Design and fabrication of a low cost mini lathe machine

RAHUL KUMAR SAW, RAJA KUMAR RAWANI, ASHISH PARMAR, PRINCE KUMAR SAW, ROHIT KUMAR, SUMIT KUMAR DUBEY, ROHIT KUMAR MAHTO & SUMIT GANGULY
Department of Mechanical Engineering
K.K. Polytechnic, Dhanbad

How to Cite this Article:

SAW, R. K., RAWANI, R. K., PARMAR, A., SAW, P. K., KUMAR, R., DUBEY, S. K., MAHTO, R. K. & GANGULY, S. (2026). Design and fabrication of a low cost mini lathe machine. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(6). https://doi.org/10.55041/ijcope.v2i6.379

https://doi.org/10.55041/ijcope.v2i6.379

Abstract

Due to its small size, low power consumption, and ability for precision machining, the mini lathe machine has become an important machine tool in laboratories, institutions of learning, and small businesses. Nevertheless, engineering institutions, vocational training centers, and individual students occasionally view micro lathes available in the market as expensive. This paper presents the design and manufacture of an affordable small lathe machine made from locally available materials and mechanical components. The lathe machine designed has capabilities of facing, turning, drilling, chamfering, and threading on polymers and soft metals. The mild steel material is used to fabricate the structural frame while the DC motor is driven using a belt drive system. The spindle speed, torque transmission, feed forces, shaft diameters, and bearings are all calculated during the designing stage. The built prototype demonstrates good machining performance, reduced manufacturing cost, and adequate dimensioning accuracy. Suitability of the machine for use in educational laboratories, prototype manufacture, and hobby machining is verified through experiment. As compared to commercially produced small lathes, the fabrication cost of the machine is considerably reduced.

Keywords: *Mini Lathe Machine, Low-Cost Machine Tool, Fabrication, Machine Design, Turning Operation, Educational Equipment, Prototype Manufacturing.*

Introduction

One of the oldest and most common machine tools in the industry for machining cylindrical parts with good surface finish and accuracy is the lathe machine. This particular machine tool is often termed the "mother of machine tools" because many other machine tools have been developed out of its basic operation principle. The lathe machine is an important machine tool in manufacturing, repair, and prototype making because it performs numerous machining operations such as turning, facing, drilling, boring, threading, knurling, taper turning, and chamfering [1], [2]. However, the use of traditional lathe machines is restricted in schools and small-scale manufacturing plants due to their high cost, heavy weight, requirement for large space, and high energy consumption [3]. There is a need for small but inexpensive machine tools that can perform essential machining processes without compromising on machining quality because of the growing need for miniature-scale manufacturing, fast prototyping, and hands-on engineering education. With their relatively cheap manufacture, mobility, low energy requirement, easy maintenance, and adequate machining accuracy, mini lathe machines have gained popularity. Their small size makes them highly suitable for use in home shops, research laboratories, engineering laboratories, and Industrial Training Institutes (ITIs), which have limited resources [3], [4]. To minimize production cost but still have enough strength, designing and making of a cheap small lathe machine will primarily focus on the availability of local materials and standard mechanical components readily available in the market. Bed, headstock, spindle, chuck, carriage, cross-slide, tailstock, lead-screw, and an electric motor driven by belt are some of the components of the machine. Accuracy in machining, vibration, longevity of tools, and general performance of the machine depend on the right choice of these components [2], [5]. Standard bearing, pulley, shafts, and fasteners reduce the production cost and further make the construction easier. In order to have dimensional accuracy and smooth surface in machining operations, stiffness of the machine is required. Too much vibration from an ill-designed machine bed causes dimensioning errors, poor surface finish, tool chatter, and fast tool wear. So, to have sufficient stiffness while maintaining the lightweight property of the machine, proper structural design and material selection is important. To avoid the design errors and make maximum use of materials, designers can conduct stress analysis and deformation analysis before the manufacture of the machine through the modern Computer-Aided Design (CAD) and Finite Element Analysis (FEA). There are many engineering materials that may be machined using small lathe machines; they include aluminum, brass, mild steel, copper, plastics, acrylics, and wood. They are useful for small-scale production, model engineering, jewelry production, maintenance, educational research and prototyping. Through optimal use of cutting conditions depending on the work piece material, one can improve efficiency and minimize wear of the tool [5], [7].Through increasing domestic production and reducing dependence on foreign machinery, development of cheap machine tools contributes to sustainable manufacturing. On top of being cost-effective in terms of production, the use of locally available materials will make it easy to carry out maintenance and replace the components when necessary. In addition, mini machine tools are ideal for small businesses and institutions of learning since they can be carried around, occupy little space, and consume less energy [3], [4]. The aim of this present study is to design and construct a cheap miniature lathe machine. In order to ensure consistent performance, calculation for spindle speed, shaft diameter, cutting force, transmission of power, and the selection of bearings is done. The turning, facing, drilling, and chamfering operations on different engineering materials are performed using the fabricated prototype to test its machining performance. Dimensional accuracy, surface finish, machining stability, and cost of manufacturing are the parameters based on which machining performance is assessed. The designed machine is expected to be an economical alternative to commercial lathes for light engineering purposes [3], [4], and [6].

