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# Development of a Mini Laboratory Wood Lathe Machine using Locally Sourced Materials

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**ABSTRACT**

*This work is aimed at producing a functional portable wood lathe machine. This type of lathe is capable of creating different wood designs using the cheapest available materials and easy technology. Analysis of different component parts of the machine were carried out to determine their strength, stress, dimensions and suitable materials. The design of portable mini wood machine was done with Auto desk inventor. Selection of standard parts were made before manufacturing and assembly of component parts. The mini wood lathe is a portable machine of dimension 1150 mm × 300 mm × 40 mm. Available local materials utilized. The machine was fabricated to hold the work piece and move the tool in sliding mechanism. The parts were assembled and the machine performance was evaluated.*



## 1. INTRODUCTION

Lathe machine is the most versatile machine use in the engineering workshop to achieve various operations ranging from turning, facing, threading, sanding, knurling, drilling, or deformation such as metal spinning with tools that are applied to the work piece to create an object which has symmetry about an axis of rotation (Parmar *et al*., 2014a). Roy and Kumar (2013) reported that, lathe machines are manufactured in various types, such as precision work lathe, bench and huge lathes for turning of large steel shafts. The advent of technological advancement in the manufacturing industry has demanded for greater research in the development of wood lathe machine (Moses and Ashok 2015). Wood lathe machine is a type of machine that was introduced to reduce human stress in getting various wooden design and models done at the carpentry shop (Mahajan *et al*., 2018).

Wood lathe is a portable machine with the body made of iron and metal sheet material for rigidity and strength. It is commonly used for machining wooden or plastic work pieces (Griffiths, 2017; Mahajan *et al*., 2018). There has been an increase in need of various wooden designs for likes of interior decoration, furniture making, and the designs of other wood equipment (Lizarralde *et al*, 2009). With these, all designers want to be unique in their choice of design and model, so instead of going the old way of carving with knife and other stressful ways or probably using other bigger machines which would definitely take more time and possibly more expensive getting a mini wood lathe machine would help in getting the jobs done faster and easier (Lizarralde *et al*, 2009; Roy and Kumar, 2013).

Wood turning lathes do not have cross-slides, but rather have banjos which are flat pieces that sit crosswise on the bed. The position of a banjo can be adjusted by hand; no gearing is involved. Ascending vertically from the banjo is a tool-post, at the top of which is a horizontal tool-rest. In woodturning, hand tools are braced against the tool rest and levered into the work piece (Parmar *et al*., 2014b). The aim of this work is to develop a wood mini lathe machine using locally sourced materials and evaluate its performance.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The components parts of the machine that were bought in the open market were sourced locally at the metal and steel market in Akure and Lagos, Nigeria. While other fabricated components were undertaken at the central workshop, Federal University of Technology, Akure, Nigeria. The machine was designed using Auto Desk inventor according to Waiyagan and Bohez, (2005). It is made up of headstock, chuck, tool post, carriage, electric motor, cross slide and tailstock resting on the bed frame.

### 2.2. Materials Selection

Different materials were selected for the various components of the implement. The selection was based on number of factors such as impact forces, operation of the components and the surface reaction of the material selected. Table 1 shows the various implement components and the material selected, the most appropriate material and the available material used. The reasons for using the material were also indicated.

Table 1: Materials selection for machine components

| Implement component | Criterial for selection | Most suitable material | Material actually selected |
|---|---|---|---|
| Bed frame | Malleability, weldability, rigidity, availability, cost | Mild steel | Mild steel |
| Tail stock | Malleability, weldability, availability. | Mild steel | Mild steel |
| Carriage | Malleability, availability, weldability, cost, rigidity | Mild steel | Mild steel |
| Head stock | Malleability, availability, weldability | Mild steel | Mild steel |
| Shaft | High tensile strength, wear resistance | High carbon steel | High carbon steel |

### 2.3. Description of the Machine

The mini wood lathe machine is a table machine and it consists of bed which provides support and sit for other components and head stock. The head stock provides power for the lathe operation by transmitting electrical power to rotational power. In between the headstock and the tailstock is the tool carriage. The tool carriage provides balance and support for working tools for whatever operation (the choice of tools used depend on the type of operation been perform by the machine user). The tail stock is the other end of the bed. It also provides supports for the work piece as it rotates cylindrical pattern. Figure 1 shows the exploded view; Figure 2 shows the isometric view while Figure 3 shows the orthographic view of the mini laboratory wood lathe machine.

