INTRODUCTION

A capstan or a turret lathe is a production lathe used to manufacture any number of identical pieces in the minimum time. The capstan or turret lathe consists of a bed, all geared headstocks, and a saddle on which a four station tool post is mounted to hold four different tools. A tool post fitted at the rear of the carriage holds a parting indexed by hand. In a capstan or turret lathe there is no tailstock, but in its place a hexagonal turret is mounted on a slide which rests upon the bed. All the six faces of the turret can hold six or more number of different tools. The turret may be indexed automatically and each tool may be brought in line with the lathe axis in a regular sequence.

The longitudinal and cross feed movement of the turret saddle and cross slide are regulated by adjustable stops. These stops enable different tools set at different stations to move by a predetermined amount for performing different of the machined surface in each case. These special characteristics of a capstan or turret lathe enable it to perform a series of operations such as turning, drilling, boring, thread cutting, reaming, chamfering and many other operations in a regular sequence to produce a large number of identical pieces in a minimum time.
The ram type turret lathe or capstan lathe carries the hexagonal turret on a ram or a short slide. The ram slides longitudinally on slide positioned and clamped on lathe bed ways. This type of machine is lighter in construction and is suitable for machining bar of smaller diameter. The tools are mounted on the square turret and six faces of the hexagonal turret. The feeding movement is obtained when the ram moves from left to the right, and when the ram is moved backward the turret indexes automatically and the tools mounted on the next face comes into operation.

The hexagonal turret is mounted directly on a saddle and the whole unit moves back and forth on the bed ways to apply feed. This type of turret lathe is heavier in construction and is particularly adapted for larger diameter bar work and chucking work. The machine can accommodate longer workpieces than that in a capstan lathe.
PARTS OF CAPSTAN AND TURRET LATHE

BED

The bed is a long box like casting providing with accurate guide ways upon which are mounted the carriage and turret saddle. The bed is designed to ensure strength, rigidity and permanency of alignment under heavy duty services.

HEAD STOCK

The head stock is a large casting located at the left hand end of the bed. The head stock may be of the following type.

1. STEP CONE PULLEY DRIVE HEAD STOCK

   It is used for machining almost constant diameter of workpiece. The machine required special counter shaft where starting, stopping and reversing of the spindle can be affected by simply pressing front pedal.

2. ELECTRIC MOTOR DRIVEN HEADSTOCK

   The spindle and the armature shaft of the motor are one and the same any speed variation or reversal is effected by simply controlling the motor the machine is suitable for smaller diameter of workpieces rotated at high speed.

3. ALL GEARED HEADSTOCK

   On the large lathes, the headstock is geared and different mechanisms are employed for speed changing by actuating levers. The speed changing may be done without stopping.

4. PRESELECTIVE HEADSTOCK

   It is an all geared headstock with previous for rapid stopping starting and speed changing the required speed for next operation is selected
and the speed changing lever is placed at the selected position, after the first operation is complete a button is simply actuated and the spindle starts rotating at the selected speed required for the second operation. This mechanism is effected by the friction clutches.

5. CROSS SLIDE AND SADDLE

In small capstan lathes, hand operated cross slide and saddle are used which are clamped on the lathe bed at the required position. In large capstan lathes usually conventional type carried are equipped. It bridges the gap between the front and rear bed ways and it equipped with four station type tool post at the front. And one rear toll post at the back of the cross slide.

6. TURRET SADDLE AND AUXILIARY SLIDE

In a capstan lathe the turret saddle bridges the gap between two bed ways and the top face is accurately machined to provide bearing surface. The saddle way is adjusted on lathe bed ways and clamped at the desired on lathe bed ways. The hexagonal turret is mounted on the auxiliary slide the turret is a hexagonal shaped tool holders intended for holding six or more tools. Six stop bass are mounted on the saddle which restricts the movement of each tool mounted on each face of the turret to the fed to a predetermined amount for duplicating workpieces.

RESULT

From the experiment the construction and working details of the capstan and turret lathe is studied.
STUDY OF MILLING MACHINE

CONSTRUCTION

The milling machine has two main structural elements, namely a column shaped main frame and a knee shaped projection. Column contains the spindle and its driving mechanism. Knee can be moved vertically on the column by rotating the hand wheel on it. This type of milling machines has a table, which travels longitudinally on the saddle. The saddle, which travels transversely, is mounted on the column in a manner, which permits it with the table to be lowered or raised to the desired height. Thus the table can be moved on a column, which in turn moves over the knee and the knee can slide over the column, allows the machines to have motion along three directions, namely in longitudinal, transverse and vertical directions.

WORKING PRINCIPLE

In a milling machine, the metal is cut by means of a multi-tooth-rotating cutter. For cutting operation, the workpiece is feed against a rotary cutter. As the work moves against the cutting edge, a tip of metal of torched shape is removed. Machined surfaces are formed in one or more passes of the work. The speed of the cutting tool and the rate at which the workpiece travels is depends upon the kind of material being machined. Optimum cutting efficiency is also related to machine capacity, cutter design, work holding fixture design, etc.
MAIN PARTS OF MILLING MACHINE

1. BASE

   It is the heavy casting that forms the foundation and thus supports all other parts of the milling machine. The base carries the column at the back end. Base also carries the elevating screw to support and move the knee up and down.

2. COLUMN

   This is the main casting of the machine and the column houses the driving motor and the gear mechanism for transmitting power to the spindle and the work table. The front of the column has vertical parallel column ways in which knee slides up and down. The top of the column supports the over-arm, which extend outward at the front of the milling machine.

3. KNEE

   The knee is with enclosed one feed charge gearing mechanism. The knee can be raised or lowered on the column face. It is supported and can be adjusted by the elevating screw. The top of the knee is machined at right-angles to the vertical surface and support the saddle, which slides on knee either towards or away from the face of the column.

4. SADDLE

   Saddle supports the table and it is supported and guided by the accurately machined surface of the knee. A precisely machined surface, usually dovetail, on the top of the saddle holds the table.

5. TABLE

   Table is mounted on the top of the saddle and holds the workpiece. The table has T – slots running lengthwise on its top surface. T – Slots can be used to fasten either the work or work holding device to the table.
6. **OVER-ARM**

   It is mounted on the top of the column and is guided in perfect alignment by the machined dovetail surfaces. The over arm is adjustable and can be tightened in any position. The over arm supports the arbor.

7. **SPINDLE**

   It is a hollow shaft, which revolves in bearing in the upper end of the column. The front end of the spindle projected from the column face has a tapered hole and driving keys for receiving the standard shanks of milling arbors.

8. **ARBOR**

   This is an accurately machined shaft. One end has a taper, which fits into a corresponding taper in the machine spindle. Arbor is designed to hold rotary milling cutters. Arbor is held firmly in place by tightening the drawbar.

