Review Paper on Lathe Machine Components and It's Application

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Abstract - *The lathe, probably one of the earliest machine tools, is one of the most versatile and widely used machine tool, so also known as mother machine tool [1]. It is the most essential machine tool in an engineering workshop for performing various operations on workpieces as required by the machinist. In this research paper, we have explained the working parts such as Spindle, Tailstock, Carriage, Chuck and Jaws of lathe machine as well as our study on concept of work-holding accuracy and applications of lathe machine in industry.*

***Key Words*: Lathe, Carriage, Chuck, Tools, Spindle, Jaws, Work-Holding**

1. INTRODUCTION

A lathe is a machine commonly used to cut metal or wood. It works by rotating the workpiece against a stationary tool which provides cutting action. The primary application of the lathe is to get rid of undesirable parts of material and form the required shape and size. The job to be machined is held and rotated in a lathe chuck; a cutting tool is advanced which is stationary against the rotating job. Since the cutting tool material is harder than the work piece, the metal is easily removed from the job[1]. A feed refers to the tool's motion in one direction. People have used lathes to make components for different machinery, in addition to forte gadgets like bowls and musical instruments. Whatever the sort and function, all of them perform the use of this simple hold and rotating mechanism. Some of the common operations performed on a lathe are facing, turning, drilling, threading, knurling, and boring etc. [1]

The basic structure of a machine tool consists of base and column arrangement which serves as a balancing support for the entire machine. Here, depending on the machining process, the tool is fixed in the tool post and the work piece is held on the chuck of a typical lathe structure. The relative motion is achieved by movements parallel to the three spatial axes. This is achieved by means of linear guide ways and bearings, axial movements along the screws, rack and pinion arrangements etc. The machine is built of heavy steel and iron parts. The base of the machine is rigid and usually is of cast iron.[5].

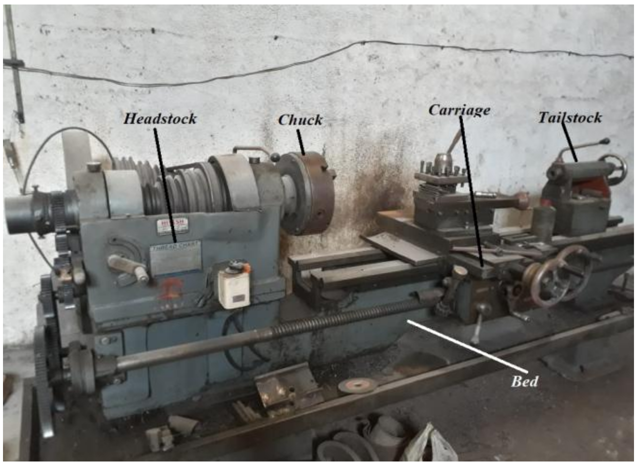

Fig -1: Basic Structure Of A Lathe

1.1 History

Since the Egyptians, lathes have existed in some form. Consider the similarities to the pottery wheel: thrown pottery has been around for thousands of years, so it's only natural that lathes, which operate on the same principle but with a workpiece moving against a stationary cutting tool, would follow.

The most basic lathes permitted workers to remove materials by hand. Metal and wood lathes became more technologically advanced throughout time, eventually evolving into machine tools with integral heads. Each head was mounted on cross-slides that ran the length of the lathe bed and were used to rotate the workpiece.

Basic lathes were used for precision metalworking until the introduction of the engine lathe, which used an automated feed to the cutting tool. Even back then, each lathe was different, but the process was the same. Engine lathes aided in the birth of the Industrial Revolution, which saw the introduction of steam-powered lathes capable of higher rotation rates and torque, allowing for the spinning of heavier parts. Lathes had evolved into heavy-duty machining machines. The lathe machine, like the milling machine, simplified the machining process as they became more advanced. With the introduction of Computer Numerical Control in the second half of the twentieth century, the next significant leap forward was made (CNC). Operators might programme a set of instructions for each machine tool using

CNC-equipped lathes. This enabled for exact repetition of those instructions, resulting in increasingly accurate components and a reduction in the number of workers required to keep each machining tool running at the same time. Today's technology allows for more precise CNC programming with an ever-increasing number of axes.

