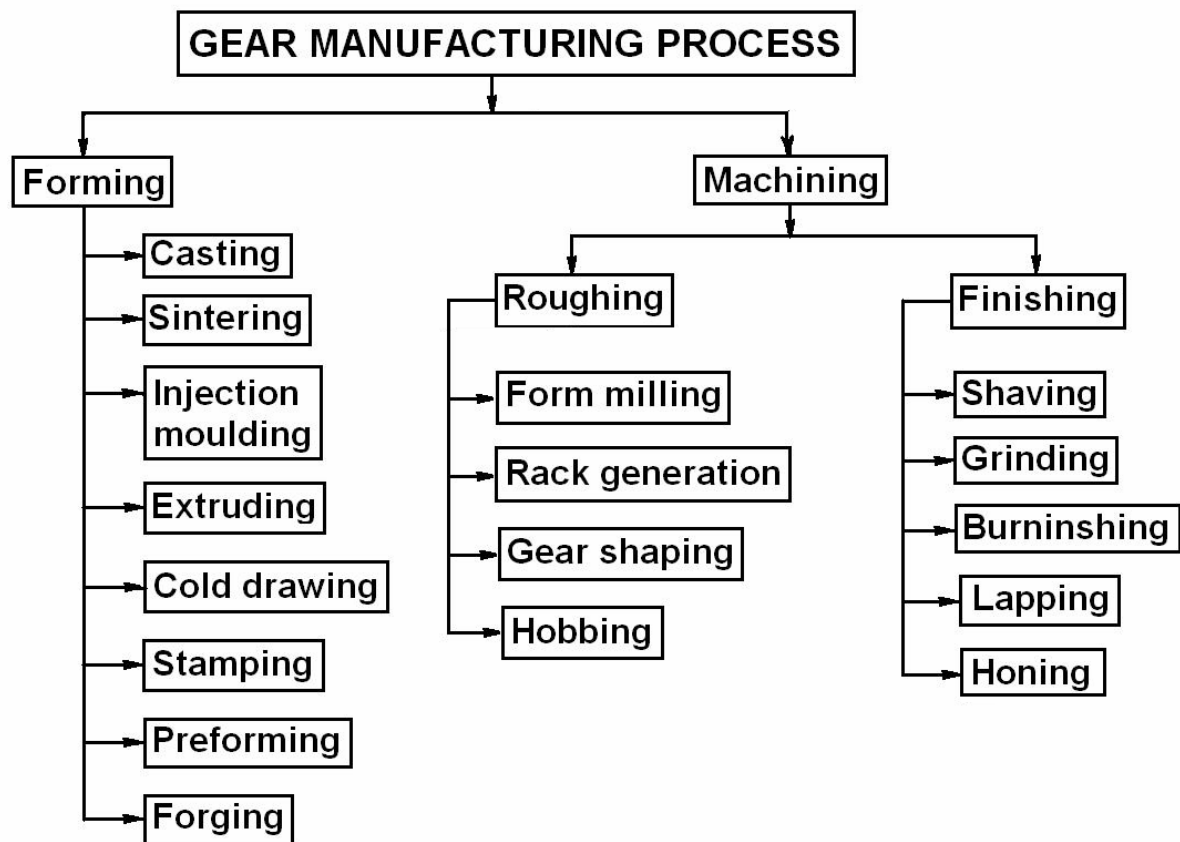


## LECTURE – 5 GEAR MANUFACTURING

### Contents of the lecture

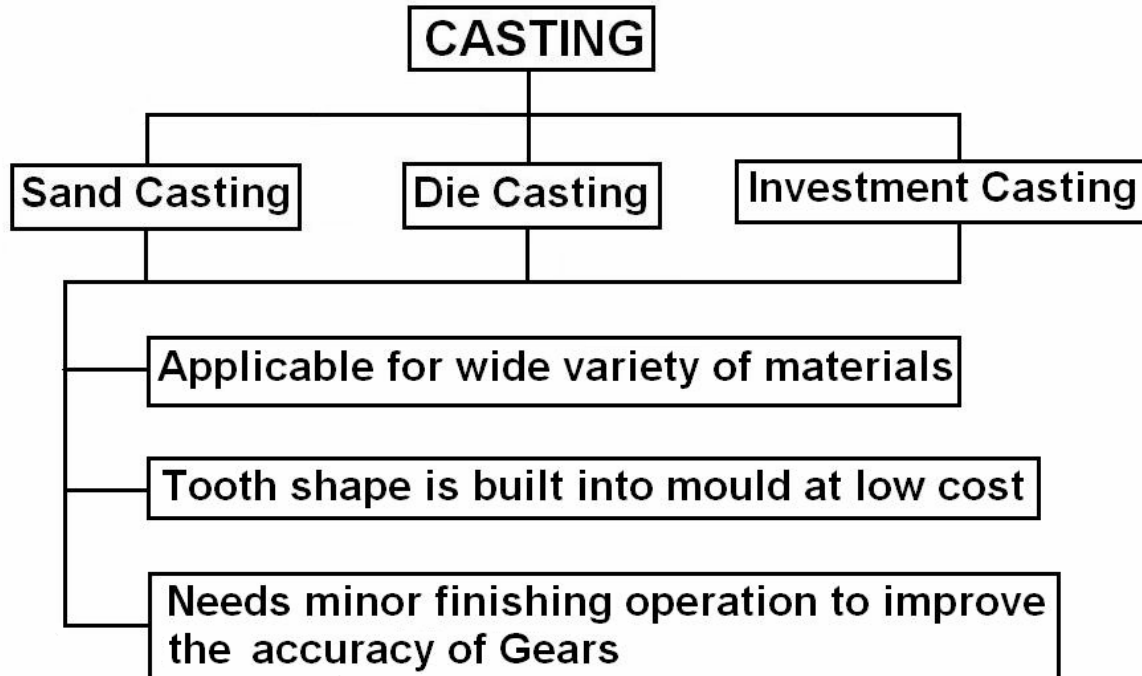
Gear manufacture can be divided into two categories, forming and machining. Forming consists of direct casting, molding, drawing, or extrusion of tooth forms in molten, powdered, or heat softened materials. Machining involves roughing and finishing operations.



### FORMING GEAR TEETH:

**Characteristics:** In all tooth-forming operations, the teeth on the gear are formed all at once from a mold or die into which the tooth shapes have been machined. The accuracy of the teeth is entirely dependent on the quality of the die or mold and in general is much less than that can be obtained from roughing or finishing methods.

Most of these methods have high tooling costs, making them suitable only for high production quantities .



## **SAND CASTING**

### **Characteristics :**

- **Cheaper low quality gear in small numbers**
- **The tooling costs are reasonable**
- **Poor Surface finish and dimensional accuracy**
- **Due to low precision and high backlash, they are noisy.**
- **They are suited for non- critical applications**

### **Applications: (without finishing operation)**

**Toys , small appliances, cement-mixer barrels, Hoist gearbox of dam gate lifting mechanism, Hand operated crane etc.,**

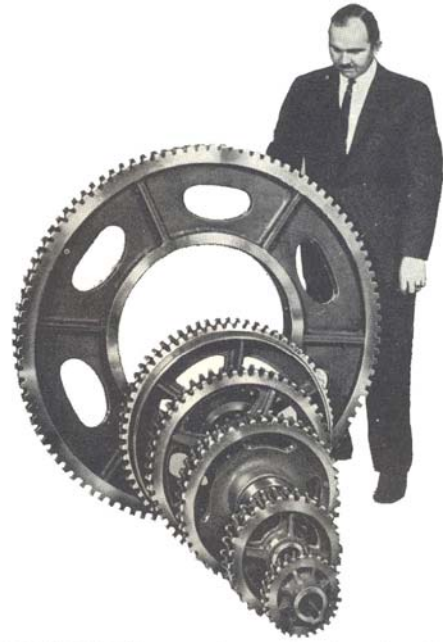
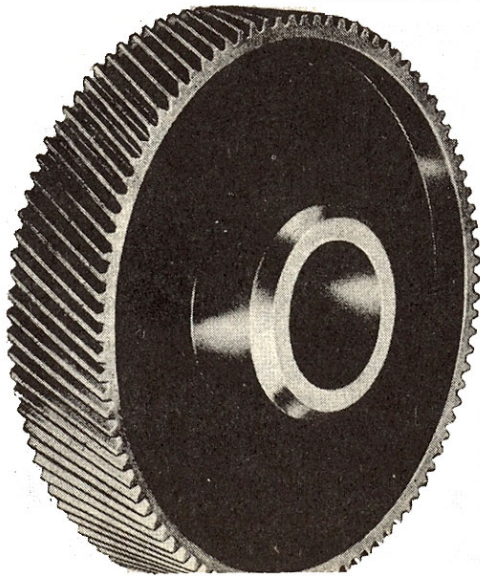
### **Materials:**

**C I, cast steel, bronzes, brass, ceramics**

**The process is confined to large gears that are machined later to required accuracy.**

**SAE 4640** cast steel helical gear is flame hardened and quenched to hardness of 65 to 75 Shore.

Philadelphia Gear Works, Inc.