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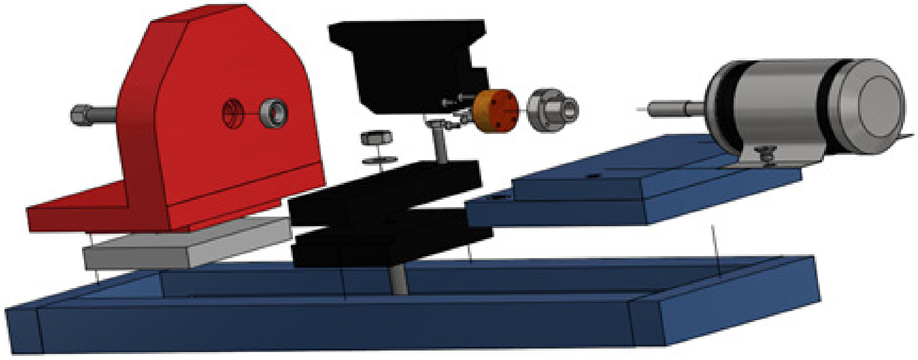


Figure 1: Exploded view of the mini laboratory wood lathe machine

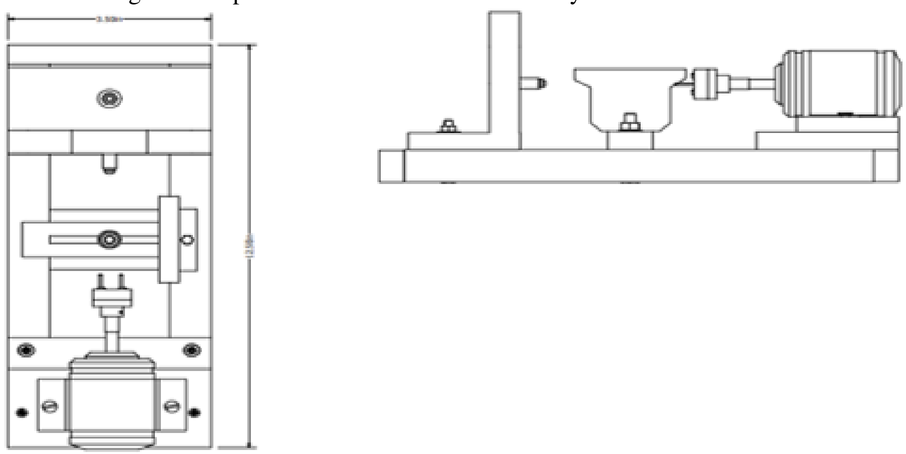


Figure 2: Orhtogonal view of mini laboratory wood lathe machine

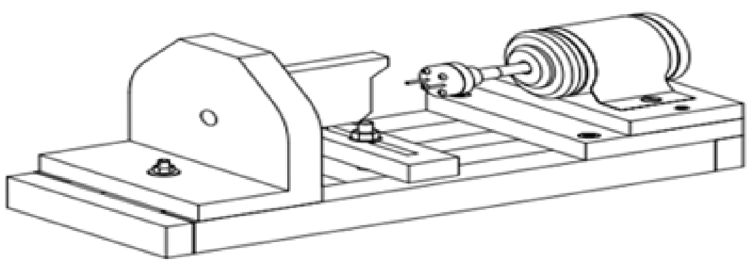


Figure 3: Isometric view of mini laboratory wood lathe machine

**2.4. Design Specifications and Fabrication of Components**

Fabrication of the component involved the forging and construction of the component that makes up the machine. The machine is made up of headstock, chuck, tool post, carriage, electric motor, cross slide and tailstock resting on the bed. The design parameters considered for each of the fabricated components are specified and discussed in the following.

