost-effective mini lathe machine capable of producing small and precise components. The bench lathe was chosen for its versatility, ease of use, and suitability for woodworking applications. The design process involved using SolidWorks for modelling, and Finite Element Analysis (FEA) was conducted to assess structural integrity. 1345 Aluminium Alloy was selected for its strength-to-weight ratio and durability. The analysis revealed that the spindle experienced a maximum stress of 7.6 MPa, well below its yield strength of 27.57 MPa, with a Factor of Safety (FoS) of 3.4, ensuring safe operation. The prototype successfully performed cutting, grinding, and turning with minimal difficulties. While it is limited to wood due to motor constraints, it meets all design and fabrication objectives. Regular maintenance is required for long-term functionality. Overall, the mini lathe machine demonstrates efficiency, reliability, and practicality for small-scale applications.

Keywords: Mini Lathe Machine, Design, Fabrication

## 1 INTRODUCTION

Lathe machines are essential tools commonly found in workshops. They rotate a workpiece along a central axis to perform various operations, including cutting, grinding, knurling, drilling, facing, and turning [1]. One particularly popular type of lathe is the bench lathe, valued for its compact size, versatility, and ease of use. Due to its user-friendly design, it is widely employed for educational and training purposes.

Lathe machines generally serve two primary purposes: industrial and artisanal applications. In industrial settings, they are used to manufacture small components for vehicles or large-scale construction parts. Conversely, artisans utilize lathes to shape metal, wood, and plastic, crafting furniture such as tables and chairs [2].

A lathe machine has three main components: the headstock, tailstock, and bed. The headstock is crucial, housing the main spindle, gears, and motor while also holding and rotating the workpiece. Positioned at the opposite end, the tailstock supports the workpiece and can hold taper taps for threading operations. The bed is the machine's foundation, securing both the headstock and tailstock to ensure stability and prevent movement during operation [1, 3].

## **2 LITERATURE REVIEW**

Lathe machines are essential tools in workshops, enabling various machining operations such as cutting, grinding, knurling, drilling, facing, and turning. These machines rotate a workpiece along an axis to achieve precision shaping and finishing. Among the many types available, the bench lathe is particularly popular due to its compact size, versatility, and ease of use, making it an ideal choice for both professional and educational applications.

Lathe machines are generally categorized into industrial and artisanal uses. In industrial settings, they are employed to manufacture small components for vehicles and construction. At the same time, artisans use them to shape metal, wood, and plastic to create furniture and other handcrafted items. The bench lathe, in particular, is a preferred option for small-scale projects due to its user-friendly nature and adaptability.

A standard lathe machine comprises three main components: the headstock, tailstock, and bed. The headstock is critical as it houses the main spindle, gears, and motor while also holding and rotating the workpiece. The tailstock at the opposite end serves as a support mechanism and can also accommodate taper taps for threading. The bed provides structural stability, securing both the headstock and tailstock to prevent movement during operation.

The compact nature of bench lathes makes them an excellent choice for individuals or small workshops that require precision machining on a smaller scale. Their affordability and ease of maintenance further enhance their appeal, making them an indispensable tool for professionals and hobbyists.

## **3 METHODOLOGY**

The figure 1 illustrates the chosen concept sketch for this prototype, specifically depicting the tailstock assembly of the mini lathe machine. The motor will be housed within the motor base, secured by two screws with a diameter of three millimetres. To minimize vibrations, the motor base will be firmly attached to the bed using four screws. Additionally, the motor base will feature an 18.80-millimetre hole through which the spindle will pass.

To protect the motor from wood chips and dust, the motor base will enclose the exposed parts while being securely fastened to the bed with two screws on each side. The two holes at each end will tightly clamp down on the protruding parts of the motor and chuck. As the motor rotates, the coupler will transfer motion to the chuck, ensuring smooth and efficient operation.

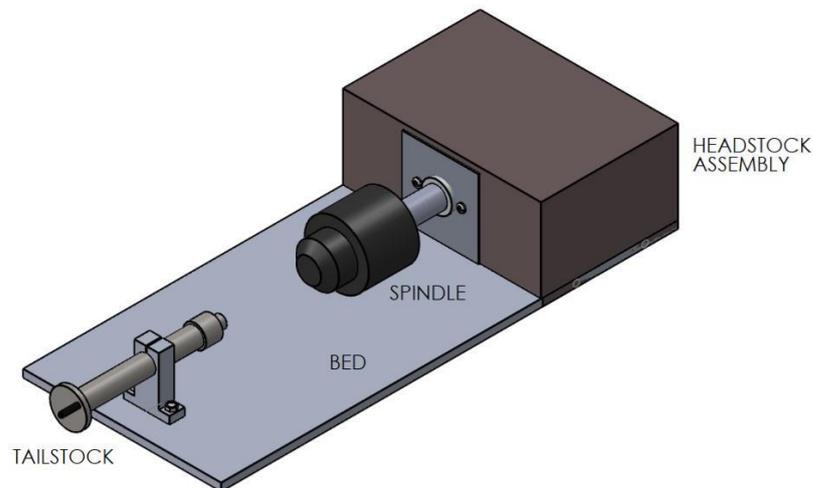


Fig 1: Solidwork design of the machine

The methodology used in this analysis involves Finite Element Analysis (FEA) to assess the mechanical behaviour of the mini lathe machine's components under applied forces. The first step is material selection, where 1345 Aluminum Alloy was chosen due to its high strength-to-weight ratio, corrosion resistance, and ease of machining. The yield strength of the material is 27.57 MPa, while the tensile strength is 82.72 MPa, making it suitable for sustaining mechanical loads.