2. COMPONENTS

The essential components of a lathe are the bed, headstock, tailstock, spindles, carriage, chuck, tool holder and motor.

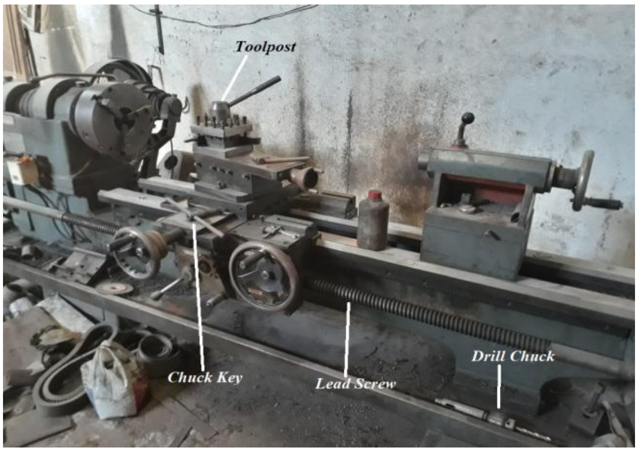

Fig -2: Components

2.1 Bed

The bed is made up of two heavy metal slides that run lengthwise and have ways or 'V' created on them that are rigidly held by cross girths. It is the lathe's foundation and one of the criteria that determines the piece's size. That is, the maximum diameter limit is determined by the distance between the main spindle and the bed. It has three main uses:

- It is suitably stiff and has a high damping capability for vibration absorption.
- It prevents the cutting forces from causing deflection.
- It supports the lathe machine's headstock, tailstock, carriage, and other components

2.2 Headstock

The principal action takes place on the headstock. This is where the motor's power is transferred to the workpiece. The drive mechanism and electrical mechanism of a Lathe machine tool are housed in the Head Stock, which is located on the left side of the lathe bed. The work is held in place by the spindle nose, which has external screw threads and an internal Morse taper for retaining the lathe centre. It rotates at a varied speed thanks to a cone pulley or an all-geared drive. A hole runs the length of the spindle to accommodate long bar work. The feed rod, lead screw, and thread cutting mechanism all receive power from the spindle via the Head Stock.

Fig -3: Headstock

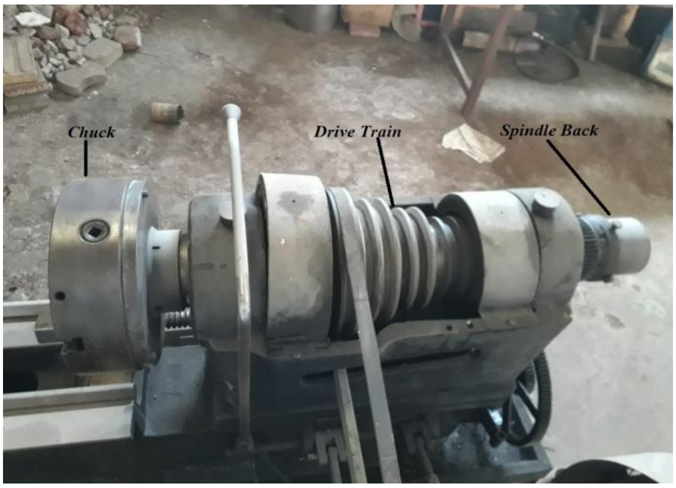

Fig -4: Headstock Top View

Fig -5: Motor And Drive behind Headstock

Below the headstock is a separate speed change gearbox that reduces the speed so that variable feed rates for threading and automatic carriage lateral movement can be achieved. Most turning activities are performed with the feed rod, while thread cutting operations are performed with the lead screw.