**OPERATIONS**

   The different milling operations done on a milling machine are given below.

   1. Plain Milling.
   2. Form Milling
   3. Face Milling
   4. Side Milling
   5. End Milling
   6. ‘T’ – Slots Milling

**RESULT**

   From the experiment the construction and working details of the milling machine is studied.
STUDY OF GRINDING MACHINE

INTRODUCTION

Grinding is metal cutting operation performed by means of a rotating abrasive wheel that acts as a tool. This is used to finish workpieces which must show a high surface quality, accuracy of shape and dimension. Mostly grinding is the finishing operation it removes comparatively little metal, 0.25 to 0.50mm in most operations and the accuracy in dimensions is in the order of 0.000025mm. Grinding is also done to machine materials which are too hard for other machining methods that use cutting tools.

CYLINDRICAL CENTER-TYPE GRINDERS

Centre-type cylindrical grinders are intended primarily for grinding plain cylindrical parts, although they can also be used for grinding contoured cylinders, fillets, and even cams and crankshafts.

MAIN FEATURES

The workpiece is usually held between dead centers and rotated by a dog and driver on the face plate. The work may also be rotated about its own axis in a chuck.

There are four movements involved in a cylindrical center-type grinding:

1. the work must revolve,
2. the wheel must revolve,
3. the work must pass the wheel, and
4. The wheel must pass the work.
They are equipped with a mechanism which enables the grinding wheel to be fed in automatically towards the work for successive cuts. Hand feed is employed only in adjusting the wheel or starting the cut. A provision is also made for varying the longitudinal movement of the work or the wheel, and the rotating speed of the work to suit different conditions. The traverse of the work past the wheel or vice versa, is controlled by dogs which cause the table or wheel to reverse at the end of each stroke. An important feature of some types of grinders is that the operation may be stopped automatically when the workpiece has been finished to size.

Usually in cylindrical grinding machine, two distinct types of grinding operation are done.

1. **Traverse grinding**, in which the work is reciprocated as the wheel feeds to produce cylinders longer than the width of the wheel face.

2. **Plunge grinding**, the work rotates in an affixed position as the wheel feeds to produce cylinders of a length equal to or shorter than the width of the wheel. This has the important advantage that cylindrical shapes can be produced as easily as straight cylinders in a single “plunge” of the wheel simply by forming the periphery of the wheel.

The general range of work speeds for cylindrical grinding is from 20 to 30 s.m.p.m. (surface speed in meter per minute). In grinding cranks or other work that is out of balance, lower surface speed is necessary. Plunge grinding requires very low speed. Thread grinding requires work speed as low as 1 to 3 s.m.p.m. wheel speeds usually range from 1500 to 2000 s.m.p.m. Traverse speeds should be in proportion to the width of the wheel face and the finish desired.
The in feed, or depth of cut, at each reversal should be from 0.025 to 0.125 mm for roughing and from 0.0125 to 0.0625 mm for finishing. The longitudinal feed should be from $\frac{1}{4}$ to $\frac{3}{4}$ of the width of the wheel’s face, depending on the power and rigidity of the machine.
PLAIN CENTRE-TYPE CYLINDRICAL GRINDERS

A plain grinding machine is essentially a lathe on which a grinding wheel has been substituted for the single point tool. It consists of the following parts:

BASE

The base or bed is the main casting that rests on the floor and supports the parts mounted on it. On the top of the base are precision horizontal ways set at right angles for the table to slide on. The base also houses the table-drive mechanism.

TABLES

There are two tables-lower table and upper table. The lower table slides on ways on the bed provides traverse of the work past the grinding wheel. It can be moved by hand or power within desired limits. The upper table that is provided at its center is mounted on the top of the sliding table. It has T-slots for securing the headstock and tailstock and can be positioned along the table to suit the length of the work. The upper table can be swiveled and clamped in position to provide adjustment for grinding straight or tapered work as desired. Setting for tapers up to + or - 10° can be made in this way. Steep tapers are ground by swivelng the wheel head. Adjustable dogs are clamped in longitudinal slots and they are provided at the side of the lower or sliding table and are set up to reverse the table at the ends of the stroke.

HEADSTOCK

The headstock supports the workpiece by means of dead center and drives it by means of a dog, or it may hold and drive the workpiece in a chuck.
TAILSTOCK

The tailstock can be adjusted and clamped in various positions to accommodate different lengths of workpieces.

WHEEL HEAD

The wheel head carries a grinding wheel and its driving motor is mounted on a slide at the top and rear of the base. The wheel head may be moved perpendicularly to the table ways, by hand or power, to feed the wheel to the work.

CROSS FEED

The grinding wheel is fed to the work by hand or power as determined by the engagement of the cross-feed control lever. On plain grinding machine, the operation may be stopped automatically when the workpiece has been finished to size. In one method it uses an automatic caliper type gauging attachment to measure the workpiece and stop the operation at the proper time.

UNIVERSAL CENTRE-TYPE GRINDERS.

Universal grinders are widely used in tool rooms for grinding tool, etc. A Universal machine has the following additional features:

1. The headstock spindle may be used alive or dead, so that the work can be held and revolved by chuck as well as ground between centers.
2. The headstock can be swiveled at an angle in a horizontal plane.
3. The wheel head and slide can be swiveled and traversed at any angle. The wheel head can also be arranged for internal grinding by the addition of an auxiliary wheel head to revolve small wheels at high speeds.
CENTRELESS GRINDERS

Centre less grinding is a method of grinding exterior cylindrical, tapered, and formed surfaces on workpieces that are not held and rotated on centre. The principal elements of an external centre less grinder are the grinding wheel, regulating or back up wheel, and the work rest. Both wheels are rotated in the same direction. The work rest is located between the wheels. The work is placed upon the work, rest, and the latter, together with the regulating wheel, is fed forward, forcing the work against the grinding wheel. The axial movement of the work past the grinding wheel is obtained by tilting the regulating wheel at a slight angle from horizontal. An angular adjustment of 0 to 8 or 10 degrees is provided in the machine for this purpose. The actual feed can calculate by the formula:

\[ S = \pi dn \sin \alpha \]

Where

- \( S \) = feed in mm per minute.
- \( n \) = revolving per minute.
- \( d \) = diameter of regulating wheel in mm.
- \( \alpha \) = angle if inclination of wheel.