A linear elastic, isotropic model was applied, and the failure criterion was set using Von Mises Stress Theory, which determines if the component will yield under loading conditions. The spindle was meshed into finite elements, and a 70N force was applied at the tailstock to simulate actual operating conditions.

#### 4 RESULTS AND DISCUSSION

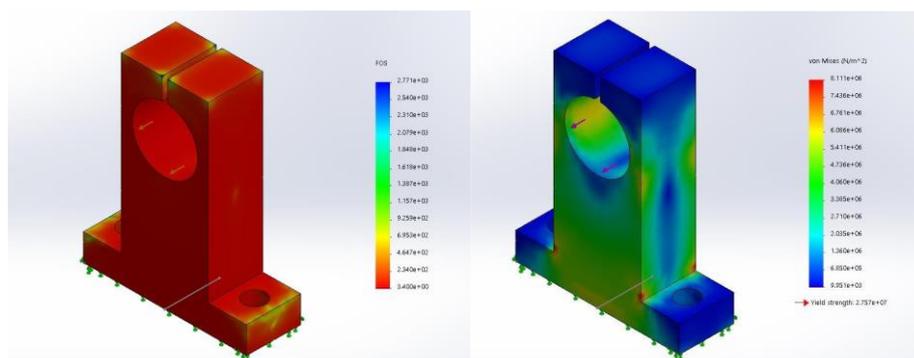


Fig 2.: Stress analysis and Factor of safety analysis of tailstock

The analysis results as in Figure 2 reveal that stress concentration occurs at specific points on the spindle, highlighted in red in the stress distribution plot. The maximum stress recorded was 7.6 MPa, well below the yield strength of 27.57 MPa, ensuring safe operation. Additionally, the Factor of Safety (FoS) was calculated as 3.4, indicating that the spindle can withstand 3.4 times the applied load before failure, equating to 238N. These results confirm that the design is structurally sound and capable of handling the intended operational forces.

However, minor design optimizations could further enhance durability and efficiency.

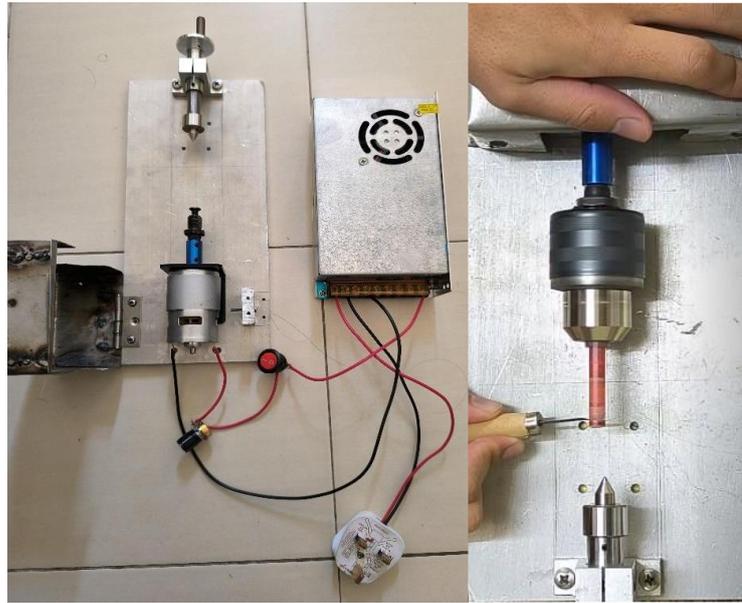


Fig 3.: Assembling the parts and wiring with test the prototype

The prototype successfully meets its intended objectives, demonstrating practical functionality in machining operations as in Figure 3. The motor speed and chisel sharpness enable smooth execution of cutting, grinding, and turning processes with minimal difficulties. The chuck securely clamps the workpiece, ensuring stability and preventing it from slipping or falling out during operation.

Operating the mini lathe machine is straightforward and user-friendly. Since it uses a three-pin plug, it can be connected to any standard electrical outlet available in Malaysia. Once plugged in, the power supply activates, providing energy to the motor. The workpiece is then secured in the chuck and tightened while the tailstock offers additional support at the other end.

The switch is turned on to begin operation, and the motor speed can be adjusted using the potentiometer. As the workpiece rotates, the chisel is applied against it to remove material from the surface, enabling precise cutting, shaping, or finishing as required.

## 5 CONCLUSIONS

This research aimed to develop a compact, cost-effective mini lathe machine capable of producing small, precise components. While the machine's reduced size allows for fine fabrication, it is limited to working with wood due to the motor's insufficient power for metal machining. The project encountered some challenges, particularly in working with stainless steel, which proved difficult to machine. Regular maintenance is required to ensure the machine's longevity, and it is categorized into daily, weekly, and monthly tasks. Despite the challenges, the project successfully met both primary objectives: designing the mini lathe machine using SolidWorks and fabricating the working prototype. The outcome validates the feasibility of a small-scale lathe for woodworking applications.

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