ECONOMISATION IN MACHINING PROCESS (In Turning Process)

[1]Syed Mustafa Rahmani, [2]Kethawath Anil Kumar,
[3]Syed Yasear, [4]Shivam Kumar Dubey, [5]Narender Kuriyal
[1]B.E. MECHANICAL [2]B.E. MECHANICAL [3]B.E. MECHANICAL [4]B.E. MECHANICAL [5]B.E. MECHANICAL,
[1]MECHANICAL ENGINEERING DEPARTMENT,
[1] Methodist College Of Engineering And Technology, Abids, Hyderabad, Telangana State, India.

Abstract : In the modern world, there is a need of materials with very high hardness and shear strength in order to satisfy industrial requirements. So many materials which satisfy the properties are manufactured. Machining of such materials with conventional method of machining was proved to be very costly as these materials greatly affect the tool life. So to decrease tool wear, power consumed and to increase surface finish Hot Machining can be used. Here the temperature of the work piece is raised to several hundred or even thousand degree Celsius above ambient, so as to reduce the shear strength of the material. Various heating method has been attempted, for example, bulk heating using furnace, area heating using torch flame, plasma arc heating, induction heating and electric current resistance heating at tool-work interface. From the past experiments it was found the power consumed during turning operations is primarily due to shearing of the material and plastic deformation of the metal removed. Since both the shear strength and hardness values of engineering materials decrease with temperature, it was thus postulated that an increase in work piece temperature would reduce the amount of power consumed for machining and eventually increase tool life. The experiment is conducted in an auto feed lathe. The work piece is heated in furnace and the temperature is measured by a IR thermometer. The statistical analysis is done by furnace method. Furnace method provide a powerful and efficient method for safe heating that operates consistently and optimally over a variety of conditions. The primary goal is to minimize power consumption and to reduce the cutting forces.

***IndexTerms* – Lathe Machine, Arc Furnace, Cutting Tool Material, Lathe Tool Dynamometer, High Spees Steel, High Carbon Steel, Temperature Measuring Device.**

I. INTRODUCTION

With advancement in science and technology, there is a need of materials with very high hardness and shear strength in the market. So many materials which satisfy the properties are manufactured. Machining of such materials with conventional method of machining was proved to be very costly as these materials greatly affect the tool life. So to decrease the power consumption and for improving the machinability an innovative process Hot Machining came into existence. Here the temperature of the work piece is raised to several hundred or even thousand degree Celsius above ambient, so as to reduce the shear strength of the material. Various heating method has been attempted, for example, bulk heating using furnace, area heating using torch flame, plasma arc heating, induction heating and electric current resistance heating at tool-work interface. From the past experiments it was found the power consumed during turning operations is primarily due to shearing of the material and plastic deformation of the metal removed. Since both the shear strength and hardness values of engineering materials decrease with temperature, it was thus postulated that an increase in work piece temperature would reduce the amount of power consumed for machining and eventually increase tool life.

II. HOT MACHINING

The process of hot machining was developed to overcome the problems of low cutting speeds and feeds and heavier load on the machine bearings and slides which are commonly encountered when machining newer, hard and tough alloys.

The process of hot machining is simple and convenient in the sense t it can make use of the conventional machine tool. It utilizes the heat applied locally by some external source just ahead of the cutting tool to reduce the shear strength of the component material. This permits easy formation of the cutting chip accomplished with lessened shocks to th little and comparatively good surface finish on the work material tool There is l. le evidence of any adverse effect on the microstructure of the work material.

The amount and place of application of heat is of great importance in this process. The heating requirements and the methods available to heat the work piece are discussed below.

Heating Requirements

The heating method should be so designed as to satisfy the following requirements:

1. It should provide a high rate of heat input so that the work material is raised to the specified temperature in a short time.
2. It should allow heating of the shear zone only, as the penetration of beat to too great a depth can cause thermal damage.
3. It should provide a wide range of constant temperatures.
4. It should be easy to set up and control.
5. The capital investment as well as operating cost should be low.

BASIC REQUIREMENTS OF WORKPIECE HEATING TECHNIQUE:

There are certain basic requirements for hot machining process. These are as follows:

1. The application of external heat should be localized at the shear zone, i.e. just ahead of the cutting edge, where the deformation of the work piece material is maximum amount.
2. Heating should be confined to a small area as possible limiting work piece expansion, so that the dimensional accuracy can be tolerated.
3. The method of heat supply should be incorporated with fine temperature control device as the tool life is temperature sensitive.
4. The method of heat supply should be such that the limitations imposed by the work piece shape and size, conditions and machining process are minimal.
5. Machined surfaces must not be contaminated or over heated, resulting in possible metallurgical change or distortion to the uncut material.
6. The heat source must be able to supply a large specific heat input to create a rapid response in temperature ahead of the tool.
7. The heating equipment used should be low in the initial investments well as in operation and maintenance.
8. It is absolutely essential that the method employed is not dangerous to the operator.

Methods of Heating

Several methods of heating to cover the various machining applications are available The selection of a specific method depends not only on the component material but also on the shape or type of the component. Some of the heating method a have found use in certain applications are discussed below.

Flame Heating

In this method, a gas flame is employed to heat the component material just ahead of the cutting tool. Either oxy-acetylene, propane or town gas can be used. In order to increase the heat input and its concentration, a multi-jet head may be used. It is a versatile method and uses relatively inexpensive equipment. It has been found to be very economical for milling long but narrow jobs. For wider jobs, the problems of the localization of heat and the maintenance of a constant temperature over a larger area make this method unsuitable. Further, there is a risk of overheating or oxidation of work material which necessitates some post-hot machining operation, like grinding, in some cases.

D.C. Arc Heating

In this method, an electric are produced with carbon (or tungsten) electrode and the work material is used to heat nonmagnetic or refractory materials required to be hot machined The negative terminal of the arc welding machine is connected to the work piece and the positive terminal to the electrode which draws the heating arc just ahead of the cutting tool. A magnetic field may be used to direct and to prevent the arc from wandering.

The maintenance of a constant temperature of work material is, however, a problem with this method.

Plasma Arc Heating

The plasma arc employs a restricted arc through which a selected gas is made to flow. This method has been satisfactorily used for heating most of the low permeable materials since temperatures can easily be controlled. The process can provide temperatures as high as 20,000 K and heating rates can by controlled to prevent surface damage. This is significant because metals of low impedance are usually relatively insensitive to heat damage.

The initial equipment cost is high but operating costs are low. Large areas of metallic work pieces can be heated and machined at high rates if provision for adequate power and gas supplies is made.

To avoid the effects of radiation the same safety precautions, as for Plasma Are Machining', must be observed.

Furnace Heating

This is one of the simplest methods of heating the work piece. A gas or electrical furnace is used, the temperature of which is raised to the required degree for the machining operation. The work material is placed in the furnace and allowed to remain there until its surfaces at the same temperature as that of the furnace. It is then taken out and held in a fixture on the machine on which it is to be machined. No time should be lost between the removal of the work material from the furnace and the start of the machining operation.

This method of heating is economical when a furnace of the required type already exists and the metal cutting machine tool can be located adjacent to the furnace. It is difficult to control the depth of the heating zone, and thus, there exists the possibility of work piece damage due to uneven cooling.

