बिहार सरकार

Govt. of Bihar

Department of Science & Technology

Government Polytechnic Vaishali

PRODUCTION PROCESS

Semester-IV (Mechanical Engineering)

Unit -3.2

GEAR MANUFACTURING

by

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- NOTES
- EXAMPLES
- QUESTION BANK

Gear Manufacturing

Manufacture of Gears

Manufacture of gears needs several processing operations in sequential stages depending upon the material and type of the gears and quality desired. Those stages generally are:

- Preforming the blank without or with teeth
- Annealing of the blank, if required, as in case of forged or cast steels
- Preparation of the gear blank to the required dimensions by machining
- Producing teeth or finishing the preformed teeth by machining
- Full or surface hardening of the machined gear (teeth), if required
- Finishing teeth, if required, by shaving, grinding etc
- Inspection of the finished gears

Forming and Generation

Gear teeth are produced by machining based on

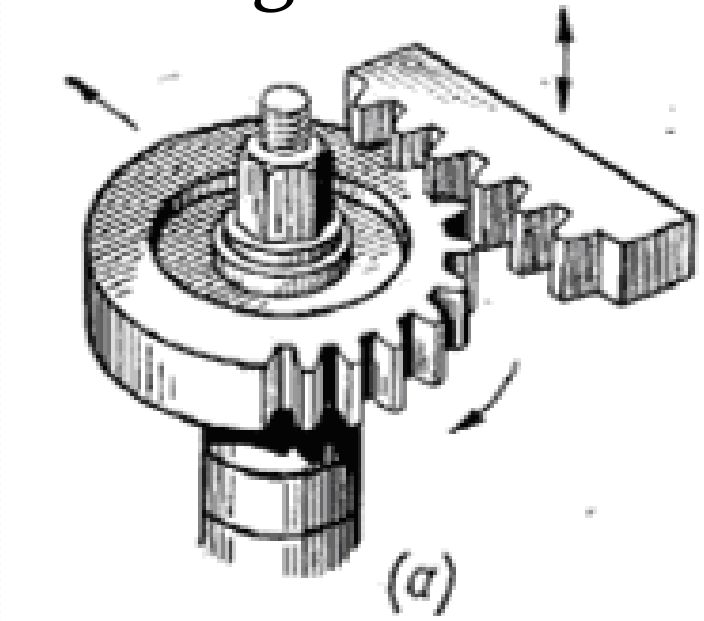
Forming – where the profile of the teeth are obtained as the replica of the form of the cutting tool (edge); e.g., milling, broaching etc.

Generation – where the complicated tooth profile are provided by much simpler form cutting tool (edges) through rolling type, tool – work motions, e.g., hobbing, gear shaping etc.

Gear Generation

Sunderland method using rack type cutter

- The rack type HSS cutter (having rake and clearance angles) reciprocates to accomplish the machining (cutting) action while rolling type interaction with the gear blank like a pair of rack and pinion.



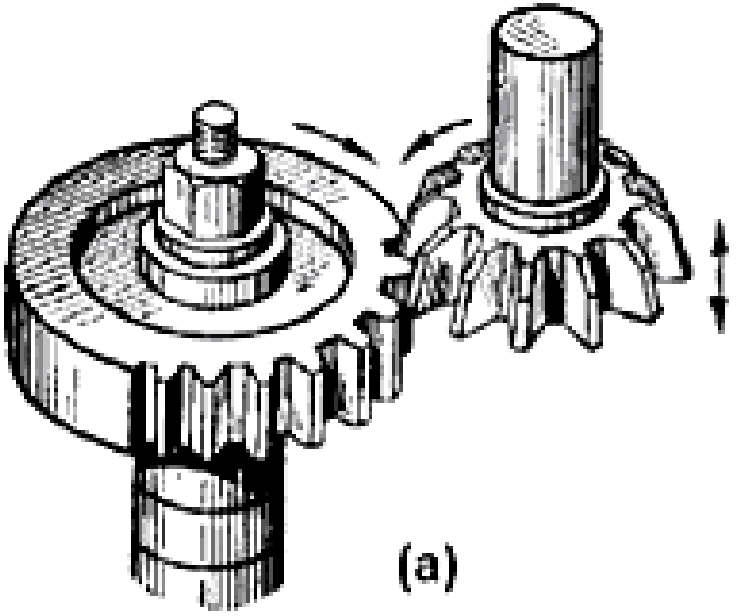
External gear teeth generation by rack type cutter (Sunderland method)

