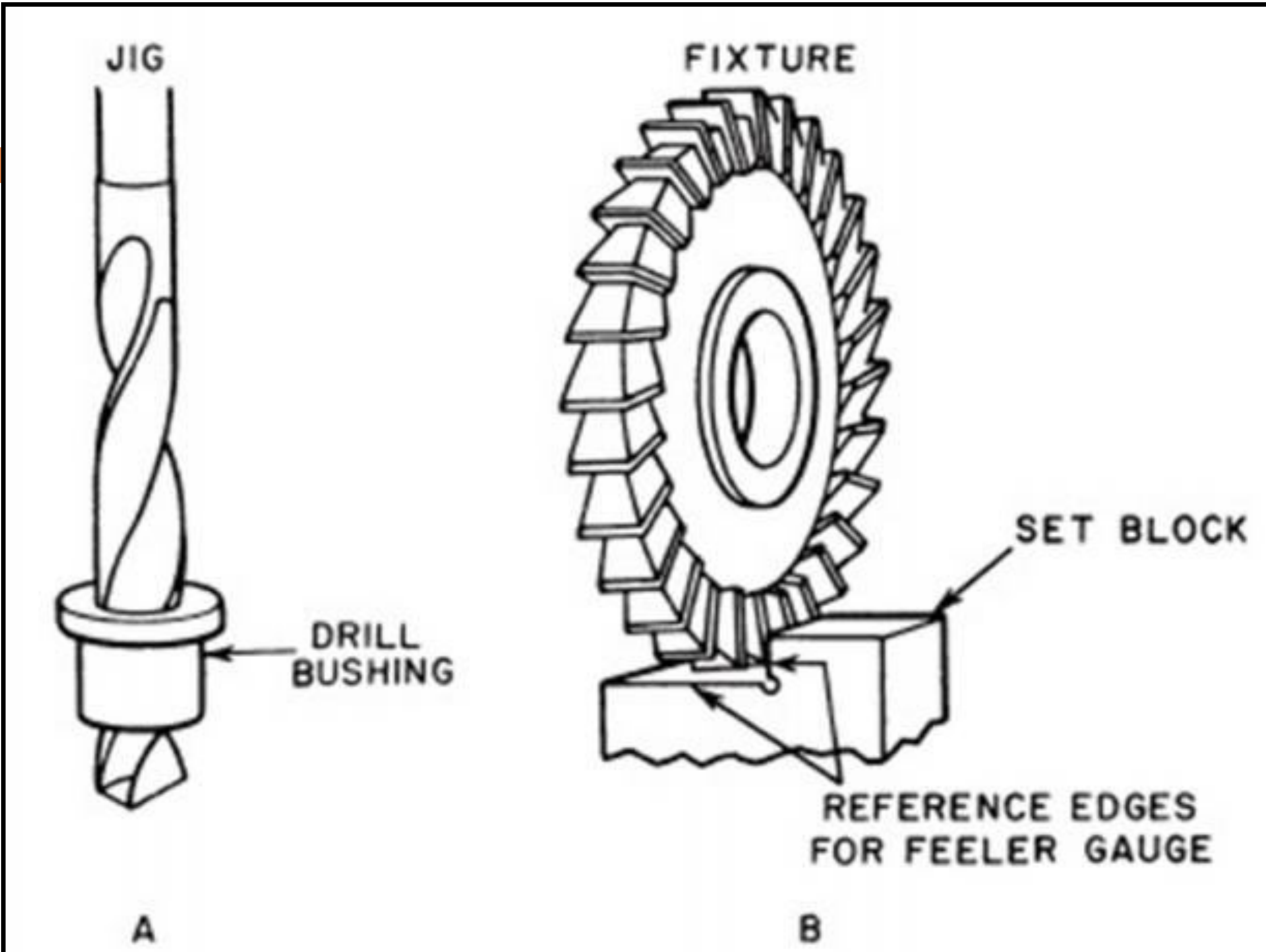
DESIGN OF JIGS & FIXTURES

Introduction

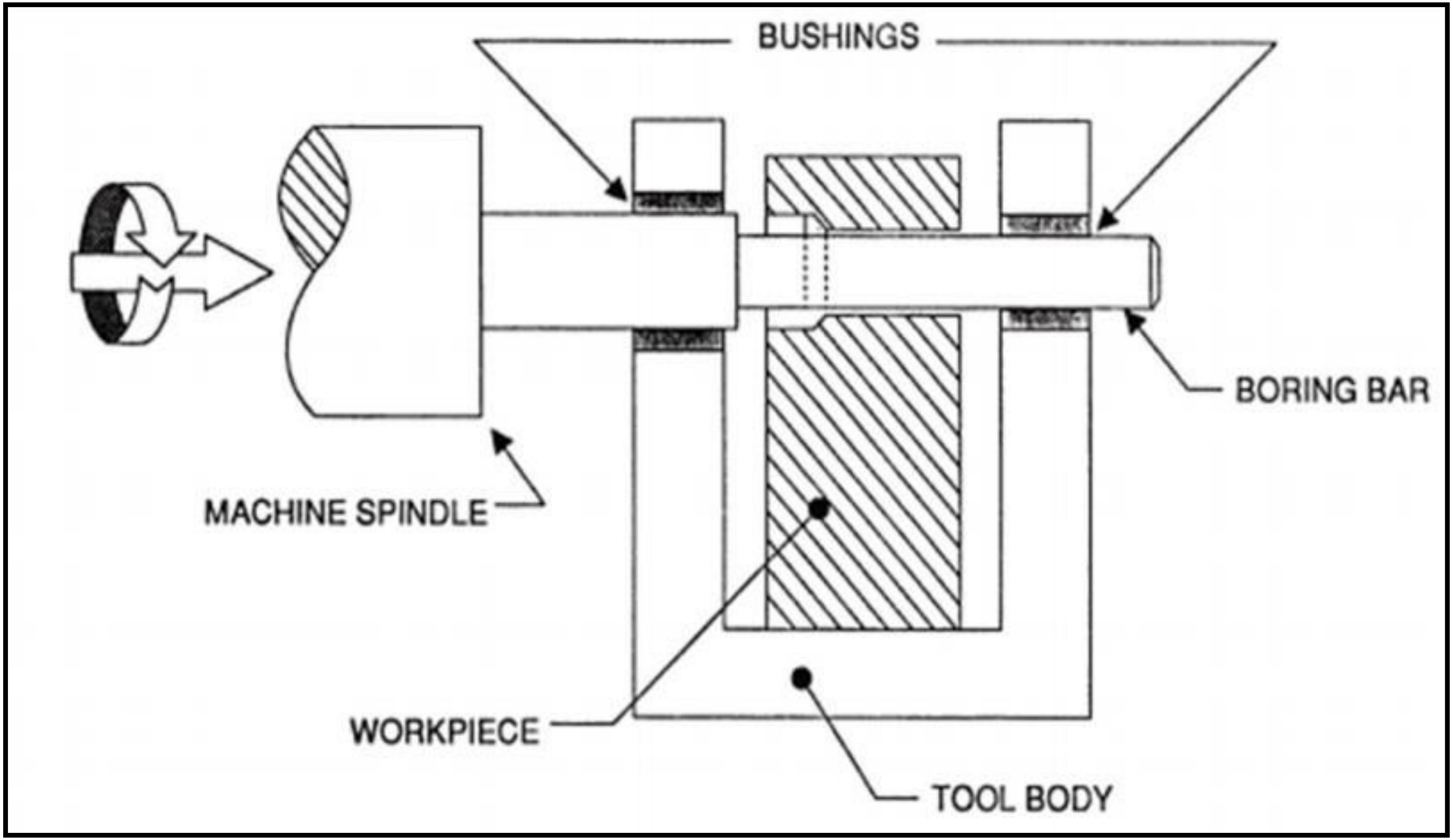
- The successful running of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand a fast and easy method of positioning work for accurate operations on it.
- **Jigs and fixtures** are production tools used to accurately manufacture duplicate and interchangeable parts. Jigs and fixtures are specially designed so that large numbers of components can be machined or assembled identically, and to ensure interchangeability of components.


JIG
DRILL
BUSHING
A
FIXTURE
SET BLOCK
REFERENCE EDGES
FOR FEELER GAUGE
B

JIGS

- It is a work holding device that holds, supports and locates the work piece and guides the cutting tool for a specific operation. Jigs are usually fitted with hardened steel bushings for guiding or other cutting tools. a jig is a type of tool used to control the location and/or motion of another tool. A jig's primary purpose is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. A device that does both functions (holding the work and guiding a tool) is called a jig. An example of a jig is when a key is duplicated, the original is used as a jig so the new key can have the same path as the old one.

