GEAR MANUFACTURING PROCESS

1. 1. Introduction

Gears are used extensively for transmission of power. They find application in: Automobiles, gear boxes, oil engines, machine tools, industrial machinery, agricultural machinery, geared motors etc. To meet the strenuous service conditions the gears should have: robust construction, reliable performance, high efficiency, economy and long life. Also, the gears should be fatigue free and free from high stresses to avoid their frequent failures. The gear drives should be free form noise, chatter and should ensure high load carrying capacity at constant velocity ratio. To meet all the above conditions, the gear manufacture has become a highly specialized field. Below, we shall discuss the various materials and manufacturing processes to produce gears.

1. 2. Materials used in gear manufacturing process

The various materials used for gears include a wide variety of cast irons, non ferrous material &non – material materials the selection of the gear material depends upon:-

i) Type of service
ii) Peripheral speed
iii) Degree of accuracy required
iv) Method of manufacture
v) Required dimensions & weight of the drive
vi) Allowable stress
vii) Shock resistance
viii) Wear resistance.

1) Cast iron is popular due to its good wearing properties, excellent machinability & Ease of producing complicated shapes by the casting method. It is suitable where large gears of complicated shapes are needed.
2) Steel is sufficiently strong & highly resistant to wear by abrasion.
3) Cast steel is used where stress on gear is nigh & it is difficult to fabricate the gears.
4) Plain carbon steels find application for industrial gears where high toughness combined with high strength.
5) Alloy steels are used where high tooth strength & low tooth wear are required.
6) Aluminum is used where low inertia of rotating mass is desired.
7) Gears made of non – Metallic materials give noiseless operation at high peripheral speeds.

1. 3. Classification of gears

1. Milling process

(i) Disc type cutter

(ii) End mill cutter

2. Gear planning process

(i) The Sunderland process

(ii) The Maag process

3. Gear shapers

(i) Rack – type cutter generating process

(ii) Pinion type cutter generating process

4. Gear hobbing

(i) Axial hobbing

(ii) Radial hobbing

(iii) Tangential hobbing

5. Bevel gear generating

(i) Straight Bevel – gear generator

(ii) spiral bevel –gear Generator

1. 4. Gear manufacture by casting method:-

Gears can be produced by the various casting processes. Send casting is economical and can take up large size and module, but the gears have rough surfaces and are inaccurate dimensionally. These gears are used in machinery where operating speed is low and where noise and accuracy of motion can be tolerated, for example, farm machinery and some hand operated devices. Send casting is suitable for one off or small batches. Large quantities of small gears are made by "Die – Casting". These gears are fairly accurate and need little finishing. However the materials used are low melting ones, such as alloys of zinc, aluminum and copper so, there gears are suitable for light duty applications only (light loads at moderate speeds), for example, gears used in toys. Cameras and counters and counters etc. Gears made by "Investment Casting" may be accurate with good surface finish. These can be made of strong materials to withstand heavy loads. Moderate – size gears are currently being steel cast in metal moulds to produce performs which are later forged to size. Light gears of thermoplastics are made by "Injection Moulding". This method is satiable for large volume production. However, gear tooth accuracy is no high and initial tool cost is high. These gears find use in instruments, household appliances etc.

For phosphor bronze worm wheel rims, "centrifugal casting" is used far more extensively than any other method. Centrifugal casting is also applied to the manufacture of steel gears. Both vertical and horizontal axis spinners are used. After casting, the gears are annealed or nomalized to remove cooling stresses. They may then be heat treated, if required, to provide the needed properties. Centrifugally cast gears perform as well as rolled (discussed ahead) gears and are usually less expensive. "Shell moulding" is also sometimes used to produce small gears and the product is a good cast gear of somewhat lower accuracy than one made by investment casting but much superior to sand casting.

1. 5. Methods of forming gears

1. 5. 1. Roll forming:-

In roll forming, the gears blank is mounted on a shaft & is pressed against hardened steel of rolling dies. The rolls are fed inward gradually during several revolutions which produce the gear teeth. The forming rolls are very accurately made & roll formed gear teeth usually home both by not and cold.

In not roll forming, the not rolled gear is usually cold –rolled which compiles the gear with a smooth mirror finish. In cold roll forming, higher pressures are needed as compared to not rolling many of the gears produced by this process need no further finishing. It becomes stronger against tension & fatigue. Spur & helical gears are made by this process.