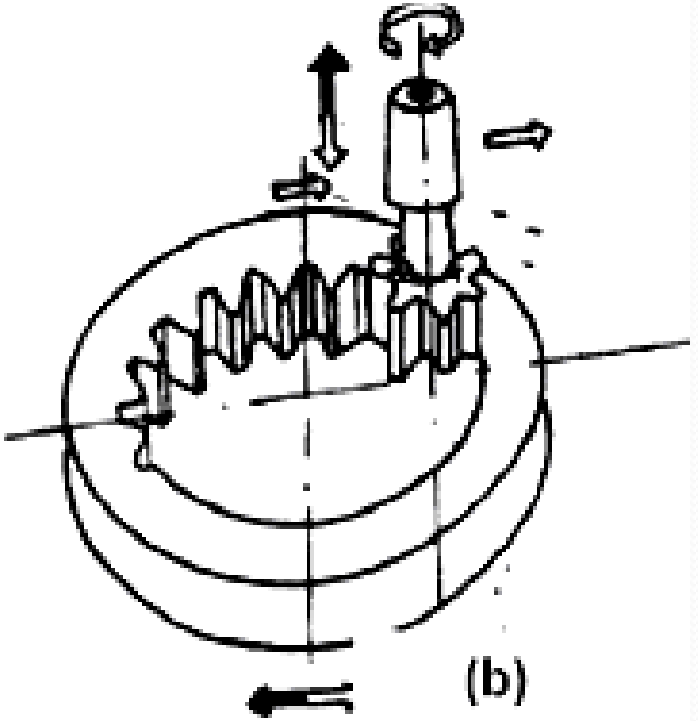
Sunderland method using rack type cutter

- Applications of this method (and machine) include:
- Moderate size straight and helical toothed external spur gears with high accuracy and finish
- Cutting the teeth of double helical or herringbone gears with a central recess (groove)
- Cutting teeth of straight or helical fluted cluster gears
- However this method needs, though automatic, few indexing operations.

Gear shaping

- Gear shaping is similar to the rack type cutting process, excepting that, the linear type rack cutter is replaced by a circular cutter where both the cutter and the blank rotate as a pair of spur gears in addition to the reciprocation of the cutter.