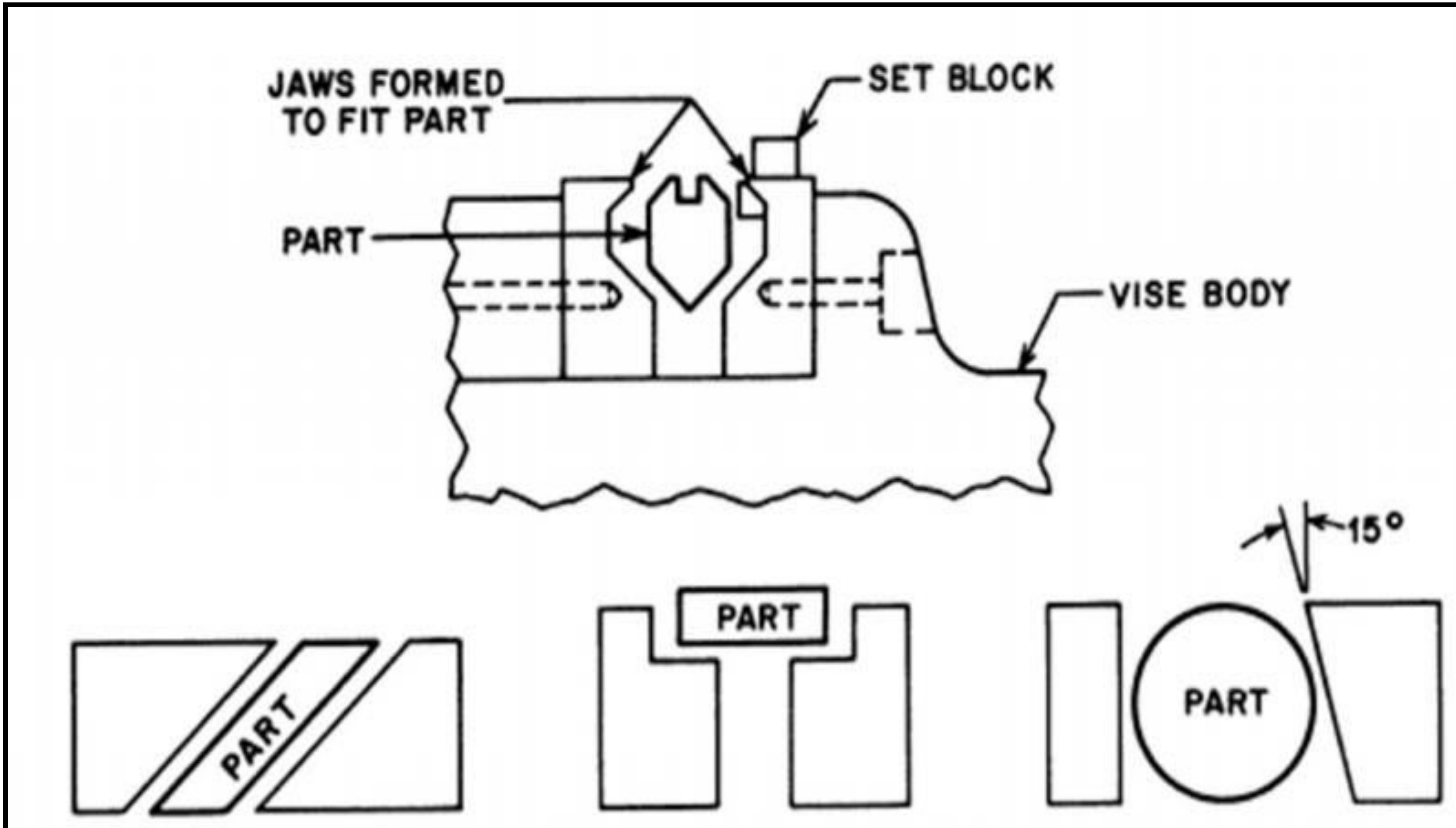
BORING JIG



FIXTURES

- It is a work holding device that holds, supports and locates the work piece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device. What makes a fixture unique is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and in some cases hold a work piece during either a machining operation or some other industrial process. A jig differs from a fixture in that a it guides the tool to its correct position in addition to locating and supporting the work piece. Examples: Vises, chucks

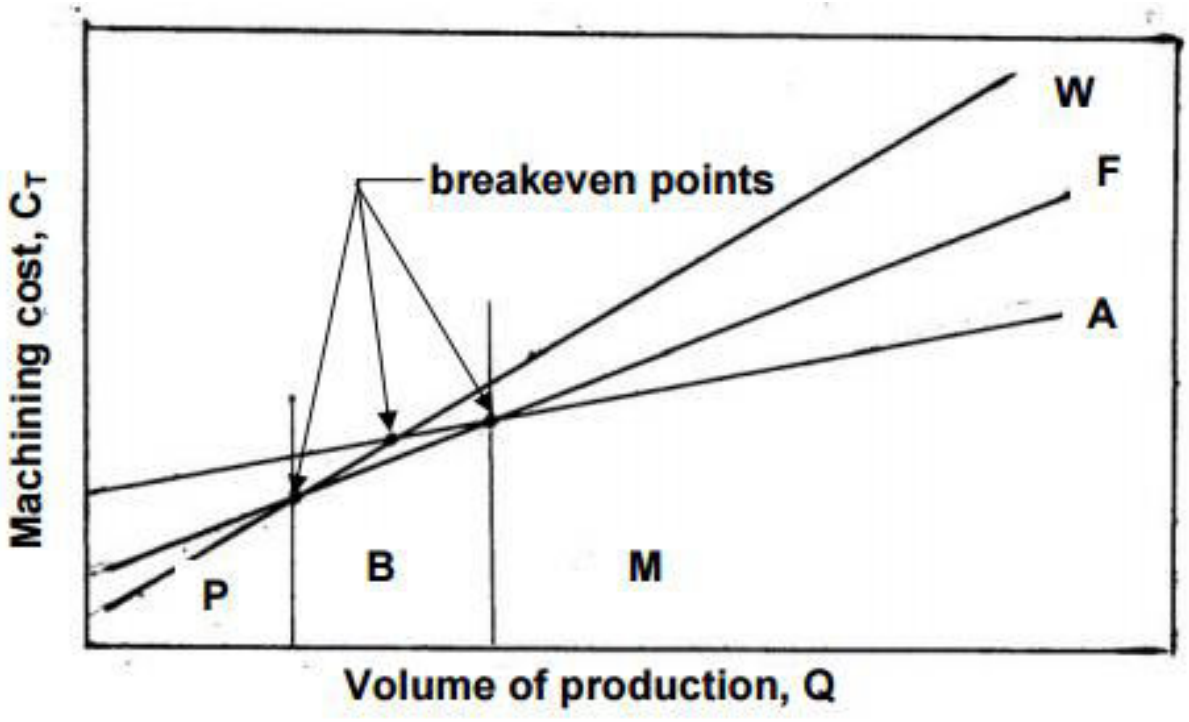
A VISE-JAW FIXTURE



The basic purposes of developing and using suitable jigs and fixtures for batch production in machine shops are :

- to eliminate marking, punching, positioning, alignments etc.
- easy, quick and consistently accurate locating, supporting and clamping the blank in alignment of the cutting tool
- guidance to the cutting tool like drill, reamer etc.
- increase in productivity and maintain product quality consistently
- to reduce operator’s labor and skill – requirement
- to reduce measurement and its cost
- enhancing technological capacity of the machine tools
- reduction of overall machining cost and also increase in interchangeability.