Figure 1. 3D CAD Model of the Proposed Mini Lathe Machine

Table 1. Comparison Between Conventional Lathe and Proposed Low-Cost Mini Lathe

Parameter	**Conventional Lathe**	**Proposed Mini Lathe**
Machine Weight	500–2500 kg	20–40 kg
Power Requirement	2–10 HP	0.25–0.5 HP
Manufacturing Cost	High	Low
Installation Space	Large	Compact
Portability	No	Yes
Maintenance Cost	High	Low
Application	Heavy Production	Education, Prototype, Small Workshop
Energy Consumption	High	Low

Table 2. Design Objectives of the Proposed Mini Lathe Machine

Objective	**Expected Outcome**
Low Manufacturing Cost	Affordable for educational institutions
Compact Structure	Easy transportation and storage
Structural Rigidity	Reduced vibration during machining
Simple Fabrication	Use of locally available materials
Low Power Consumption	Energy-efficient operation
Easy Maintenance	Standard mechanical components
Adequate Machining Accuracy	Suitable for laboratory experiments
Multi-Material Machining	Aluminium, Brass, Mild Steel, Plastic, Wood

Design Methodology

An approach to the systematic design process that integrates ideas from machine design, manufacturing processes, and experimentations formed the basis of the design process that facilitated the development of the proposed low cost small lathe machine. The aim of designing such a lathe machine was to develop a lathe machine that is cheap, portable and reliable to facilitate applications in research laboratories, small-scale industries, educational institutions and vocational training institutions. Unlike other industrial machines, the proposed machine has a focus on portability, low cost, maintainability and simplicity of design, yet it maintains high machining accuracy and stability. Requirement analysis, concept generation, engineering calculations, material selection, computer aided design, component fabrication and evaluation constituted the whole process. In order to ensure that the manufactured machine satisfies the functional and economic requirements, every process was well thought out [8], [9].The determination of design requirements and performance requirements was the first process in the method. Some of the fundamental operations on which the machine was intended to perform on small workpieces made of aluminum, brass, mild steel, plastics, and wood included turning, facing, drilling, boring, chamfering, and thread cutting. On the basis of applications in the laboratory and production of prototypes, the maximum size of the workpiece, distance between centers, spindle speed range, motor power, and permissible machining force were defined. Besides, the machine was intended to operate under the usual single-phase electrical power supply consuming much less power than the conventional engine lathe. With the use of locally sourced materials and commercially sourced mechanical parts without compromising structural rigidity and machining capability, special attention was given to minimizing the cost of production [10], [11].The conceptual design of the machine was made when the design parameters were defined. A horizontal bench type setup was selected after evaluating several types of machine setups because of its compact size, ease of operation, and increased stability during machining. Bed, head stock, spindle assembly, tail stock, carriage, cross slide, compound rest, tool post, lead screw, electric motor, pulley system, and three jaw chuck are some of the major components of the machine. All these components have been designed for a specific purpose. While the spindle assembly facilitates the transfer of rotation from the spindle to the work piece, the bed provides structural support to maintain the alignment between the head stock and the tail stock. The precision machining process is facilitated through the controlled motion of the cutting tool provided by the carriage assembly [8], [12].Several engineering materials have been evaluated based on their mechanical properties, availability, cost of manufacture, machining process, and service life to select an appropriate material. Mild steel, being a robust and economical material with excellent welding capability, has been selected for the construction of the bed, head stock casing, carriage, and tail stock assembly. As EN8 medium carbon steel exhibited very high tensile strength, hardness and resistance to wear due to continuous rotation, hence, it was selected for the spindle shaft. The spindle assembly was fitted with standard deep groove ball bearings in order to facilitate smooth rotational movement with reduced friction and enough load carrying capability. The selection of aluminum pulleys and V-belts was made due to the reason