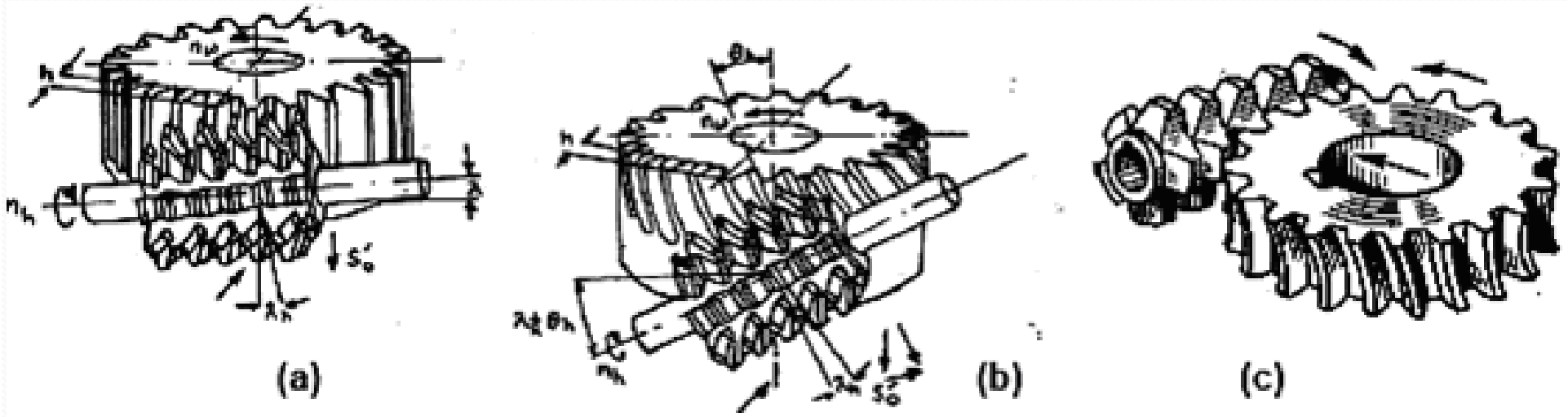


Gear shaping

- Generation method is characterised by automatic indexing and ability of a single cutter to cover the entire range of number of teeth for a given combination of module and pressure angle and hence provides high productivity and economy.
- The gear type cutter is made of HSS and possesses proper rake and clearance angles.
- The additional advantages of gear shaping over rack type cutting are:
  - Separate indexing is not required at all
  - Straight or helical teeth of both external and internal spur gears can be produced with high accuracy and finish
  - Productivity is also higher.

Gear Hobbing

- The HSS or carbide cutter having teeth like gear milling cutter and the gear blank apparently interact like a pair of worm and worm wheel.
- The hob (cutter) looks and behaves like a single or multiple start worms.



(a) Straight (b) helical tooth and (c) worm wheel

Gear Hobbing

- Having lesser number (only three) of tool – work motions, hobbing machines are much more rigid, strong and productive than gear shaping machine.
- But hobbing provides lesser accuracy and finish and is used only for cutting straight or helical teeth (single) of external spur gears and worm wheels.

Advantages of Gear Hobbing

(a) The method is versatile and can generate spur, helical, worm and worm wheels.

(b) Since gear hobbing is a continuous process, it is rapid; economical and highly productive.

(c) The method produces accurate gears and is suitable for medium and large batch production.

(d) The cutter is universal, because it can cut all gears of same module, irrespective of number of teeth on the gear.

Disadvantages of gear Hobbing

(a) Gear hobbing cannot generate internal gears and bevel gears.

(b) Enough space has to be there in component configuration for hob approach.

Applications of Hobbing

- The gears produced by gear hobbing are used in automobiles, machine tools, various instruments, clocks and other equipments.

Milling

- Gear teeth can be produced by both disc and end mill type form milling cutter.