Role of Jigs and Fixtures on machining cost



W – without using jig & fixture
F – using jig and fixture
A – automatic (special purpose) machine
P – piece production
B – batch production
M – mass production

How do jigs and fixtures differ

JIGS	FIXTURES
1. It is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation	1. It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool
2. Jigs are not clamped to the drill press table unless large diameters to be drilled and there is a necessity to move the jig to bring one each bush directly under the drill.	2. Fixtures should be securely clamped to the table of the machine upon which the work is done.
3. The jigs are special tools particularly in drilling, reaming, tapping and boring operation.	3. Fixtures are specific tools used particularly in milling machine, shapers and slotting machine.
4. Gauge blocks are not necessary.	4. Gauge blocks may be provided for effective handling.
5. Lighter in construction.	5. Heavier in construction.

Advantages of Jigs and Fixtures

PRODUCTIVITY:

- Jigs and fixtures increases the productivity by eliminating the
- individual marking, positioning and frequent checking. The
- operation time is also reduced due to increase in speed, feed
- and depth of cut because of high clamping rigidity.

INTERCHANGEABILITY AND QUALITY:

- Jigs and fixtures facilitate the production of articles in large
- quantities with high degree of accuracy, uniform quality and
- interchangeability at a competitive cost .

Advantages of Jigs and Fixtures

SKILL REDUCTION:

- There is no need for skillful setting of work on tool. Jigs and
- fixtures makes possible to employ unskilled or semi skilled
- machine operator to make savings in labor cost.

COST REDUCTION:

- Higher production, reduction in scrap, easy assembly and
- savings in labor cost results in ultimate reduction in unit
- cost.

Fundamental principles of Jigs and Fixtures design

- LOCATING POINTS: Good facilities should be provided for locating the work. The article to be machined must be easily inserted and quickly taken out from the jig so that no time is wasted in placing the work piece in position to perform operations. The position of work piece should be accurate with respect to tool guiding in the jig or setting elements in fixture.
- FOOL PROOF: The design of jigs and fixtures should be such that it would not permit the work piece or the tool to inserted in any position other than the correct one.

Fundamental principles of Jigs and Fixtures design

- **REDUCTION OF IDLE TIME:** Design of Jigs and Fixtures should be such that the process, loading, clamping and unloading time of the Work piece takes minimum as far as possible.
- **WEIGHT OF JIGS AND FIXTURES: It** should be easy to handle, smaller in size and low cost in regard to amount of material used without sacrificing rigidity and stiffness.
- **JIGS PROVIDED WITH FEET:** Jigs sometimes are provided with feet so that it can be placed on the table of the machine.

Fundamental principles of Jigs and Fixtures design

MATERIALS FOR JIGS AND FIXTURES: Usually made of hardened materials to avoid frequent damage and to resist wear. Example- MS, Cast iron, Die steel, CS, HSS.

CLAMPING DEVICE: It should be as simple as possible without sacrificing

- effectiveness. The strength of clamp should be such that not only to hold the work piece firmly in place but also to take the strain of the cutting tool without springing when designing the jigs and fixtures.

Principles And Methods Of Locating, Supporting And Clamping Blanks And Tool Guidance In Jigs And Fixtures

- It is already emphasized that the main functions of the jigs and fixtures are :

(a) easily, quickly, firmly and consistently accurately

- locating
- supporting and
- clamping the blank (in the jig or fixture) in respect to the cutting tool(s)

