MODULE – 1 Conventional Manufacturing

Overview of Mechanical Engineering: Role of Mechanical Engineering in Industries and Society, Emerging Trends and Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors.

Conventional Manufacturing Processes:

Machining: Working principle of Lathe, Lathe operation- turning, facing, thread cutting, knurling Working principle of Drilling machine, tapping, reaming, boring

Working principle of horizontal Milling machine.

Introduction to Mechanical Engineering

Mechanical Engineering is considered to be the oldest branch of engineering, which has contributed to several innovations. There is a wide scope after completion of this course. Mechanical Engineers are instrumental in designing efficient motor vehicles, aircrafts, manufacturing units and industrial machinery. They also contribute towards the development of complex machinery systems, engines and power equipment. Their job responsibility includes the designing, manufacturing, maintenance and testing of this equipment.

What is Mechanical Engineering?

Mechanical Engineering is that branch of engineering which combines physics, mathematics, engineering principles with materials science. This field aims at designing, analyzing, manufacturing and maintaining mechanical systems. Mechanical Engineering is considered to be the broadest and the oldest of the engineering disciplines. This branch focuses on the core areas that include thermodynamics, mechanics, dynamics, structural analysis, electricity and materials science.

ROLE OF MECHANICAL ENGINEERING IN INDUSTRIES AND SOCIETY

<u>Role of Mechanical Engineering in Industries</u>

Knowledge of Mechanical Engineering in the industry helps to do the following

- Analyze problems to see how mechanical and thermal devices might help solve a particular problem
- Design or redesign mechanical and thermal devices or subsystems, using analysis and computer-aided design
- Develop and test prototypes of devices they design

- Investigate equipment failures or difficulties to diagnose faulty operation and to recommend remedies
- Analyze the test results and change the design or system as needed
- Oversee the manufacturing process for the device

The following are the examples of Role of Mechanical Engineering in Industries:

- **Automotive Industry:** Mechanical engineers contribute to the design and development of automobiles, including the engine, chassis, suspension, and other critical components. They work on improving fuel efficiency, performance, safety, and emissions control. They also play a role in manufacturing processes and quality control.
- **Aerospace Industry:** Mechanical engineers are involved in designing and manufacturing aircraft and spacecraft. They work on propulsion systems, aerodynamics, structural design, and materials selection. They also focus on ensuring safety, reliability, and efficiency in aircraft and spacecraft systems.
- **Energy Industry:** Mechanical engineers contribute to various energy-related sectors, including power generation, renewable energy, and energy conservation. They design and optimize power plants, turbines, engines, and renewable energy systems. They work on energy storage, efficiency improvement, and environmental sustainability.
- **Manufacturing Industry:** Mechanical engineers are involved in the design and optimization of manufacturing processes and equipment. They work on improving productivity, quality, and cost-effectiveness in production lines. They also contribute to automation and robotics, implementing advanced manufacturing technologies.
- **HVAC and Building Systems**: Mechanical engineers play a significant role in designing heating, ventilation, and air conditioning (HVAC) systems for buildings. They ensure energy efficiency, comfort, and air quality. They also work on plumbing systems, fire protection, and other mechanical systems in buildings.
- **Robotics and Automation**: Mechanical engineers contribute to the development of robotic systems and automation technologies. They design robotic mechanisms, grippers, and control systems. They work on applications in industries such as manufacturing, healthcare, logistics, and agriculture.
- **Consumer Products**: Mechanical engineers are involved in the design and development of various consumer products, including appliances, electronic devices, sporting equipment, and more. They ensure product functionality, safety, and user experience.

- **Biomedical Engineering**: Mechanical engineers contribute to the design and development of medical devices and equipment. They work on prosthetics, implants, diagnostic tools, and rehabilitation devices. They collaborate with healthcare professionals to improve patient care and quality of life

Role of Mechanical Engineers in Society

The important role of Mechanical Engineers in Society is listed below,

1) Transportation
2) Medical
3) Agricultural
4) Defense
5) Power generation

1. **Transportation:** Mechanical engineering is largely concerned with road transportation, and networks, rail and subway systems, airports, and shipping ports.
2. **Medical:** A mechanical engineer specialized in medical science can be called as 'medical engineer'. Engineer's responsibilities in medicine can include research, development, testing and evaluation of medical devices, advisement on new biomedical purchases for hospitals and medical centers.
3. **Agricultural:** The graduates are trained professionals who understand technology and are capable of solving problems in the areas of agricultural production and management of rural areas with a special focus on machinery.
4. **Defense:** Manage the teams of skilled technicians that monitor, maintain and repair formidable military hardware such as tanks, artillery guns and armored logistic vehicles. Not all types of entry are open for this job.
5. **Power generation:** When working in thermal power plants, mechanical engineers make sure heavy machinery like boilers and turbines, are working in optimal condition and power is continually generated. Mechanical engineers also work with the operations of the plant.