SILICON BRONZE ALLOYS were used to cast these heavy duty drive gears, which range from 200 mm to 1600 mm in diameter. Some of these drive gears must withstand up to 2 million Nm of torque in industrial service.

## **DIE-CASTING**

### **Characteristics :**

- Better surface finish and accuracy (tooth spacing and concentricity)
- High tooling costs
- Suited for large scale production

### **Applications:**

Instruments, cameras, business machines, washing machines, gear pumps, small speed reducers, and lawn movers.

### **Materials:**

Zinc, aluminium and brass

The gears made from this process are not used for high speeds and heavy tooth loading. Normally applied for small size gears.

## **INVESTMENT CASTING OR LOST WAX PROCESS**

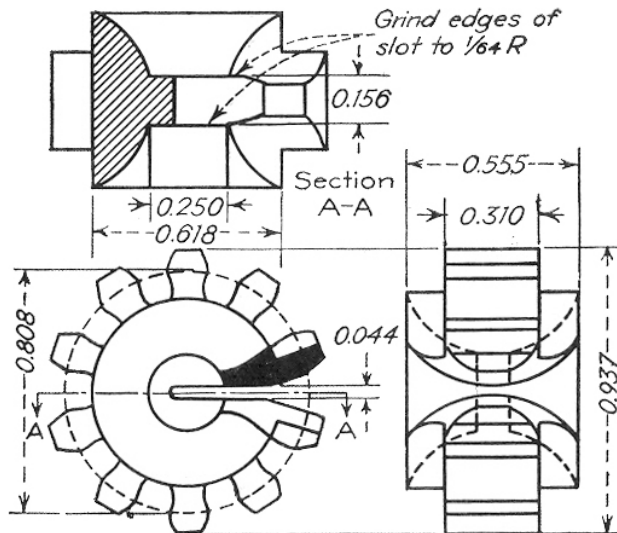
### **Characteristics:**

- Reasonably accurate gears
- Applicable for a variety of materials
- Refractory mould material
- Allows high melt-temperature materials
- Accuracy depends on the original master pattern used for the mold.

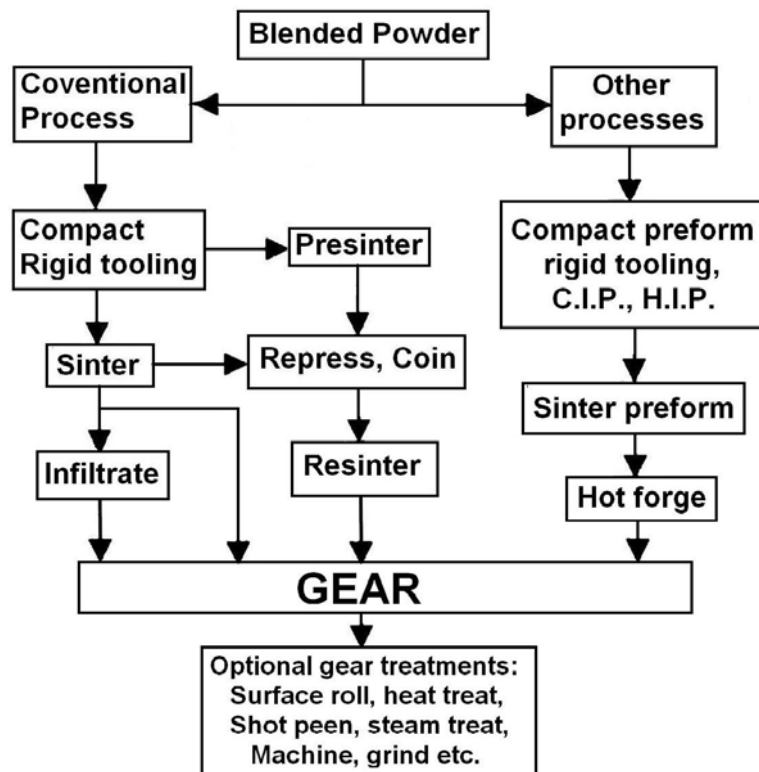
### Materials:

- Tool steel, Nitriding steel, Monel, Beryllium copper.
- The process is used only if no other process is suitable since production cost is high.

Wire twister stellite gear which mates with a rack made by IC. Complicated shape makes it economical to produce by investment casting process.



### SINTERING OR P/M PROCESS



## **P/M OR SINTERED GEARS**

### **Characteristics**

- Accuracy similar to die-cast gears
- Material properties can be Tailor made
- Typically suited for small sized gears
- Economical for large lot size only

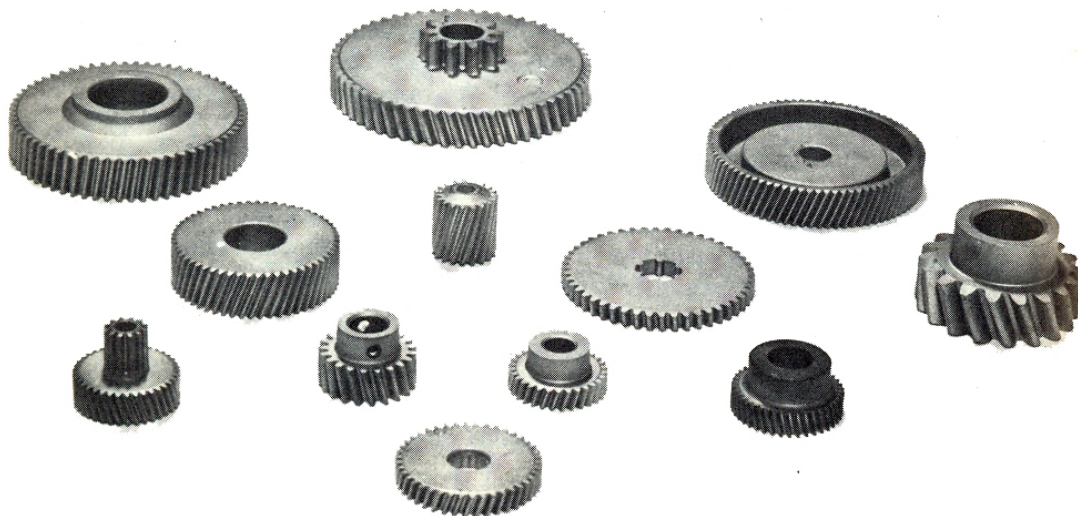
**Secondary machining is not required.**