**2.4.1. Bed frame**

The bed provides sit for other components and support the head stock, carriage, tailstock and other components of the lathe machine. It is made of angle iron. It is made to be rigid enough to provide a good damping for the lathe during operation. The size of the bed is determined as follow.

Length of the bed (L) = 1150 mm

Width of the bed (B) = 300 mm.

Height of bed (H) = 40 mm.

The volume of bed was determined using Equation 1 as follows:

$$V = L \times B \times H \quad (1)$$

$$= 1.38 \times 10^7 \text{ mm}^3$$

**2.4.2. Head stock**

The head stock houses electric motor and other components including chuck. Headstock is made of mild steel plate with thickness of 6 mm. With the aid of steel rule and scriber, the correct measurements of the selected mild steel were marked and cut out using cutting disc and then welded as shown in Figure 4. It is square in shape of 100 mm by 100 mm. It has a circular hole at the centre of one side to provide space for the shaft holding the spindle from the electric motor. The area of the head stock was determined using Equation 2.

$$A = L \times B \quad (2)$$

Where, L = Length of the headstock

B = Breadth of the headstock

L= 320 mm, B = 280 mm

Using Equation 2, the area of the head stock was determined as $A = 8.96 \times 10^4$ mm$^2$.

Figure 4: Head stock frame

Figure 5: The tail stock

Figure 6: Carraige mechanism during construction

**2.4.3. Tail stock**

The tail stock is made of 10 mm thickness iron sheet and its oval in shape. It is used as support for circular work and has at the middle a pointed-like shaft with the pointed mouth for holding work piece. The dead centre rotates with the workpiece to avoid friction. It can also be adjusted for alignment and firm support. Figure 5 shows the tail stock after construction.

**2.4.4. Carriage**

The carriage is mounted on the outer guide ways of the lathe bed and it can move in a direction parallel to the spindle axis (Figure 6). The lower part of the carriage is termed the apron in which there are gears to constitute apron mechanism for adjusting the direction of the feed using clutch mechanism and the split half nut for automatic feed. The cross-slide is basically mounted on the carriage, which generally travels at right angles to the spindle axis.

**2.4.5. Chuck**

Chuck is the device for holding and rotating of the job in the lathe machine. It is attached to the head stock spindle. It is short, objects of irregular shapes, hol1ow objects, and cylindrical objects that cannot be mounted conveniently between centers, and are rigidly held in the chuck.

**2.4.6. Electric motor**

Electric motor of 1 hp was selected because of the required power. Since the major operation on the lathe machine is turning, reduced or low speed electric motor is required. The specifications of the selected electric motor are as follow (Mahajan *et al.,* 2018).

Weight of electric motor = 2.2 kg

Power rating = 1 hp (750 W)

Speed = 1440 (or 2880) rpm

**2.5. Calculation of Turning Operations on the Machine**

The cutting speed of a tool is the speed at which the metal is removed by the tool from the work piece. In a lathe, it is the peripheral speed of the work past the cutting tool expressed in meters per minute. Cutting speed is calculated according to Equation 3 (Khurmi and Gupta, 2005).

$$\text{Cutting Speed} = \frac{\pi d n}{1000} \quad (3)$$

Where d = diameter of the workpiece surface and n = speed in revolution per minute of the work

The depth of cut (t) is the perpendicular distance measured from the machined surface to the uncut surface of the workpiece (Equation 4) (Khurmi and Gupta, 2005).

$$\text{Depth of Cutting} = \frac{d_2 - d_2}{2} \quad (4)$$

Where $d_1$ = diameter of the workpiece surface before machining, $d_2$ = diameter of the machined surface.

Machine time is the time taken for whole machining operation was calculated using the formula as presented in Equation 5.

$$\text{Machine time} = \frac{l}{s \times n} \quad (5)$$

Where s = feed of the job per revolution expressed in mm and l = length of the job in mm

**2.6. Assembling of the Components**

All the components were carefully assembled to form the mini wood lathe machine. The machine was produced by cutting the frame to required shape and size, angle iron was welded to its sides to hold it firmly.