Centrals grinding may be done in one of the three ways

1. Through feed,
2. In feed and
3. End feed.

In through grinding, the work is passed completely through the space between the grinding wheel and regulating wheel, usually with guides at both ends. This method is used when there are no shoulders or other forms to interfere with the passage of the work. It is useful for grinding long, slender shafts or bars. The layer of metal removed by the grinding wheel in one pass reduces the diameter of the workpiece by 0.02 to 0.3mm.
In feed grinding, which is similar to plunge grinding or form grinding, the regulating wheel is drawn back so that workpieces may be placed on the work-rest blade. Then it is moved in to feed the work against the grinding wheel. This method is useful to grind shoulders, and formed surfaces. In end feed grinding, used to produce taper, either the grinding wheel or regulating wheel or both are formed to a taper. The work is fed lengthwise between the wheels and is ground as it advances until it reaches the end stop.

The advantages of centre less grinding are:

1. As a true floating condition exists during the grinding process, less metal needs to be removed.
2. The workpiece being supported throughout its length as grinding takes place, there is no tendency for chatter or deflection of the work and small, fragile or slender workpieces can be ground easily.
3. The process is continuous and adapted for production work.
4. No centre holes, no chucking or mounting of the work on mandrels or other holding devices are required.
5. The size of the work is easily controlled.
6. A low order of skill is needed in the operation of the machine.

SURFACE GRINDING

Surface grinding is used to produce a smooth finish on flat surfaces. It is a widely used abrasive machining process in which a spinning wheel covered in rough particles (grinding wheel) cuts chips of metallic or nonmetallic substance from a workpiece, making a face of it flat or smooth. Surface grinding is the most common of the grinding operations. It is a finishing process that uses a rotating abrasive wheel to smooth the flat surface of metallic or nonmetallic materials to give them a more refined look or to attain a desired surface for a functional purpose.
The surface grinder is composed of an abrasive wheel, a workholding device known as a chuck, and a reciprocating or rotary table. The chuck holds the material in place while it is being worked on. It can do this one of two ways: ferromagnetic pieces are held in place by a magnetic chuck, while non-ferromagnetic and nonmetallic pieces are held in place by vacuum or mechanical means. A machine vise (made from ferromagnetic steel or cast iron) placed on the magnetic chuck can be used to hold non-ferromagnetic workpieces if only a magnetic chuck is available.

Factors to consider in surface grinding are the material of the grinding wheel and the material of the piece being worked on. Typical workpiece materials include cast iron and mild steel. These two materials don't tend to clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics. When grinding at high temperatures, the material tends to become weakened and is more inclined to corrode. This can also result in a loss of magnetism in materials where this is applicable.

The grinding wheel is not limited to a cylindrical shape and can have a myriad of options that are useful in transferring different geometries to the object being worked on. Straight wheels can be dressed by the operator to produce custom geometries. When surface grinding an object, one must keep in mind that the shape of the wheel will be transferred to the material of the object like a mirror image.

Spark out is a term used when precision values are sought and literally means "until the sparks are out (no more)". It involves passing the workpiece under the wheel, without resetting the depth of cut, more than once and generally multiple times. This ensures that any inconsistencies in the machine or workpiece are eliminated.
TOOL ANGLE GRINDING WITH TOOL AND CUTTER GRINDING

A tool and cutter grinder is used to sharpen milling cutters and tool bits along with a host of other cutting tools. It is an extremely versatile machine used to perform a variety of grinding operations: surface, cylindrical, or complex shapes. The image shows a manually operated setup, however highly automated Computer Numerical Control (CNC) machines are becoming increasingly common due to the complexities involved in the process.

The operation of this machine (in particular, the manually operated variety) requires a high level of skill. The two main skills needed are understanding of the relationship between the grinding wheel and the metal being cut and knowledge of tool geometry. The illustrated set-up is only one of many combinations available. The huge variety in shapes and types of machining cutters requires flexibility in usage. A variety of dedicated fixtures are included that allow cylindrical grinding operations or complex angles to be ground. The vise shown can swivel in three planes. The table moves longitudinally and laterally, the head can swivel as well as being adjustable in the horizontal plane, as visible in the first image. This flexibility in the head allows the critical clearance angles required by the various cutters to be achieved.

GRINDING MACHINE

A grinding machine, often shortened to grinder, is any of various power tools or machine tools used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece via shear deformation. Grinding is used to finish workpieces that must show high surface quality (e.g., low surface roughness) and high accuracy of shape and dimension. As the accuracy in dimensions in grinding is on the order of 0.000025 mm, in most applications it tends to be a finishing operation and removes comparatively little metal, about 0.25 to 0.50 mm
depth. However, there are some roughing applications in which grinding removes high volumes of metal quite rapidly. Thus, grinding is a diverse field.

The grinding machine consists of a bed with a fixture to guide and hold the workpiece, and a power-driven grinding wheel spinning at the required speed. The speed is determined by the wheel’s diameter and manufacturer’s rating. The user can control the grinding head to travel across a fixed workpiece, or the workpiece can be moved while the grind head stays in a fixed position.

Fine control of the grinding head or tables position is possible using a Vernier calibrated hand wheel, or using the features of numerical controls. Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat. To cool the workpiece so that it does not overheat and go outside its tolerance, grinding machines incorporate a coolant. The coolant also benefits the machinist as the heat generated may cause burns. In high-precision grinding machines (most cylindrical and surface grinders), the final grinding stages are usually set up so that they remove about 200 nm (less than 1/10000 in) per pass; this generates so little heat that even with no coolant, the temperature rise is negligible.

**SURFACE GRINDER**

Surface grinding uses a rotating abrasive wheel to remove material, creating a flat surface. The tolerances that are normally achieved with grinding are ±2 × 10⁻⁴ inches for grinding a flat material, and ±3 × 10⁻⁴ inches for a parallel surface (in metric units: 5 μm for flat material and 8 μm for parallel surface). The surface grinder is composed of an abrasive wheel, a work holding device known as a chuck, either electromagnetic or vacuum, and a reciprocating table. Typical workpiece materials include cast iron and steel. These two materials donot tend to clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics.
CYLINDRICAL GRINDING

Cylindrical grinding (also called center-type grinding) is used to grind the cylindrical surfaces and shoulders of the workpiece. The workpiece is mounted on centers and rotated by a devise known as a drive dog or center driver. The abrasive wheel and the workpiece are rotated by separate motors and at different speeds. The table can be adjusted to produce tapers. The wheel head can be swiveled. The five types of cylindrical grinding are: outside diameter (OD) grinding, inside diameter (ID) grinding, plunge grinding, creep feed grinding, and centerless grinding.