2.3 Spindle

The machine tool spindle provides the relative motion between the cutting tool and the workpiece which is necessary to perform a material removal operation. In turning, it is the physical link between the machine tool structure and the workpiece, while in processes like milling, drilling or grinding, it links the structure and the cutting tool. The spindle is supported by two bearings separated by different spans.[5] The cylindrical work piece is held in this portion of the lathe machine. Different attachments and accessories can be added to the spindles, including the rotating main spindle that holds the workpiece. The primary spindle is generally hollow and threaded on the outside to accommodate these fittings. Centre's, chucks, and faceplates are all helpful attachments for the main spindle. These can be used to position and hold the workpiece in place.

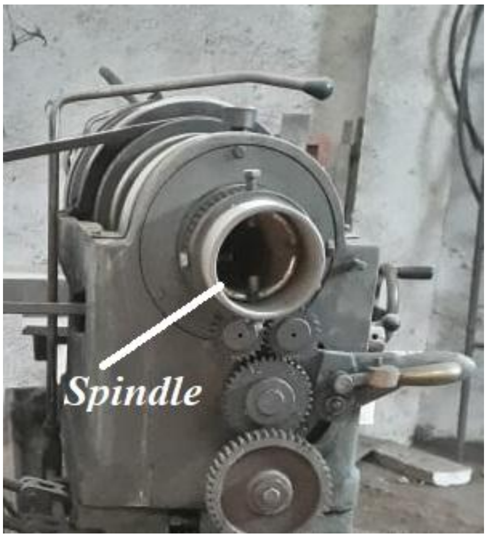

Fig -6: Spindle Back View

2.4 Tailstock

The tail stock is located above the lathe bed on the right side. The tailstock is a non-rotating spindle that travels down the bedways and is concentric with the main lathe spindle. The tailstock is typically used to support the ends of long workpieces, but it can also be equipped with a drill chuck to perform drilling and other holemaking operations.

Fig -7: Tailstock

2.5 Carriage

When the machining is finished, the carriage is utilised to support, guide, and feed the tool against the job. It houses the compound rest over. It is in charge of holding, moving, and controlling the cutting tool. During operations, it provides stiff support for the tool. It uses an apron mechanism to transfer power from the feed rod to the cutting tool for longitudinal cross-feeding. With the help of a lead screw and half-nut mechanism, it makes thread cutting easier.

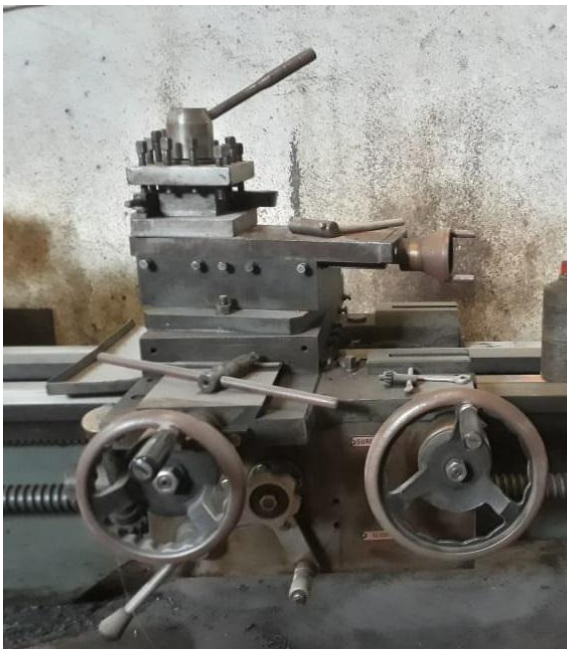

Fig -8: Carriage

2.6 Tool Post

The cutting tool is held in place by a tool post that is firmly secured in the T-slots of the compound rest. Tool posts can have a variety of designs, but the following are the most common:

- Quick Release Tool Post: This tool post is becoming increasingly popular. In the ready-to-use holders, an infinite number of tools are pre-programmed. Tool height may be quickly and easily modified using a fastener, and it can be pre-set for each tool that has been removed from the lathe.