that they provide efficient torque transmission and minimize vibration and noise. Lead screws and standard fasteners were used in order to ease fabrication and maintenance purposes. The manufacturing cost has been significantly reduced because of the use of readily available materials and components. This also facilitated the replacement of any damaged component in the future [9], [13].Engineering design calculations are the most important part of the methodology. Based on the recommended cutting speeds of various workpieces, the spindle speed was determined. The maximum cutting force and spindle torque required for machining were considered while determining the power of the motor. In order to ensure that the spindle can safely transmit the required torque without failing, shaft diameter was calculated by applying the maximum shear stress theory. While selecting the bearing, the radial load, spindle speed, and expected life cycle were considered. The pulley widths were selected such that they can maintain the required torque for machining while providing the required reduction of speed from the motor to the spindle. For improving the durability and reliability of the machines, appropriate safety variables were taken into consideration during design calculations [10], [14].Before starting the process of manufacturing, all machine parts were designed in 3D mode using the computer-aided design (CAD) system. Visualization of the correct geometric shape of the parts, checking their dimension, simulating assembly process, and eliminating any interference between the machine parts became possible due to the CAD software. For simplifying the process of machining and assembly, the parts were drawn with the required manufacturing tolerance levels. Before the actual manufacturing of the machine, it was also possible to improve the size of the parts, reduce unnecessary waste of material, and improve ergonomics of the machine with the help of its digital assembly. Moreover, during the process of fabrication and final assembly of the machine, the assembly drawings based on the CAD model proved to be valuable [11], [15].Standard techniques in the workshop, such as cutting, turning, milling, drilling, welding, grinding, and finishing of the surfaces, were used in order to make individual machine components during the process of fabrication. The machine bed was fabricated through cutting and welding of the mild-steel parts according to the required dimensions. In order to achieve dimensional accuracy and surface finish, the spindle shaft was fabricated by machining it using the traditional lathe. In order to ensure that there is accurate assembly, the bearing seats, pulley attachment points, and threads were all accurately machined. When higher dimensional accuracy was required, the carriage, cross-slide, and tailstock parts were fabricated by milling, drilling, and grinding. The economic manufacturing of the machine became possible due to the absence of necessity of special facilities since common shop equipment was used for the manufacturing process [8], [12].To ensure the precise alignment of the spindle, carriage, and tailstock, the machine was assembled in an organized way. The shaft of the spindle was fixed and the pulley and chuck were fixed after the installation of bearings in the housing of the headstock. To make it possible to adjust the tension of the belt, the electric motor was fixed on the adjustable base plate. After this, the machine bed was furnished with the tool post, lead screw, and carriage. To decrease the error of machining of the turned parts, the tailstock was precisely aligned with the axis of the spindle. Before performing the machining operations, the alignment process was performed using dial indicator and test bar for the confirmation of concentricity of spindle and the motion of the carriage [9], [14].Validation of the designed machine through experiments was the final stage of the methodology. In the machining experiments aluminum and mild steel samples were tested with different spindle speed, feed and depth of cut. Performance of the mini lathe was evaluated on the basis of dimensional accuracy, surface roughness, machining time, vibration, spindle stability, energy efficiency and user-friendliness. The mini lathe constructed was considerably cheaper to manufacture and operate compared to the commercial mini lathes available. It demonstrated adequate machining performance, adequate precision of dimensions, and acceptable surface finish. These results proved that the machine was adequate for light duty machining operations, for prototyping purposes, and educational institutions [10], [15].