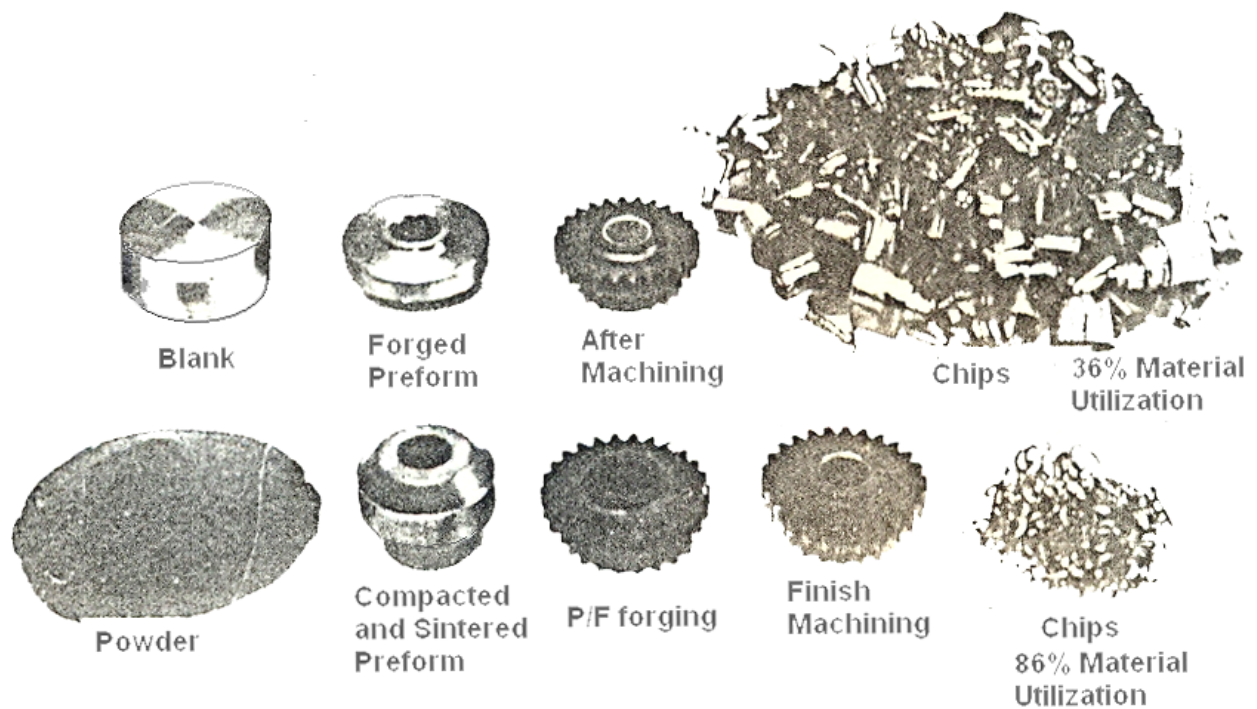
**Cluster gears, different types of gears can be combined and keyways can be built-in.**



**Helical gears and combination of gears**

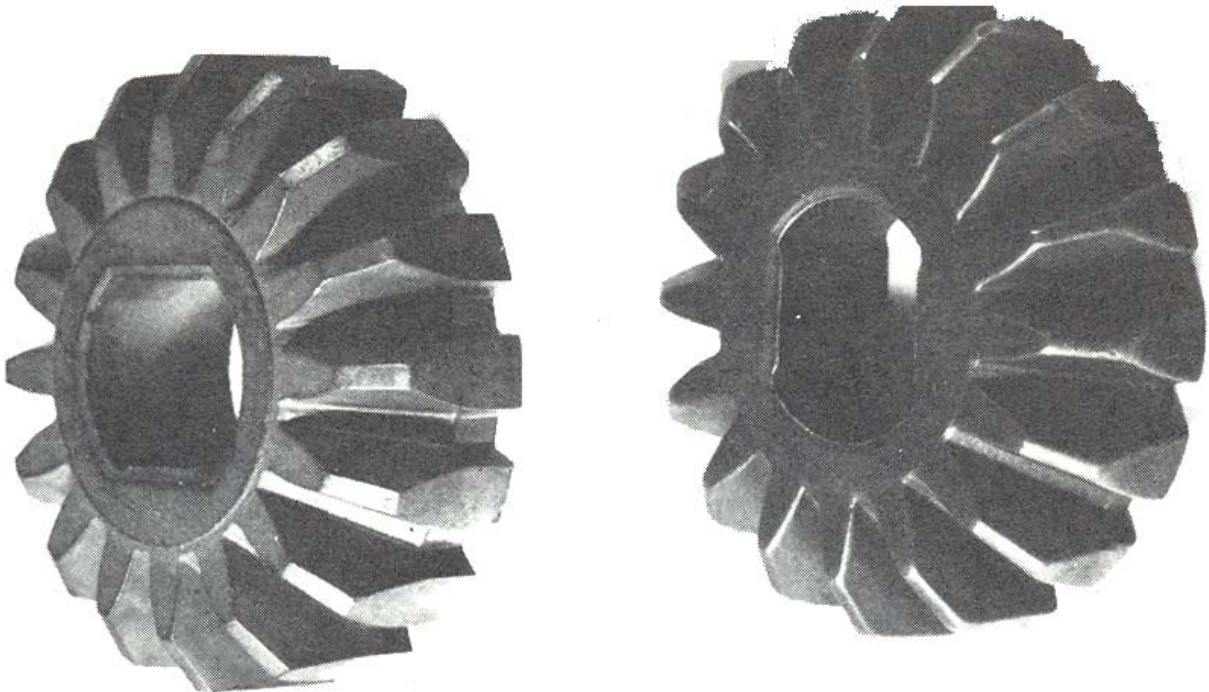
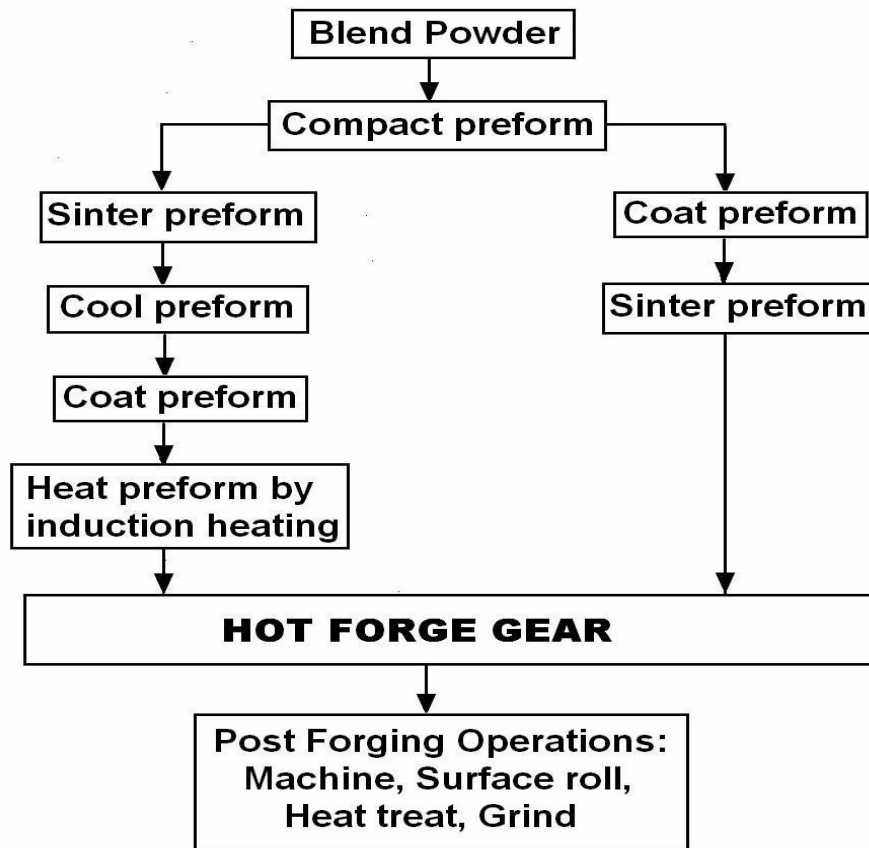