- Index Tool Post: This tool post allows for four tools to be mounted on the turret at the same time. Each tool is safeguarded separately, allowing you to utilise anywhere from one to four tools at the same time. The turret's outstanding indexing system allows it to be placed in 24 locations, each at 15 degrees, allowing the widest range of machining processes. With a millionth of an edge repeatability, it is possible to index from one cutting tool to another in less than one second.

- Pillar Type Tool Post: The Pillar Type Tool Post, also known as the American Pillar, is commonly used for light-duty lathes. Shaking the boat part in its round seating adjusts the tool height quickly and easily. Unfortunately, this type of tool post lacks the inflexibility required for the tool's mission. The useful cutting angles vary depending on how far the boat component is advanced or changed.

- Clamp Type Tool Post: Clamp type tool post, also known as English Clamp, is simple and effective, with the exception of some difficulty. The tedious process of adding or subtracting stuffing and shims until the tool is at the exact height with the spindle axis is the only way to keep the tool's height. This must remain consistent as the tool adjusts. Furthermore, only one tool is accepted at a time, and fast tool change is not possible while machining a small batch of complicated components.

- Turret (4-Way) Tool Post: This form of tool post saves tool changing when constructing a mechanism, with each tool swinging into place as needed. The number of tools in this array is limited to four, and vertical changes are made by inserting packing beneath the tool. The tool's shank size is too small.

- Super Six Index Turret: When multi-process work necessitates the use of more than one tool, the index turret tool post is designed to make machining easier and more efficient on Engine Lathes. For outside and inside machining processes, the rotary index turret can be equipped with up to six tools. Every tool has its own height adjustment in this unit, and tool changes take less than a second.

2.7 Chuck

Chucks are accessories that are used to hold a work-piece or cut down tool on a machine tool. The chuck is actually essential to a lathe's functioning as it fixtures the portion to the spindle axis of the work-holding machine [6]. It is connected to main spindle of the headstock. Lathe chucks are used to clamp a workpiece accurately on a lathe for turning operations or on an indexing fixture for milling activities. A screw or pinion opens or closes the jaws of a manual lathe chuck. The jaws of a power lathe chuck are closed by hydraulics, pneumatics, or electricity. They are designed for mass production and have a high grasping accuracy.

Different types of chuck used in the lathe machine are:

1. Three jaw chuck
2. Four jaw chuck
3. Magnetic Chuck
4. Collet Chuck
5. Combination Chuck
6. Air/ Hydraulic Operated
7. Drill Chuck

- Self-Centering Chucks : Since all jaws work in unison and automatically centre the item, self-centering scroll chucks are suitable for holding cylindrical or concentric work. The scroll's jaws are opened and closed by a wrench that rotates on a pinion. As a stationary fixture, 2-jaw self-centering are employed for rectangular shaped pieces. The most versatile and ideal for handling spherical items are 3-jaw self-centering jaws (bars, rings and pipes.) For square pieces, 4-jaw self-centering is used. For thin-walled items, 6-jaw self-centering is used. More gripping points ensure that clamping forces are distributed evenly and that distortion is avoided.

- Independent Jaw Chucks: Jaws in independent chucks are designed to move separately rather than together. Ideal for eccentric operations or holding oddly shaped workpieces. They require more time to set up than self-centering chucks.

- Three Jaw Chuck: The three jaw chuck is the most frequent method of holding a workpiece on a lathe. It's simple and quick to use. However, it can only hold workpieces that are round, triangular, or hexagonal. Though it is quite exact, it is rarely as accurate as a four jaw chuck, yet it is adequate for many projects. To hold a workpiece, both the three jaw and four jaw chucks would almost invariably be attached to the spindle in the headstock. However, they can be utilised to hold a tool or even be attached to the tailstock in select situations. It is possible to create three-jaw chucks with reversible jaws. Three jaw chuck have advantage of self centering and limitation is that it not recommended for high-speed load condition.[3]