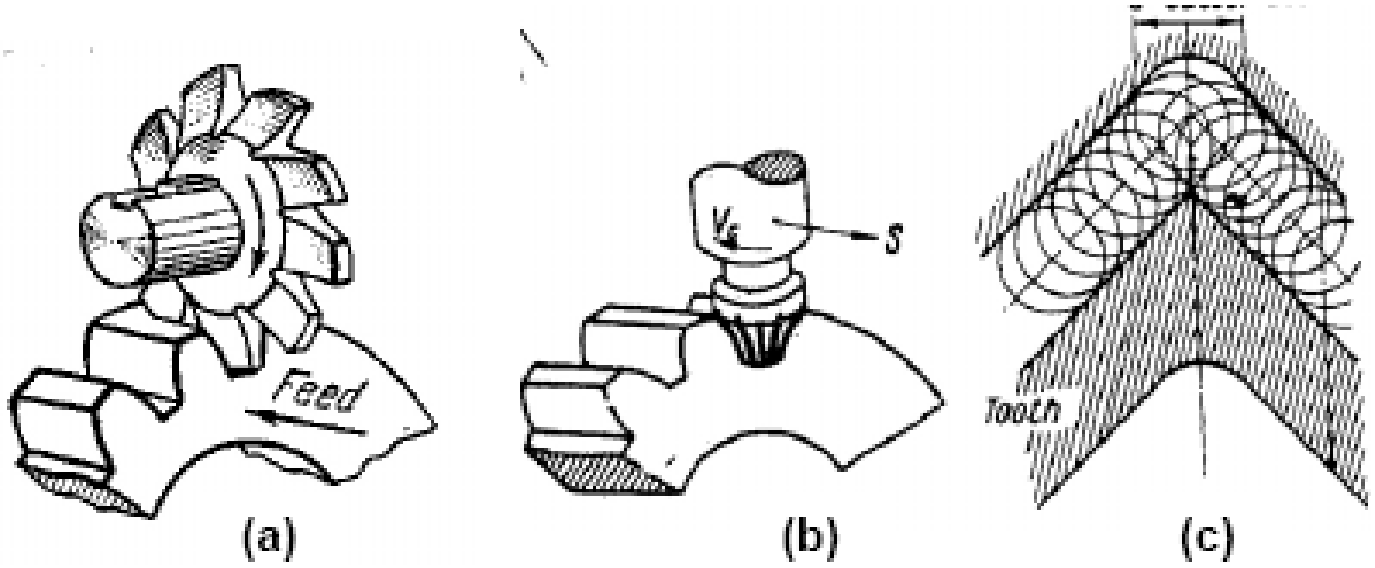


Fig. (a) disc type and end mill type for
(b) single helical and
(c) double helical teeth

Milling

Production of gear teeth by form milling are characterised by:

- Use of HSS form milling cutters
- Use of ordinary milling machines
- Low production rate for
  - Need of indexing after machining each tooth gap
  - Slow speed and feed
- Low accuracy and surface finish
- Inventory problem – due to need of a set of eight cutters for each module – pressure angle combination
- End mill type cutters are used for teeth of large gears and / or module.

Shaping, Planning and Slotting

- Straight toothed spur gear can be produced in shaping machine.
- Both productivity and product quality are very low in this process which therefore, is used, if at all, for making one or few teeth on one or two pieces of gears as and when required for repair and maintenance purpose.
- Planning and slotting machines work on the same principle. Planning machine is used for making teeth of large gears whereas slotting for internal gears.

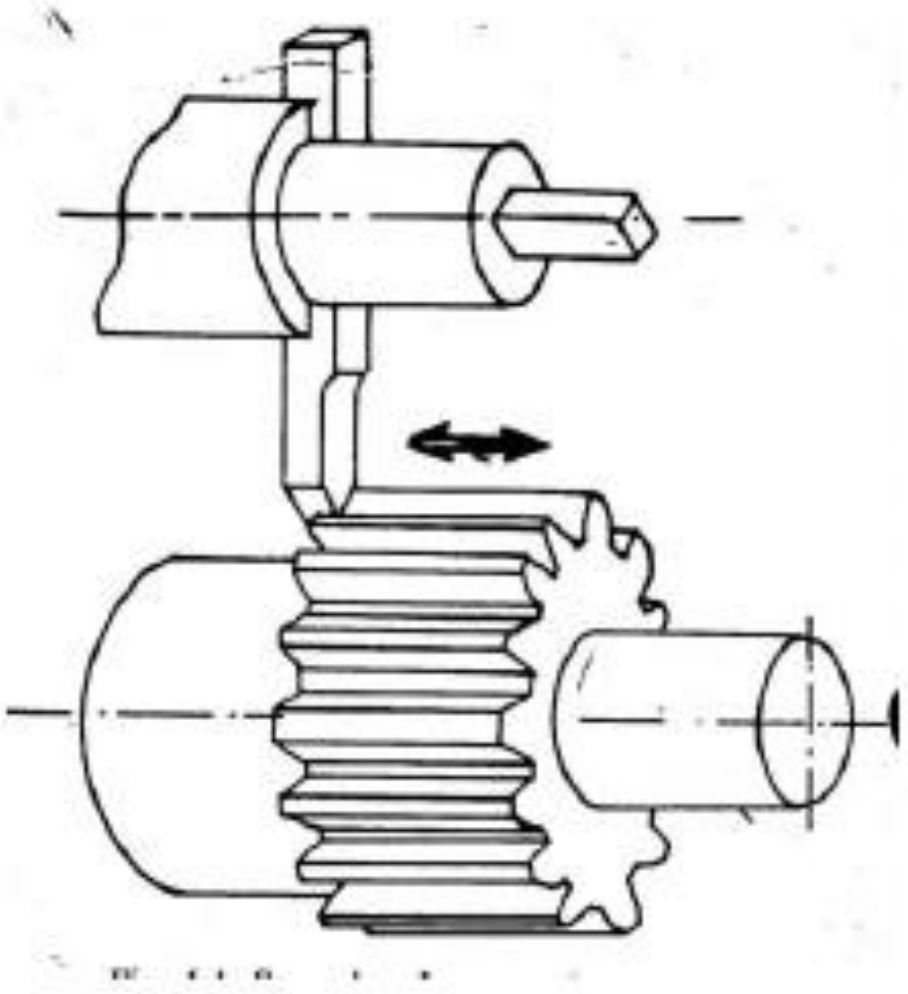
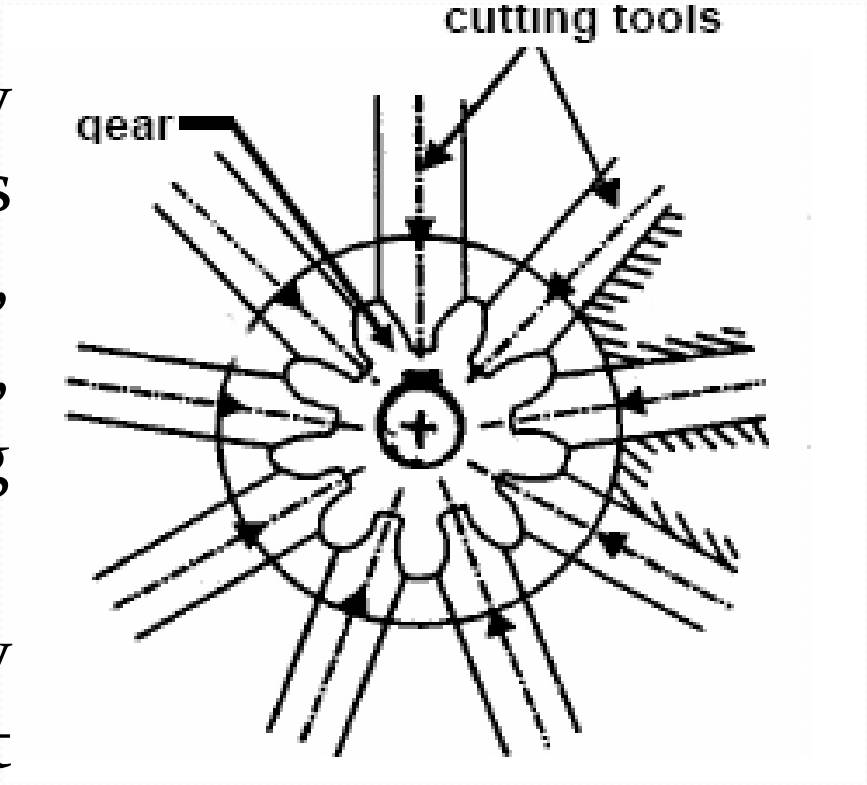