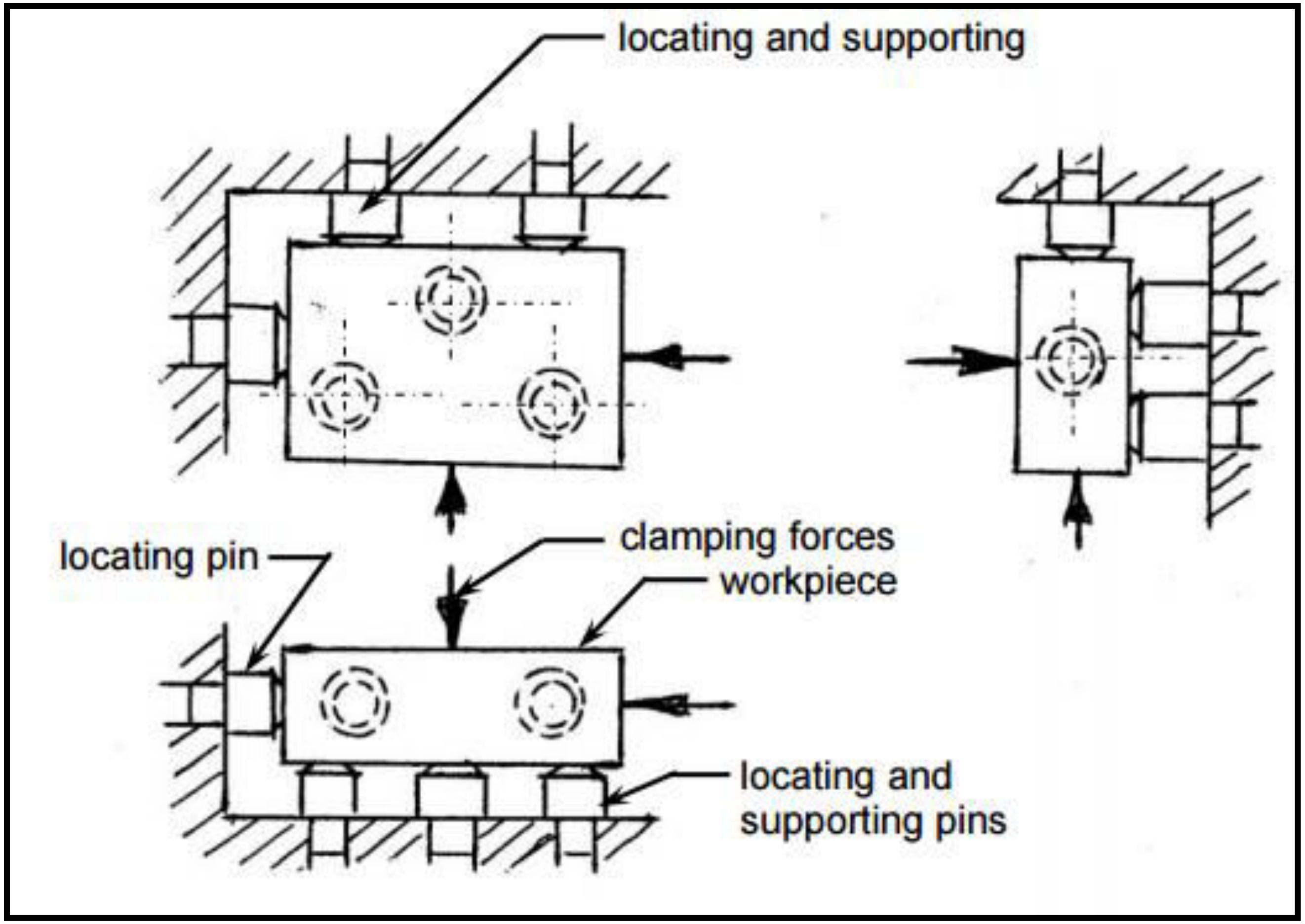
(b) providing guidance to the slender cutting tools using proper bushes There are and can be several methods of locating, supporting and clamping depending upon the size, shape and material of the job, cutting tool and the machining work required. But some basic principles or rules are usually followed while designing for locating, supporting and clamping of blank in fixtures.

Principles or rules of locating in jigs and fixtures

- For accurate machining, the work piece is to be placed and held in correct position and orientation in the fixture (or jig) which is again appropriately located and fixed with respect to the cutting tool and the machine tool. It has to be assured that the blank, once fixed or clamped, does not move at all. Any solid body may have maximum twelve degrees of freedom as indicated in Fig

Principles or rules of locating in jigs and fixtures

By properly locating, supporting and clamping the blank its all degrees of freedom are to be arrested as typically shown in Fig

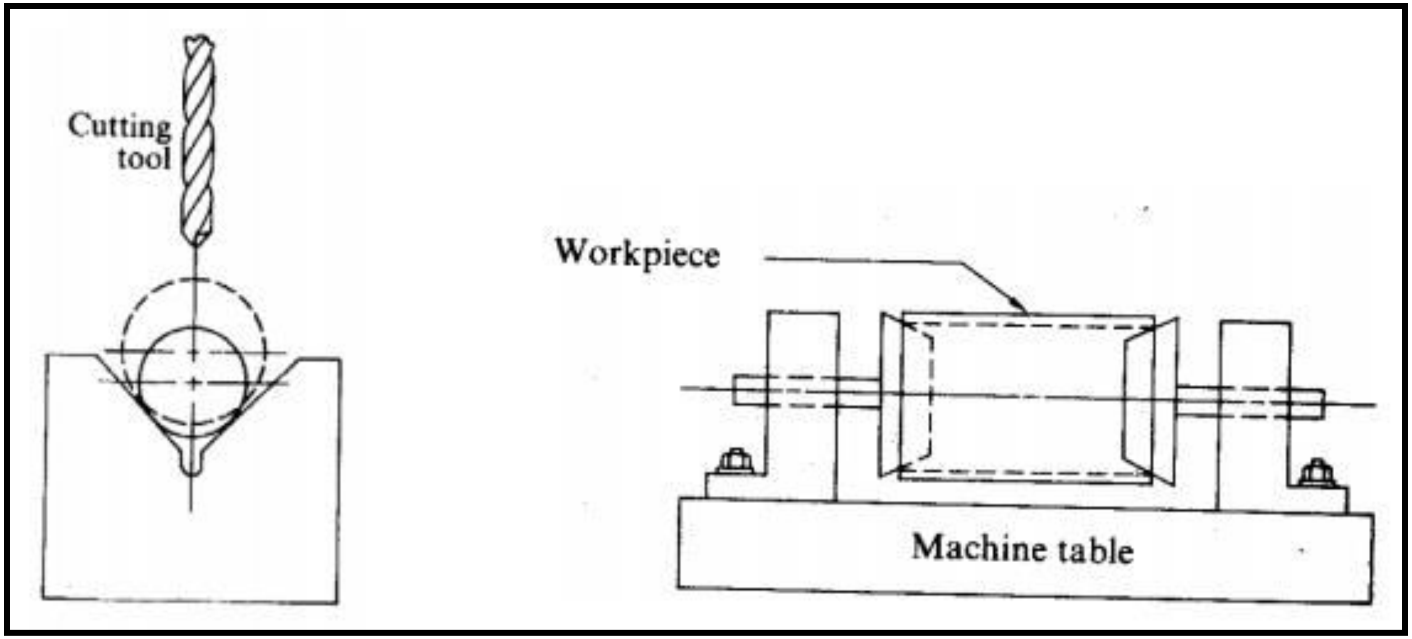


Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as;