Resistance Heating

This is another simple method of heating the work piece which involves passing 50 cycle ac. through the component part or through the heating elements incorporated in the body of the work holding fixture.

As the component temperature can be kept fairly constant without much difficulty, there is little adverse effect of distortion and dimensional discrepancy caused by uneven cooling. One main precaution to be observed in this process is that arcing must not be allowed to occur.

This method of heating is simple and relatively inexpensive. It is particularly suitable for the milling of small area jobs.

Radio Frequency Resistance Heating

This method of heating makes use of radio frequency currents which follow the path of least impedance. The equipment used in this method permits the transfer of current to the work piece and a low impedance path is provided across it so that the applied current heats only the predetermined area. The required low impedance path is obtained by placing a conductor (called return conductor) very close to the work piece so that the current is made to flow in a direction opposite to the current path in the component.

The main advantage of this method is that heat is localized in the surface area as well as in the depth with high input.

This method is gaining popularity and it appears that further advances in the design of equipment for this method will definitely boost the application of hot machining techniques. It has presently been applied successfully for end and face milling and for turning operations. Arcing must be prevented in this method as in conventional resistance heating methods.

Induction Heating

This method of heating makes use of an alternating current at a frequency of 3,000 c/s to 1.2 M.C./s. The heating current is induced in the component by transformer action with the help of a primary coil which is designed to cover the area to be machined.

This method also provides localized heat without much difficulty. The control of temperature, required depth of heat zone and repeatability of conditions can he achieved without undue problems.

The equipment required for this method of heating is relatively costly but it has many other applications within an engineering works. Sometimes, difficulty may be faced in mounting a work piece on the machine. This may be overcome in many cases by the use of heating coils of the required size and shape.

Tool Life and Production Rate

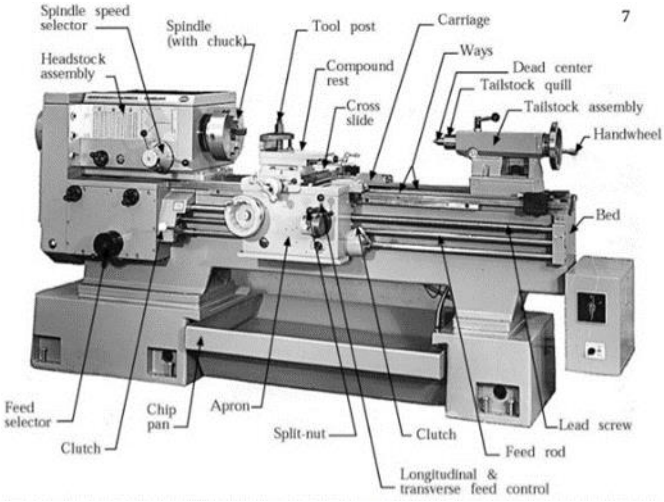
An increase in tool life is possible when the component which is to be machined is heated to about 800 K. Higher temperatures cannot be employed due to the problem of welding of chip to the tool. In case of face milling, it has been reported that the use of a slab of asbestos at the entry side of the component can lead to increased tool life. It is felt that the asbestos tends to act as a damper to reduce the severity of the impact shock between the teeth and the component. A chemical reaction is assumed to be set up by the heated impact which serves a lubricating function.

Cutting speeds up to 800 rpm have been achieved on lathe and milling machines with metal removal rates up to 30 cm3/min/KW. After selecting the most suitable heating temperature to suit the material of the component, the machining is done as fast as possible, commensurate with the required surface finish. If the component is subjected to high temperatures for too long a period, it will temper and lose its hardness, which may be undesirable. Apart from the possible adverse effects of tempering, there has been, so far, no evidence of any important change in micro- structure

III. LATHE

Lathe machine is a basic machine which is used in every metal forming industries. It is combination of many parts which works together to perform a desire function. A lathe machine is used to machine cylindrical work piece which is 360 degree symmetrical form the axis of rotation. It used to perform turning, chamfering, boring, facing, internal threading, shaping, slot cutting etc. on cylindrical work piece.

There are many types of lathe machine but each machine consist some basic part which are essential for its proper working. These parts are bed, tool post, Chuck, head stock, tail stock, legs, Gear chain, lead screw, carriage, cross slide, split nut, apron, chip pan, guide ways etc. These parts work together to obtain desire motion of tool and work piece so it can be machined.



The lathe consist following parts.

1. Bed

It is the main body of the machine. All main components are bolted on it. It is usually made by cast iron due to its high compressive strength and high lubrication quality. It is made by casting process and bolted on floor space.

2. Tool post

It is bolted on the carriage. It is used to hold the tool at correct position. Tool holder mounted on it.

3. Chuck

Chuck is used to hold the workspace. It is bolted on the spindle which rotates the chuck and work piece. It is four jaw and three jaw according to the requirement of machine.

4. Head stock

Head stock is the main body parts which are placed at left side of bed. It is serve as holding device for the gear chain, spindle, driving pulley etc. It is also made by cast iron.

5. Tail stock

Tail stock situated on bed. It is placed at right hand side of the bed. The main function of tail stock to support the job when required. It is also used to perform drilling operation.

6. Lead screw

Lead screw is situated at the bottom side of bed which is used to move the carriage automatically during thread cutting.

7. Legs

Legs are used to carry all the loads of the machine. They are bolted on the floor which prevents vibration.

8. Carriage

It is situated between the head stock and tail stock. It is used to hold and move the tool post on the bed vertically and horizontally. It slides on the guide ways. Carriage is made by cast iron.

9. Apron

It is situated on the carriage. It consist all controlling and moving mechanism of carriage.

10. Chips pan

Chips pan is placed lower side of bed. The main function of it to carries all chips removed by the work piece.

11. Guide ways

Guide ways take care of movement of tail stock and carriage on bed.

12. Speed controller

Speed controller switch is situated on head stock which controls the speed of spindle.

13. Spindle

It is the main part of lathe which holds and rotates the chuck.

14. Feed mechanism

The movement of the tool relative to the work piece is termed as “feed”. The lathe tool can be given three types of feed, namely, longitudinal, cross and angular. When the tool moves parallel to the axis of the lathe, the movement is called longitudinal feed. This is achieved by moving the carriage.

When the tool moves perpendicular to the axis of the lathe, the movement is called cross feed. This is achieved by moving the cross slide. When the tool moves at an angle to the axis of the lathe, the movement is called angular feed. This is achieved by moving the compound slide, after swivelling it at an angle to the lathe axis.

15. Feed rod

The feed rod is a long shaft, used to move the carriage or cross-slide for turning, facing, boring and all other operations except thread cutting. Power is transmitted from the lathe spindle to the apron gears through the feed rod via a large number of gears.

Working operation on Lathe

Lathe machine is used to cut the metal from cylindrical work piece, and convert it into desire shape. It turns the cylindrical work piece, and during turning a sharp edge cutting tool introduce, which cuts the metal. Its working can be described as follow.

1. A cylindrical work piece fixed to the chuck. A chuck may have three jaw or for jaw according to the requirement. The work piece is at the center or some eccentric according to the process perform.
2. The spindle starts to rotate and set it at desire speed. The spindle speed plays a huge role during cutting. The spindle rotates the chuck and work piece.
3. Now check the work piece is turning properly. If it not set the work piece using dial gauge.