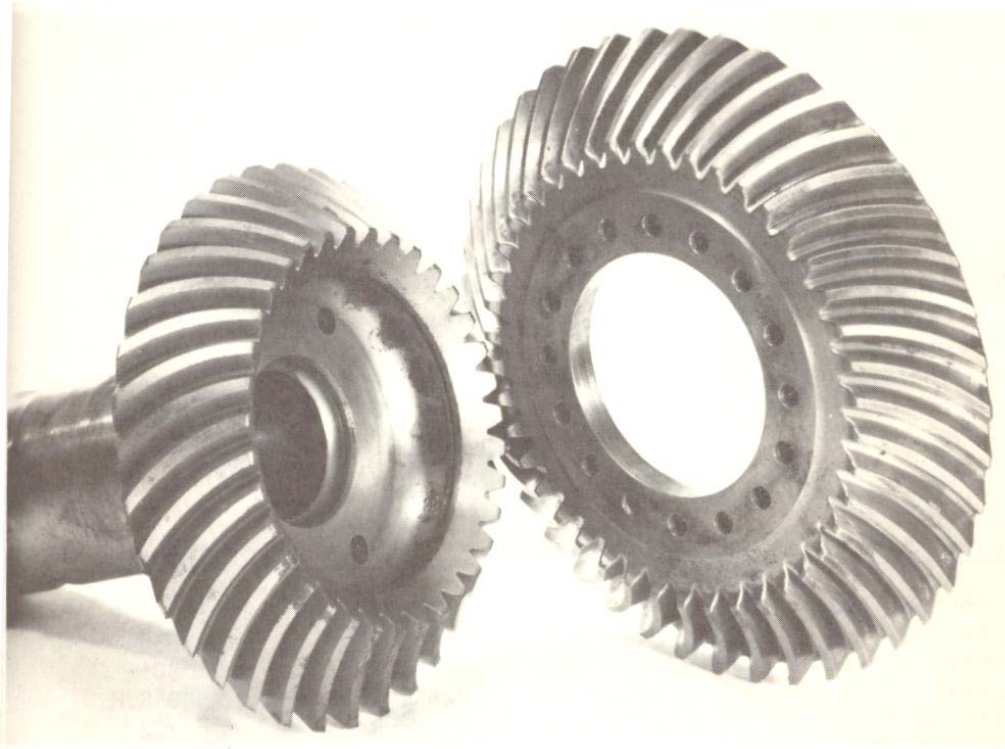
**Material utilization is more than 95%**



**P/M GEAR PRODUCTION BY HOT FORGING PROCESS**







**Semifinished Spiral Bevel Gear Set**

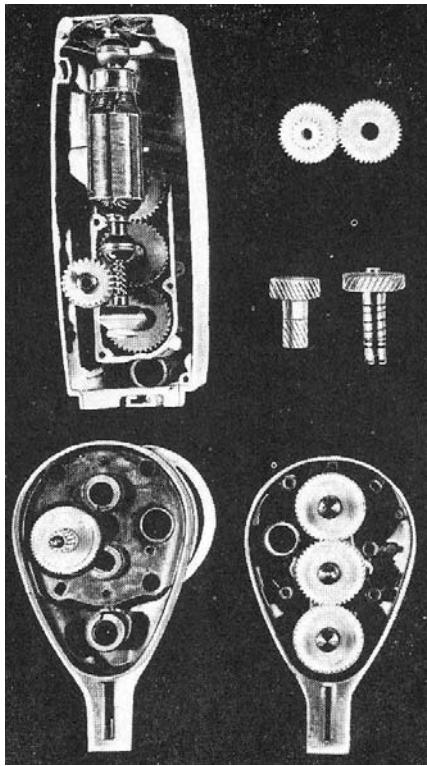
### **INJECTION MOLDING**

**INJECTION MOLDING** is used to make nonmetallic gears in various thermoplastics such as nylon and acetal. These are low precision gears in small sizes but have the advantages of low cost and the ability to be run without lubricant at light loads.

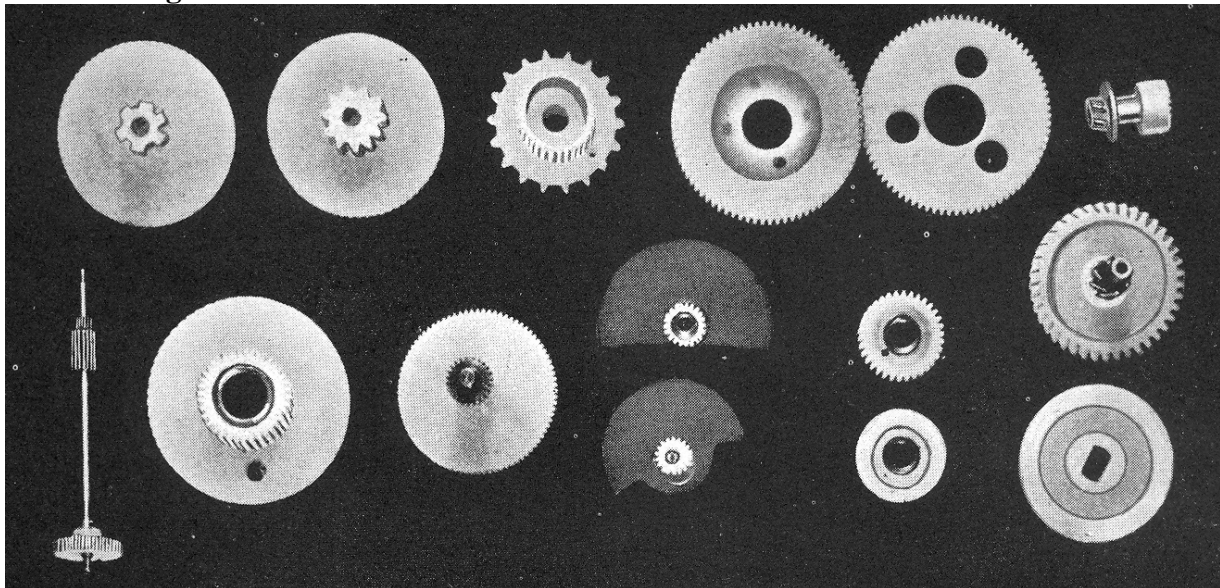
**IM** gears are used in cameras , projectors, wind shield wipers, speedometer, lawn sprinklers, washing machine,

**Materials:** Nylon, cellulose acetate, polysteren, poly imide  
**Phenolics.**

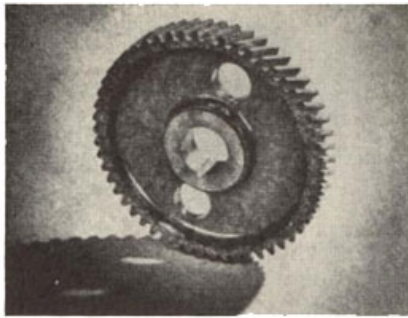




**IM camera gears**

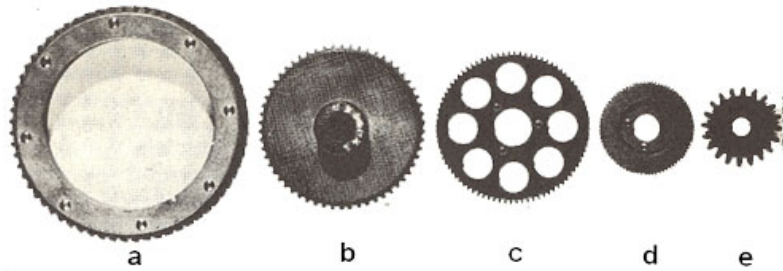


**COMPRESSION MOULDED GEAR**



Bakelite Co.

Phenolic-glass moulding is specified for engine timing gear because of its high strength and impact resistance.