1. 5. 2. Stamping:-

Large quantities of gears are made by the method known as stamping 'blanking' or 'fine blanking'. The gears are made in a punch press from sheet; up to 12.7mm think such gears find application in: toys, clocks 4 timers, watches, water & Electric maters & some business Equipment. After stamping, the gears are shaved; they give best finish & accuracy. The materials which can be stamped are: low, medium & high carbon steels stainless steel. This method is suitable for large volume production.

1. 5. 3. Powder metallurgy:-

High quality gears can be made by powder metallurgy method. The metal powder is pressed in dies to convert into tooth shape, after which the product is sintered. After sintering, the gear may be coined to in crease density & surface finish. This method is usually used for small gears. Gears made by powder metallurgy method find application in toys, instruments, small motor drivers etc.

1. 5. 4. Extrusion:-

Small sized gear can also be made by extrusion process. There is saving in material & machining time. This method can produce any shape of tooth & is suitable for high volume production gears produced by extrusion find application in watches, clocks, type writers etc.

1. 6. GEAR GENERATING PROCESS

1. 6. 1 Gear Hobbing:-

Hobbing is the process of generating gear teeth by means of a rotating cutter called a hob. It is a continues indexing process in which both the cutting fool & work piece rotate in a constant relationship while the hob is being fed into work. For in route gears, the hob has essentially straight sides at a given pressure angle. The hob and the gear blank are connected by means of proper change gears. The ratio of hob & blank speed is such that during one revolution of the hob, the blank turns through as many teeth. The teeth of hob cut into the work piece in Successive order & each in a slightly different position. Each hob tooth cuts its own profile depending on the shape of cutter, but the accumulation on the shape of cutter, but the accumulation of these straight cuts produces a curved form of the gear teeth, thus the name generating process. One rotation of the work completes the cutting up to certain depth.

1. 6. 2 TYPE OF HOBBING :-

1) Arial hobbing :-

This type of feeding method is mainly used for cutting spur or helical gears. In this type, firstly the gear blank is brought towards the hob to get the desired tooth depth. The table side is them clamped after that, the hob moves along the face of the blank to complete the job. Axial hobbing which is used to cut spur & helical gears can be obtained by 'climb noting' or 'convential hobbing!

2) Radial hobbing :-

This method of hobbing is mainly used for cutting worm wheels. In this method the hob & gear blank are set with their ones normal to Each other. The gear blank continues to rotate at a set speed about its vertical axes and the rotating hob is given a feed in a radial direction. As soon as the required depth of tooth is cut, feed motion is stopped.

3) Tangential hobbing:-

This is another common method used for cutting worm wheel. In this method, the worm wheel blank is rotated in a vertical plane about a horizontal axes. The hob is also held its axis or the blank. Before starting the cut, the hob is set at full depth of die tooth and then it is rotated. The rotating hob is then fed forward axially. The front portion of the hob is tapered up to a certain length & gives the fed in tangential to the blank face & hence the name 'Tangential feeding'.

1. 7. Gear shaping :- (The Fellows process)

In gear shapers, the cutters reciprocate rapidly. The teeth are cut by the reciprocating motion of the cutter. The cutter can either be 'rack – type cutter' or a rotary pinion type cutter'.

1. 7. 1. Rack – type cutter generating process:-

The rack cutter generating process is also called gear shaping process. In this method, the generating cutter has the form of a basic rack for a gear to be generated. The cutting action is similar to a shaping machine. The cutter reciprocates rapidly & removes metal only during the cutting stroke. The blank is rotated slowly but uniformly about its axis and between each cutting stroke of the cutter, the cutter advances along its length at a speed Equal to the rolling speed of the matching pitch lines. When the cutter & the blank have rolled a distance Equal to one pitch of the blank, the motion of the blank is arrested, the cutter is with drawn from the blank to give relief to the cutting Edges & the cutter is returned to its starting position. The blank is next indexed & the next cut is started following the same procedure.

1. 7. 2. Pinion type cutter generating process :-

The pinion cutter generating process is fundamentally the same as the rack cutter generating process, and instead of using a rack cutter, it uses a pinion to generate the tooth profile. The cutting cycle is commenced after the cutter is fed radically into the gear blank Equal to the depth of tooth required. The cutter is then given reciprocating cutting motion parallel to its axis similar to the rack cutter and the cutter & the blank are made to rotate slowly about their axis at speeds which are Equal at the matching pitch surfaces. This rolling movement blow the teeth on the blank are cut. The pinion cutter in a gear shaping m/c may be reciprocated either in the vertical or in the horizontal axis.

