GEAR MANUFACTURING, THREAD MANUFACTURING

GEAR MANUFACTURING

Gears are among the most important of all machine elements because of their capability for transmitting motion and power. They find applications in automobiles, gear boxes, oil engines, machine tools, industrial machinery, geared motors etc. Gears should have robust construction, reliable performance, high efficiency, economy and long life. They should be fatigue free and free from high stresses to avoid their frequent failures. They should be free from noise, chatter and should ensure high load carrying capacity at constant velocity ratio. Special attention is paid to gear manufacturing because of the specific requirements to the gears. The gear tooth flanks have a complex and precise shape with high requirements to the surface finish. The selection of gear materials depends upon type of service, peripheral speed, degree of accuracy required, method of manufacture, required dimension and weight of the drive, allowable stress, shock resistance and wear resistance.

Gears can be manufactured by most of the manufacturing processes such as casting, forging, extrusion, powder metallurgy, blanking, etc. 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 is referred to as blanking operations; the starting product in gear machining is called a gear blank.

Two principal methods of gear manufacturing include:

1. Gear forming
2. Gear generation

GEAR FORMING

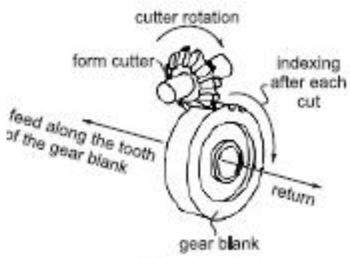
The cutting edge of the cutting tool has a shape identical with the shape of the space between the gear teeth. Two machining operations, milling and broaching can be employed to form cut gear teeth.

The principle of gear forming.

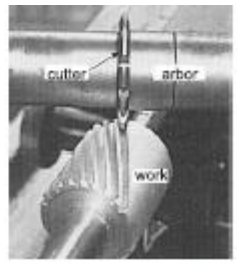
Form milling

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 After each tooth is cut, the cutter is withdrawn, the gear blank is rotated (indexed) and the cutter proceeds to cut another tooth.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.



Setup of form milling.



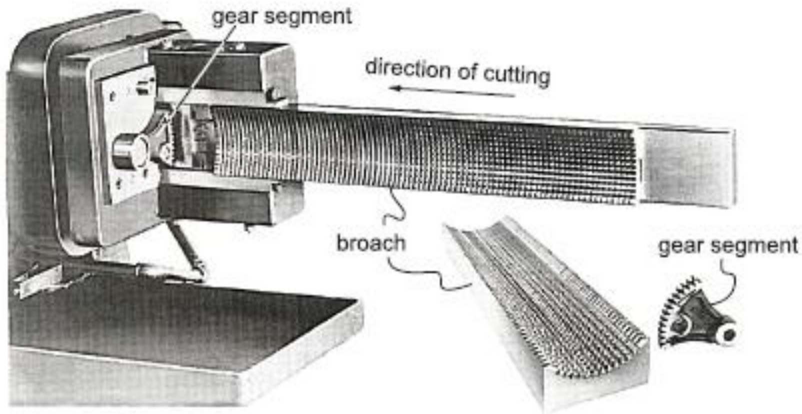
Form milling of a helical gear.


Form cutters for finishing cutting (*Left*) and for rough cuts (*Right*).


Dividing head (*Left*), and footstock (*Right*) used to index the gear blank in form milling.

Broaching

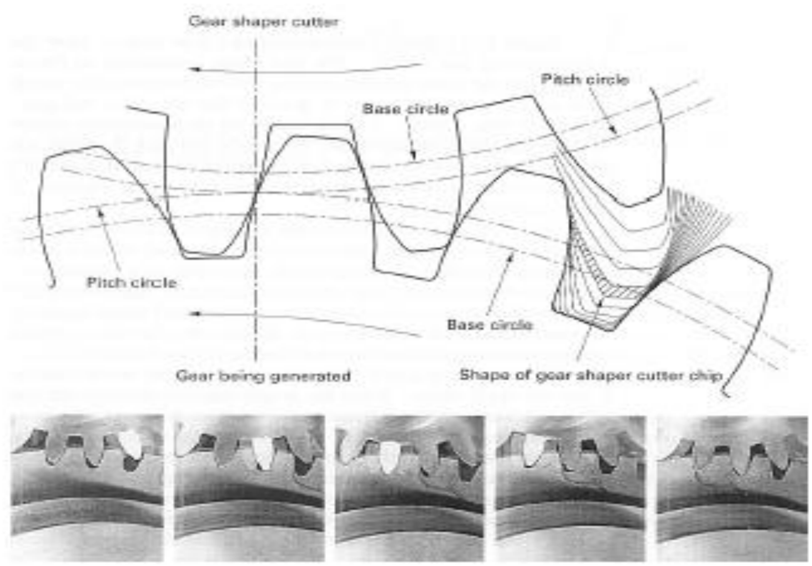
It can also be used to produce gear teeth and is particularly applicable to internal teeth. The process is rapid and produces fine surface finish with high dimensional accuracy. However, because broaches are expensive and a separate broach is required for each size of gear, this method is suitable mainly for high quantity production. Internal gears, racks and gear sectors have been produced by broaching.



Broaching the teeth of a gear segment by horizontal external broaching in one pass.

GEAR GENERATION

In gear generating, the tooth flanks are obtained or generated as an outline of the subsequent positions of the cutter, which resembles in shape the mating gear in the gear pair. In gear generating, two machining processes are employed, shaping and milling.



Generating action of a gear-shaper cutter; (*Bottom*) series of photographs showing various stages in generating one tooth in a gear by means of a gear shaper, action taking place from right to left, corresponding to a diagram above. One tooth of the cutter was painted white.