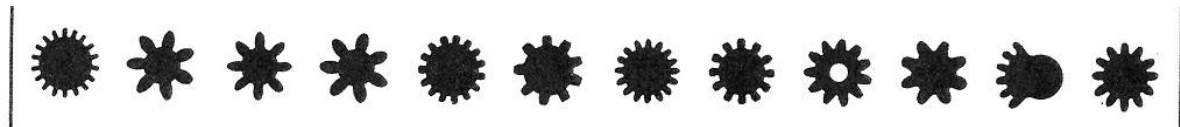


Quaker City Gear Works; Synthene Corp

Cotton-base phenolic laminate gear (a) with structural brass plates is used in voice recording instrument. Cotton-base gear (b) is used in noiseless elevating equipment. Fabric-base gear (c) is used in electronic instruments. Nylon fabric laminate gear (d) is part of motion picture sound projector. Similar gear (e) is used for television set control.

## EXTRUDING

**EXTRUDING** is used to form teeth on long rods, which are then cut into usable lengths and machined for bores and keyways etc. Nonferrous materials such as aluminum and copper alloys are commonly extruded rather than steels. Results in good surface finish with clean edges and pore free dense structure with higher strength















Aluminum, Copper, Naval brass, architect-ural bronze, phosphor bronze are commonly extruded.

**Applications:**

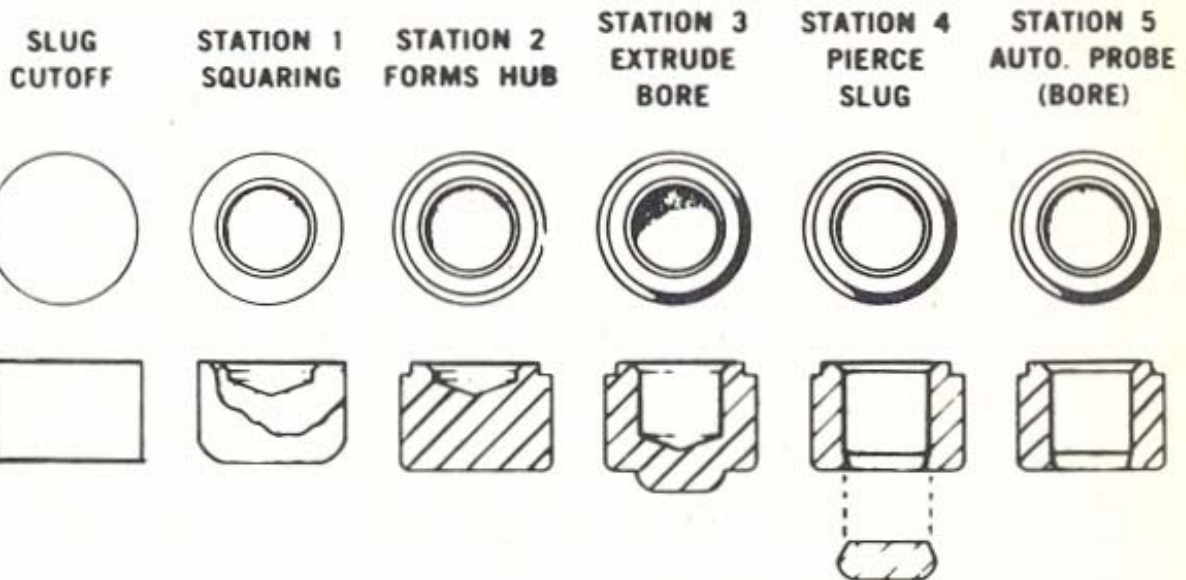
Splined hollow & solid shafts, sector gears

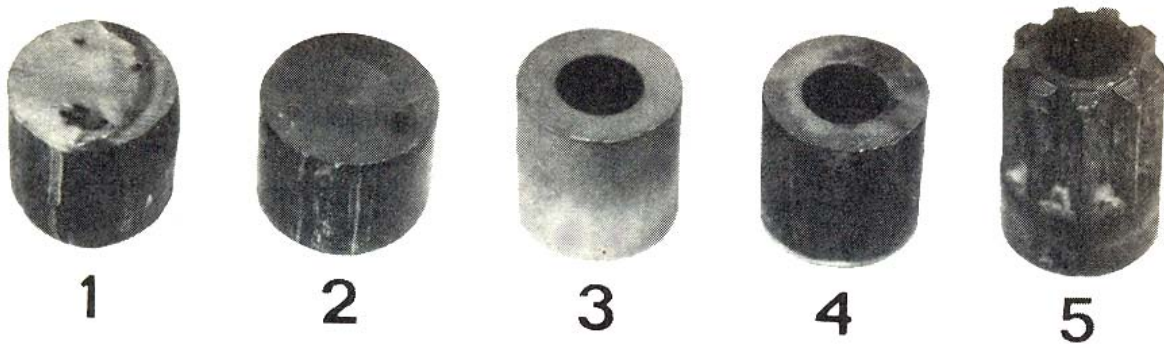
### Typical Extruded Sections

	Number Teeth	Outside Diameter	Pitch Diameter	Root Diamter	Pitch	Tooth Thickness
	18	1.241	——	0.972	16	0.098
	7	1.487	1.062	0.775	6	0.261
	8	0.985	0.800	0.544	10	0.157
	7	1.430	——	0.712	6	0.261
	15	2.020	——	1.588	8	0.1963
	9	1.325	——	0.920	14	0.196
	16	1.285	——	0.985	15	0.112
	8	1.150	——	0.750	Tolerance = 0.010	
	12	1.8	1.5		8	CP = 0.3927
	11	1.8	——	1.265 hole drawn to 1.215		
	6	Segment for Easy washer, body 0.720, radii 1/32 in.				
	12 <sup>1</sup>	5.25	4.38	3.625	Tolerance = $\pm$ 0.034	

<sup>1</sup>Aluminium

### PROGRESSION OF A COLD-FORMED GEAR BLANK





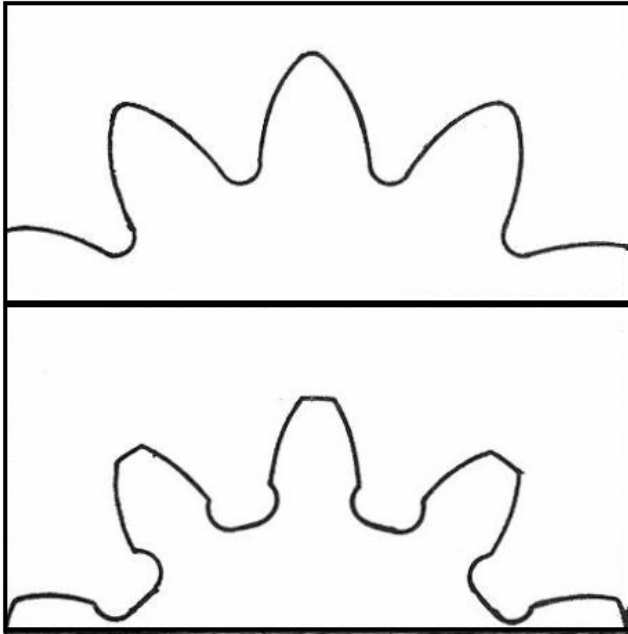
Stages in extrusion of a gear



Helical gear made by extrusion

## COLD DRAWING

Cold drawing forms teeth on steel rods by drawing them through hardened dies. The cold working increases strength and reduces ductility. The rods are then cut into usable lengths and machined for bores and keyways, etc.



For cold- drawing, the 11-tooth pinion below is enlarged by AGMA- ASA standard to the form above, avoiding undercut and giving radiused rather than sharp corners.

### **STAMPING**

**STAMPING:** Sheet metal can be stamped with tooth shapes to form low precision gears at low cost in high quantities. Surface finish and accuracy are poor.