EMERGING TRENDS AND TECHNOLOGIES IN DIFFERENT SECTOR.

Some of important emerging trends and technologies in different sector are discussed below,

1. Energy sector,
2. Manufacturing sector,
3. Automotive sector,
4. Aerospace sector,
5. Marine sector.

1. ENERGY SECTOR

- **Renewable Energy:** There is a growing focus on renewable energy sources such as solar, wind, hydro, and geothermal power. Advancements in solar panel efficiency, wind turbine technology, and energy storage systems are driving the adoption of renewable energy on a larger scale.

- **Energy Storage:** The development of advanced energy storage technologies, such as lithium-ion batteries, flow batteries, and hydrogen storage, is crucial for managing the intermittent nature of renewable energy sources and enabling grid flexibility.
- **Smart Grids:** Smart grid technologies incorporate digital communication and control systems into traditional electrical grids. They enable more efficient electricity distribution, demand response mechanisms, and integration of renewable energy sources into the grid.

2. MANUFACTURING SECTOR:

- **Additive Manufacturing (3D Printing)**: Additive manufacturing allows the production of complex parts and prototypes using layer-by-layer material deposition. It offers advantages such as design flexibility, reduced material waste, and rapid prototyping, transforming manufacturing processes.
- **Industrial Internet of Things (IIoT):** IIoT involves the integration of sensors, devices, and data analytics to optimize manufacturing processes, monitor equipment performance, enable predictive maintenance, and enhance overall productivity.
- **Artificial Intelligence (AI) and Machine Learning:** AI and machine learning are being used to improve automation, optimize production lines, and analyze vast amounts of data for predictive analytics and quality control in manufacturing.

3. AUTOMOTIVE SECTOR:

- **Electric Vehicles (EVs):** The automotive industry is experiencing a shift towards electric vehicles powered by batteries or hydrogen fuel cells, reducing dependence on fossil fuels and minimizing emissions.
- **Autonomous Vehicles:** Self-driving or autonomous vehicles are being developed with advanced sensors, machine learning algorithms, and connectivity technologies. They have the potential to revolutionize transportation, improving safety, efficiency, and mobility.
- **Connected Cars:** Connectivity and communication technologies are being integrated into vehicles, enabling features such as real-time traffic information, remote diagnostics, and vehicle-to-vehicle communication.

4. AEROSPACE SECTOR:

- **Lightweight Materials:** The aerospace industry is exploring advanced lightweight materials, such as carbon fiber composites and titanium alloys, to reduce weight and improve fuel efficiency in aircraft.
- **Electric Propulsion:** Electric propulsion systems, including electric motors and batteries, are being developed for aircraft. They offer potential benefits such as reduced emissions, noise, and operating costs.

- **Advanced Aerodynamics:** Innovations in aerodynamics, including improved wing designs, laminar flow control, and adaptive structures, aim to enhance aircraft performance and fuel efficiency

5. **MARINE SECTOR:**

- **Alternative Fuels:** The marine industry is exploring alternative fuels like liquefied natural gas (LNG), biofuels, and hydrogen to reduce emissions and comply with environmental regulations.
- **Autonomous Vessels:** Autonomous or unmanned vessels are being developed for various applications, including cargo shipping, surveying, and offshore operations. They have the potential to increase efficiency, reduce costs, and enhance safety.
- **Sustainable Ship Design:** The focus on sustainability in the marine sector includes the development of eco-friendly ship designs, such as energy-efficient hull shapes, hybrid propulsion systems, and improved waste management systems.

Conventional Manufacturing Processes:

Introduction to machine tools:

A machine tool is a power-driven machine, designed to hold and move a sharp cutting tool against a rigidly held workpiece material or vice versa, so as to remove excess material from the workpiece in order to produce the desired shape, size and finish.
A few commonly used machine tools include, Lathe, drilling machines, milling machines, and Grinding machines.