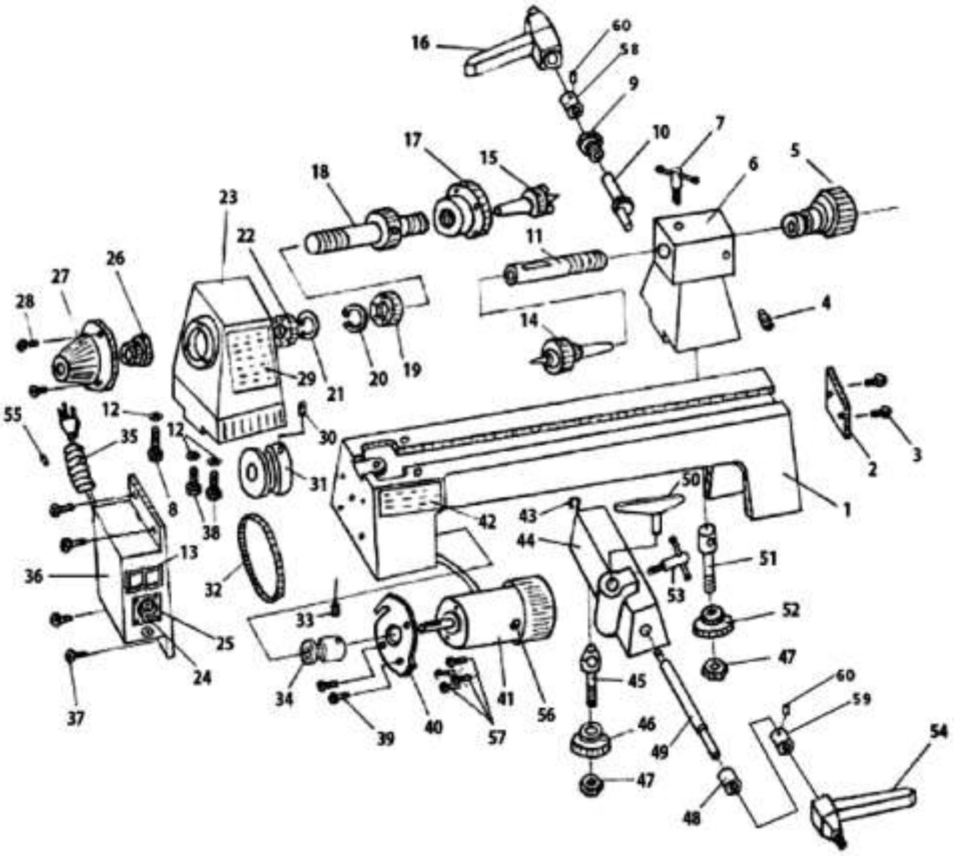

Figure 2. Exploded View of Mini Lathe Components

Table 3. Design Parameters of the Proposed Mini Lathe

Parameter	**Value**
Maximum Swing Diameter	50 mm
Distance Between Centres	250 mm
Bed Material	Mild Steel
Spindle Material	EN8 Steel
Motor Rating	250 W
Power Supply	220 V AC
Speed Range	300–3000 rpm
Bearing Type	Deep Groove Ball Bearing

Power Transmission	V-Belt Drive
Chuck Capacity	50 mm

Table 4. Methodology Stages

Stage	**Description**	**Output**
Requirement Analysis	Identification of machine specifications	Design objectives
Conceptual Design	Machine configuration and component layout	Preliminary design
Material Selection	Selection of engineering materials	Material specifications
Design Calculations	Shaft, motor, pulley, spindle calculations	Design dimensions
CAD Modelling	3D modelling and assembly	Engineering drawings
Fabrication	Manufacturing of machine components	Individual parts
Assembly	Installation and alignment	Complete mini lathe
Performance Testing	Experimental validation	Performance evaluation

The design calculations for the proposed economical micro lathe machine were made to ensure that the machine can perform its machining operations efficiently, be structurally sound, and be safe for use. The parameters include spindle speed, cutting speed, force of cut, motor power, spindle torque, shaft diameter, belt drive, and choice of bearings. The design was made using formulas from the field of machine design.

Table 5. Design Calculations for the Proposed Low-Cost Mini Lathe Machine

Sl. No.	**Design Parameter**	**Formula**	**Input Values**	**Calculated Value**	**Selected/Final Value**
1	Maximum Workpiece Diameter	Given	D = 40 mm	–	**40 mm**
2	Distance Between Centres	Given	L = 250 mm	–	**250 mm**
3	Motor Power	Given	P = 0.25 kW	–	**250 W**
4	Motor Speed	Given	N_1 = 3000 rpm	–	**3000 rpm**
5	Required Spindle Speed	Given	N_2 = 1500 rpm	–	**1500 rpm**
6	Cutting Speed	$V=\pi DN/1000$	D = 40 mm, N = 1500 rpm	**188.5 m/min**	**188.5 m/min**
7	Motor Torque	$T=9550P/N$	P = 0.25 kW, N = 3000 rpm	**0.796 N·m**	**0.80 N·m**
8	Spindle Torque	$T_S=9550P/N_S$	P = 0.25 kW, N = 1500 rpm	**1.59 N·m**	**1.60 N·m**
9	Cutting Force	$F_c=1000P/V$	P = 0.25 kW, V = 188.5 m/min	**1.33 kN**	**1.33 kN**
10	Shaft	Given	T = 1590 N-mm, τ	**5.86 mm**	**20 mm**