**Uses:**

**Toy gears, hand operated machine gears, slow speed mechanism**

### **Precision stamping:**

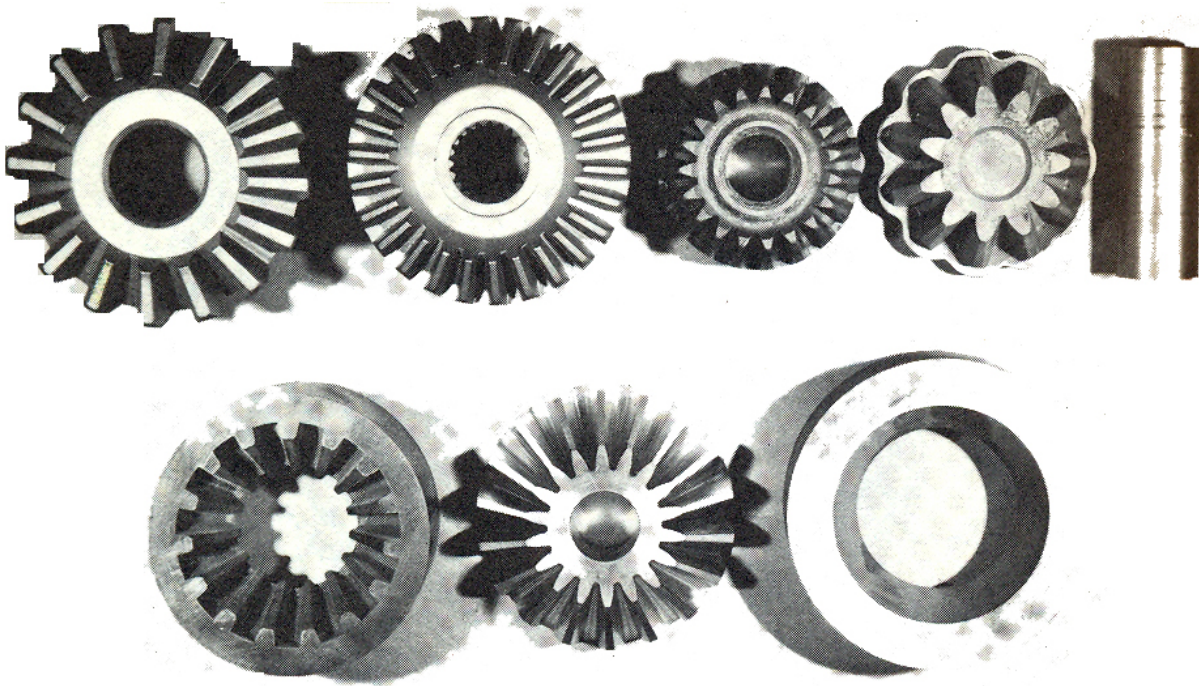
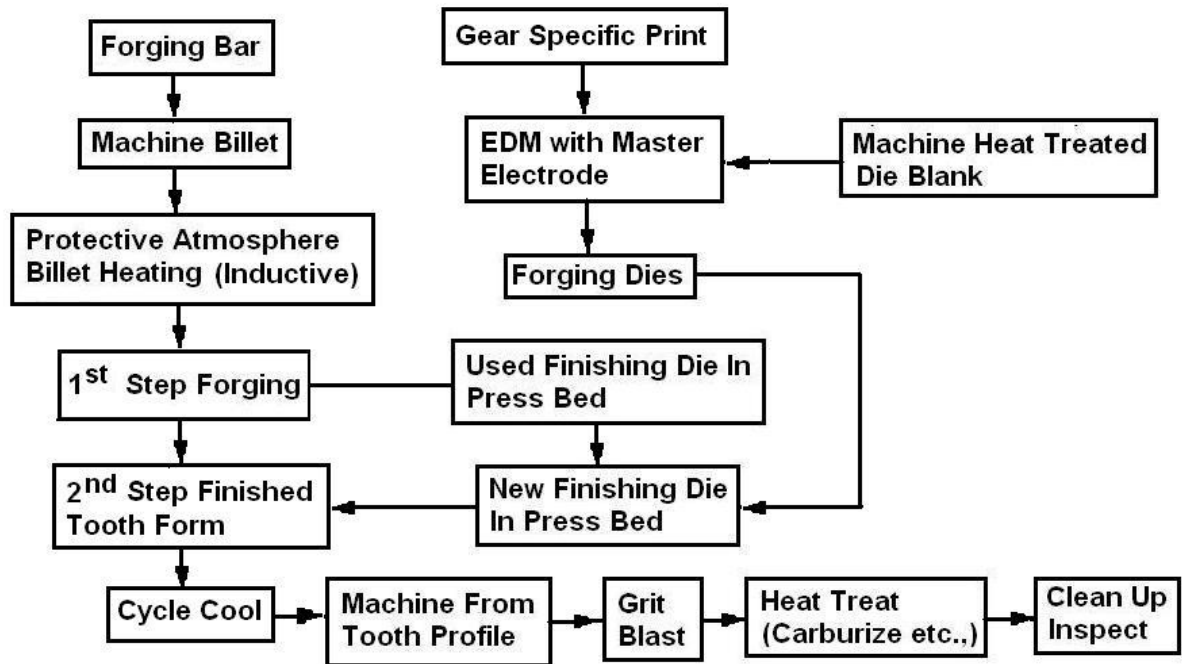
**The dies are made of higher precision with close tolerances. The stamped gears will not have burrs.**