Fig- gear teeth cutting in ordinary shaping machine

Fast production of teeth of spur gears

Parallel multiple teeth shaping

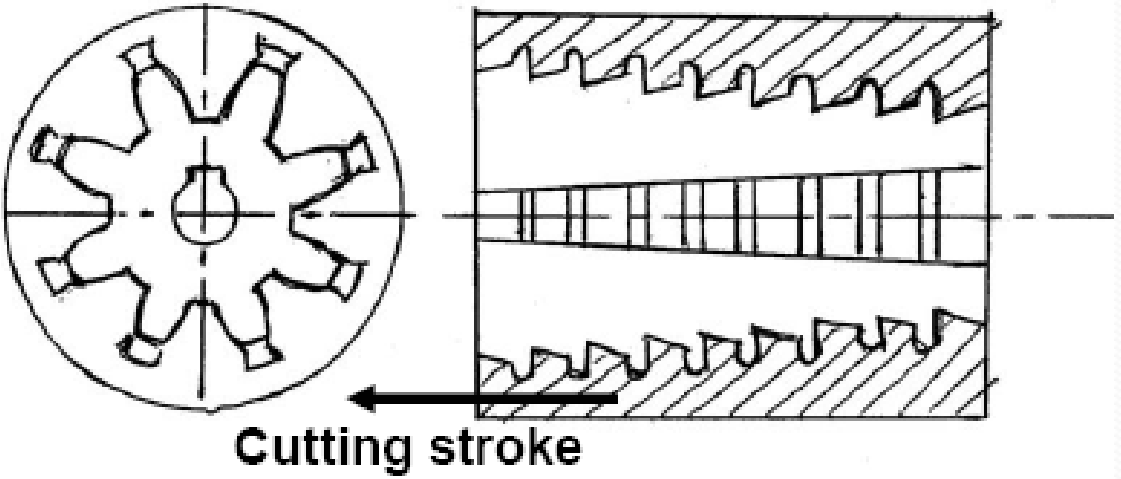
- It is similar to ordinary shaping but all the tooth gaps are made simultaneously, without requiring indexing, by a set of radially in feeding single point form tools.
- This old process was highly productive but became almost obsolete for very high initial and running costs.