There are a variety of machine tools designed for various applications, however in general, most machine tools perform the following functions:

a) Hold the work material.
b) Hold the cutting tool in position.
c) Impart motion to the work material, or cutting tool, or both, in the desired direction.
d) Regulate the cutting speed and also the feeding movement between the cutting tool and work material.

LATHE

Lathe is the oldest of all machine tool and perhaps the most basic tool used in industries**.**

<u>Working principle of Lathe</u>

- **The lathe is a machine tool which holds the work piece between two rigid and strong supports called centers or in a chuck.**
- The cutting tool is rigidly held and supported in a tool post which is fed against the revolving work.
- The normal cutting operations are performed with the cutting tool fed either parallel or at right angles to the axis of the work.
- The cutting tool may also be fed at an angle relative to the axis of work for machining tapers and angles.

- **The below figure** shows the working principle of the Lathe.

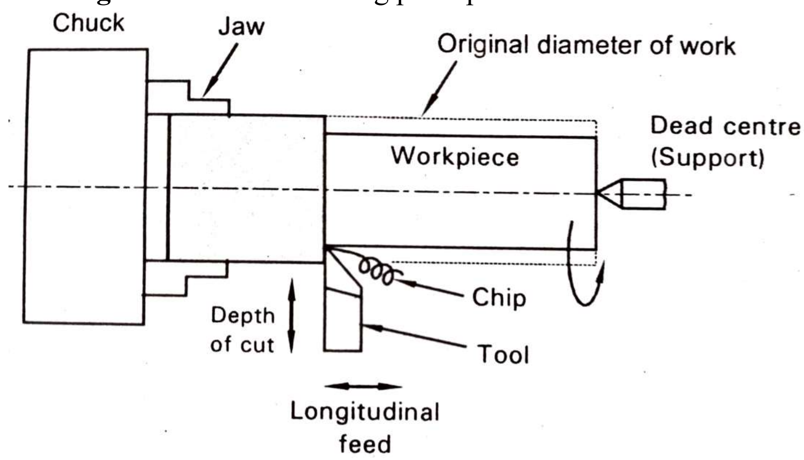


Fig. Working principle of Lathe

LATHE OPERATIONS OR MACHINING PROCESS ON LATHE

The operations that can be performed on a lathe are

a) **By holding the job between centers or between chuck and dead center**

1. Turning – plain
2. Facing
3. Knurling
4. Thread cutting

1) PLAIN TURNING OR CYLINDRICAL TURNING

- The process of metal removal from the cylindrical jobs is called straight or plain turning. It is a machining process for producing a cylindrical surface on the workpiece as shown figure below.
- The work-piece is supported in-between the two centres which permit the rotation of the work-piece. A single point cutting tool is fed perpendicular to the axis of the work-piece to a known predetermined depth of cut, and is then moved parallel to the axis of the work-piece.
- Cross-slide and the carriage are used to perform turning operations and make the operation faster and economical. Plain turning operations are generally performed in two steps-rough and finish turning.
- Rough turning is usually done for rolled, cast, or forged parts to remove the uneven or sandy, or rough surface on the jobs. A roughing tool does roughing and used for excess stock removal. For finishing a tool with a slightly round cutting edge is used. The depth of cut rate is at the range of 0.2 to 1 mm and the feed rate between 0.1 to 0.3 mm.