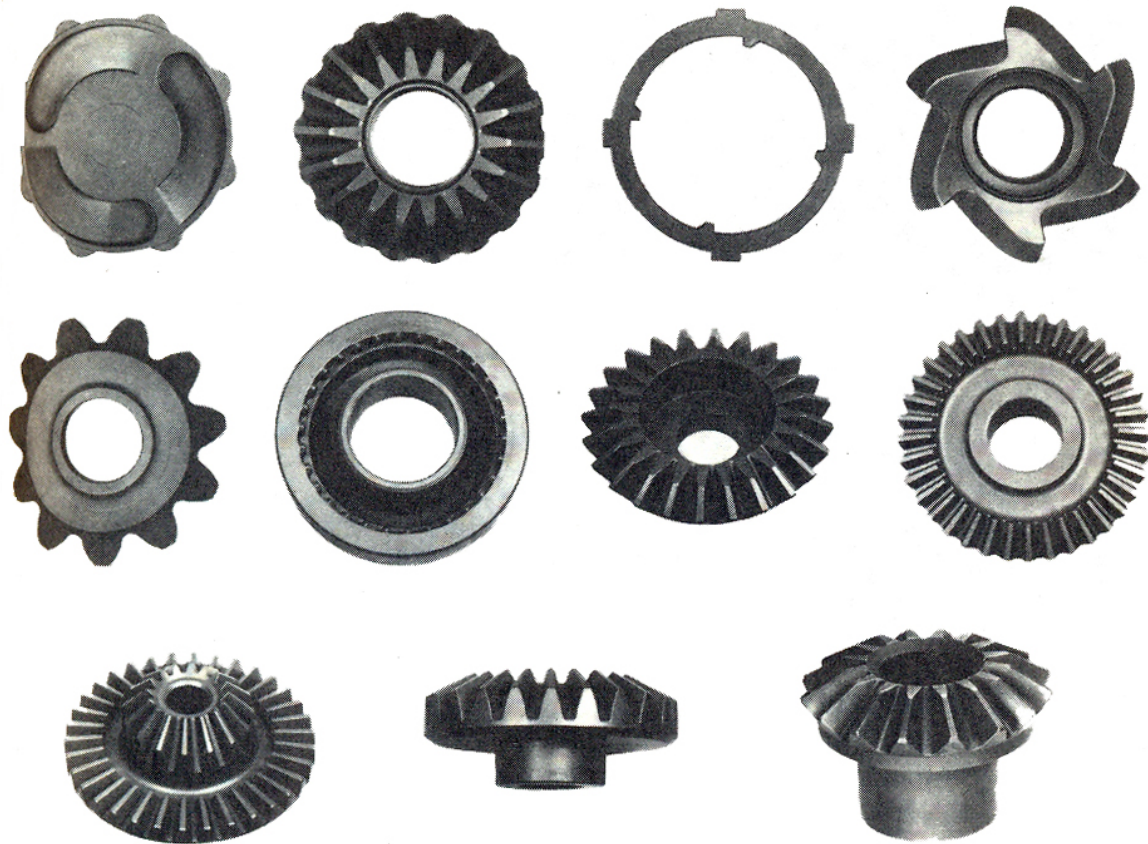
**Uses:**

**Clock gears, watch gears etc.**

### **Forging of Gears**

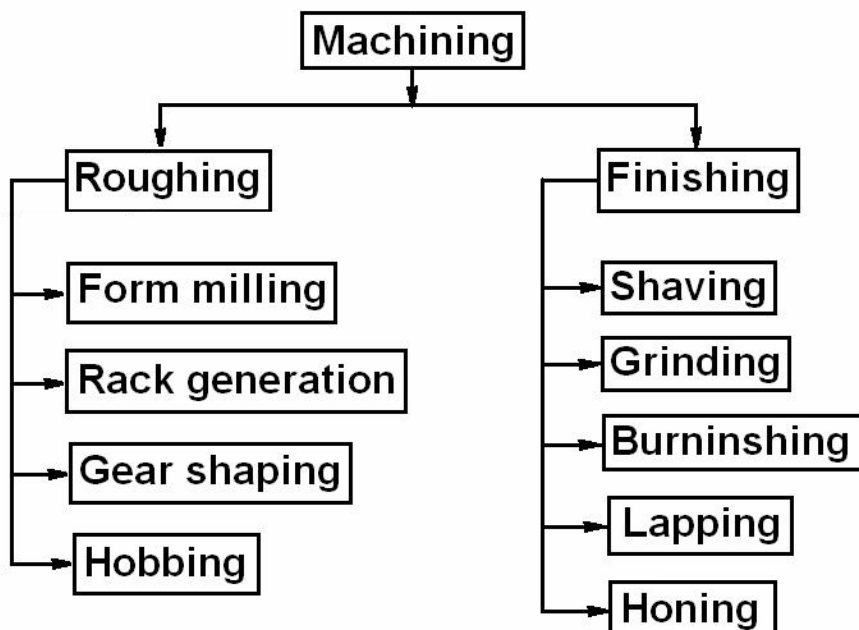




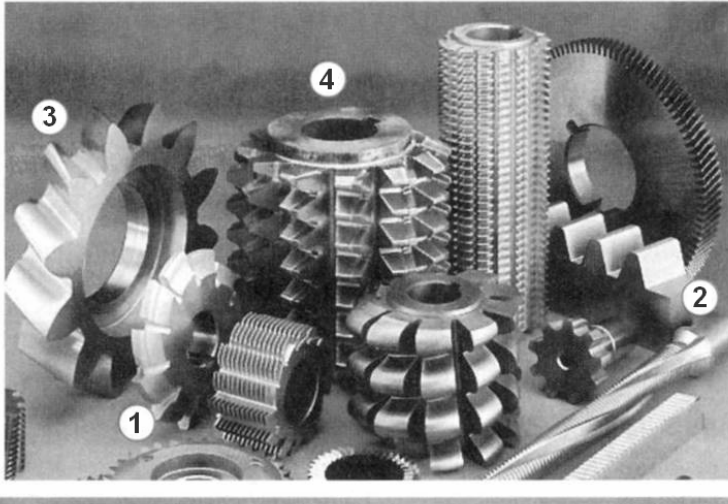


## MACHINING

The bulk of power transmitting metal gears of machinery are produced by machining process from cast, forged, or hot rolled blanks.



## VARIOUS GEAR CUTTERS



A collection of Gear-Cutting Tools: 1—Disc type Milling Cutter, 2— Rack Cutter, 3— Shaper Cutter, 4—Hob Cutter.

**Roughing processes include milling the tooth shape with formed cutters or Generating the shape with a rack cutter, a shaping cutter or a hob cutter.**

**Despite its name, the roughing processes actually produce a smooth and accurate gear tooth. Only for high precision and quiet running, the secondary finishing operation is justified at added cost.**

## GEAR SHAPING

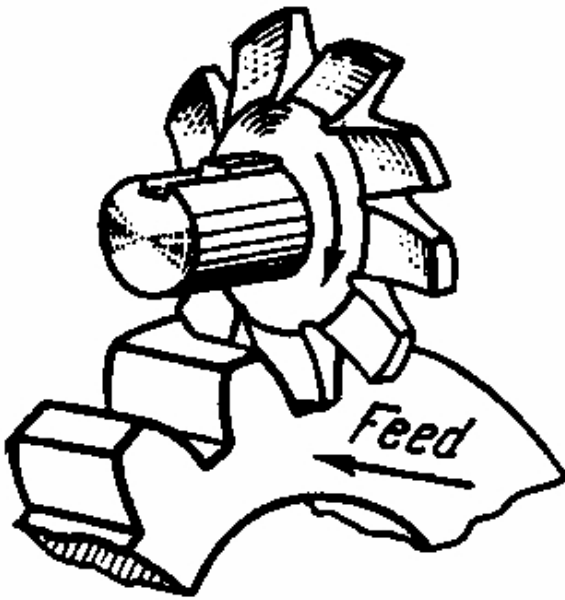
**GEAR SHAPING** used a cutting tool in the shape of a gear which is reciprocated axially across the gear blank to cut the teeth while the blank rotates around the shaper tool. It is a true shape-generation process in that the gear-shaped tool cuts itself into mesh with the gear blank.

**The bulk of power transmitting metal gears of machinery are produced by machining process from cast, forged, or hot rolled blanks. Roughing processes include milling the tooth shape with formed cutters or generating the shape with a rack cutter, a shaping cutter or a hob cutter.**

## ROUGHING PROCESSES

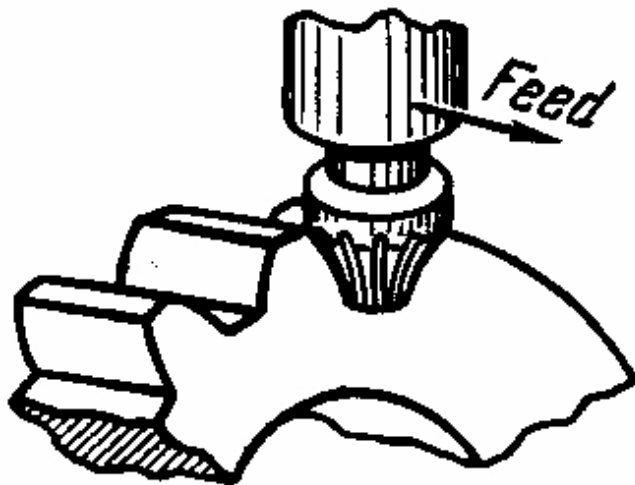
### FORM MILLING BY DISC CUTTER

**The disc cutter shape conforms to the gear tooth space. Each gear needs separate cutter. However, with 8 to 10 Std. cutters, gears from 12 to 120 teeth can be cut with fair accuracy. Tooth is cut one by one by plunging the rotating cutter into the blank.**



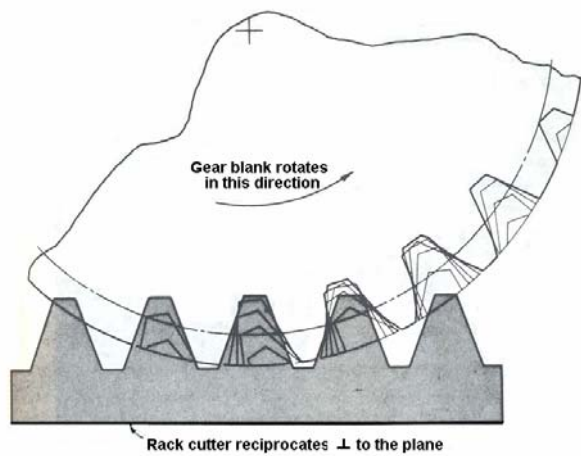
### FORM MILLING BY END MILL CUTTER

The end mill cutter shape conforms to tooth spacing. Each tooth is cut at a time and then indexed for next Tooth space for cutting. A set of 10 cutters will do for 12 to 120 teeth gears. Suited for small volume production of low precision gears.