Advantages:-

1) The gears produced by the method are of very high accuracy.
2) Both internal & external gears can be cut by this process.
3) Non – convential types of gears can also be cut by this method.

Disadvantages:-

1) The production rate with gear shaper is lower than Hobbing.
2) There is no cutting on the return stroke in a gear shaper.
3) Worm & worm wheels can't be generated on a gear shaper.

1. 8. Gear cutting by milling

1. 8. 1 Disc type cutter

For cutting a gear on a milling m/c, the gear lank is mounted on am arbor which is supported b/w a dead centre & a lieu centre in the in dering head. The cutter is mounted on the arbor of the cutter must be aligned exactly vertically with the centre line of the indexing head spindle. The table of m/c is moved upward until the cutter just touches the periphery of gear blank. The vertical feed dial is set to zero. The table is then moved horizontally until the cutter clears the gear b lank. The table is then moved upwards by an amount Equal to the full depth of the gear tooth. The vertical movement may be less if the gear is to be cut in two or more passes. After this, the longitudinal feed of the table is engaged. The gear blank moves under the rotating cutter & a tooth space is cut. After this, the movement of the table is reversed so that the cutter again clears the gear blank. The gear blank is then indexed to the next position for cutting the second tooth space. This procedure is repeated until all the teeth have been milled.

There is a flat circular disc type cutter and the plane of rotation of the cutter is radial with respect to the blank.

1. 8. 2 <u>End mill cutter</u>:-

In this method the cutter rotates about am axis which is set racially with respect to the blank & at the same time the cutter is traversed parallel to the axes of the blank. The cutting edge tie on a surface of revolution, So that any axial cross- section of the cutter corresponds to the shape required for the space b/w two adjacent teeth on the finished wheel. The milling m/c used in this method is vertical milling m/c.

The End mill cutter is mounted straight on the milling m/c spindle through a chuck.

1) The disc type of cutter is used to cut big spur gear of cutter is Employed for the manufacture of pinion of large pitch.

2) This method is very slow since only one tooth is cut at a time. To overcome these drawbacks, "multiple tools shaping cutter head" is used to cut all the tooth spaces of the gear at the same time.

Advantage

1) Gear milling is a simple, Economical & flexible method of gear making.

2) Spur, helical, bevel gears and racks can be produced by this method.

Used

The anajor disadvantage of this method is that a separate cutter must be used not only for every piton but for every no. of teeth.

1. 9. Bevel Gear Generating

The teeth of bevel gears constantly change in form, from the large to the small Encl. There are to common types of bevel – gear generators, on cuts straight teeth & other cuts spiral teeth.

1. 9. 1 Straight Bevel – gear generator :-

For generating straight – bevel gears, the rolling motions of two pitch cones are employed motions of two pitch cones are employed instead of pitch cylinder.

In this method, two reciprocating tools which work on top & bottom sides of a tooth & are carried on the machine cradle. The cradle & work roll up together with the gear blank at the top of roll, when a tooth has been completely generated, the work is withdrawn from the tool and the m/c inclined, while the cradle is rolled down to the starting position. The operating cycle is repeated automatically until all the teeth in the gear have been cut.

The advantages of this process are that a previous roughening cut is not necessary, thus saucing one handling of the blank, longer cutter life, improved quality of gear and less set – up time.

1. 9. 2 spiral bevel –gear Generator :-

In this method, a rotating circular cutter generates spiral teeth that are curved & oblique proper tooth profile shapes are obtained by relative motion in the m/c b/w work cutter. The m/c has adjustment by which both spiral – bevel gears & hypoid gears can be generated.

Spiral bevel gears have an advantage have on advantage over straight bevel gear is that teeth are Engage with one another gradually by eliminating any noise & shock in their operation.

1. 10 Gleason Method:-

In this method, two disc milling cutters are employed, fig. The tools form the blanks of a tooth simulating the basic crown wheel. Cutter teeth are inter – meshing and the discs are inclined to each other at the pressure angle (usually 20*). The following motions are involved while cutting a tooth:

1. The rotating cutters revolve about their axes to provide the cutting action.

2. They travel in planes passing through the sides of the teeth on the imaginary crown gear to shape the teeth along their teeth.

3. At the same time, they participate in the relative rolling motion between the cutters and blank to obtain the required tooth profile.

Indexing takes place after each tooth space has been completed and the machine is fully automatic in its motions. When gear has been completed, the machine stops, the cutters with drawand the workpiece can be changed with little delay. This type of machine is a high production rate machine and very useful for dealing with large batches of identical gears.