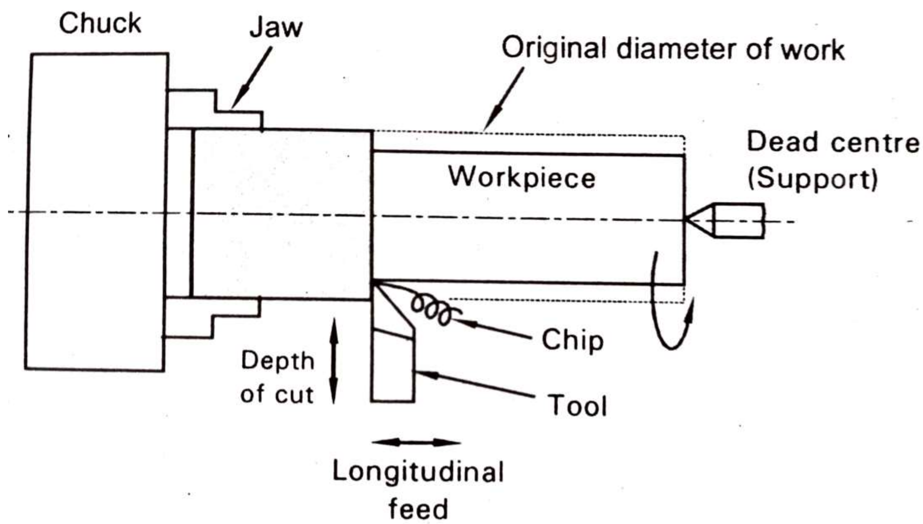


Fig. Cylindrical Turning

2) FACING

- Facing is a machining process for producing a flat surface at the end face of the workpiece as shown in figure below.
- Is the operation of machining the ends of a piece of the work to produce a flat surface square with the axis.
- This is used to cut the work to the required length. The operation involves feeding the tool perpendicular to the axis of rotation of the workpiece.
- A regular cutting tool may be used for facing a large workpiece. The cutting edge should be set at the same height as the center of the workpiece. A properly ground-facing tool is mounted in a tool holder in the tool post to accomplish facing operation.

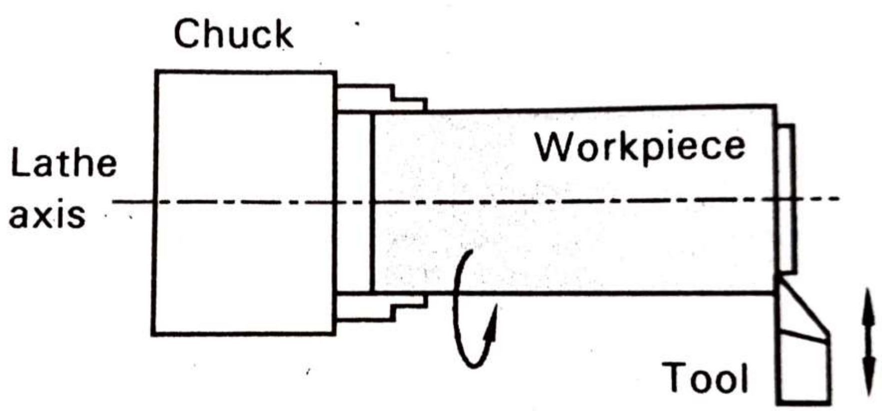


Fig. Facing

3) THREAD CUTTING:

- Thread cutting or threading is a machining process for cutting screw threads on metallic parts as shown in the figure below.
- A thread is a helical ridge formed on the cylindrical rod surface. By employing a V-

Shaped cutting tool it is possible to accomplish threads on the workpiece.

- In operation, a suitable tool which gives the required thread profile, say V-thread, square thread etc., is mounted on the tool post of the lathe.
- The workpiece is made to revolve at a very slow speed with uniform motion.
- The depth of cut is selected and the tool is made to move parallel to the lathe axis by means of automatic arrangements. (An appropriate gear ratio is maintained between the spindle on which the work piece is mounted and the lead screw)
- Thread cutting is carried out in a number of passes. The final cut is a finishing cut with a very small depth of cut in order to obtain a good surface finish.

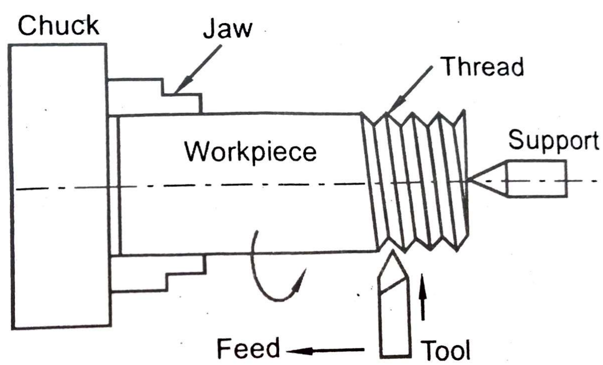


Fig. Thread cutting

4) KNURLING:

- Knurling is an operation performed on the lathe to generate serrated surface on the work piece. This is used to produce a rough surface for griping like the barrel of the micrometer or screw gauge. This is done by a special tool called knurling tool which has a set of hardened roller with the desired serrations. As shown in figure (a) and figure (b)