- One or more surfaces (preferably machined) and / or drilled / bored hole(s) are to be taken for reference
- The reference surfaces should be significant and important feature(s) based on which most of the dimensions are laid down
- Locating should be easy, quick and accurate
- In case of locating by pin, the pins and their mounting and contact points should be strong, rigid and hard
- A minimum of three point must be used to locate a horizontal flat surface

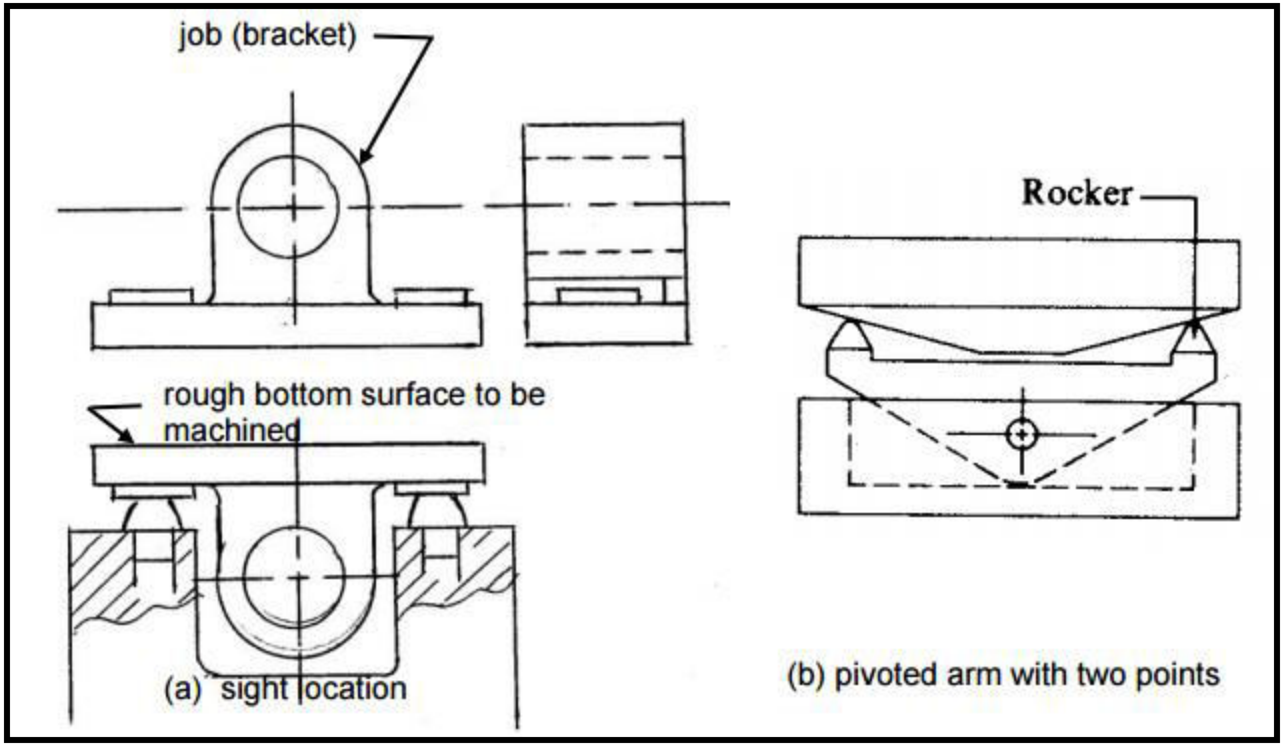
Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as;

- The locating pins should be as far apart as feasible
- V-block and cones should be used for self-locating solid and hollow cylindrical jobs as typically shown in Fig



Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as;

- Sight location is applicable to first – operation location of blank with irregular surfaces produced by casting, forging etc. as indicated in Fig when the bracket is first located on two edges to machine the bottom surface which will be used for subsequent locating.



(a) sight location

(b) pivoted arm with two points

Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as;

- Sight location is applicable to first – operation location of blank with irregular surfaces produced by casting, forging etc. as indicated in Fig when the bracket is first located on two edges to machine the bottom surface which will be used for subsequent locating.

Essential features of Jigs and Fixtures

- Reduction of idle time – Should enable easy clamping and unloading such that idle time is minimum
- Cleanliness of machining process – Design must be such that not much time is wasted in cleaning of scarfs, burrs, chips etc.
- Replaceable part or standardization – The locating and supporting surfaces as far as possible should be replaceable, should be standardized so that their interchangeable manufacture is possible
- Provision for coolant – Provision should be there so that the tool is cooled and the swarfs and chips are washed away

Essential features of Jigs and Fixtures

- Hardened surfaces – All locating and supporting surfaces should be hardened materials as far as conditions permit so that they are not quickly worn out and accuracy is retained for a long time

- Inserts and pads – Should always be riveted to those faces of the clamps which will come in contact with finished surfaces of the workpiece so that they are not spoilt

- Fool-proofing – Pins and other devices of simple nature incorporated in such a position that they will always spoil the placement of the component or hinder the fitting of the cutting tool until the latter are in correct pos

Essential features of Jigs and Fixtures

- Economic soundness – Equipment should be economically sound, cost of design and manufacture should be in proportion to the quantity and price of producer

- Easy manipulation – It should be as light in weight as possible and easy to handle so that workman is not subjected to fatigue, should be provided with adequate lift aids

