**Milling**

Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine. Milling is an interrupted cutting operation: the teeth of the milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to withstand these conditions. Cutting fluids are essential for most milling operations. Three types of feed in milling can be identified:

Feed per tooth: the basic parameter in milling equivalent to the feed in turning.

Feed per tooth is selected with regard to the surface finish and dim ensional accuracy required. Feeds per tooth are i n the range of 0.05~0.5 mm/tooth, lower feeds are for finishing

cuts; feed per revolution: it determines the amount of material cut per on e full revolution of the milling cutter. Feed per revolution is calculated as fr = fz being the nu mber of the cutter’s

teeth;

Feed per minute fm: Feed per minute is calculated taking into account the rotational speed

N and number of the cutter’s teeth z, fm = fzN = frN

Feed per minute is used to adjust the feed change gears.

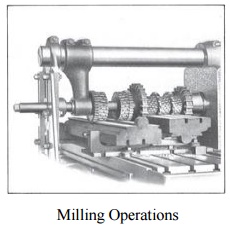
Three types of feed in milling can be identified:

Feed per tooth fz: the basic pa rameter in milling equivalent to the feed in t urning.

Feed per tooth is selected wit h regard to the surface finish and dimensiona l accuracy required (see Section 5.10 Selection of Cutting Conditions). Feeds per tooth ar e in the range of 0.05~0.5 mm/tooth, lower feeds are for finishing cuts; feed per revoluti on fr: it determines the amount of material cut pe r one full revolution of the milling cutter. Fee d per revolution is calculated as

fr = fz ,z being the number of the cutter’s teeth;

Feed per minute fm: Feed per minute is calculated taking into account the rotational speed N and number of the cutter’s tee th z, fm = fzN = fr,NFeed per minute is use d to adjust the feed change gears. In down millin g, the cutting force is directed into the work table, which allows thinner workparts tobe machined. Better surface finish is obtained but the stress load on the teeth is abrupt, which may da mage the cutter.In up milling, the cutting fo rce tend to lift the workpiece. The work conditi ons for the cutter are more favourable. Because the cutter does not start to cut when it makes contact (cutting at zero cut is impossible), the surface has a natural waviness.



Milling Operations

Owing to the variety of shapes possible and its high production rates, m illing is one of the most versatile and widely used machining operations. The geometric form created by milling fall into three major groups: P lane surfaces: the surface is linear in all thre e dimensions. The simplest and most convenient type of surface;

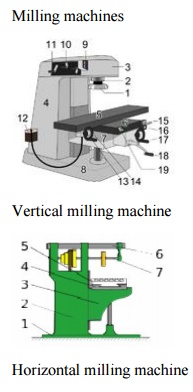
Two-dimensional surfaces: th e shape of the surface changes in the direc tion of two of the axes and is linear along the third axis. Examples include cams;

Three-dimensional surfaces: the shape of the surface changes in all three d irections.

Examples include die cavities, gas turbine blades, propellers, casting patter ns, etc.

Milling machines

Vertical milling machine and Horizontal milling machine



The conventional milling ma chines provide a primary rotating motion fo r the cutter held in the spindle, and a linear feed motion for the workpiece, which is fastened onto the worktable. Milling machines for machin ing of complex shapes usually provide both a rotating primary motion and a curvilinear fe ed motion for the cutter in the spindle with a stationary workpiece. Various machine designs are available for various milling operations. In this section we discuss only the most popular ones, classified into the followin g types:

Column-and-knee milling ma chines; v Bed type milling machines;

Machining centers.

Column-and-knee milling ma chines

The column-and-knee millin g machines are the basic machine tool for milling. The name comes from the fact that this machine has two principal components, a column that supports the spindle, and a knee that su pports the work table. There are two differen t types of column-and-knee milling machines according to position of the spindle axis:

horizontal, and vertical.

Milling cutters

Brazed cutters: Very limited numbers of cutters (mainly face mills) are made with brazed carbide inserts. This design is largely replaced by mechanically attached cuutters.

Mechanically attached cutters: The vast majority of cutters are in this category. Carbide inserts are either clamped or p in locked to the body of the milling cutter.

Classification of milling cutters may also be associated with the various milling operations

**Gear**

Gears can be manufactured by most of manufacturing processes discussed so far (casting, forging, extrusion, powder metallurgy, blanking). But as a rule, machining is applied to achieve the final dimensions, shape and surface finish in the gear. The initial operations that produce a semi finishing part ready for gear machining as referred to as blanking operations; the starting product in gear machining is called a gear blank.

Two principal methods of gear manufacturing include

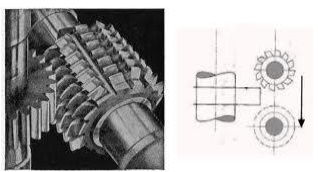
Gear forming, and Gear generation.

Each method includes a number of machining processes, the major of them included in this section.

Gear forming

In gear form cutting, the cutting edge of the cutting tool has a shape identical with the shape of the space between the gear teeth.