1. 11 Templet Gear cutting process :-

The templet gear cutting process involves the production of a gear tooth profile by a single point cutting tool, which is racy probated and made to follow a guided path by a templet. After one tooth is finished, the blank is indexed by the usual manner. The templet method is employed for producing very large spur gear teeth & for cutting accurate bevel gears.

1. 12 <u>Gear finishing process</u>:-The following processes are generally used for finishing of gears.

1. 12. 1 <u>Gear shaving:-</u>

Gear sharing is the most common method for gear finishing. In this method, a very hard gear is used to ramous fine chips from the gear – tooth profile. The sharing cutter can be: Rotary type or Rack type in rotary shoring, the cutter & the gear are run in mesh. As they rotate, the gear is traversed longitudinally across the shaving cutter or vie versa. The rotary sharing cutter has a member of peripheral gashes or grooves to from a series of cutting Edges. The cutter & Gear are set up in a gear shoring m/c with crossed axes in the form of spiral gearing. The usual angles are 10* to 15*.

In rock sharing, the cutter is in the form of a rack. During the operation, the gear is rolled in mesh with the cutter. The cutter is reciprocated & at the End of Each stroke is fed into the year.

1. 12. 2 <u>Gear grindings</u>:-

Grindings is the most accurate method of gear finishing. By grinding, teeth can be finished either by generation or forming. In forming, the work is made to roll in contact with a fiat faced rotating grinding wheel, corresponding to the face of the imaginary rack meshing with the gear. One side of the tooth is ground at a time. After the grinding wheel is given the shape by space b/w two adjacent teeth. Both flanks are finished together.

The second method tends to be rather quicker, but both give equally accurate results and which of the methods is to be used depends upon the availability of the type of grinding m/c.

Disadvantage.

1) Considerable time is consumed in the process.

2) Low production capacity.

3) Grinding wheels are Expensive.

1. 12. 3 Gear lopping:-

It is another extensively used process of gear finishing & it is accomplished by having the gear in contact with one or more cast iron lap gear of true shape the work is mounted b/w centre & is slowly driven by rear lap. It is in term driven the front lap & at the same time both laps are rapidly reciprocated across the gear face. Each lap has individual adjustment & pressure control. A fine abrasive is used with kerosene or light oil to assist the cutting action. The largest time of gear lapping is about 15 minutes. Prolonged lapping damages the profile.

1. 12. 4 Shot blasting:-

It provides a finishing process resembling that produced by lapping although it has other functions, such as removing slight burrs, reducing stress concentration in tooth fillets & sometimes providing slight tip & root relief to teeth.

1. 12. 5 Phosphate coating:-

It is a chemical process which attacks the treated ferrous surface and leaves a deposit on it about 0.01 mm. in thickness. It prevents from scuffing, particularly in hypoid gears, by permitting the Engaging tooth Surface under the prevailing boundary lubrication conditions.

1. 13 Gear planning:-

This is one of the oldest methods of gear production but is still extensively used. It employs rack type cutters for generation of spur & helical gears. Involutes rack has straight Edges & sharp corners can be (Easily) manufactured easily & accurately.

There are two types of gear planning machines, one based on 'The Sunderland process & the other on 'The Maag process' Both the methods are identical in principle but differ in m/c configuration & detail.

1. 13. 1 The Sunderland process:-

In this method, the work (gear balance) is mounted with axis horizontal & the cutter slide is carried on a saddle position that moves vertically downward as cutting proceeds. For cutting super gears, the cutter reciprocates parallel to the work axis (but) because it can be swiveled in the vertical plane to any desired angle. The m/c is also used for cutting single helical gears. The cutter is gradually fed to the desired depth of teeth after which the depth remains constant. Simultaneously the gear blank is rotating & rack is traversed at a tangent, the motion of rack & blank being geared to act on their respective pitch lines. This relative motion beings fresh part of the blank & rack into contact & thus causes the teeth of the cutter to generate wheel teeth of the cutter to generate wheel teeth. The indexing really consisting slopping the rotation of the blank & causing the rack to moue. The process is repeated until the blank has completed one revolution.

1. 13. 2 The maag process:-

In this method, the work is mounted on the m/c table with its axis vertical. The rack cutter is carried in a cutter head: that is made to moue in a vertical plane but the actual direction of motion can be set at any desired angle.

1. 14. **Principal of gear planning:**

The cutter during its cutting stroke is in contact with several teeth at the same time but with different part of each tooth, it planes comparatively a narrow strip on each tooth at each stroke and a different part of each tooth is submitted to the action of the cutter at the next stroke.