- Initial location – Should be ensured that workpiece is not located on more than 3 points in anyone plane test to avoid rocking, spring loading should be done

- Position of clamps – Clamping should occur directly above the points supporting the workpiece to avoid distortion and springing

Essential features of Jigs and Fixtures

- Clearance – Sufficient amount of clearance should be provided around the work so that operator's hands can easily enter the body for placing the workpiece and any variations of work can be accommodated

- Ejecting devices – Proper ejecting devices should be incorporated in the body to push the workpiece out after operation

- Rigidity and stability – It should remain perfectly rigid and stable during operation. Provision should be made for proper positioning and rigidly holding the jigs and fixtures

- Safety – The design should assure perfect safety of the operator

General rules for designing

- Compare the cost of production of work with present tools with the expected cost of production, using the tool to be made and see that the cost of buildings is not in excess of expected gain.
- Decide upon locating points and outline clamping arrangement
- Make all clamping and binding devices as quick acting as possible
- Make the jig fool proof
- Make some locating points adjustable
- Avoid complicated clamping arrangements

General rules for designing

- Round all corners
- Provide handles wherever these will make handling easy
- Provide abundant clearance
- Provide holes on escapes for chips
- Locate clamps so that they will be in best position to resist the pressure of the cutting tool when at work
- Place all clamps as nearly as possible opposite some bearing point of the work to avoid springing action
- Before using in the shop, test all jigs as soon as made

MATERIALS USED

- Jigs and Fixtures are made of variety of materials, some of which can be hardened to resist wear.
- Materials generally used:
- High speed Steel: Cutting tools like drills, reamers and milling cutters.
- Die steels: Used for press tools, contain 1% carbon, 0.5 to 1% tungsten and less quantities of silicon and manganese.
- Carbon steels: Used for standard cutting tools.
- Collet steels: Spring steels containing 1% carbon, 0.5% manganese and less of silicon.

MATERIALS USED

5. Non shrinking tool steels:

High carbon or high chromium

Very little distortion during heat treatment.

Used widely for fine, intricate press tools.