A cylindrical grinder has a grinding (abrasive) wheel, two centers that hold the workpiece, and a chuck, grinding dog, or other mechanism to drive the work. Most cylindrical grinding machines include a swivel to allow for the forming of tapered pieces. The wheel and workpiece move parallel to one another in both the radial and longitudinal directions. The abrasive wheel can have many shapes. Standard disk shaped wheels can be used to create a tapered or straight workpiece geometry while formed wheels are used to create a shaped workpiece. The process using a formed wheel creates less vibration than using a regular disk shaped wheel. Tolerances for cylindrical grinding are held within five ten-thousandths of an inch (+/- 0.0005) (metric: +/- 13 um) for diameter and one ten-thousandth of an inch (+/- 0.0001) (metric: 2.5 um) for roundness. Precision work can reach tolerances as high as fifty millionths of an inch (+/- 0.00005) (metric: 1.3 um) for diameter and ten millionths (+/- 0.00001) (metric: 0.25 um) for roundness. Surface finishes can range from 2 to 125 microinches (metric: 50 nm to 3 um), with typical finishes ranging from 8-32 microinches. (metric: 0.2 um to 0.8 um)
CREEP-FEED GRINDING

Creep-feed grinding (CFG) was invented in Germany in the late 1950s by Edmund and Gerhard Lang. Unlike normal grinding, which is used primarily to finish surfaces, CFG is used for high rates of material removal, competing with milling and turning as a manufacturing process choice. Depths of cut of up to 6 mm (0.25 inches) are used along with low workpiece speed. Surfaces with asoftergrade resin bond are used to keep workpiece temperature low and an improved surface finish up to 1.6 micrometersRmax with CFG it takes 117 sec to remove 1 in.3 of material, whereas precision grinding would take more than 200 sec to do the same. CFG has the disadvantage of a wheel that is constantly degrading, and requires high spindle power, 51 hp (38 kW), and is limited in the length of part it can machine.

To address the problem of wheel sharpness, continuous-dress creep-feed grinding (CDCF) was developed in the 1970s. It dresses the wheel constantly during machining, keeping it in a state of specified sharpness. It takes only 17 sec. to remove 1 in3 of material, a huge gain in productivity. 38 hp (28 kW) spindle power is required, and runs at low to conventional spindle speeds. The limit on part length was erased.

High-efficiency deep grinding (HEDG) uses plated superabrasive wheels, which never need dressing and last longer than other wheels. This reduces capital equipment investment costs. HEDG can be used on long part lengths, and removes material at a rate of 1 in3 in 83 sec. It requires high spindle power and high spindle speeds. Peel grinding, patented under the name of Quickpoint in 1985 by Erwin Junker Maschinenfabrik, GmbH in Nordrach, Germany, uses a tool with a with superabrasive nose and can machine cylindrical parts.
VIPER (Very Impressive Performance Extreme Removal), 1999, is a process patented by Rolls-Royce and is used in aerospace manufacturing to produce turbine blades. It uses a continuously dressed aluminum oxide grinding wheel running at high speed. CNC-controlled nozzles apply refrigerated grinding fluid during the cut. VIPER is performed on equipment similar to a CNC machining center, and uses special wheels. Ultra-high speed grinding (UHSG) can run at speeds higher than 40,000 fpm (200 m/s), taking 41 sec to remove 1 in.3 of material, but is still in the R&D stage. It also requires high spindle power and high spindle speeds.

**CENTERLESS GRINDING**

Form grinding is a specialized type of cylindrical grinding where the grinding wheel has the exact shape of the final product. The grinding wheel does not traverse the workpiece. Internal grinding is used to grind the internal diameter of the workpiece. Tapered holes can be ground with the use of internal grinders that can swivel on the horizontal.

Center less grinding is when the workpiece is supported by a blade instead of by centers or chucks. Two wheels are used. The larger one is used to grind the surface of the workpiece and the smaller wheel is used to regulate the axial movement of the workpiece. Types of center less grinding include through-feed grinding, in-feed/plunge grinding, and internal center less grinding. Pre-grinding when a new tool has been built and has been heat-treated, it is pre-ground before welding or hard facing commences. This usually involves grinding the OD slightly higher than the finish grind OD to ensure the correct finish size.
Electrochemical grinding is a type of grinding in which a positively charged workpiece in a conductive fluid is eroded by a negatively charged grinding wheel. The pieces from the workpiece are dissolved into the conductive fluid. Electrolytic in-process dressing (ELID) grinding is one of the most accurate grinding methods. In this ultra precision grinding technology the grinding wheel is dressed electrochemically and in-process to maintain the accuracy of the grinding. An ELID cell consists of a metal bonded grinding wheel, a cathode electrode, a pulsed DC power supply and electrolyte. The wheel is connected to the positive terminal of the DC power supply through a carbon brush whereas the electrode is connected to the negative pole of the power supply. Usually alkaline liquids are used as both electrolytes and coolant for grinding. A nozzle is used to inject the electrolyte into the gap between wheel and electrode. The gap is usually maintained to be approximately 0.1mm to 0.3 mm. During the grinding operation one side of the wheel takes part in the grinding operation whereas the other side of the wheel is being dressed by electrochemical reaction. The dissolution of the metallic bond material is caused by the dressing which in turns results continuous protrusion of new sharp grits.

**GRINDING WHEEL**

A grinding wheel is an expendable wheel used for various grinding and abrasive machining operations. It is generally made from a matrix of coarse abrasive particles pressed and bonded together to form a solid, circular shape, various profiles and cross sections are available depending on the intended usage for the wheel. Grinding wheels may also be made from a solid steel or aluminum disc with particles bonded to the surface.
STUDY OF GEAR SHAPING

GEAR SHAPING

Gear shaping is a machining process for creating teeth on a gear using a cutter. Gear shaping is a convenient and versatile method of gear cutting. It involves continuous, same-plane rotational cutting of gear.

A gear shaper is a machine tool for cutting the teeth of internal or external gears. The name shaper relates to the fact that the cutter engages the part on the forward stroke and pulls away from the part on the return stroke, just like the clapper box on a planer shaper.

The cutting tool is also gear shaped having the same pitch as the gear to be cut. However number of cutting teeth must be less than that of the gear to be cut for internal gears. For external gears the number of teeth on the cutter is limited only by the size of the shaping machine. For larger gears the blank is sometimes gashed to the rough shape to make shaping easier.
The principal motions involved in rotary gear shaper cutting are of the following:

1. **Cutting Motion**: The downward linear motion of the cutter spindle together with the cutter.

2. **Return Stroke**: The upward linear travel of the spindle and cutter to withdraw the latter to its starting position.

3. **Indexing Motion**: Slow speed continuous rotation of the cutter spindle and work spindle to provide circular feed, the two speeds being regulated through the change gears such that against each rotation of the cutter the gear blank revolves through \( \frac{n}{N} \) revolution, where "n" is the number of teeth of the cutter, and "N" is the number of teeth to be cut on the blank.