4. Now set the tool at desire feed by moving the tool post and carriage. The feed also play main role during cutting. Large feed may cause unwanted temperature increase.

5. After it tool is introduce between moving work piece at desire feed rate. It cut the metal from work piece. The feed rate is set at the cutting condition.

6. Now all unwanted metal is removed by moving the carriage form horizontally and vertically as desire according to the job requirement. After complete all process we got a well finished job.

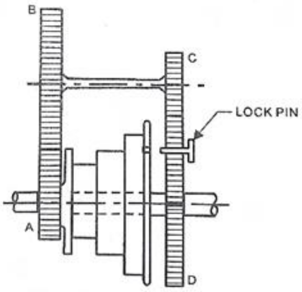
7. Lathe can perform turning, boring, chamfering, shaping, facing, drilling knurling, grooving as shown in figure.

LATHE SPEED SETUP:

In belt driven lathe, speed rangers are obtained by the following methods:

1. Direct speed (or) speed without back gear and
2. Indirect speed (or) speed with back gear.

Direct speed, without back gear, a three step pulley permits three speed changes are obtained. The mechanism is shown in figure.



BACK GEAR OF LATHE

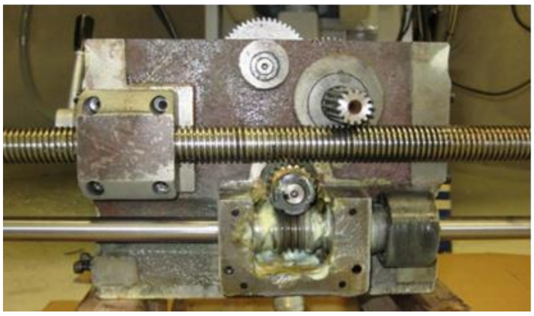
Pinion 'A's is attached to cone pulley which is freely mounted on lathe spindle and gear 'D' is keyed to the lathe spindle. Gear 'B' and pinion 'C' are compound gears and are in mesh with pinion 'A' and gear 'D' respectively when the back gear is engaged. When the back gear is disengaged, gear ' B' and pinion 'c' moved away and cone pulley is locked to gear 'D' by means of a lock pin .when higher speed is needed, belt is shifted to smaller step and for lower speeds the higher diameter step is used.

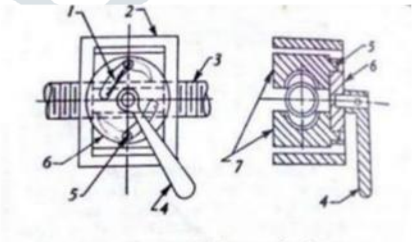
If slower spindle speeds are desired, the back gear is engaged. It consists of disconnecting the cone pulley from gear 'D' by pulling out lock pin and bringing the back gear into position so that the pinion 'A' meshes with gear 'B' and pinion 'C' with gear 'D'.Thus the spindle from cone pulley is transmitted to spindle through gear train .The back gear is generally engaged during thread cutting and for turning large diameter work or for heavier cuts.

LEAD SCREW MECHANISM

Most standard engine lathes are equipped with feed rod and a lead screw. feed rod is used to provide automatic feed for all turning operations except for thread cutting. The lead screw transmits feed motion for screw cutting. In the absence of feed rod, the lead screw may be used for carriage feeds as well as thread cutting. The feed rod and lead screw obtain motion from the lathe spindle (via gears) and transmit it to the carriage through gears and feed clutches.

On old lathes, gears have to be selected and mounted in place to suite different feeds and thread pitches. The modern lathes are provided with quick change gear box to obtain a wide range of feeds and thread pitches. In this case a feed reverse lever is used for providing automatic feed the carriage. It fitted on the left hand side of the head stock and has three position. When the lever is in the top position the cutting action is towards the head stock i.e. tool moves towards the head stock. Neutral position automatic feed is disconnected. The bottom position of feed lever reverse the direction of feed.





Half nut mechanism
1. Cam slot, 2. Guide or frame, 3. Lead screw, 4. Hand lever, 5. Pin, 6. Circular plate, 7. Half nuts.

The lead screw is a long threaded bar located slightly below and parallel to the bead ways. Lead screw is used as feed mechanism for some type of job operation to obtain fine speed, so you don't have to sit there and cried the handle. Lead screw is fitted to the carriage assembly such that it may be engaged or disengaged during the operation with help of slip nut. Lead screw is engaged with carriage (by closing halfnut or split nut) only for cutting threads or to give smooth feed to carriage and should always be disengaged.

ARC FURNACE

In the experiment an arc or electric Furnace is been used which is easier method for heating the work pieces which works by Electricity. It is a box type ceramic Fibre muffle furnace for laboratory heating equipment.

It has self tuning features by which we can set the exact temperature at which we want metal to be heated.

Here in the experiment power consumption by furnace for heating the work pieces are not taken into account as the experiment is done by keeping in view of industry or firm where bulk heating of many thousands of work pieces are done in one attempt. We can postulate here that power consumed for heating one work piece and for bulk work pieces say ten in number takes the same time and electrical energy. That's the reason why here in the experiment power consumption by furnace is being neglected.

CUTTING TOOL MATERIAL

In the experiment HIGH SPEED STEEL TOOL is used for machining the work piece at room temperature and at elevated temperatures.

High speed steel (HSS):

These are special alloy steel which are obtained by alloying tungsten, Chromium, Vanadium, Cobalt and molybdenum with steel. HSS has high hot hardness, wear resistance and 3 to 4 times higher cutting speed as compare to carbon steel. Most commonly used HSS have following compositions.

a) 18-4-1 HSS i.e. 18% tungsten, 4% chromium, 1% vanadium with a carbon content of 0.6 - 0.7%. If vanadium is 2% it becomes 18-4-2 HSS.

b) Cobalt high speed steel: This is also referred to as super high speed steel. Cobalt is added 2 – 15%. The most common composition is tungsten 20%, 4% chromium, 2% vanadium and 12% cobalt.

c) Molybdenum high speed steel: It contains 6% tungsten, 6% molybdenum, 4% chromium and 2% vanadium

High speed steel (HSS):

These are special alloy steel which are obtained by alloying tungsten, Chromium, Vanadium, Cobalt and molybdenum with steel. HSS has high hot hardness, wear resistance and 3 to 4 times higher cutting speed as compare to carbon steel. Most commonly used HSS have following compositions.

a) 18-4-1 HSS i.e. 18% tungsten, 4% chromium, 1% vanadium with a carbon content of 0.6 - 0.7%. If vanadium is 2% it becomes 18-4-2 HSS.

b) Cobalt high speed steel: This is also referred to as super high speed steel. Cobalt is added 2 – 15%. The most common composition is tungsten 20%, 4% chromium, 2% vanadium and 12% cobalt.

c) Molybdenum high speed steel: It contains 6% tungsten, 6% molybdenum, 4% chromium and 2% vanadium

High speed steel (HSS):