Fig -9: 3-Jaw Self Centering Chuck

- Four Jaw Chuck: For Non-Self Centering Four Jaw Chuck, each of the chuck stepped jaws are controlled by a separate screw giving them independent movement. This feature allows the four-jaw independent chuck to secure any form. Using two to four of the various jaws, this type of chuck may fasten circular, rectangular, square, irregular, and other shapes. Self-Centering Four Jaw Chucks are never utilised in metalworking as in woodworking. A four-jaw chuck with self-centering jaws can hold both round and square pieces. For a carpenter, this covers significantly more jobs than for a metalworker. A self-centering four jaw chuck loses the advantages of a four jaw chuck to the metal worker – great accuracy and the ability to handle odd shapes. However, the craftsman is uninterested in these. However, he finds it incredibly useful to be able to grip round and square forms simply and swiftly. Four Jaw Chucks are critical units of the high-speed horizontal lathe, while the interference fit between the chuck and spindle is one of most important factors influencing the performance of the high-speed horizontal lathe. It is very important to monitor the chucking condition of the power chucks for safety consideration in Lathes, especially high-speed lathes. They can be used to hold irregularly shaped parts. Multiple gripping method is one of the advantages of four jaw chuck.[3]

Fig -10: 4-Jaw Independent Jaw Chuck

- Magnetic Chuck: The magnetic chuck is used to hold very thin parts in place. These thin pieces are made of a magnetic substance that can't be grasped in a standard chuck. Due to the pressure of typical chuck jaws, there is a risk of the work piece bending, buckling, twisting, or deforming in any way. Magnetic lathes are employed in these situations. The radiated magnetic flux is obtained by the chuck from these magnets. This magnetism helps the chuck keep the work item in place.

- Collet Chuck: Collet chucks are commonly used in factories and industries to hold bar stock where it must be quickly fixed and properly centred. A collet is a bushing that resembles a lean cylinder and has carved slots running the length of its edge. The collet's internal bore can be hexagonal, cylindrical, square, or any other shape. The shape of the workpiece passing through it determines its shape. The collet has a tapered outside surface. This tapered surface fits into the taper hole on the chuck's body, and the threaded tail end interlocks with a key.

- Combination Chuck: A combination chuck can be used as a self-centering and independent chuck at the same time. This aspect of this chuck contributes to the benefits of both types of chucks. The jaws are operated by separate screws. The scroll discs control all the jaws independently. The bottom frame is carved with teeth that interlock with the scroll. The screws, like the jaws, move in a radial manner. This movement occurs when a pinion turns the scroll.

- Air/Hydraulic Chuck: Most of the time, air chucks or hydraulic chucks are useful in mass production processes. To operate an air or hydraulic used chuck, a hydraulic or air cylinder is required. This chuck's holding calibre is quick and effective. This cylinder is attached to the rear end of the headstock spindle and rotates. Fluid pressure is transferred to the cylinder by operating a valve with a lever, causing the piston to drop within the cylinder. The piston's motion is transmitted to the jaws via a connecting rod and links, which securely grip the workpiece.

- Drill Chuck: Drill chucks are spindle-mounted mechanisms used to hold a drill or other cutting tool. They are available in keyed, keyless, and hybrid systems, which allow for quick drill bit changes. Drill Chucks are frequently connected to a machine's spindle via a removable Drill Chuck Arbor. The arbour is essentially a steel shaft with two ends, one machined to fit into a machine's spindle and the other to fit into the rear of a drill chuck. Jaws are commonly used in chucks to hold the tool or workpiece. Jaws (also known as dogs) are typically arranged in a radially symmetrical pattern, similar to the points of a star.

2.8 Jaws

Permanent Jaws for retaining a workpiece in a lathe chuck are known as hard lathe chuck jaws. They're composed of case-hardened steel and include a serrated clamping surface to keep the piece secure during machining. It's ideal for parts that haven't been finished yet. Lathe Chuck jaws that are soft (machinable) are used to hold a workpiece while it is being turned on a lathe. They're constructed of soft materials like aluminium or mild steel and can be machined to precise dimensions for precisely aligning the workpiece during an operation. They can be trimmed to match the diameter of a certain item, increasing the contact surface area. Use on finely machined items to get the best results.