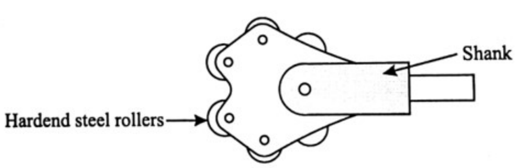


Figure (a): A typical knurling tool

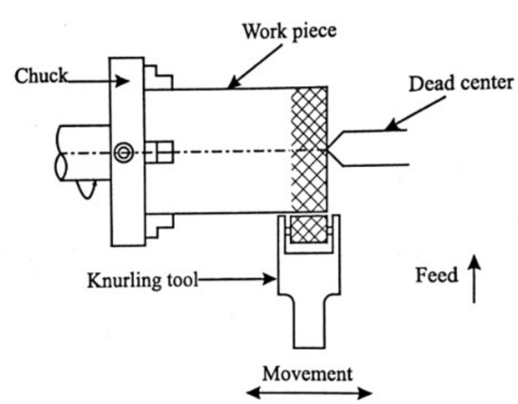


Figure (b): Knurling operation

- During knurling operation, the hardened rollers of the tool are pressed against the slowly rotating work pieces such that the impression of tool serrations are formed on the work pieces surface.

- Usually, there are three different pattern of knurling produced as per requirements and is as shown in Fig. (c)

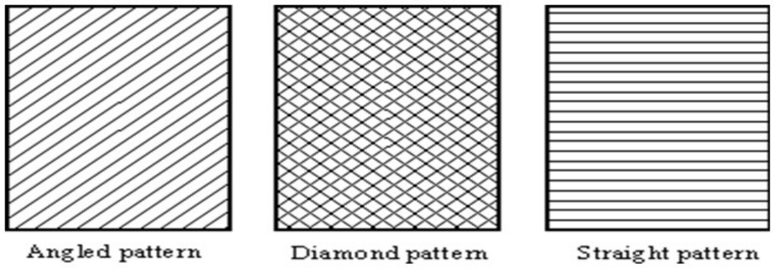


Fig. (c) different pattern of knurling produced

DRILLING

- Drilling is a machining operation of producing a cylindrical hole in a solid workpiece by means of a revolving tool called drill bit.
- The tool is also called twist drill since it has sharp twisted edges formed around a cylindrical body. Figure shows the drilling operation.
- In operation, the drill bit is held rigidly in the chuck of the machine and rotated by the spindle at high speeds.

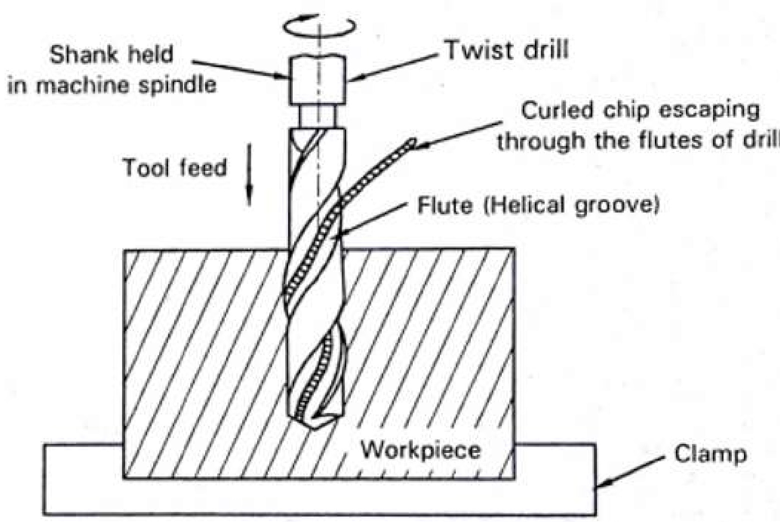


Fig. Drilling

- With the help of a hand wheel or by automatic means, the drill bit is forced to move against the rigidly clamped workpiece.
- A hole is generated by the sharp cutting edges of the rotating drill bit and meanwhile, the excess material removed (chips) gets curled and escapes through the helical grooves provided in the drill bit.

- Although drilling seems to be a simple process, it is actually a complex one. The tool apart from performing the cutting action also extrudes the cut material (chips) from the workpiece.
- Since the cutting action takes place inside the workpiece, a lot of heat generated is minimized by circulating a suitable coolant.

CLASSIFICATION OF DRILLING MACHINES

- Drilling machines are classified according to their general construction and type of work they are required different to do. The types of drilling machines include:
  a) Portable drilling machine
  b) Bench or Sensitive drilling machine
  c) Radial drilling machine
     - Plain radial drilling machine
     - Universal radial drilling machine
     - Semi-universal radial drilling machine

DRILLING MACHINE OPERATIONS:

A number of operations that can be performed on a drilling machine using the various tools are as follows:

a) Drilling
b) Boring
c) Reaming
d) Tapping
e) Counter-sinking
f) Counter-boring
g) Spot facing

a) Drilling

- Drilling is defined as the metal removal process carried out by forcing a rotating drill bit against rigidly clamped solid work-piece to get a cylindrical hole.