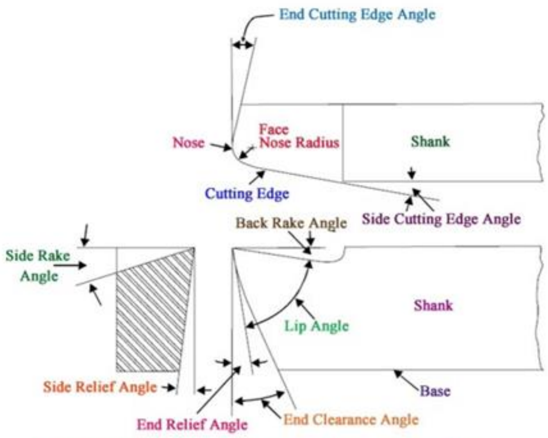
These are special alloy steel which are obtained by alloying tungsten, Chromium, Vanadium, Cobalt and molybdenum with steel. HSS has high hot hardness, wear resistance and 3 to 4 times higher cutting speed as compare to carbon steel. Most commonly used HSS have following compositions.

a) 18-4-1 HSS i.e. 18% tungsten, 4% chromium, 1% vanadium with a carbon content of 0.6 - 0.7%. If vanadium is 2% it becomes 18-4-2 HSS.

b) Cobalt high speed steel: This is also referred to as super high speed steel. Cobalt is added 2 – 15%. The most common composition is tungsten 20%, 4% chromium, 2% vanadium and 12% cobalt.

c) Molybdenum high speed steel: It contains 6% tungsten, 6% molybdenum, 4% chromium and 2% vanadium

TOOL NOMENCLATURE



Nomenclature of Single Point Cutting Tool

Recommended rake and relief angles for HSS tool

The standard angles of a cutting tool are the bangles with depend upon the shape of the tool. Those angles hour

1. Rake Angle: Rake angle is the slope of the top, away from the cutting edge. It is the slope of the tool face and is formed between tool face and a plane parallel to its base.

(i) Back rake angle: Black rake angle is also known as top rake angle or front rake angle. It measures the download slope of the top surface of the tool from the nose to the rear along the longitudinal axis. It is the angle by which the face of the tool is inclined towards the back side.

(ii) Side rake angle: It is the angle between the face of a tool and a line parallel to the base. Side rake allows chips to flow by the side of the tool away from the tool post.

2. Side relief angle: It is the angle between the portion of the side flank immediately below the side cutting edge and a line drawn through this cutting edge perpendicular to the base. This angle permits the tool to be fed sideways into the job, so that it can cut without rubbing.

3. End relief angle: It is the angle between the portion of the side flank immediately below the end cutting edge perpendicular to the base. This angle prevents the cutting tool from rubbing against the job.

4. Nose angle are nose radius: This is the angle between side cutting edge and end cutting edge. The chatter may be included if the nose radius is large. Nose angle increases surface finish, reduces tool wear, improve heat conduction, and reduces cutting forces and Power consumption.

5. Tool holder angle: It is the angle between the bottom of the bit slot and the base of the tool holder.

6. Flat and drag angle: It is the straight portion of the end cutting edge at zero degree angle. It improves surface finish.

7. Clearance angle: The clearance angle is greater than the relief angle. It is the angle between the perpendicular to the base of the tool and that portion of the shank immediately below the relieved flank. This angle avoids the rubbing of machining surfaces.

8. Side cutting edge angle or primary approach angle: The side cutting edge angle is the angle between the straight side cutting edge and the side of the shank .It is also called as lead angle. Its adequate values vary from 15 to 30 degrees for general machining.

9. End cutting edge angle: It is the angle between the cutting edge on the end of the tool and a line at right angles to the side edge of the straight portion of the tool shank. It values varies from 0° to 90° and usual value is 15°.

METHOD OF METAL CUTTING

Basically there are two methods of metal cutting, depending upon the arrangement of the cutting edge with respect to the direction of relative work tool motion.

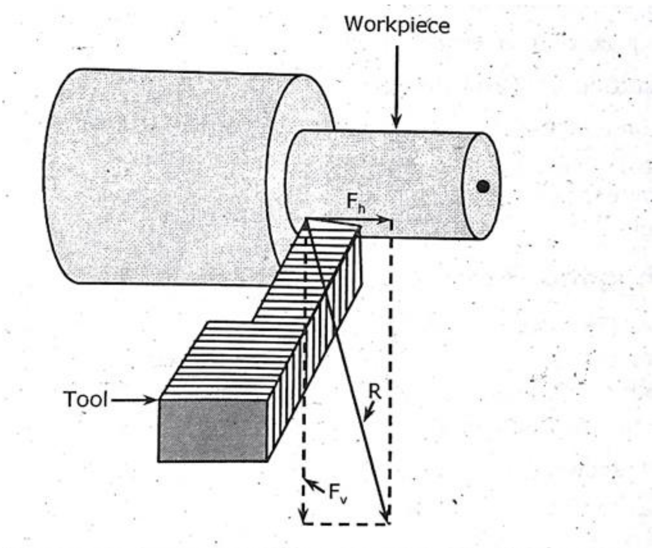
1. Orthogonal cutting or two dimensional cutting.

2. Oblique cutting or three dimensional cutting.

1. Orthogonal cutting (Two dimensional cutting)

Orthogonal cutting occurs when the major cutting edge of the tool is presented to the work piece perpendicular to the direction of the feed motion. The width of the tool used in orthogonal cutting is more than that of the work piece. Orthogonal cutting involves only two forces and this make the analysis of cutting motion much easier.

The magnitude of the cutting mainly depends upon factors like

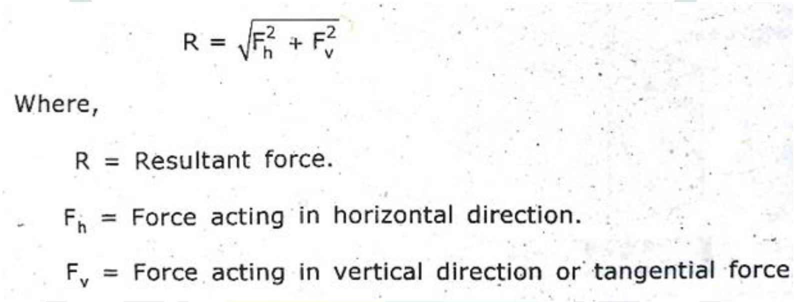


Forces Acting on a Cutting Tool in Orthogonal Cutting

Work piece material, rate of feed, depth of cut, coolant, cutting speed. Figure shows the forces acting on a cutting tool in orthogonal cutting.

JETIR

Therefore, from figure the resultant force 'R' is



$$R = \sqrt{F_h^2 + F_v^2}$$

Where,

R = Resultant force.