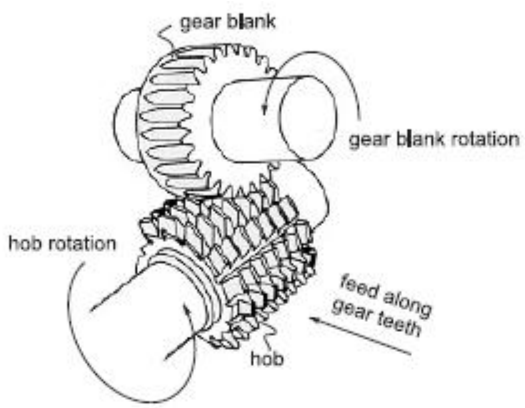
There are several modifications of these processes for different cutting tool used;

i. Gear hobbing (milling with a hob)
ii. Gear shaping with a pinion-shaped cutter, or
iii. Gear shaping with a rack-shaped cutter

Cutters and blanks rotate in a timed relationship: a proportional feed rate between them is maintained. Gear generating is used for high production and for finishing cuts.

Gear hobbing

It is a machining process in which gear teeth are progressively generated by a series of cuts with a helical cutting tool (hob). All motion in hobbing are rotary and the hob and gear blank rotate continuously as in two gears meshing until all teeth are cut.



Setup of gear hobbing opeartion.

When hobbing a spur hear, the angle between the hob and the gear blank axes is 90^o 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 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.

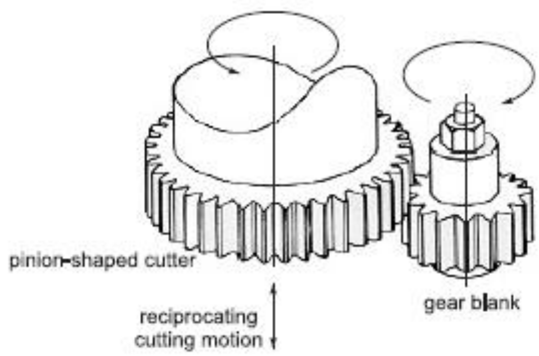

Coated HSS gear hob.

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 downstroke 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, and 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. They have the advantages of high dimensional accuracy being achieved and they are not too expensive tool. This process is applied for finishing operation in all types of production rates.



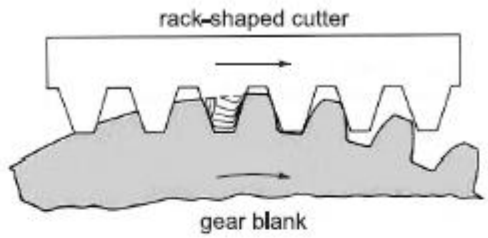
Setup of gear shaping opeartion with a pinion-shaped cutter.

Coated HSS pinion-shaped gear cutter.

Shaping with a rack-shaped cutter

In this, gear teeth are generated by cutting tool called rack shaper. The rack shaper reciprocates parallel to the axis of the gear axis. It moves slowly linearly with the gear blank rotation at the same pitch-cycle velocity.

The rack shaper is actually a segment of a rack. Because it is not practical to have more than 6-12 teeth on a rack cutter, the cutter must be disengaged at suitable intervals and returned to the starting point, the gear blank meanwhile remaining fixed. It is of high dimensional accuracy and cheap cutting tool. The process can be used for low-quantity as well as high-quantity production of spur and helix external gears.



Setup of gear shaping opeartion with a rack-shaped cutter.

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 gear shaving, and a number of abrasive operations, including, gear burnishing, gear grinding, lapping and honing.

THREAD MANUFACTURING

Threads are of prime importance to engineering. They are used as fasteners, to transmit power or motion and for adjustment. Threads are manufactured by the following processes:

1. **Casting:** They have limited field of application because threads made of sand casting are rough.
2. **Thread chasing:** The method of cutting of threads with a single point tool on a centre lathe and with a multipoint tool on a turret lathe is called thread chasing. Thread chasing is a form of cutting operation, with the form tool corresponding to the profile of desired thread space.
3. **Thread rolling:** It is a cold working process in which a blank diameter approximately equal to the pitch diameter of the required thread is rolled between hardened steel rolling dies having a negative contour of the thread to be produced.
4. **Die threading and tapping:** Die threading is the method of cutting external threads on cylindrical or tapered surfaces by the use of solid or self opening dies. However, taps are the tools for cutting internal threads. A tap is similar to a threaded bolt, with one to four flutes cut parallel to its axis.
5. **Thread milling:** The threads are cut by a revolving form milling cutter conforming to the shape of the thread to be produced. Both external and internal threads can be produced by this method. It is a fast thread cutting method for producing threads usually too large a diameter for die heads. The threads produced are more accurate than those cut by dies, but less accurate than produced by grinding. The method is desirable when the pitch of the thread is too coarse to be cut with a die. The method is more efficient than cutting thread on a lathe, especially when the job is long or when large amounts of metal are to be removed.
6. **Thread grinding:** It is used to produce more accurate threads. It is also employed to cut threads on hardened materials for which the other methods of thread cutting are not possible. It is also useful for materials too soft to get a good surface finish by other methods. Thread grinding is used to cut threads on taps, micrometer screws, lead screws, thread gauges and thread milling.

Review questions

1. What are the desirable properties of gear?
2. How can threads be produced?
3. Differentiate between gear forming and gear generating
4. Explain the following:
   i. Broaching
   ii. Gear hobbing
5. Highlight the finishing operations involved in gear manufacturing.