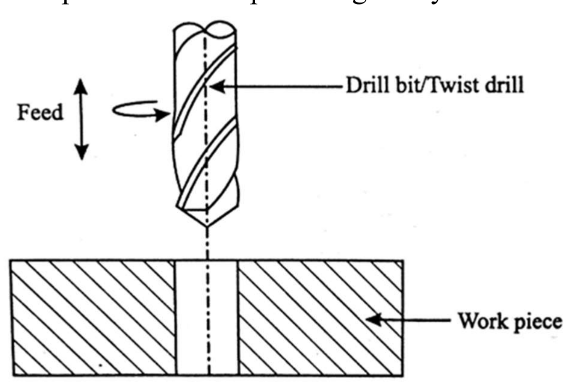


Fig. Drilling

- A typical drilling operation is shown in figure. Drilling is carried out by a rotating cutting tool to make circular holes in solid materials. The tool which makes the hole is called as twist drill, since it has a sharp twisted edge formed around a cylindrical tool provided with a helical groove along its length to allow the cut material to escape through it.

- The sharp edges of the conical surfaces ground at the lower end of the rotating twist drill cuts the material by peeling it circularly layer by layer when forced against a work-piece. The removed material chips get curled and escapes through the helical groove provided in the drill. A liquid coolant is generally used while drilling to remove the heat of friction and obtain a better finish for the hole.

b) Boring

- Boring is a machining process carried out for enlarging a previously drilled hole by means of an adjustable cutting tool having only one cutting edge. shown figure below.
- Boring is usually performed when a drill bit of the required dimension is not available.
- In such cases, a hole is first drilled to the nearest dimension and then a single point cutting tool is fastened and adjusted to a boring bar to enlarge the size of the existing hole to the required dimension.
- While boring, the tool is rotated at speeds slower than that of reaming. In addition to enlarging a previously drilled hole, boring operation corrects the hole location and out-of- roundness, if any, as the tool can be adjusted to remove Previously drilled hole more metal from one side of the hole than the other.

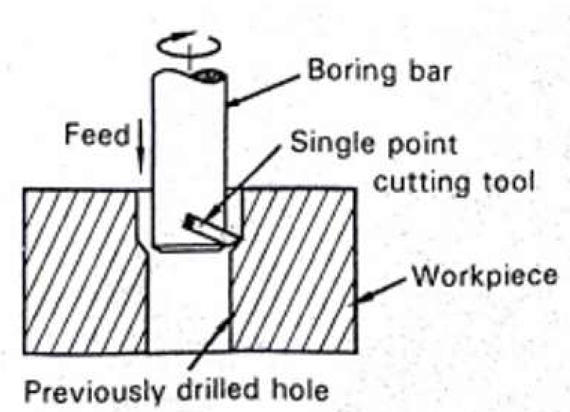


Fig. Boring

c) Reaming

- Reaming is a machining process carried out for finishing a previously drilled hole so as to bring it to a more exact size and to improve the surface finish of the hole. Refer figure below.
- The operation is carried out using a multi-tooth revolving tool called reamer, which consists of a set of parallel straight or helical cutting edges along the length of the cylindrical body.
- While reaming, the speed of the spindle is reduced to nearly half of that of the drilling. The material is removed in small amounts, and hence the surface of the drilled hole is finished with high accuracy.

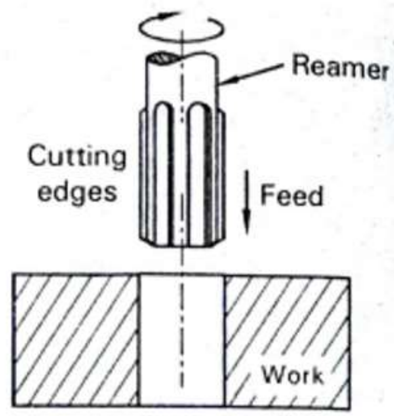


Fig. Reaming

d) Tapping

- The tapping is the process of cutting internal threads with a thread cutting tool called tap.
- A tap is a fluted threaded tool used for cutting internal threads. Before tapping, a hole which is slightly smaller than the size of the tap is drilled.