4. **Completion of Cutting Operation**: The indexing and reciprocating motions continue until the required number of teeth to the required depth is cut all along the periphery of the gear blank.
STUDY OF GEAR HOBBING

Hobbing is a machining process for making gears, splines and sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the workpiece by a series of cuts made by a cutting tool called a *hob*. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities. It is the most widely used gear cutting process for creating spur and helical gears and more gears are cut by hobbing than any other process since it is relatively quick and inexpensive.

Hobbing uses a hobbing machine with two skew spindles, one mounted with a blank workpiece and the other with the hob. The angle between the hob's spindle and the workpieces spindle varies, depending on the type of product being produced. For example, if a spur gear is being produced, then the hob is angled equal to the helix angle of the hob; if a helical gear is being produced then the angle must be increased by the same amount as the helix angle of the helical gear. The two shafts are rotated at a proportional ratio, which determines the number of teeth on the blank; for example, if the gear ratio is 40:1 the hob rotates 40 times to each turn of the blank, which produces 40 teeth in the blank. Note that the previous example only holds true for a single threaded hob; if the hob has multiple threads then the speed ratio must be multiplied by the number of threads on the hob. The hob is then fed up into workpiece until the correct tooth depth is obtained. Finally the hob is fed into the workpiece parallel to the blank's axis of rotation.

Up to five teeth can be cut into the workpiece at the same time. Oftentimes multiple gears are cut at the same time. For larger gears the blank is usually gashed to the rough shape to make hobbing easier.
EQUIPMENT

Modern hobbing machines, also known as hobbers, are fully automated machines that come in many sizes, because they need to be able to produce anything from tiny instrument gears up to 10 ft (3.0 m) diameter marine gears. Each gear hobbing machine typically consists of a chuck and tailstock, to hold the workpiece or a spindle, a spindle on which the hob is mounted, and a drive motor.

For a tooth profile which is a theoretical involute, the fundamental rack is straight-sided, with sides inclined at the pressure angle of the tooth form, with flat top and bottom. The necessary addendum correction to allow the use of small-numbered pinions can either be obtained by suitable modification of this rack to a cycloidal form at the tips, or by hobbing at other than the theoretical pitch circle diameter. Since the gear ratio between hob and blank is fixed, the resulting gear will have the correct pitch on the pitch circle, but the tooth thickness will not be equal to the space width.
Hobbing machines are characterized by the largest module or pitch diameter it can generate. For example, a 10 in (250 mm) capacity machine can generate gears with a 10 in pitch diameter and usually a maximum of a 10 in face width. Most hobbing machines are vertical hobbers, which mean the blank is mounted vertically. Horizontal hobbing machines are usually used for cutting longer workpieces; i.e. cutting splines on the end of a shaft.
STUDY OF CNC PROGRAMMING

BASIC COMPONENTS OF NC SYSTEMS

An operational Numerical Control (NC) system consist of the following basic components

1. Program of instruction
2. Controller units, also called Machine control unit
3. Machine tool or other controlled process

PROGRAM INSTRUCTION

The program of instruction is detailed step by step set of directions, which tell the machine tool what to do, it is coded in numeric or symbolic form on some type of input medium that can be interpreted by controller unit input to NC machines is b either manual data input (MDI) or direct numerical control (DNC). Someone called part programmer prepares the program of instruction. The programmer’s job is to provide a set of detailed instruction by which sequence of processing steps is to be performed. For machine operation, the processing steps involve the relative movements between the cutting tool and the work place.

NC PROCEDURE

To utilize the numerical control in manufacturing the following steps must be accomplished

**Process Planning:** The interpretation of engineering drawing work part in terms of manufacturing process is process planning and is concerned with the preparation of route sheet

**Part Programming:** A part programmer plans the process for the portion of the jobs to be accomplished by NC. There are two ways to program NC.
1. Manual Part Programming
2. Computer assisted part programming

Manual Part Programming: A part programming plans the process for the portions of the job to be accomplished by NC. In manual part programming the machining instruction are prepared by the programmer on a special form called a part program Manuscript. The manuscript comes in various form depending on the machine tool and the tape format to be used, For example the manuscript form for the two axis point to point drilling machine would be different than one for a three axis machine. The manuscript is a listing of the relative cutter or workpiece positions, which must be followed to machine the part it also includes other data such as preparatorycommand. Miscellaneous instructions, and speed, feed specifications, all of which are needed to operate the machine under tape control.

Computer assisted Part Programming: Most part machined on NC System are considerably more complex in more complicated point to point jobs and on contouring applications manual part programming becomes has extremely tedious task and subject to errors. Use of the computer in these situations resulted in significant saving in part programming time. In computer assisted part programming much of the tedious computational work required. In manual part programming is transferred to the computer. This is especially appropriate for complex workpiece geometries and jobs with many machining steps.

Manual programming language systems have been developed to transform automatically more of the calculation, which the programmer would, otherwise is being forced to do. This saves time and results in more accurate and efficient part program.

1. Defining the work part geometry
2. Specifying the operation, sequence and tool path
NC part Programming:

The following is the list of different types of words in the formation of a block in an NC program. The manner in which the words are expressed will different between machines.

**Sequence Number (N-words):**

This is used to identify the block

**Preparatory Word (G-words):**

This word is used to prepare the controller for instructions that are to follow, for example the words G02 are used to prepare NC controller unit for circular interpolation long an arc in the clock wise direction

**Coordinates (X, Y and Z):**

These give the coordinate position of the tool in a two-axis system only two of the words are used. In a four or five axis machine additional a word or b- word would specify the angular position

**Feed Rate (F-word):**

This specifies the speed in the Machining operation units is inches/minute by conventional.

**Cutting Speed (S-word):**

This specifies the cutting speed of the process the rate at which the spindle rotates

**Tool Selection (T-word):**

This word would be needed only for machine with the tool turret are automatic too changer. The T-word specifies which tool is to be used in the operation. For example T05 might be the designation of a 1/2-inch drill bit in turret position 5 on an NC turret drill.
**Miscellaneous Function (M-word):**

The M-word is used to specify certain miscellaneous of auxiliary function which may be available on the machine tool. To identify the end of the instruction an end of block is used.