Two sets of jaws are usually included in a three-jaw chuck. The internal jaws are one set. These can be utilised to retain the work item on its outside surface using the long edges. They can also use the stepped faces on the interior of the workpiece to hold it. The external jaws are the other set. Only the internal stepped edges are ground on these, and they are intended to be used to hold the workpiece, hence the workpiece is always held on an external surface when using these. These are normally hardened and ground, and must be utilised as is.

When employing soft jaws, the location of the jaws is never important because the edge that will hold the workpiece can be produced anywhere on the jaw. The main criterion is that it is preferable to utilise, as little metal as possible while still completing the task.

The teeth and alignment slots are the most significant parts of the soft jaws. It should be feasible to make parts that fit on these as long as they work. When these components wear out, they are unbolted and replaced with new components.

Fig -9: 3-Jaw Workholding

Fig -10: Inverted 3-Jaws Workholding

When twisting the soft jaws to hold a part on its exterior, the jaws must be forced out at the same time. Holding a circular portion that contacts the rear of the jaws is one way to accomplish this. Even if the cut isn't precisely round, it'll be concentric when the jaws are tightened on a round object. Similarly, the jaws must be driven out when holding the workpiece on an inside edge.

3. ACCURACY OF WORK HOLDING IN A THREE – JAW CHUCK

When holding a round bar, the axis of the bar must be concentric with the axis of the spindle for a three-jaw chuck to be accurate.

There are two types of errors that could occur here:

- When a piece of ground round stock is clamped in a three jaw chuck and tested with a dti, it is frequently found to be a few hundredths off. In a lot of circumstances, this is perfectly okay. This inaccuracy varies depending on the wear of the chuck's scrolls, therefore it could be different for workpieces of different diameters.

- If a workpiece is held in a three chuck that is off centre, any surfaces turned on it in one pass, that is, without removing it from the chuck, will be concentric relative to each other and to the spindle's axis of rotation. This means a workpiece can have any number of round surfaces as long as they are all concentric. Turning between centres is made possible by this feature. However, if the workpiece is held in a chuck for some reason, it is not possible to turn the surface that is being held. As a result, it usually indicates that the part can be created but must subsequently be disassembled. The workpiece must be large enough to be turned down to the required size. As a result, we won't be able to use any existing surface on the final workpiece because it will be eccentric to any.

4. APPLICATIONS

On an industrial scale, large lathes turn out a huge number of parts, such as automobile driveshafts, table legs, and so on. A gigantic metal cone or disc can be turned with large-scale lathe equipment, whereas a metal chess piece can be carved out with small-scale devices.

On a larger scale, lathes can be rather massive, but a toolroom lathe is typically a smaller machine tool. Because of its versatility, a metal lathe is the workhorse of many small machine shops and tool-and-die shops. A lathe is useful to many professionals and amateurs outside of the machine shop.

Today, every industrial metalworking lathe is completely automated, with multiple-bit-holding heads. This means that a single lathe can handle a variety of tasks: rough bits for grinding out material, finer bits for refining pieces, and even sanding and polishing bits. A trained operator can use a CNC lathe to programme a metalworking lathe to take a single workpiece from raw material to completed product with no human intervention after the programme is started.

5. CONCLUSION

The lathe machine has proved to be one the most versatile and helping piece of machine tool in a tool room workshop and has variety of applications for making possible operations required to make a workpiece its desired shape and size. We have studied various parts of the workshop lathe giving information about the bed, the tailstock, the toolpost and its types, the headstock, the carriage, chucks and their types, jaws and their types. Also we have worked on workholding accuracy of a 3 jaw chuck that explains the types of errors the jaws show while holding a concentric workpiece. Also, we have explained the day-to-day applications of a workshop lathe in small scale and large scale industries.

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