6. Nickel chrome steels: Used for gears.

7. High tensile steels: Used for fasteners like high tensile screws

8. Mild steel:

Used in most part of Jigs and Fixtures

Cheapest material

Contains less than 0.3% carbon

MATERIALS USED

9. Cast Iron:

Used for odd shapes to some machining and laborious fabrication

CI usage requires a pattern for casting

Contains more than 2% carbon

Has self lubricating properties

Can withstand vibrations and suitable for base

10. Nylon and Fiber: Used for soft lining for clamps to damage to workpiece due to clamping pressure

11. Phospher bronze:

Used for nuts as have high tensile strength

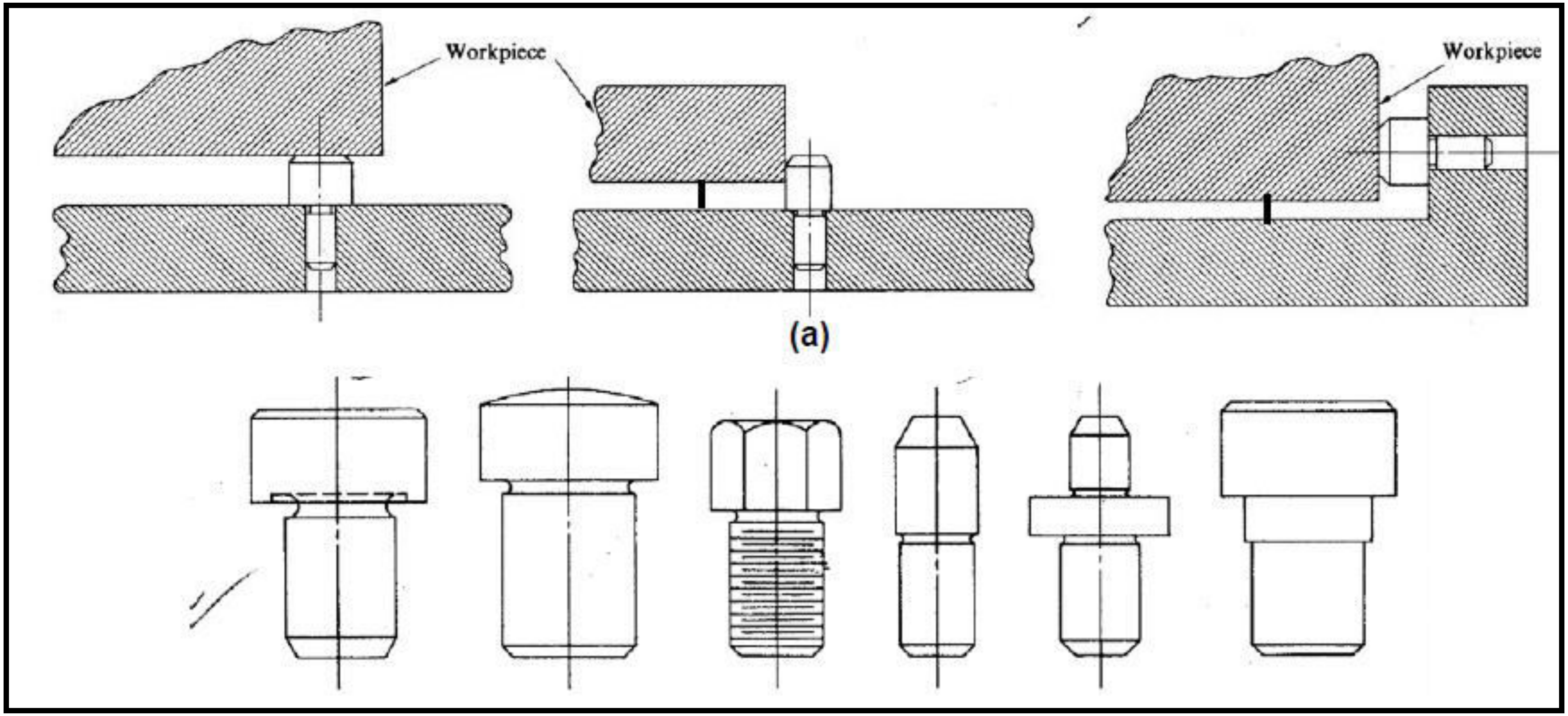
Used for nuts of the lead screw