Some of the important NC languages:

1. APT (Automatically Programmed Tool)
2. ADAPT (Adaptation of APT)
3. EXAPT (Extended subset of APT)
4. UNIAPT (United APT)
5. SPLIT (Sunstrand processing language internally Translated)

APT is not only an NC language it is also computer program that perform the calculation to generate cutter positions based on APT statements. There are three types

1. **Geometry Statement:** These define the geometric elements that comprise the work part they are also some time called definition statements
2. **Motion Statement:** These apply to the specify machine tool and control system. They are used to specify speeds and feeds and to actuate other features of the machine
3. **Auxiliary Statement:** These are miscellaneous statement used to identify the part, tool, tolerance and so on.
### PREPARATORY FUNCTIONS (G-CODES)

<table>
<thead>
<tr>
<th>G CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>G00</td>
<td>POSITIONING</td>
</tr>
<tr>
<td>G01</td>
<td>LINEAR INTERPOLATION</td>
</tr>
<tr>
<td>G02</td>
<td>CLOCKWISE CIRCULAR INTERPOLATION</td>
</tr>
<tr>
<td>G03</td>
<td>COUNTER CLOCKWISE CIRCULAR INTERPOLATION</td>
</tr>
<tr>
<td>G04</td>
<td>DWELL</td>
</tr>
<tr>
<td>G20</td>
<td>CALL FOR STANDARD SUBROUTINE</td>
</tr>
<tr>
<td>G21</td>
<td>CALL FOR PARAMETRIC SUBROUTINE</td>
</tr>
<tr>
<td>G22</td>
<td>DEFINITION OF STANDARD SUBROUTINE</td>
</tr>
<tr>
<td>G23</td>
<td>DEFINITION OF PARAMETRIC SUBROUTINE</td>
</tr>
<tr>
<td>G24</td>
<td>END OF SUBROUTINE</td>
</tr>
<tr>
<td>G25</td>
<td>UNCONDITIONAL JUMP / CALL</td>
</tr>
<tr>
<td>G26</td>
<td>CONDITIONAL JUMP / CALL IF ZERO</td>
</tr>
<tr>
<td>G27</td>
<td>CONDITIONAL JUMP / CALL IF DIFFERENT FROM ZERO</td>
</tr>
<tr>
<td>G28</td>
<td>CONDITIONAL JUMP / CALL IF SMALLER THAN ZERO</td>
</tr>
<tr>
<td>G29</td>
<td>CONDITIONAL JUMP / CALL IF EQUAL OR GREATER THAN ZERO</td>
</tr>
<tr>
<td>G33</td>
<td>THREAD CUTTING</td>
</tr>
<tr>
<td>G36</td>
<td>AUTOMATIC RADIUS BLEND</td>
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<tr>
<td>G37</td>
<td>TANGENTIAL APPROACH</td>
</tr>
<tr>
<td>G38</td>
<td>TANGENTIAL EXIT</td>
</tr>
<tr>
<td>G39</td>
<td>CHAMFERING</td>
</tr>
<tr>
<td>G40</td>
<td>MISCELLANEOUS FUNCTIONS (M CODES)</td>
</tr>
</tbody>
</table>
M-CODE LIST (LATHE)

M00    PROGRAM STOP
M01    OPTIONAL PROGRAM STOP
M02    END OF PROGRAM
M03    SPINDLE START FORWARD CW
M04    SPINDLE START REVERSE CCW
M05    SPINDLE STOP
M08    COOLANT ON
M09    COOLANT OFF
M29    RIGID TAP MODE
M30    END OF PROGRAM RESET
M40    SPINDLE GEAR AT MIDDLE
M41    LOW GEAR SELECT
M42    HIGH GEAR SELECT
M68    HYDRAULIC CHUCK CLOSE
M69    HYDRAULIC CHUCK OPEN
M78    TAILSTOCK ADVANCING
M79    TAILSTOCK REVERSING
M94    MIRROR IMAGE CANCEL
M95    MIRROR IMAGE OF X AXIS
M98    SUBPROGRAM CALL
M99    END OF SUBPROGRAM
<table>
<thead>
<tr>
<th>M CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M00</td>
<td>PROGRAM STOP</td>
</tr>
<tr>
<td>M01</td>
<td>OPTIONAL PROGRAM STOP</td>
</tr>
<tr>
<td>M02</td>
<td>END OF PROGRAM</td>
</tr>
<tr>
<td>M03</td>
<td>SPINDLE START FORWARD CW</td>
</tr>
<tr>
<td>M04</td>
<td>SPINDLE START REVERSE CCW</td>
</tr>
<tr>
<td>M05</td>
<td>SPINDLE STOP</td>
</tr>
<tr>
<td>M06</td>
<td>TOOL CHANGE</td>
</tr>
<tr>
<td>M07</td>
<td>COOLANT ON – MIST COOLANT/COOLANT THRU SPINDLE</td>
</tr>
<tr>
<td>M08</td>
<td>COOLANT ON – FLOOD COOLANT</td>
</tr>
<tr>
<td>M09</td>
<td>COOLANT OFF</td>
</tr>
<tr>
<td>M19</td>
<td>SPINDLE ORIENTATION</td>
</tr>
<tr>
<td>M28</td>
<td>RETURN TO ORIGIN</td>
</tr>
<tr>
<td>M29</td>
<td>RIGID TAP</td>
</tr>
<tr>
<td>M30</td>
<td>END OF PROGRAM (RESET)</td>
</tr>
<tr>
<td>M41</td>
<td>LOW GEAR SELECT</td>
</tr>
<tr>
<td>M42</td>
<td>HIGH GEAR SELECT</td>
</tr>
<tr>
<td>M94</td>
<td>CANCEL MIRROR IMAGE</td>
</tr>
<tr>
<td>M95</td>
<td>MIRROR IMAGE OF X AXIS</td>
</tr>
<tr>
<td>M96</td>
<td>MIRROR IMAGE OF Y AXIS</td>
</tr>
<tr>
<td>M98</td>
<td>SUBPROGRAM CALL</td>
</tr>
<tr>
<td>M99</td>
<td>END OF SUBPROGRAM</td>
</tr>
</tbody>
</table>
EX.NO: 1 CONTOUR SHAPE OF MILLING

DATE:

AIM

To machine the given rod as per given dimensions shown in the sketch by using the Milling machines.

TOOLS REQUIRED

1. Milling cutter
2. Table
3. Fixture
4. Vernier caliper
5. Steel rule

PROCEDURE

1. The given aluminum plate [length 130mm x 100mm] is inserted to in the fixture.
2. The fixture is clamped in the table.
3. Side and face milling cutter 10” dia is set in the arbor of the vertical milling machine.
4. The rotary table is fixed on the table of the milling machine.
5. The plate is positioned with respect to the cutters.
6. Machining is initiated for 80mm lengthso that thin dimension is maintained between two parallel faces.
7. The feed depth is increased by raising the table of the milling machine.
8. Similarly, all the sides’ plate of the contour shape has to be machined.
9. Finally the dimension of the finished job is checked with the help of vernier caliper.