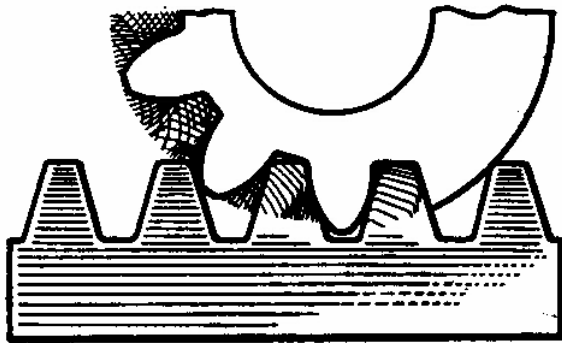
To reduce costs, the same cutter is often used for the multiple-sized gears resulting in profile errors for all but one number of teeth. Form milling method is the least accurate of the roughing methods.

### RACK GENERATION



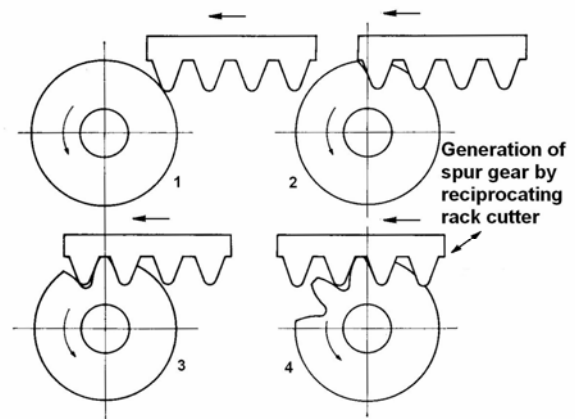
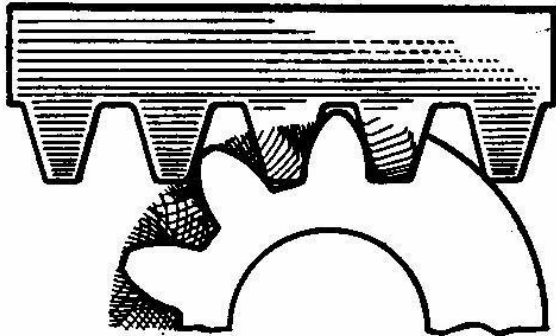
In rack cutter the tooth shape is trapezoid and can be made easily. The hardened and sharpened rack is reciprocated along the axis of the gear blank and fed into it while gear blank is being rotated so as to generate the involute tooth on the gear blank.

The rack and gear blank must be periodically repositioned to complete the circumference. This introduces errors in the tooth geometry making this method less accurate than shaping and hobbing.





The process is limited to small gears since the length of the rack has to be equal to circumference of the gear at pitch diameter.

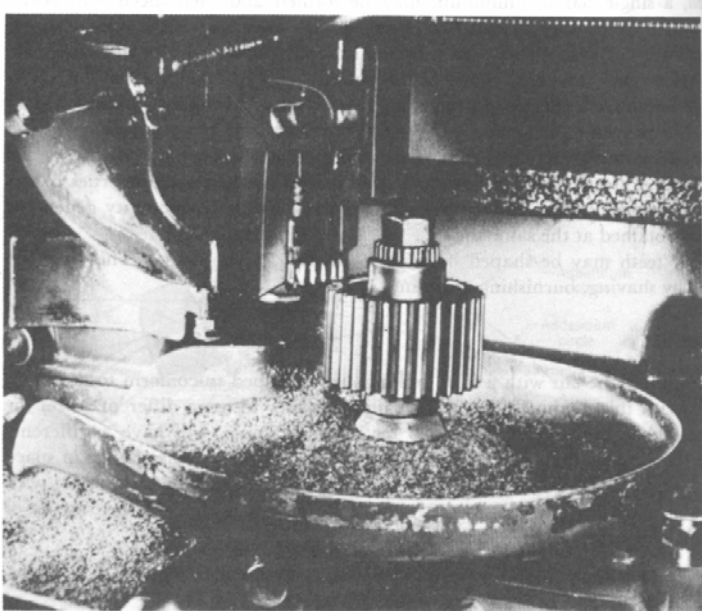


Generation of spur gear by planing

In gear shaping, a cutting tool of the shape of a gear reciprocates axially across the gear blank to cut the teeth while the blank rotates around the shaper tool. It is a true shape-generation process in that the gear-shaped tool cuts itself into mesh with the gear blank.

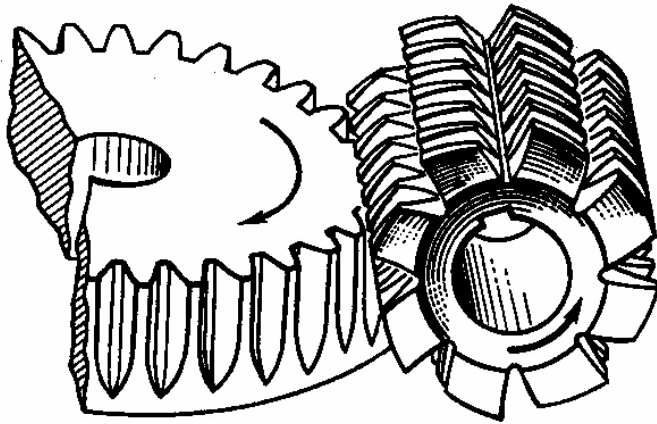
## GEAR SHAPING

The accuracy is good, but any errors in one tooth of the shaper cutter will be directly Transferred to the gear. Internal gears can be cut with this method as well.



## HOBGING

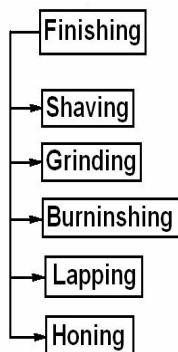
Hob teeth are shaped to match the tooth space and are interrupted with grooves to provide cutting surfaces. It rotates about an axis normal to that of the gear blank, cutting into the rotating blank to generate the teeth.



**It is the most accurate of the roughing processes since no repositioning of tool or blank is required and each tooth is cut by multiple hob-teeth, averaging out any tool errors. Excellent surface finish is achieved by this method and it is widely used for production of gears.**

### **FINISHING PROCESSES**

**When high precision is required secondary operation can be performed to gears made by any of the above roughing methods. Finishing operations typically removes little or no material but improves dimensional accuracy, surface finish, and or hardness.**



### **SHAVING**

**Shaving is similar to gear shaping, but uses accurate shaving tools to remove small amounts of material from a roughed gear to correct profile errors and improve surface finish.**

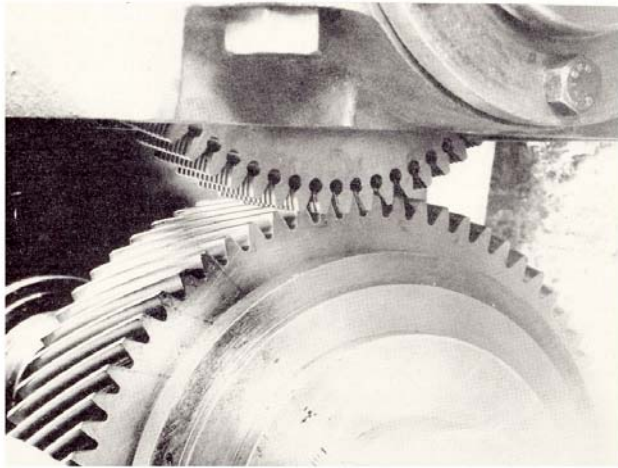


Fig. 13.1. External gear being shaved. (Courtesy of David Brown Gear Industries Ltd.)

## GRINDING

In grinding, a contoured grinding wheel is run over machined surface of the gear teeth using computer control. With a small amount of metal removal high surface finish is obtained.