Fast production of teeth of spur gears

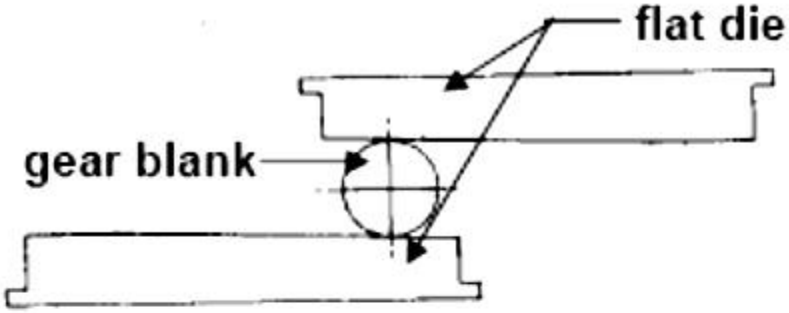
Broaching

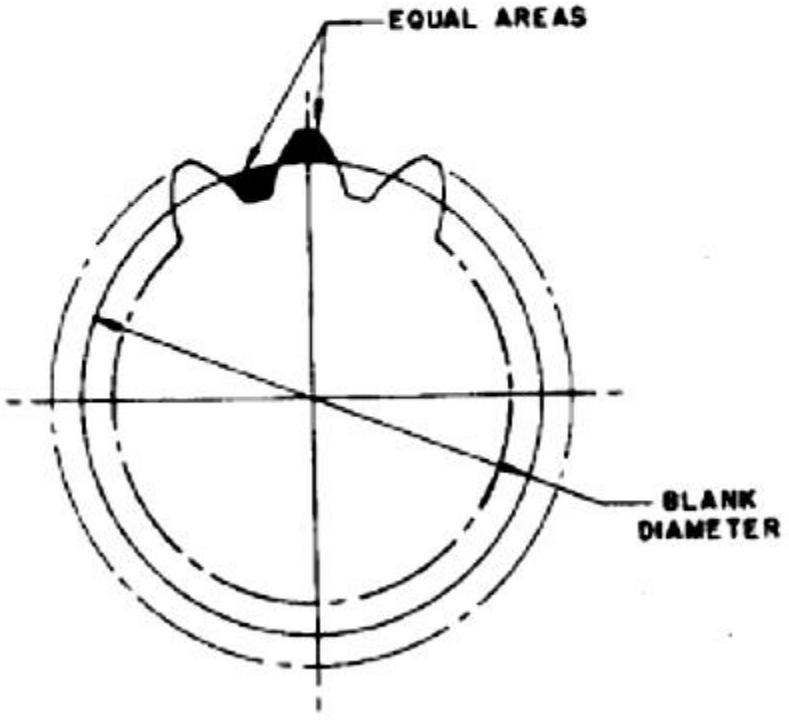
- Teeth of small internal and external spur gears; straight or single helical, of relatively softer materials are produced in large quantity by broaching.
- This method leads to very high productivity and quality but cost of machine and broach are very high.



Manufacture of gears by rolling

- The straight and helical teeth of disc or rod type external steel gears of small to medium diameter and module are generated by cold rolling by either flat dies or circular dies.
- Such rolling imparts high accuracy and surface integrity of the teeth which are formed by material flow unlike cutting.
- Gear rolling is reasonably employed for high productivity and high quality though initial machinery costs are relatively high.
- Larger size gears are formed by hot rolling and then finished by machining.