RESULT

Thus the given workpiece is machined to the given dimensions using milling machine.
EX.NO: 2  FACING, PLAN TURNING, DRILLING GROOVING AND PARTING OFF IN A CAPSTAN LATHE

DATE:

AIM
To machine the workpiece to the given dimensions using capstan lathe.

TOOLS REQUIRED
1. Stopper
2. Drill chuck
3. Counter sink bit
4. Drill bit
5. Turning tool
6. Parting off tool
7. Venire Caliper.

PROCEDURE
1. Prepare the tooling layout for the given workpiece.
2. Set the tools in their respective positions of the tool stations.
3. The workpiece is chucked and checked for the rotation.
4. The adjustment to the length of feed for each tool is adjusted by rotating the adjustment screws.
5. Feed the tools in the required sequence to machine the given workpiece.
RESULT

Thus the given workpiece is machined to the given dimensions using capstan lathe.
EX.NO: 3  CYLINDRICAL GRINDING
DATE:

AIM
To grind the given workpiece to a tolerance of +/- 0.05 mm using cylindrical grinding machine.

TOOLS REQUIRED
1. Vernier Caliper
2. Micrometer
3. Center Drill BS4
4. Spanner

PROCEDURE
1. The given rod should be turned to the required diameter in the lathe as given below.
2. After facing operation is performed to get the required length of the job, a counter sunk is produced on both ends of the job in the capstan lathe.
3. Then the turning tool is fixed on the tool post and one end is step turned to a diameter of 15 mm to a length of 25 mm.
4. Another turning operation for diameter of 20 mm to a length of 25 mm is done.
5. Another end is step turned to a diameter of 15 mm to a length of 25 mm.
6. After turning operation is completed an undercut for required dimensions is made at a distance of 45 mm from one end.
7. Undercut is done to a diameter of 15 mm for 5 mm width.
8. Finally chamfering operation is performed on both ends of the job.
9. Then the job is mounted between centers of the cylindrical grinder using dog and carrier.
10. The job is then ground at the required portion in length wise direction.
11. Care should be taken that the ground portion should be within the tolerance of +/- 0.05 mm from the given dimension.

RESULT

Thus the given workpiece is ground to a tolerance of +/- 0.05 mm from the given dimension.
EX. NO: 4  CENTRELESS GRINDING

DATE:

AIM

To grind the given M.S. round rod to a tolerance of +/-0.05mm for the given dimension using centreless grinding machine.

TOOLS REQUIRED

1. Vernier Caliper
2. Drill bit
3. Single point Cutting Tool
4. Spanner

PROCEDURE

1. The given rod should be turned to the required diameter in the lathe
2. Then the job is mounted on the table of the cylindrical grinder between the centers of the rotating wheel.
3. The job is then grounded at the required portion.
4. Care should be taken that the grounded portion should be within the tolerance limit of +/-0.05mm from the given dimension.
5. Continuous apply of coolant may result in good surface finish
RESULT

Thus the given M.S. rod is grounded to a tolerance of +/- 0.05mm from the given dimension.
EX. NO: 5  SURFACE GRINDING

DATE:
AIM
To grind the given lob for the specified dimension in the Surface Grinding machine.

TOOLS REQUIRED
1. Vernier caliper
2. Single point cutting tool
3. Spanner
4. Drill bit
5. Boring tool
6. Centre punch drill

PROCEDURE
1. Mark the dimension for the given workpiece (plate50x50mm).
2. Fit it to the vice and file the job.
3. Fix the job in the magnetic chuck and lock it
4. Remove the surface in a micron level in the job
5. Measure the surface to the given micron level using gauge.
RESULT

Thus the M.S. plate is machined on the given job as per dimension.
EX. NO. 6               DRILL TOOL DYNAMOMETER

DATE :

AIM

To drill the given dimension on the M.S. plate and find Thrust and Torque.

TOOLS REQUIRED

1. Steel rule,
2. Hammer,
3. Centre punch
4. Scriber
5. Drill bit

PROCEDURE

1. First take specimen and mark as per the given dimension.
2. Using the punch go for a vertical spot.
3. Set the drill bit in the tool holder and specimen is kept on the work table and drills it.
4. Similarly go for remaining holes as per the diameter given.
5. While drilling, note the Torque and Thrust reading, for four different readings.
where,

- $F_c$ = cutting force (measured)
- $F_t$ = tangential force (measured)
- $R$ = resultant of $F_c$ and $F_t$

**CALCULATE**

where,

- $F$ = friction force between tool and chip
- $N$ = normal force between tool and chip

![Thrust force ($F_z$) and Torque ($M_z$)](image)

![Graph showing forces and torques](image)
RESULT

Thus thrust force and torque are found for drilling the given workpiece.
EX.NO: 7 LATHE TOOL DYNAMOMETER

DATE:

AIM

To Calculate the various cutting forces using lathe tool dynamometer.

TOOLS REQUIRED

1. Chuck key
2. Tool head key
3. Cutting tool
4. Steel rule
5. Outside caliper.

PROCEDURE

1. The outside diameter of the workpiece is measured by using the Vernier caliper.

2. The cylindrical rod is clamped on the three-jaw chuck of the lathe.

3. The cutting tool on the dynamometer such that the cutting tool point is perfectly with the center of the job.

4. The feed is given to the workpiece by automatic lead screw.

5. The required amount of speed is given.

6. During the machining operation note the reading by dynamometer and do the calculation for different cutting forces.
\[ R = \text{resultant cutting force, lbf (kN)} \]
\[ F_T = \text{shear force, lbf (kN)} \]
\[ F_G = \text{normal to shear force, lbf (kN)} \]
\[ F_C = \text{cutting force, lbf (kN)} \]
\[ F_N = \text{normal to cutting force, lbf (kN)} \]
\[ F = \text{friction force, lbf (kN)} \]
\[ N = \text{normal to friction force, lbf (kN)} \]
\[ t_1 = \text{depth of cut or feed, in. (mm)} \]
\[ t_2 = \text{chip thickness, in. (mm)} \]
\[ \theta = \text{shear angle, } ^\circ \]
\[ \beta = \text{friction angle, } ^\circ \]
\[ \alpha = \text{rake angle, } ^\circ \]
RESULT

Thus the various cutting forces are calculated by using lathe tool dynamometer.
EX.NO: 8  TOOL ANGLE GRINDING WITH TOOL AND CUTTER GRINDING

DATE:

AIM

To calculate the various tool angle grinding with tool and cutter grinding.

TOOLS REQUIRED

1. Universal Vice
2. Grinding Wheel
3. Goggles
4. Steel rule
5. 12 mm.HSS bit

PROCEDURE

1. The tool is held rigidly with the Universal vice provided which is mounded on the bed ways.
2. Tool is kept at the end clearance angle 2-3 degree and 6 degree clearance is length.
3. Maintain side relief angle at 6 degree.
4. Maintain side rake of 8 degree and back rake angle of 4 degree.
RESULT

Thus the various tool angle grinding with tool and cutter Grinding are calculated.
EX.NO: 9 SPUR GEAR MILLING

DATE:

AIM

To machine out a spur gear on the given block for the specified dimension in the milling machine.