Two machining operations, milling and broaching can be employed to form cut gear teeth



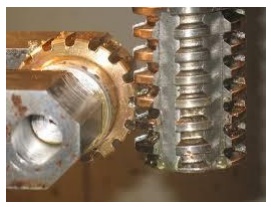
**Gear milling**

In form milling, the cutter called a form cutter travels axially along the length of the gear tooth at the appropriate depth to produce the gear tooth. After each tooth is cut, the cutter is withdrawn, the gear blank is rotated (indexed), and the cutter proceeds to cut another tooth. The process continues until all teeth are cut.

Each cutter is designed to cut a range of tooth numbers. The precision of the form-cut tooth profile depends on the accuracy of the cutter and the machine and its stiffness. In form milling, indexing of the gear blank is required to cut all the teeth. Indexing is the process of evenly dividing the circumference of a gear blank into equally spaced divisions. The index head of the indexing fixture is used for this purpose.

The index fixture consists of an index head (also dividing head, gear cutting attachment) and footstock, which is similar to the tailstock of a lathe. The index head and footstock attach to the worktable of the milling machine. An index plate containing graduations is used to control the rotation of the index head spindle. Gear blanks are held between centers by the index head spindle and footstock. Workpieces may also be held in a chuck mounted to the index head spindle or may be fitted directly into the taper spindle recess of some indexing fixtures.

**Gear hobbing**



Gear hobbing is a machining process in which gear teeth are progressively generated by a series of cuts with a helical cutting tool (hob). All motions in hobbing are rotary, and the hob and gear blank rotate continuously as in two gears meshing until all teeth are cut when bobbing a spur gear, the angle between the hob and gear blank axes is 90° minus the lead angle at the hob threads. For helical gears, the hob is set so that the helix angle of the hob is parallel with the tooth direction of the gear being cut. Additional movement along the tooth length is necessary in order to cut the whole tooth length: The action of the hobbing machine (also gear hobber) is shown in the figures. The cutting of a gear by means of a hob is a continuous operation. The hob and the gear blank are connected by a proper gearing so that they rotate in mesh. To start cutting a gear, the rotating hob is fed inward until the proper setting for tooth depth is achieved, then cutting continues until the entire gear is finished.

The gear hob is a formed tooth milling cutter with helical teeth arranged like the thread on a screw. These teeth are fluted to produce the required cutting edges.

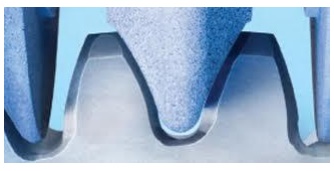
**Shaping with a pinion-shaped cutter**

This modification of the gear shaping process is defined as a process for generating gear teeth by a rotating and reciprocating pinion-shaped cutter:

The cutter axis is parallel to the gear axis. The cutter rotates slowly in timed relationship with the gear blank at the same pitch-cycle velocity, with an axial primary reciprocating motion; to produce the gear teeth. A train of gears provides the required relative motion between the cutter shaft and the gear-blank shaft. Cutting may take place either at the down stroke or upstroke of the machine. Because the clearance required for cutter travel is small, gear shaping is suitable for gears that are located close to obstructing surfaces such as flanges. The tool is called gear cutter and resembles in shape the mating gear from the conjugate gear pair, the other gear being the blank.

Gear shaping is one of the most versatile of all gear cutting operations used to produce internal gears, external gears, and integral gear-pinion arrangements. Advantages of gear shaping with pinion-shaped cutter are the high dimensional accuracy achieved and the not too expensive tool. The process is applied for finishing operation in all types of production rates.

**Finishing operations**



As produced by any of the process described, the surface finish and dimensional accuracy may not be accurate enough for certain applications. Several finishing operations are available, including the conventional process of shaving, and a number of abrasive operations, including grinding, honing, and lapping.

**9. How omniversal milling machine differs from universal milling machines?**

This is a modified form of a milling machine It is provided with two spindles, one of which is in the horizontal plane while the other is carried by a universal swiveling head.

**10.What are the advantages of up milling processes?**

1.It does not require a backlash eliminator.

2.Safer operation due to separating forces between cutter and work.

3.Less wear on feed screw and nut due to the absence of pre loaded.

4.Milled surface does not have built up edge.

**11.What is meant by plain or slab milling?**

Plain or Lab milling is the operation of producing flat horizontal surface parallel to the axis of the cutter using a plain or slab milling cutter.

**1.**     **What is meant by the term indexing?**

Indexing is the process of dividing the periphery of a job in to equal number of divisions.

**13.What are the three types dividing heads?**

1.Plain or simple dividing head.

2.Universal dividing head.

3.Optical dividing head.

**14.What is cam milling?**

Cam milling is the operation of producing cams in a milling machine by the use of a universal dividing head and a vertical milling attachment.

**15. List the advantages and limitations of thread milling.**

Advantages;

1.the threads will be smoother and more accurate than those cut in a lathe. 2.Threads can be cut closer to shoulders of work piece.

3.It is a faster method.

4.It is more efficient than cutting threads in a lathe. Limitations:

1.It is Difficult to produce internal threads.

2.Threads milling cannot be used for making thread with more than 30 helix angle.

**16.List the various types of planners?**

1.Double housing

2.Open side planer

3.Pit planer

4.Edge planer

5.Divided table planer

**17.Name the various parts of a double housing planer?**

1.Bed

2.Table

3.Columns 4.Cross rail 5.Tool head