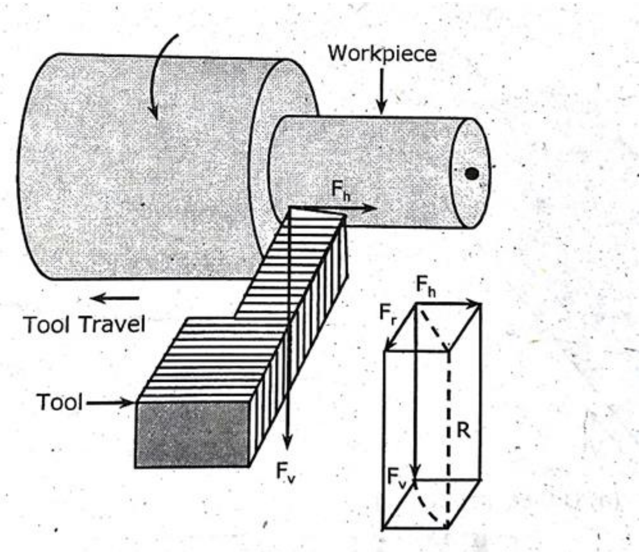
F_h = Force acting in horizontal direction.

F_v = Force acting in vertical direction or tangential force

2. OBLIQUE CUTTING(Three dimensional cutting):

Oblique cutting is also known as three dimensional cutting in which the major edge of cutting tool is presented to the work piece at an angle which is not perpendicular to the direction of feed motion. The forces which acts during the cutting or shearing of metal will acts on larger area in case of oblique cutting. Therefore, the oblique tool will have longer life compared to orthogonal cutting.

In oblique cutting, the cutting edge is inclined to the direction of the tool travel and the cut direction. The figure shows the forces acting on a cutting tool in oblique cutting process



Forces Acting on a Cutting Tool in Oblique Cutting

JETIR

In three dimensional oblique cutting, one more force components appear along the third axis i.e., Radial force. The relationship among these three components depends upon tool geometry, work Material, and tool wear.

LATHE TOOL DYNAMOMETER

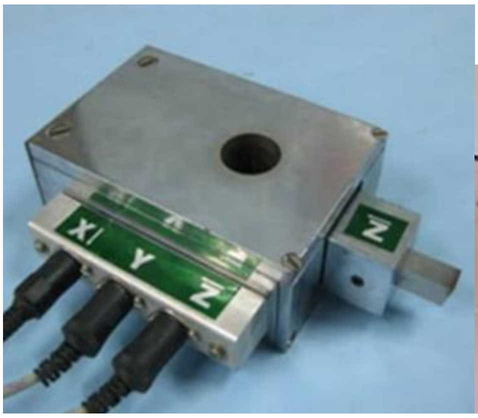
There are several important reasons for measuring or calculating forces in-machining operations which include. To estimate the forces acting on the tool, that must be resisted by the machine tool components, bearing etc. To estimate the power requirements of a machine tool.

Measuring devices used for the detection of cutting forces are called metal cutting, dynamometers. The common features in earlier types of dynaometers are measuring spring whose deflections are proportional to cutting forces. The major difference in the design of various dynamometers lies in the technique employed in measuring spring deflection.

Latest type or dynamometers are based on strain gauges or piezoelectric transducers. The stain gauges are fixed to certain elements of dynamometers. These elements undergo deformation when subjected to loads and hence strain gauges undergo strain. This strain changes the length of gauges and hence their electrical resistance. The change in electrical resistance unbalances the wheat stone bridge circuit, and the galvanometer deflects. This deflection is calibrated with applied load when cutting is performed, the cutting force is found by measuring the deflection or indication in the dynamometers.

The piezo-electric dynamometers works on the principle, that when there is a
Compressive load on the crystal, an electric output results. The electrical output is calibrated with the applied load. When cutting is performed the electrical output of dynamometers Indicate the cutting force.

Tool holder for lathe tool dynamometer



Digital indicating device

FORCE MEASUREMENT IN TURNING

I) The lathe tool dynamometer is properly located in the position of tool post of a center lathe.
ii) All electrical connections are made between the lathe tool dynamometer and milli- Voltmeter.
iii) The job is fixed in the chuck of the center lathe, and power supply to the milli-voltmeter is ensured.
iv) The job is turned at different speeds, feeds and depths of cut keeping any two parameters constant each time.

v) Making use of selector switches on milli-voltmeter panel, Pz, Py and Px at different cutting conditions are read.

vi) The output of the measuring unit is in milli volts. Using a calibration chart, milli volts are converted to equivalent force units. The data is subsequently entered in the observation table.

vii) In modern lathe tool dynamometers, the output of the forces obtained is shown in digital format with the help of Digital output device.

vii) Connect one end of the 3 core cable to the connector at the rear panel and other end to the 230v 50 HZ supply.

REQUIREMENT OF CALCULATION OF CUTTING FORCES

Generally the cutting forces are calculated in order to estimate the power requirements of machine tool by calculating cutting forces on the cutting tool. But in this experiment lathe tool dynamometer is not used to calculate the power consumption of lathe machine but to check whether the cutting forces are varying in machining of work piece from room temperature to elevated temperatures.

It can be observed from this readings that whether the work piece is became softer than earlier case or not.

FORCES ON CUTTING TOOL

1. CUTTING FORCE (Fc) acting vertically downwards and tangential to the work piece.
2. FEED FORCE (Ff) acting parallel to the work axis in the direction opposite to the feed motion.
3. RADIAL FORCE (Fr) acting perpendicular to the axis of the work.

5.5. POWER CALCULATIONS OF LATHE MACHINE

Lathe machine uses a three phase induction motor of 0.75KW / 1.0HP. Various methods are used for measurement of three phase power in three phase circuits on the basis of number of wattmeters used. We have three methods to discuss:

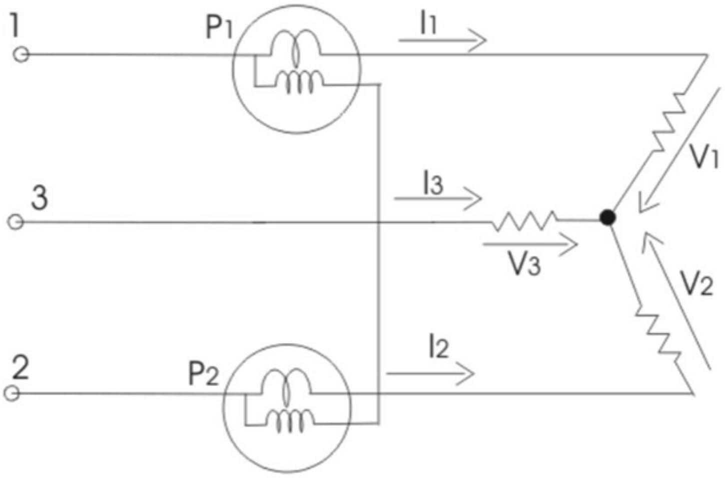
1. Three wattmeter method
2. Two wattmeter method
3. Single wattmeter method.

Measurement of Three Phase Power by Two Wattmeters Method

In this method we have two types of connections

1. Star connection of loads
2. Delta connection of loads

Here in the experiment the circuit to the Induction motor of lathe machine is connected in star resistive circuit. When the load (Lathe machine Induction motor) is connected in star connection, the diagram is shown



CIRCUIT DIAGRAM FOR INDUCTION MOTOR OF LATHE MACHINE IN STAR CONNECTION

The total power in a 3 phase circuit can be measured by 2 wattmeters.It can be shown that two wattmeters connected in two lines with their voltage coils connected in between two lines with one line common to both the voltages coils give the total power in the 3 phase circuit. Power can also be measured by 1 wattmeter and 3 wattmeter methods.