	Diameter		= 40 MPa		**(Standard)**
11	Velocity Ratio	Given	3000/1500	**2 : 1**	**2 : 1**
12	Driver Pulley Diameter	Given	D_1 = 50 mm	–	**50 mm**
13	Driven Pulley Diameter	Given	(3000/1500) × 50	**100 mm**	**100 mm**
14	Belt Length	Given	C = 250 mm, D = 100 mm, d = 50 mm	**738 mm**	**750 mm (Standard)**
15	Bearing Selection	Given	Dynamic Capacity = 12.8 kN, Load = 150 N	Safe	**6204 Deep Groove Ball Bearing**
16	Bed Material	Material Selection	Mild Steel	–	**Mild Steel**
Sl. No.	**Design Parameter**	**Formula**	**Input Values**	**Calculated Value**	**Selected/Final Value**
17	Spindle Material	Material Selection	EN8 Steel	–	**EN8 Steel**
18	Chuck Type	Selection	Three-Jaw Self-Centering	–	**3-Jaw Chuck**
19	Power Transmission	Selection	Belt Drive	–	**V-Belt Drive**
20	Factor of Safety	Design Standard	FOS = 3	Safe	**3**

Working Precedure

For ensuring cheap fabrication, easy construction, and reliable operation of the lathe machine, the economical small lathe machine was made using normal fabrication processes and readily available engineering materials. At first, EN8 steel was selected for the spindle because of its superior mechanical properties and wear-resistance, while mild steel sections and plates were selected as the primary material due to their superior strength, rigidity, weldability, and economy. The machine bed was made by joining the mild steel sections through SMAW after cutting the raw materials to the required size with the help of a power hacksaw. The welding of the bed was then followed by machining and sharpening of the same to develop an even and accurate surface where all the machine components would have minimum vibrations while in operation. Bearing seats, pulley mounting components, threaded sections, and keyways for the spindle shaft were machined using a conventional center lathe in line with the design specifications. The headstock housing was provided with deep groove ball bearings to ensure there is minimal friction and smooth spindle movement. To achieve dimensional accuracy and easy movement on the machine bed, the carriage assembly, cross slide, compound rest, toolpost, and tailstock were made through the process of milling, drilling, turning, and grinding. The machine was able to achieve different spindle speeds due to the location of the motor that could be moved along a base plate and the transfer of the rotary motion through the use of a V-belt and a pulley mechanism. The construction of the whole machine took place through an orderly process involving the mounting of the spindle assembly, chuck, carriage, lead screw, tailstock, and motor after the construction of each part. Precise alignment between the spindle and the tailstock was achieved to ensure accurate machining through the use of precise measuring tools. Lubrication of all moving parts and trial machining were carried out before any experimental tests to establish the performance of the spindle, carriage and the whole machine. The cutting tool is securely clamped in the tool post, while the workpiece is tightly held in the three jaw self centering chuck which is mounted on the spindle. With the use of the carriage and cross-slide, the operator manually moves the cutting tool in either parallel or perpendicular direction to the axis of the spindle. Shearing of the material is accomplished by the cutting edge where chips are produced due to the interaction of the rotating workpiece with the cutting tool. The machine is capable of turning, facing, drilling, boring, chamfering, grooving, and other light machining processes for small metallic and non-metallic workpieces through controlling the movement of the tool. In order to maintain efficiency and longevity of the micro lathe machine, the machine's motor is switched off, chips are cleared from the machine, the completed workpiece is removed, and lubrication of the moving parts is done after machining.