The carriage, tailstock, and headstock were fastening using the bolts and nuts to the bed frame of 1150 mm × 300 mm × 40 mm size. The carriage is made to be adjustable in respect of the size of the work piece. The tool carriage provides platform for the operation of the lathe machine tools. The tail stock is also made to be adjustable to provide balance and support for the working. The chuck is attached to the motor shaft and hold firmly by the spindle. The chuck also provides grip of the work piece for turning operation and make the work piece fit for the tool to work upon. The headstock is electrically powered with electric motor.

## 3. RESULTS AND DISCUSSION

### 3.1. Fabricated Machine

Mini laboratory wood lathe machine was developed and fabricated as shown in Figure 7. When performing various machining operations in the mini wood lathe, the job is held and driven by chuck with the other end supported on the tail stock centre.

Figure 7: Unloaded mini wood lathe machine

### 3.2. Turning Operations

It is an operation by which excess materials are removed from the workpiece to produce a cylindrical surface or a conical shaped object. In turning process, the work piece is supported in between the head stock and tail stock and metal is removed by tool, proving feed parallel to axis of rotation of job (Gomes *et al*, 2011). Figure 8 shows the schematic diagram of turning and tapering on the mini wood lathe.

### 3.3. Drilling Operations

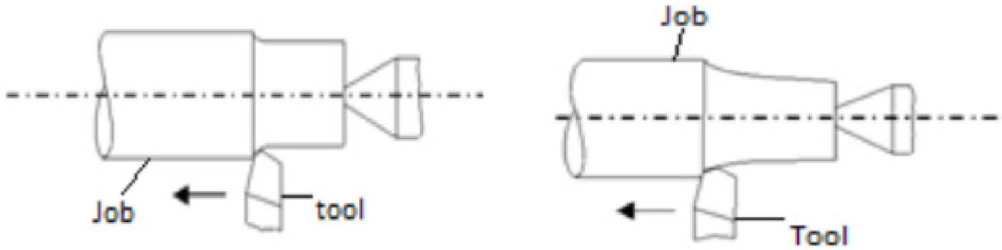
Drilling operation is achieved by removing a volume of metal from the job by cutting tool called drill bit (Figure 9). Drilling process is done by fixing the job or work piece in the chuck and the drill bit is in tail stock, but in mini lathe the drill bit is fixed in chuck and the work piece is fixed in tail stock.

### 3.4. Chamfering Operations

Chamfering is done by a form tool having angle equal to chamfer which is generally kept at 45$^o$ (Figure 10).

### 3.5. Grove Cutting Operations

Groove cutting on the mini-lathe machine is a multi-steps machining operation (Figure 11). It is a process of forming a narrow cavity of a certain depth on a cylinder, cone or a face of the part. The groove takes the shape of the cutting tool. Figure 12 shows the operation of the wood mini lathe machine when loaded for operation.




(a) (b)

Figure 8: (a) Turning on mini wood lathe (b) Taper turning on mini wood lathe


Figure 9: Drilling on mini lathe

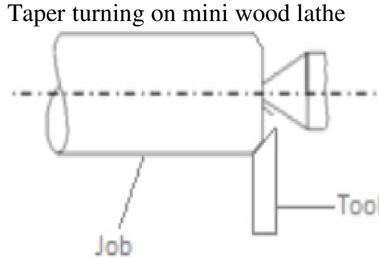



Figure 10: Chamfering on the mini wood lathe

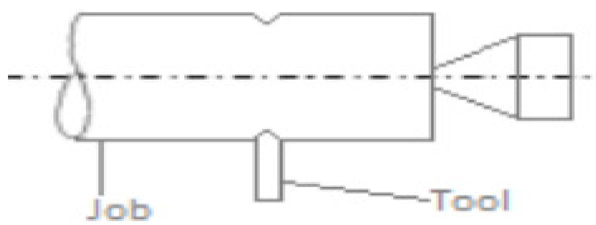



Figure 11: Groove cutting on the mini wood lathe

Figure 12: Loaded mini laboratory wood lathe machine with wood for operation

## 4. CONCLUSION

The mini wood lathe machine was developed and fabricated. The part it is powered by electricity and generates turning moment by electric motor giving space for tools to work on the work piece. It reduces human effort compare to manual method or way of doing carpentry work.

## 5. ACKNOWLEDGMENT

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## 6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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