3 phase power = 3VI cos π

Procedure for power measurement

1. Connect as per the circuit diagram.
2. Apply 415 volts across the load by varying 3 phase’s auto transformer.
3. Note the readings of first and second wattmeter and add them to get final power consumption of lathe induction motor.
4. Use safety precautions while performing the experiment.

5.6. TEMPERATURE MEASURING DEVICE

Here for measuring the temperature, a non-contactable Infra-red laser thermometer is used. This thermometer is used the experiment because temperature can be easily measured without direct contact with the hot material by this we can avoid accidents related to hot temperature.

An infrared thermometer is a thermometer which infers temperature from a portion of the thermal radiation sometimes called black-body radiation emitted by the object being measured. They are sometimes called laser thermometers as a laser is used to help aim the thermometer, or non-contact thermometers or temperature guns, to describe the device's ability to measure temperature from a distance. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined within a certain range of its actual temperature. Infrared thermometers are a subset of devices known as "thermal radiation thermometers".

The design essentially consists of a lens to focus the infrared thermal radiation on to a detector, which converts the radiant power to an electrical signal that can be displayed in units of temperature after being compensated for ambient temperature. This permits temperature measurement from a distance without contact with the object to be measured. A non-contact infrared thermometer is useful for measuring temperature under circumstances where thermocouples or other probe-type sensors cannot be used or do not produce accurate data for a variety of reasons

Specifications:

- Temperature Range: -50 °C to 550 °C (-58 °F to 1022 °F)
- Accuracy: ± 1.5% or ±1.5°C
- Repeat-ability: ± 1% or ±1°C
- Resolution: 0.1°C or 0.1°F
- Response Time: 500 m-Sec, 95% response
- Power : DC

IV. WORKING MATERIALS

The experiment carried out on two different materials namely
1. EN24 or 817M40T - EN24T
2. HIGH CARBON STEEL

1. EN24 or 817M40T - EN24T

EN24 is usually supplied in the finally heat treated condition (quenched and tempered to "T" properties) up to a limiting ruling section of 250mm, which is superior to grades 605M36, 708M40 or 709M40 . EN24 is a very popular grade of through-hardening alloy steel, which is readily machinable in the "T" condition. EN24T is most suitable for the manufacture of parts such as heavy-duty axles and shafts, gears, bolts and studs. EN24T can be further surface-hardened typically to 58-60 HRC by induction or nitride processes, producing components with enhanced wear resistance.

In addition to the above, EN24T is capable of retaining good impact values at low temperatures, hence it is frequently specified for harsh offshore applications such as hydraulic bolt tensioners and shipborne mechanical handling equipments.

817M40 (EN24) Specification

Chemical composition

Carbon	0.36-0.44%
Silicon	0.10-0.35%
Manganese	0.45-0.70%

Sulphur	0.040 Max
Phosphorus	0.035 Max
Chromium	1.00-1.40%
Molybdenum	0.20-0.35%
Nickel	1.30-1.70%

817M40 (EN24) - mechanical properties in "T" condition

Max Stress	850-1000 n/mm2	
Yield Stress	680 n/mm2 Min	(up to 150mm LRS)
Yield Stress	650 n/mm2 Min	(over 150 to 250mm LRS)
0.2% Proof Stress	665 n/mm2 Min	(up to 150mm LRS)
0.2% Proof Stress	635 n/mm2 Min	(over 150 to 250mm LRS)
Elongation	13% Min	(9% if cold drawn)
Impact KCV	50 Joules Min	(up to 150mm LRS
Impact KCV	35 Joules Min	(over 150 to 250mm LRS)
Hardness	248-302 Brinell	(850-1000 n/mm2)

2. HIGH CARBON STEEL

Carbon steel is an alloy consisting of iron and carbon. Several other elements are allowed in carbon steel, with low maximum percentages. These elements are manganese, with a 1.65% maximum, silicon, with a 0.60% maximum, and copper, with a 0.60% maximum. Other elements may be present in quantities too small to affect its properties.

Types of carbon steels based on the carbon percentage

There are four types of carbon steel based on the amount of carbon present in the alloy. Lower carbon steels are softer and more easily formed, and steels with a higher carbon content are harder and stronger, but less ductile, and they become more difficult to machine and weld. Below are the properties of the grades of carbon steel we supply:

1. Low Carbon Steel – Composition of 0.05%-0.25% carbon and up to 0.4% manganese. Also known as mild steel, it is a low-cost material that is easy to shape. While not as hard as higher-carbon steels, carburizing can increase its surface hardness.
2. Medium Carbon Steel – Composition of 0.29%-0.54% carbon, with 0.60%-1.65% manganese. Medium carbon steel is ductile and strong, with long-wearing properties.
3. High Carbon Steel – Composition of 0.55%-0.95% carbon, with 0.30%-0.90% manganese. It is very strong and holds shape memory well, making it ideal for springs and wire.
4. Very High Carbon Steel - Composition of 0.96%-2.1% carbon. Its high carbon content makes it an extremely strong material. Due to its brittleness, this grade requires special handling.

O'Neal Steel stocks a wide variety of carbon steel plate, shapes, and bar products in the hot rolled condition. Contact our staff to select the carbon steel product that is right for your application

HARDNESS TEST

HARDNESS-It is defined as the resistance of a metal to plastic deformation against Indentation, scratching, abrasion of cutting. In the experiment,Hardness test is performed at room temperature and at elevated temperature in order to find whether properties of the Materials are changed due to heating the Material and machining at elevated temperature.

There are three types of Hardness tests.

1. Brinell Hardness test.
2. Vickers’s Hardness test.
3. Rockwell Hardness test.

1.BRINELL HARDNESS TEST (BHN)

In Brinell hardness trying,a hardend steel ball pressed into the surface specimen for 10 to 15sec,and the diameter of the impression is measured using a low power graduated microscope. The Brinell Hardness number (BHN)is using a the following formula

$$BHN=2P/\pi D(D-\sqrt{D^2-d^2})$$

Where

P=load in kg

D=Diameter of the ball in mm, and

d = dua of indentation in mm

2.VICKERS' HARDNESS TEST (VHN)

In Vickers hardness teste,is made using a square base diamond pyramid with an angle of 136°bewteen opposite faces.the vary from 5 to 120kg depending upon the Material and are usually applied for 15sec, Vickers hardness number (VHN)is calculated using the formula

3.ROCKWELL HARDNESS TEST (RHN)

The hardness of a material by this Rockwell hardness test method is measured by the depth of Penetration of the indenter. The depth of Penetration is inversely proportional to the hardness. Both ball or diamond cone types of indenters are used in this test. There are three scales on the machine for taking hardness readings.

Scale “A” with load 60 kgf or 588.4 N and diamond indenter is used for performing tests on thin steel and shallow case hardened steel.

Scale “B” with load 100 kgf or 980.7 N and 1.588 mm dia ball indenter is used for performing tests on soft steel, malleable iron, copper and aluminum alloys .

Scale “C” with load 150 kgf or 1479.1 N and diamond indenter is used for performing tests on Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel, and other materials harder than 100 on the Rockwell B scale.

First minor load is applied to overcome the film thickness on the metal surface. Minor load also eliminates errors in the depth of measurements due to spring of the machine frame or setting down of the specimen and table attachments.