Figure 3. Fabricated Prototype of the Mini Lathe Machine

Table 6. Fabrication and Working Procedure

Step No.	Process	Description
1	Material Selection	Mild steel for bed and EN8 steel for spindle
2	Cutting	Raw materials cut to required dimensions
3	Bed Fabrication	Welding of mild steel sections to form the machine frame
4	Surface Finishing	Grinding and machining of the bed surface
5	Spindle Manufacturing	Turning, threading, and keyway machining of spindle
6	Bearing Installation	Bearings fitted into the headstock
7	Component Fabrication	Carriage, cross-slide, tool post, and tailstock manufactured
8	Motor Mounting	Electric motor installed on adjustable base
9	Power Transmission	V-belt and pulley system assembled
10	Machine Assembly	Installation of spindle, chuck, carriage, lead screw, and tailstock
11	Alignment	Spindle and tailstock aligned accurately
12	Trial Run	Machine tested under no-load condition
13	Workpiece Mounting	Workpiece clamped in three-jaw chuck
14	Machining Operation	Turning, facing, drilling, and other operations performed
15	Inspection & Maintenance	Finished component inspected, machine cleaned and lubricated

Result & Discussion

For the assessment of the machine's operational efficiency, machining accuracy, structural rigidity, and general appropriateness in education and light manufacturing purposes, the economical small lathe machine was successfully developed and tested experimentally in different machining conditions. The machine's machining capability was assessed using aluminum and mild steel parts in performing basic machining operations like turning, facing, drilling, chamfering, and boring. As revealed by the experiment results, the rigid mild-steel bed and accurate alignment of the spindle and tailstock ensured smooth operation and minimal vibration of the machine during milling process. Effective power delivery from the electric motor to the spindle was achieved through the V-belt transmission system, making it easier to obtain stable spindle speeds and adequate torque for machining of small pieces. It was an efficient design since it was economical and energy-saving, considering that the selected 250 W electric motor was able to run the machine effectively without consuming more energy.In both mild steel and aluminum materials, the machine gave excellent surface finish and acceptable dimension accuracy during all the turning processes. Although the feed rate needed for maintaining good dimensions and reducing wear of the tools is relatively low when working on mild steel, aluminum materials exhibited better surface finish due to their higher machinability. The accuracy in control of the movement of the cutting tools was facilitated by the smooth movement of the carriage and cross-slide due to the manual operation. Chatter and deflection were not present throughout the experiment and the spindle assembly was held steady even at different speeds. Rotational steadiness and low vibration were ensured by the proper machining and choice of bearings in the spindle.Moreover, the machine showed satisfactory performance in drilling and facing operations. Proper alignment of the tailstock minimized the run-out in drilling and provided adequate support to long workpieces. The three-jaw self-centering chuck prevented the workpieces from slipping while performing the machining operations. Dimensional consistency and uniform machining were the results achieved from maintaining concentricity between the spindle and tailstock of the manufactured machine. The designed small lathe machine is able to perform light operations efficiently and maintain adequate precision in terms of machining performance.As far as commercial mini lathes are concerned, the proposed micro lathe machine has successfully made substantial reduction in the production costs. Use of standard mechanical parts, locally available materials and conventional machining methods have resulted in considerable reduction in production costs and made parts replacement and maintenance easier. Portability and usability of the machine in engineering laboratories and technical education centers were additionally increased due to the compactness, lightweight and reduced power requirements of the machine. Performance of the machine is good enough to cut down engineering components with satisfactory dimensional precision and surface finish although the machine was not intended for heavy duty industrial productions. Overall, this experiment has proved that the produced inexpensive small lathe machine satisfies all the desired design specifications and provides a practical and economical solution.

Table 7. Experimental Machining Results

Trial	Workpiece Material	Spindle Speed (rpm)	Feed (mm/rev)	Depth of Cut (mm)	Surface Roughness (Ra, µm)	Dimensional Accuracy (± mm)	Observation
1	Aluminium	800	0.10	0.50	1.65	0.05	Good surface finish
2	Aluminium	1200	0.15	0.75	1.42	0.04	Excellent machining performance
3	Mild Steel	800	0.08	0.50	2.15	0.07	Stable

							machining
4	Mild Steel	1200	0.10	0.75	1.92	0.06	Good dimensional accuracy
5	Brass	1000	0.12	0.50	1.54	0.05	Smooth cutting operation