TOOLS REQUIRED

1. Vernier Calipers
2. Chuck Key
3. Drill Bit
4. Spanner

PROCEDURE

1. The given round block should be clamped on the rod and tightened with a nut on the other side.
2. Then the job is turned on the lathe for the prescribed diameter.
3. Now the job is clamped on the table of the milling machine between the centers using dog and carrier.
4. Before starting the operation, the job on the table should be checked for center in line with the cutter and the depth of cut is given as required by lifting the table.
5. After milling a tooth of gear, the job should be turned for milling the next tooth by indexing.
6. Thus the circumference of the rod is completely milled to form spur gear, by indexing each time after milling each tooth.
RESULT

Thus the spur gear is machined on the round block for the prescribed dimension.
EX.NO: 10  GEAR HOBBING

DATE:

AIM

To machine out a helical gear on the given block for the specified dimension in the Gear Hobbling machine.

TOOLS REQUIRED

1. Vernier caliper
2. Single point cutting tool
3. Spanner
4. Drill bit
5. Boring tool
6. Centre punch drill

PROCEDURE

1. Calculate the diameter of the job for the given number of teeth.
2. As per the calculation go for facing and turning operation by lathe.
3. In the Gear hobbling machine, set the given angle and gears.
4. Fix the job on the work table.
5. Give the feed, speed and depth of cut as per the calculation.
RESULT:

Thus the Helical Gear is machined on the given job as per dimension.
EX.NO.11 CANNED FACING AND TURNING

DATE:

AIM
To make FACING and TURNING as per the given dimensions a CNC lathe.

PROCEDURE
1. Prepare the program for machining operation using G codes and codes.
2. Feed the program to the machine
3. Analysis the program for error and check using simulation.
4. Fix the job and the floating zero value is found and entered.
5. Run the program.

PROGRAM
N0010 G53 X0 Z58.32
N0020 G53
N0030 G90 G94 G97 F70 S1500 M4
N0040 T1.1
N0050 G00 X26 Z1

N0060 G82 P0=K25 P1=K-2 P2=K-1 P3=K-2 P5=K0.5 P7=K0
P8=K0.2 P9=K50

N0070 G00 X26 Z-1.5
N0080 G81 P0=K22 P1=K-30 P2=K25 P3=K-30 P5=K0.5 P7=K0.2
P8=K0 P9=K50
N0070 G74
N0080 M05
N0090 M30
RESULT

Thus the workpiece of given dimensions is machined on the CNC lathe.
EX.NO.12   MULTIPLE TURNING

DATE:

AIM
To make MULTIPLE TURNING as per the given dimensions a CNC lathe.

PROCEDURE
1. Prepare the program for machining operation using G codes and codes.
2. Feed the program to the machine
3. Analysis the program for error and check using simulation.
4. Fix the job and the floating zero value is found and entered.
5. Run the program.

PROGRAM
N0010 G53 X0 Z75.13
N0020 G53
N0030 T1.1
N0030 G90 G94 G97 F100 S1500 M4
N0040 G00 X32 Z1
N0050 G68 P0=K15 P1=K0 P5=K0.5 P7=K0.2 P8=K0 P9=K50 P13=K0060 P14=K0110
N0060 G01 X15 F100
N0070 G01 X20 Z-10
N0080 G01 X20 Z-25
N0090 G01 X25 Z-35
N0100 G01 X25 Z-50
N0110 G01 X31 Z-50
N0110 G74
N0120 M05
N0130 M30
RESULT:

Thus the workpiece of given dimensions is machined on the CNC lathe.
EX.NO.13  CIRCULAR INTERPOLATION (CW)

DATE:

AIM
To make circular interpolation as per the given dimensions a CNC milling

PROCEDURE

1. Prepare the program for machining operation using G codes and codes.
2. Feed the program to the machine
3. Analysis the program for error and check using simulation.
4. Fix the job and the floating zero value is found and entered.
5. Run the program.

PROGRAM
N0010 (--=-=-=-=-= Exercise x -------)
N0020 (Raw material: Xmin:-150 Xmax:-50 )
N0030 ( Ymin=-150 Ymax:-50 Zmin:-130 Zmax:-100)
N0040 G53 X-189.6 Y-174.21 Z-134.37
N0050 G53
N0060 T1.1
N0070 G90 G94 G97 F150 S2000 M3
N0080 G00 X10 Y25 Z1
N0090 G01 Z-0.5 F100
N0100 G02 X25 Y10 I0 J-15
N0110 G01 X75 Y10
N0120 G02 X90 Y25 I15 J0
N0130 G01 X90 Y75
N0140 G02 X75 Y90 I0 J15
N0150 G01 X25 Y90
N0160 G02 X10 Y75 I-15 J0
N0170 G01 X10 Y25
N0180 G02 X25 Y10 I0 J-15
N0190 G00 Z5
N0200 M05
N0210 M30
RESULT:

Thus the workpiece of given dimensions is machined on the CNC Milling.

All Dimensions are in “mm”
EX.NO.14 CIRCULAR INTERPOLATION (CCW)

DATE:

AIM
To make circular interpolation as per the given dimensions a CNC Milling.

PROCEDURE:
1. Prepare the program for machining operation using G codes and codes.
2. Feed the program to the machine
3. Analysis the program for error and check using simulation.
4. Fix the job and the floating zero value is found and entered.
5. Run the program.

PROGRAM

N0010 (------------------ Exercice x -----)
N0020 (Raw material: Xmin:-150 Xmax:-50    )
N0030 ( Ymin=-150 Ymax:-50   Zmin:-130 Zmax:-100)
N0040 G53 X-189.6 Y-174.21 Z-134.37
N0050 G53
N0060 T1.1
N0070 G90 G94 G97 F150 S2000 M3
N0080 G00 X10 Y25 Z1
N0090 G01 Z-0.5 F100
N0100 G03 X25 Y10 I15 J0
N0110 G01 X75 Y10
N0120 G03 X90 Y25 I0 J15
N0130 G01 X90 Y75
N0140 G03 X75 Y90 I-15 J0
N0150 G01 X25 Y90
N0160 G03 X10 Y75 I0 J-15
N0170 G01 X10 Y25
N0180 G03 X25 Y10 I15 J0
N0190 G00 Z5
N0200 M05
N0210
RESULT:

Thus the workpiece of given dimensions is machined on the CNC Milling.