The Rockwell hardness is derived from the measurement of the depth of the impression

Ep = Depth of penetration due to Minor load of 98.07 N.

Ea = Increase in depth of penetration due to Major load.

E = Permanent increase of depth of indentation under minor load at 98.07 N even after removal of Major load.

This method of test is suitable for finished or machined parts of simple shapes.

V. PROCEDURE

1. Select the load by rotating the Knob and fix the suitable indenter.
2. Clean the test-piece and place n the special anvil or work table of the machine.
3. Turn the capstan wheel to elevate the test specimen into contact with the indenter point.
4. Further turn the wheel for three rotations forcing the test specimen against the indenter. This will ensure that the Minor load of 98.07 N has been applied
5. Set the pointer on the Scale dial at the appropriate position.
6. Push the lever to apply the Major load. A Dash Pot provided in the loading mechanism to ensure that the load is applied gradually.
7. As soon as the pointer comes to rest pull the handle in the reverse direction slowly. This releases the Major, but not Minor load. The pointer will now rotate in the reverse direction.
8. The Rockwell hardness can be read off the scale dial, on the appropriate scale, after the pointer comes to rest.

VI. METHODOLOGY APPROACH FOR EXPERIMENT

1. Before starting the process the work pieces are tested for Hardness test to know the Hardness Number on ROCKWELL HARDNESS EQUIPMENT and recorded.
2. In the experiment ,two rods of 25 mm diameter and length of 100mm of High carbon steel and EN24 are turned by fixing the jobs in lathe chuck and maintaining constant speed ,Feed, cutting time and just varying the depth of cut and recorded in the tabular column .
3. Here the entire experiment is carried on at room temperature and room pressure. Now the metal rods are heated to certain temperature below the melting point in the arc furnace and fitted in the chuck for turning operation.
4. The temperature of the material is recorded with the help of laser thermometer. Same parameters are followed as followed in above condition.
5. In both the cases High speed steel tool arrangement along with three Axis dynamometer is employed in order to measure the cutting forces acting on the work piece.
6. After machining at room temperature the work pieces are allowed to heated in Arc furnace to required temperature and then waited for some time for heat penetration into the work pieces. This time is called as Heat retaining time.
7. After this the work pieces are machined again with same parameters followed before. Readings of dynamometer are recorded for room temperature and the for elevated temperature for both the materials.
8. It is observed that cutting forces are reduced in machining of heated materials as the work pieces have become soft. Power consumed for material removal process in both the cases is calculated by using Two wattmeter method.
9. Here we are not using any cutting fluids because usage of cutting fluids carries away the heat from the work piece. To overcome tool blunt problem we are using hard tools for machining.
10. After completing the matching operation, the materials which are machined at elevated temperatures are tested again for Hardness numbers.

CUTTING FORCE CALCULATIONS BY LATGE TOOL DYNAMOMETER.

Cutting forces at room temperature is compared with at elevated temperatures.

TABLE 1

Material name: High Carbon Steel.

Cutting Length: 50mm Diameter:. 25mm Temperature: 35°c

S.
NO Speed
RPM Depth of cut
(mm) Initial diameter
(mm) Axial
Force Fx (kgf) Radial
Force Fy (kgf) Tangential
Force Fz (kgf) Final diameter
(mm) Cutting

speed (m/min) Feed

(mm/rev) MRR

(cm3/min) Cutting time
(min)

1	235	0.5	25	3	120	102	24.5	18.45	0.21	1.93	1.01
2	235	0.5	24.5	2	92	34	24	18.08	0.21	1.89	1.01
3	235	0.5	24	4	123	88	23.5	16.98	0.21	1.78	1.01

TABLE 2
Material name: High Carbon Steel.
Cutting Length: 50mm Diameter:. 25mm Temperature: 250°c

S.
NO Speed
RPM Depth of cut
(mm) Initial diameter
(mm) Axial
Force Fx (kgf) Radial
Force Fy (kgf) Tangential
Force Fz (kgf) Final diameter
(mm) Cutting
speed (m/min) Feed
(mm/rev) MRR
(cm3/min) Cutting time
(min)

1	235	0.5	25	3	47	72	24.5	18.45	0.21	1.93	1.01
2	235	0.5	24.5	4	48	78	24	18.08	0.21	1.89	1.01
3	235	0.5	24	4	54	96	23.5	16.98	0.21	1.78	1.01

OBSERVATIONS: It was observed from above two tables 1 ,2 which is one at room temperature and another at elevated temperature, that cutting forces at room temperature is higher when compared with the cutting forces at elevated temperatures. It was clearly observed that cutting forces reduced when the High carbon steel is machined at elevated temperature. Thus the above readings from two tables shows the usage of lathe tool Dynamometer in the experiment.

TABLE 3
Material name: EN24
Cutting Length: 50mm Diameter:. 25mm Temperature: 35°c

S.
NO Speed
RPM Depth of cut
(mm) Initial diameter
(mm) Axial
Force Fx (kgf) Radial
Force Fy (kgf) Tangential
Force Fz (kgf) Final diameter
(mm) Cutting

speed (m/min) Feed

(mm/rev) MRR

(cm3/min) Cutting time
(min)

1	235	0.5	25	06	90	85	24.5	18.45	0.21	1.93	1.01
2	235	0.5	24.5	03	89	72	24	18.08	0.21	1.89	1.01
3	235	0.5	24	08	66	66	23.5	16.98	0.21	1.78	1.01

TABLE 4
Material name: EN24
Cutting Length: 50mm Diameter:. 25mm Temperature: 200°c

S.
NO Speed
RPM Depth of cut
(mm) Initial diameter
(mm) Axial

Force Fx (kgf) Radial
Force Fy (kgf) Tangential
Force Fz (kgf) Final diameter
(mm) Cutting

speed (m/min) Feed

(mm/rev) MRR

(cm3/min) Cutting time
(min)

1	235	0.5	25	09	102	97	24.5	18.45	0.21	1.93	1.01
2	235	0.5	24.5	06	95	98	24	18.08	0.21	1.89	1.01
3	235	0.5	24	04	90	84	23.5	16.98	0.21	1.78	1.01

OBSERVATIONS: It was observed from above two tables 1, 2 which is one at room temperature and another at elevated temperature, that cutting forces at room temperature is higher when compared with the cutting forces at elevated temperatures. It was clearly observed that cutting forces reduced when the High carbon steel is machined at elevated temperature. Thus the above readings from two tables shows the usage of lathe tool Dynamometer in the experiment.

9.2. POWER CALCULATIONS OF LATHE MACHINE

Lathe machine runs with the help of three phase induction motor .The following are readings of power consumption of induction method at room condition of workpieces and at elevated conditions of workpieces.