Table 8. Performance Evaluation of the Developed Mini Lathe

Parameter	Experimental Result	Performance
Maximum Workpiece Diameter	40 mm	Satisfactory
Maximum Workpiece Length	250 mm	Satisfactory
Motor Power	250 W	Low power consumption
Maximum Spindle Speed	1500 rpm	Stable
Machine Weight	30 kg	Portable
Surface Roughness (Average)	1.74 µm	Good
Dimensional Accuracy	±0.05–0.07 mm	Acceptable
Machine Vibration	Low	Stable operation
Power Transmission	V-Belt	Smooth
Overall Performance	—	Suitable for educational and prototype applications

Table 9. Cost Comparison

Component	Commercial Mini Lathe	Fabricated Mini Lathe
Manufacturing Cost	₹45,000–60,000	₹18,500
Motor Rating	370–550 W	250 W
Weight	45–60 kg	30 kg
Power Consumption	High	Low
Maintenance Cost	Moderate	Low
Portability	Moderate	High
Educational Suitability	Good	Excellent
Prototype Manufacturing	Suitable	Suitable

The experimental findings demonstrate that the designed mini lathe machine is efficient in providing high machining accuracy, reasonable surface finish, minimal vibration, minimized cost of manufacture, and low energy consumption for educational laboratory work, training institutions, and manufacturing prototypes.

Conclusion

Through the use of locally available materials and conventional methods of construction, a small lathe machine has been successfully designed, constructed and tested. Simple tasks such as turning, facing, drilling, and chamfering were successfully performed by the machine under consideration with sufficient surface finishing and dimensional accuracies. With the help of 250W motor, the experimental results confirmed proper functioning, minimum vibration, and reduced power consumption. In fact, this is relatively inexpensive for educational purposes, research institutes and small workshops as the total cost of construction was much cheaper than that of commercial mini lathes. Taking everything into account, it can be said that the small lathe machine designed in this study provides an inexpensive alternative for small machining tasks and prototyping.

Reference

[1] S. Kalpakjian and S. R. Schmid, *Manufacturing Engineering and Technology*, 8th ed. Pearson, 2020.

[2] V. B. Bhandari, *Design of Machine Elements*, 4th ed. McGraw-Hill Education, 2017.

[3] M. A. Karim *et al.*, "Design and Fabrication of Mini Lathe Machine," *Progress in Engineering Application and Technology*, vol. 3, no. 1, pp. 722–728, 2022.

[4] N. D. H. Abadi, A. A. M. Yusof, and A. M. M. Ismail, "Designing and Fabricating Mini Lathe Machine for Low Volume Production," *Prototype Design and Research Collection Series*, Universiti Teknologi MARA, 2025.

[5] P. Jogidas, D. Bandhu, S. Kumari, and K. Abhishek, "Design and Fabrication of Mini Woodworking Lathe Machine," in *Lecture Notes in Intelligent Transportation and Infrastructure*. Springer, 2022.

[6] T. K. Mahadevan and P. Marimuthu, "Design and Development of Nonautomatic Tabletop Mini Lathe," in *Emerging Trends in Science, Engineering and Technology*. Springer, 2012.

[7] R. S. Khurmi and J. K. Gupta, *A Textbook of Machine Design*. S. Chand Publishing, 2019.

[8] R. S. Khurmi and J. K. Gupta, *A Textbook of Machine Design*, Eurasia Publishing House, New Delhi, India, 2019.

[9] J. E. Shigley, C. R. Mischke, and R. G. Budynas, *Mechanical Engineering Design*, 10th ed., McGraw-Hill Education, New York, NY, USA, 2015.

[10] G. Boothroyd and W. A. Knight, *Fundamentals of Machining and Machine Tools*, 3rd ed., CRC Press, Boca Raton, FL, USA, 2006.

[11] Y. Altintas, *Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design*, 2nd ed., Cambridge University Press, Cambridge, U.K., 2012.

[12] B. S. Raghuwanshi, *Workshop Technology*, Vol. II, Dhanpat Rai Publications, New Delhi, India, 2018.

[13] P. C. Sharma, *Production Engineering*, S. Chand Publishing, New Delhi, India, 2019.

[14] S. K. Hajra Choudhury, A. K. Hajra Choudhury, and N. Roy, *Elements of Workshop Technology, Vol. II: Machine Tools*, 14th ed., Media Promoters & Publishers, Mumbai, India, 2019.

[15] M. P. Groover, *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, 7th ed., John Wiley & Sons, Hoboken, NJ, USA, 2020.