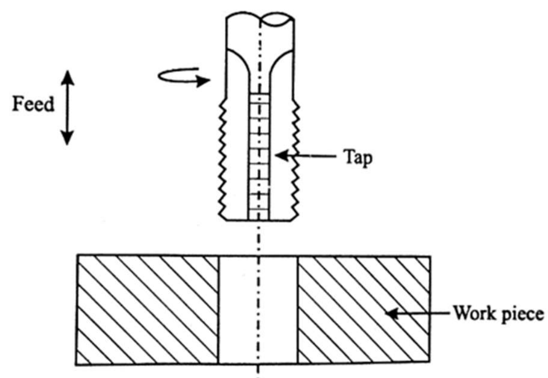


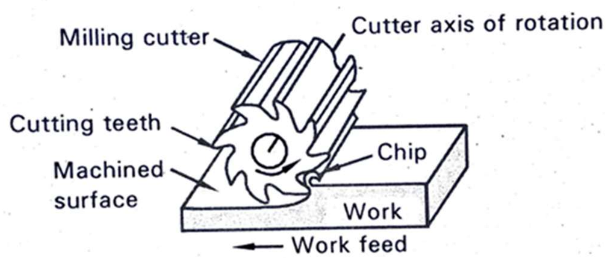
Fig. Tapping

- For cutting the threads, the tap is fitted in the tapping attachment which in turn is mounted in the drilling machine spindle, and the threads are cut in the same way as drilling.
- While tapping in a drilling machine the spindle has to rotate at very slow speeds. The tap will be held in a collapsible type of tapping chuck, which is inserted in the spindle of the drilling machine. Generally tapping is done on a drilling machine when identical threading is required on large number of parts.

INTRODUCTION TO MILLING

- Milling is a process of shaping work materials by feeding the work material against a multipoint rotating cutter. As shown in figure 1(a).
- The machine used for the purpose is called milling machine. Milling can be used for producing flat, angular or curved surfaces, for cutting threads, toothed gears, keyways, slots, and a wide variety of other operations.

- The milling cutter is a multipoint cutting tool. The work piece is mounted on a movable worktable which will be fed against the revolving milling cutter to perform the cutting operation.
- A milling machine is a power operated machine tool in which the work piece mounted on moving table is machined to various shapes when moved under a slow revolving multipoint cutter.
- The difference between drilling and milling is that, in drilling a rotating drill is fed against a stationary work piece, while in milling the work piece is fed against a milling cutter which only revolves.
- Similarly, it also differs from the lathe operation because the lathe tool is fed against rotating work piece.



(a) Milling process

THE PRINCIPLE OF MILLING

- In milling, the cutter is held in the spindle of the machine and made to rotate at suitable speeds.
- The workpiece is also held rigidly by a suitable device and is fed slowly against the rotating cutter.
- The workpiece can be fed in two different directions with respect to cutter rotation as shown in figure. below the process thus gives a means of classification of milling into two types known as up milling and down milling.
- In up milling process as shown in figure 2(a), the workpiece is fed in the direction opposite to that of the rotating cutter, while in down milling process as shown in figure 2(b), the workpiece is fed in the same direction as that of the rotating cutter. The various aspects related to the two types are tabulated in a comparison form in table 1.

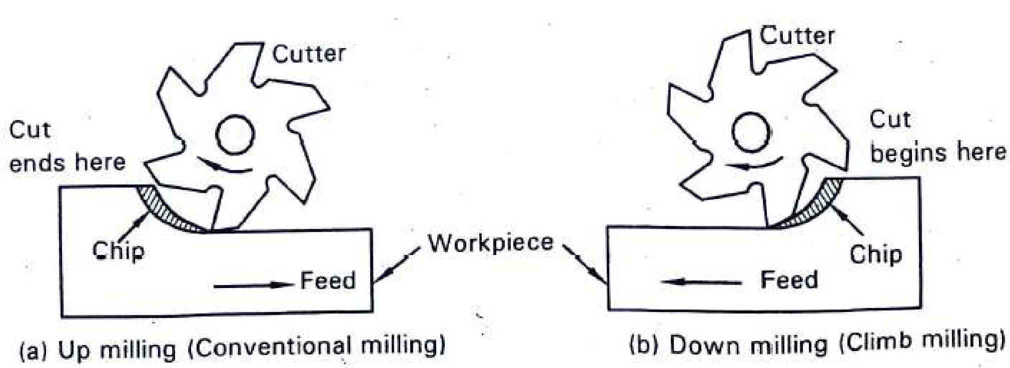
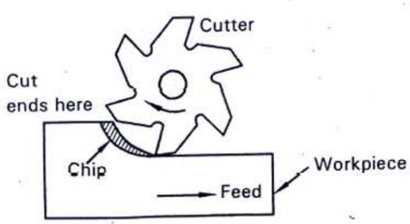
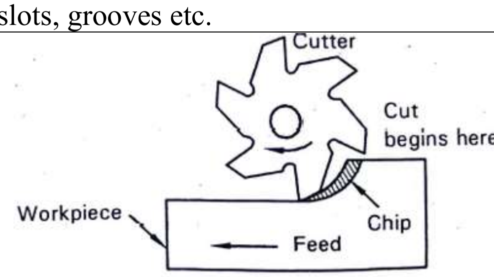