flat die (rack type)
gear blank

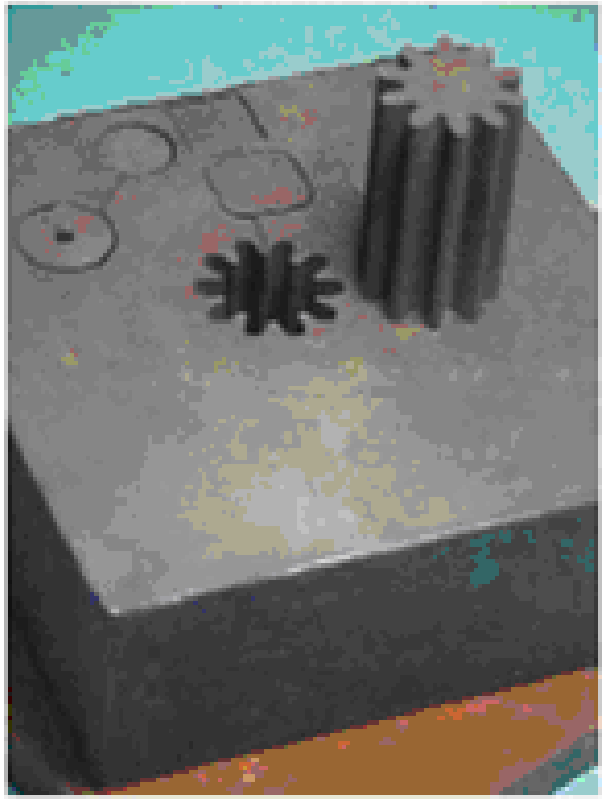

EQUAL AREAS
BLANK DIAMETER

Powder Metallurgy

- Small size high quality external or internal spur, bevel or spiral gears are also produced by powder metallurgy process.
- Large size gears are rolled after briquetting and sintering for more strength and life.
- Powder metallurgically produced gears hardly require any further finishing work.

Wire EDM

- Geometrically accurate but moderately finished straight toothed metallic spur gears, both external and internal type, can be produced by wire type Electro-discharge Machining (EDM).



Preforming Gear Blanks

- **Blanking in Press tool**
- **Plastic moulding**
- **Extrusion process**

Casting

- **Sand casting**
- **Metal mould casting**
- **Die casting**
- **Investment casting**
- **Shell mould casting**
- **Centrifugal casting**

Gear finishing process

Gear finishing process

- One of the goals of the gear finishing process in gears is to obtain a certain level of toughness in the gear teeth to reduce and/or eliminate bending and contact fatigue failures.
- Reduction of index undulation errors associated with helical gear teeth caused by the grinding process during the manufacture of the gears without degrading other gear accuracies (e.g. profile, tooth spacing) below levels required for precision (AGMA16 or DIN1) gears.
- A mold of the space between several gear teeth is obtained, with the mold having a length equal to or greater than the wavelength of the undulation error to be reduced.

- A micro finishing film is affixed to the mold and the mold is placed relative to a gear tooth so that the micro finishing film rests against a tooth surface having the undulation error.
- The grit size of the micro finishing film is such as to remove approximately 2 to 3 millionths of gear material with each pass through the teeth by the mold. Multiple passes are made by hand until the undulation error is reduced to an acceptable value. During the process the micro finishing film is replaced after approximately 3 or 4 passes and the process is repeated for each tooth of the gear.

Gear shaving

- Gear shaving is a gear finishing operation with high efficiency and high precision.
- When a work gear has been shaved by a shaving cutter with a true **involute profile**, the "mid-concave" phenomena inevitably exist around the pitch points of the work gear tooth flanks.
- Aiming at this problem, a new-style shaving cutter with unequal depth gashes is designed and manufactured.
- This paper analyses the forming of the gash on the basis of the slotting principle, and proposes a gash-designing method.
- Experiment has proven that the shaved gear has a better surface finish that achieves the anticipated effect.

Gear burnishing

- It is designed to remove or reduce gear tooth nicks and burrs, along with improving the smoothness of the tooth's active profile finish.
- The action of the burnishing dies on the tooth surface allows the machine to accomplish these quality improvements without altering the tooth profile or lead.
- Both internal and external gears are possible to burnish.

Gear Lapping

- Gear lapping is used to finish hardened gears by correcting small errors in spacing, profile, helix angle, and eccentricity.
- The operation is performed with all forms of gears running together with mating gears, and cast iron toothed laps, under a flow of fine oil mixed with an abrasive compound.