(a) POWER CONSUMPTION BY LATHE FOR MACHINING HCS MATERIAL

TABLE 5
Material Name: HCS
Power consumption at temperature: 35°c

S.No	Depth of cut (mm)	Wattmeter reading (w)
1	0.5	604
2	0.5	569
3	0.5	640
	Average:	604.33

TABLE 6
HIGH CARBON STEEL
Temperature: 250°c

S.No	Depth of cut (mm)	Wattmeter reading (w)
1	0.5	474
2	0.5	370
3	0.5	470
	Average:	438

OBSERVATIONS: From above tables 5, 6 it was observed that the average power consumption of lathe machine at room temperature (35°c) is 694 watts and the average power consumption of lathe machine at elevated temperature (250°c) is 438 watts. From the both average readings we can conclude that power consumption is reduced by 166.3 watts when the HIGH CARBON STEEL is machined by heating it at 250°c. It was observed that 27.52% of power is saved if High carbon steel is machined by heating it.

(b) POWER CONSUMPTION BY LATHE FOR MACHINING EN24 MATERIAL

TABLE 7

S.No	Depth of cut (mm)	Wattmeter reading (w)
1	0.5	550
2	0.5	520
3	0.5	544
	Average:	538

Material Name: EN24
Power consumption at 35°c (room temperature)

TABLE 8
Material Name: EN24
Power consumption at 200°c (elevated temperature)

S.No	Depth of cut (mm)	Wattmeter reading (w)
1	0.5	520
2	0.5	520
3	0.5	456
	Average:	498.66

OBSERVATION: : From above tables 7,8 it was observed that the average power consumption of lathe machine at room temperature (35°c) is 538 watts and the average power consumption of lathe machine at elevated temperature (250°c) is 498.33 watts. From the both average readings we can conclude that power consumption is reduced by 39.34watts when the EN24 is machined by heating it at 200°c. It was observed that 7.31% of power is saved if High carbon steel is machined by heating it.

9.3. HARDNESS TEST CAKCULATIONS

JETIR

Hardness test was conducted before starting the experiment and after machining at elevated temperatures for both work pieces. The main objective of conducting Hardness test was to ensure that, whether any changes in mechanical properties was occurred due to machining of work pieces at elevated temperatures. Rockwell tester was used for testing the work piece. The following are the observations tabulated during test procedure.

(a) HIGH CARBON STEEL

TABLE 9
Hardness test at temperature 35°c (room temperature)

S.NO	Load (kgf)	C -Scale reading
1	150	11
2	150	12
3	150	12
	Average:	11.7

TABLE 10
Hardness test after Hot machining at 250°c

S.NO	Load (kgf)	C-Scale reading
1	150	09
2	150	11
3	150	12
	Average:	10.67

OBSERVATION: It was observed from the above two tables 9,10 the average hardness number of HCS at room temperature (35°c) is 11.7 HRC and the average hardness number at elevated temperature (250°c) is 10.67 HRC.From both the averages negligible amount i.e., is 1.03 reduction in hardness of Material is observed. This is negligible amount and this deviations is may be due to deviations in accuracy during the entire experimental process.

(b) EN24

TABLE 11
Hardness test at temperature 35°c (room temperature)

S.NO	Load (kgf)	B -Scale reading
1	150	06
2	150	20
3	150	17
	Average:	14.33

TABLE 12
Hardness test after Hot machining at 250°c

S.NO	Load (kgf)	B -Scale reading

1	150	13
2	150	12
3	150	17
	Average:	14

OBSERVATION: It was observed from the above two tables 11,12 the average hardness number of EN24 at room temperature (35°c) is 14.33 HRC and the average hardness number at elevated temperature (200°c) is 14 HRC.From both the averages negligible amount i.e., is 0.33 reduction in hardness of Material is observed. This is negligible amount and this deviations is may be due to deviations in accuracy during the entire experimental process.

VII. EXPERIMENTAL RESULTS

(a) Cutting force results: It was observed from tabulated values that, for both the workpieces i.e.,HCS and EN24 ,the cutting forces are reduced when the workpieces are machined at elevated temperatures. This is because of softening of workpieces due to heating it. This softening of material reduces power consumption for machining.

(b) Power consumption by lathe machine results: It was observed from tabulated values for both the workpieces i.e., HCS and EN24 ,the power consumption for machining workpieces at room temperature is higher than machining the workpieces at elevated temperatures or hot machined.

- Power consumption of HCS is reduced by 27.52% when it is machined at 250°c than machining at room temperature (35°c)
- Power consumption of EN24 is reduced by 7.31% when it was machined at 200°c than machinist room temperature (35°c)

(c)Hardness test results: It was observed from tabulated values that there is negligible change in Hardness numbers for both the work pieces when they are machined at room temperature and at elevated temperatures (200-250°c)

- HIGH CARBON STEEL hardness number is deviated from 11.7HRC to 10.67HRC which is negligible amount
- EN24 hardness number is deviated from 14.33 HRC to 14 HRC which is negligible amount.

VIII. ADVANTAGES

1. Minimising the mechanical properties of work piece materials during machining .
2. For easy machining operation.
3. Increasing the machinability property of material
4. Machining at higher machining parameters (higher cutting speed, feed and depth of cut)
5. Reducing tool wear and thereby increasing tool life.
6. Increasing productivity .
7. Reducing total production cost.

IX. CONCLUSION

- So it was concluded that heating of hard material to certain temperature and softening them by this process make them to machine easily without more tool wear and thereby decreasing the machining cost successfully . .
- The main objective of the experiment is to decrease the Power consumption rate of machine tool while machining high strength and hardness materials.
- From the experimental calculations it was observed that power consumption rate is decreased if the material is machined at elevated temperatures.

Hardness test comparison reveals that there is less deviations in strength values.

FUTURE SCOPE

As the main objective of this experiment is to save power consumption for machining hard materials which are very hard to machine at room temperature. Due to limited infrastructure and equipment it is not possible to us to improve the project results. As it was observed in tables 1,2,3,4 that material removal rate,feed,cutting time,cutting speed is made constant in both the conditions.It was made constant because here lead screw mechanism is used to give feed as skilled labour is not available. Temperature is just used between 200-250°c because the experiment is done in open air. As we cannot maintain constant temperature throughout the process of we use more than this temperatures.

Using skilled labour and using computer operated and air conditioned equipment we can increase the efficiency of this experiment. We can increase metal removal rate, feed rate, cutting speed and we can increase tool life as well

REFERENCES

[1] Mukherjee, P.N., Basu, S.K., 1973. Statistical evaluation of metal cutting parameters in hot machining. Int. J. Prod. Res. 2, No-1-21-36.

[2] N.Tosun,L.Ozler,2002,A study of tool life in hot-machining using artificial neural networks and regression analysis method, J. Material .

[3] N. Tosun ,L. Ozler, 2004, Optimization for hot turning operations with multiple Performance characteristics, Int J Adv Manuf Technol 23, 777– 782.

[4] K.P. Maity, P.K. Swain, An experimental investigation of hot machining to predict tool life, Int. J. of Materials processing technology 1 9 8 (2008) 344–349.

[5] Rozzi, J. C. , Pfefferkorn, F. E., Shin, Y. C., and Incropera, F. P., "Experimental Evaluation of the Laser Assisted Machining of Silicon Nitride Ceramics.", Journal of Manufacturing Science & Engineering, Transactions of the ASME, Vol. 122, Iss. 4,

Ozler, L., Inan, A., Ozel, C., 2000. Theoretical and experimental determination of tool life in hot machining of austenitic manganese steel. Int. J. Mach. Tool & Manuf. 41,163–172.