Fig. 2(a), 2(b)

COMPARISON BETWEEN UP MILLING AND DOWN MILLING

Sl. No.	Up milling (Conventional milling)	Down milling (Climb milling)
1.	In up milling, the workpiece is fed in the direction opposite to that of the rotating cutter.	In down milling, the workpiece is fed in the same direction as that of the rotating cutter.
2.	The thickness of chip is minimum at the beginning of cut and reaches to a maximum when the cut ends.	The thickness of chip is maximum at the beginning of cut and reaches to the minimum when the cut ends.
3.	In up milling, the cutting force is directed upwards. This tends to lift the workpiece from the worktable. Hence, greater clamping force for the workpiece becomes necessary.	The cutting force is directed downwards, and this tends to keep the workpiece firmly on the worktable thereby permitting lesser clamping forces.
4.	During up milling, the chip gets accumulated at the cutting zone (tool-work interface). These chips interfere with the rotating cutter thereby impairing the surface finish on the work-surface.	In down milling, the chips do not interfere with the revolving cutter, since they are disposed easily by the cutter. Hence, there is no damage to the surface finish of the workpiece.
5.	In up milling, it is difficult for efficient circulation of coolant. The cutter rotating in the upward direction carries away the coolant from the cutting zone.	In down milling, the coolant can easily reach the cutting zone. Hence, efficient cooling of the tool and the workpiece can be achieved.
6.	Up milling is preferred for rough cuts, especially for castings and forgings, because this method enables the cutter to dig-in and start the cut below the hard upper surface.	Down milling produces better surface finish because there is no dig-in of the cutter. It is particularly used for finishing operations and small work like cutting slots, grooves etc.
7.	 (a) Up milling (Conventional milling)	 (b) Down milling (Climb milling)

TYPES OF MILLING MACHINES

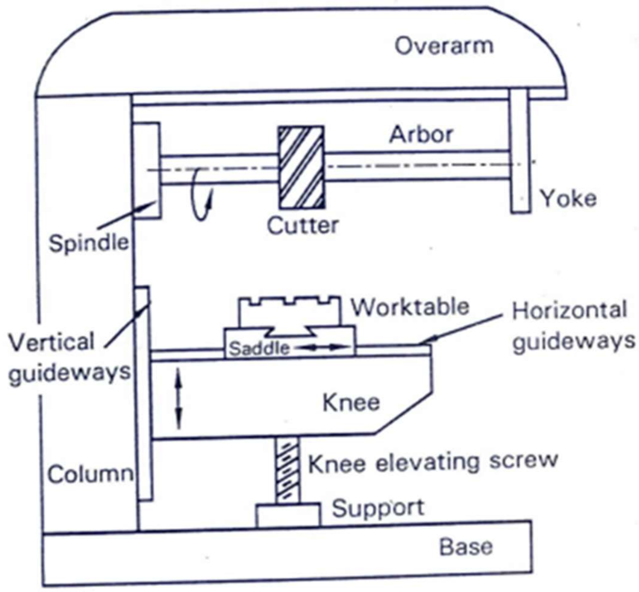
The different types of milling machines are listed as follows.

Column and knee milling machines.

a) Plain column and knee type milling machines
   - Horizontal spindle type
   - Vertical spindle type

Horizontal Spindle Column & Knee Milling Machine

- It is one of the most popular types of milling machine, and is commonly called horizontal milling machine, because of the horizontal position of the spindle.
- This type of machine is used to cut grooves, slots, keyways, gear teeth etc. figure (a) shows one of the principal views of a horizontal milling machine.



(a) End view of a horizontal-spindle column and knee milling machine

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