IES - 1992

Gear lapping

(a) An operation after heat treatment

(b) An operation prior to heat treatment

(c) An independent operation for gear reconditioning

(d) None of the above

IES - 2006

Which of the following is/are used for cutting internal gears?

1. Gear hobber
2. Gear shaper
3. Rack cutter
4. Jig borer

Select the correct answer using the codes given below:

(a) Only 1 and 2
(b) Only 2 and 3
(c) Only 1 and 4
(d) Only 2

IES - 2005

In helical milling, the ratio of the circumference of the gear blank to the lead of the helix determines the:

(a) Proper speed to use

(b) Proper feed and depth of cut required

(c) Angle setting of the machine table

(d) Gear ratio for table screw and dividing head

IES 2010

Match List I with List II and select the correct answer using the code given below the lists:

List I (Type of work)	**List II (Manufacturing)**
A. High rate production of worm Gears and worm wheel	**1. Gear shaving**
B. Generating internal gears and Cluster gears	**2. Gear milling**
C. Finishing of gear tooth profiles	**3. Gear hobbing**
D. Repair and piece production of gears	**4. Gear shaping**

	A	B	C	D
(a)	2	1	4	3
(b)	3	1	4	2
(c)	2	4	1	3
(d)	3	4	1	2

IES - 1996

Gear cutting on a milling machine using an involute profile cutter is a

(a) Gear forming process

(b) Gear generating process.

(c) Gear shaping process

(d) Highly accurate gear producing process.

IES - 2000

Which one of the following processes of gear manufacture results in best accuracy of the involute gear tooth profile?

(a) Milling

(b) Hobbing

(c) Rotary gear shaper

(d) Rack type gear shaper

IES - 2009

By which one of the following machines the teeth of an internal spur gear can be cut accurately?

(a) Milling machine

(b) Slotting machine

(c) Hobbing machine

(d) Gear-shaping machine

IES - 2004

Gear shaping is a process of manufacturing gears.

Which one of the following principles is employed by it?

(a) Form cutting with cutter

(b) Generating tooth form with a reciprocating cutter

(c) Generating tooth form by a rotating cutter

(d) Generating form with a reciprocating and revolving cutter

IES - 1992

In gear hobbing

(a) Only hob rotates

(b) Only gear blank rotates

(c) Both hob and gear blank rotate

(d) Neither hob nor gear blank rotates

IES - 2008

Which machining processes are used for gear manufacture?

1. Form milling
2. Broaching
3. Roll forming
4. Hobbing

Select the correct answer using the code given below:

(a) 1, 2 and 3
(b) 1, 3 and 4
(c) 1, 2 and 4
(d) 2, 3 and 4

IES - 2007

Which of the following methods are gear generating processes?

1. Gear shaping
2. Gear hobbing
3. Gear milling

Select the correct answer using the code given below:

(a) 1, 2 and 3 (b) 1 and 2 only

(c) 2 and 3 only (d) 1 and 3 only

GATE – 2007 (PI)

Which one of the following gear manufacturing processes is NOT based on generation principle?

(a) Gear Hobbing

(b) Gear Shaping

(c) Gear Milling

(d) Gear Shaving

IES - 1993

Internal gear cutting operation can be performed by

(a) Milling

(b) Shaping with rack cutter

(c) Shaping with pinion cutter

(d) Hobbing

GATE-2016

Internal gears are manufactured by

(a) Hobbing

(b) Shaping with pinion cutter

(c) Shaping with rack cutter

(d) Milling

IES - 2006

Which of the following cannot be cut by hobbing process?

(a) Helical gears

(b) Bevel gears

(c) Worm gears

(d) Spur gears

IES - 1992

Gear burnishing process for

(a) Removing residual stresses from teeth roots

(b) Surface finishing

(c) Under-cut gears

(d) Cycloidal gears

IES - 1994

Consider the following machine tools:

1. Hobbing machine
2. Gear shaping machine
3. Broaching machine.

The teeth of internal spur gears can be cut in

(a) 1, 2 and 3 (b) 1 and 2

(c) 1and 3 (d) 2 and 3