General methods of locating

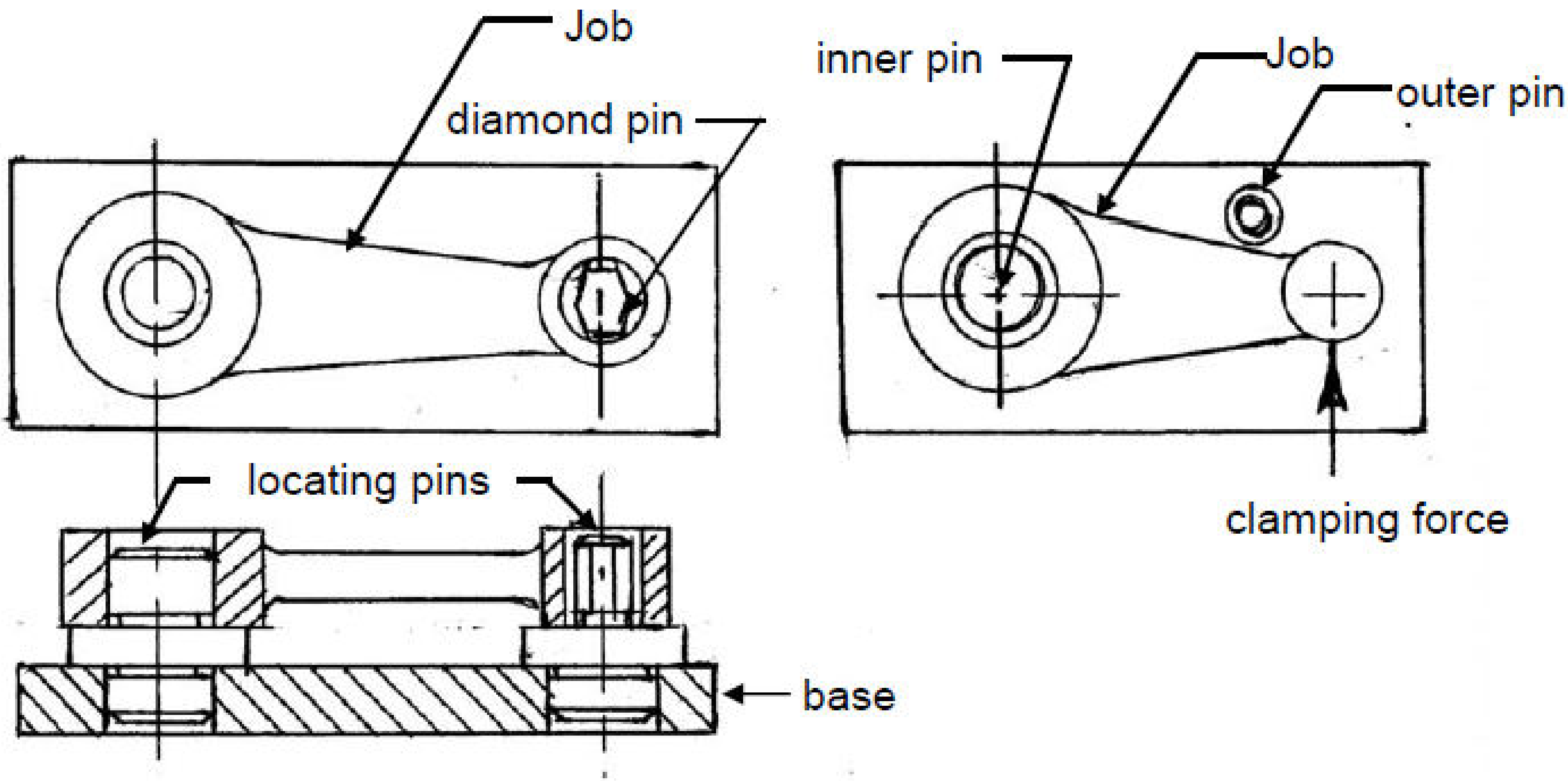
- **Locating blanks for machining in lathes**
- In lathes, where the job rotates, the blanks are located by
  - o fitting into self centering chuck
  - o fitting into 4 – independent jaw chuck and dead centre
  - o in self – centering collets
  - o in between live and dead centers
  - o by using mandrel fitted into the head stock – spindle
- fitting in a separate fixture which is properly clamped on a driving plate which is coaxially fitted into the lathe spindle.

Locating by flat surfaces

- Fig. typically shows locating jobs by their flat surfaces using various types of flat ended pins and buttons.



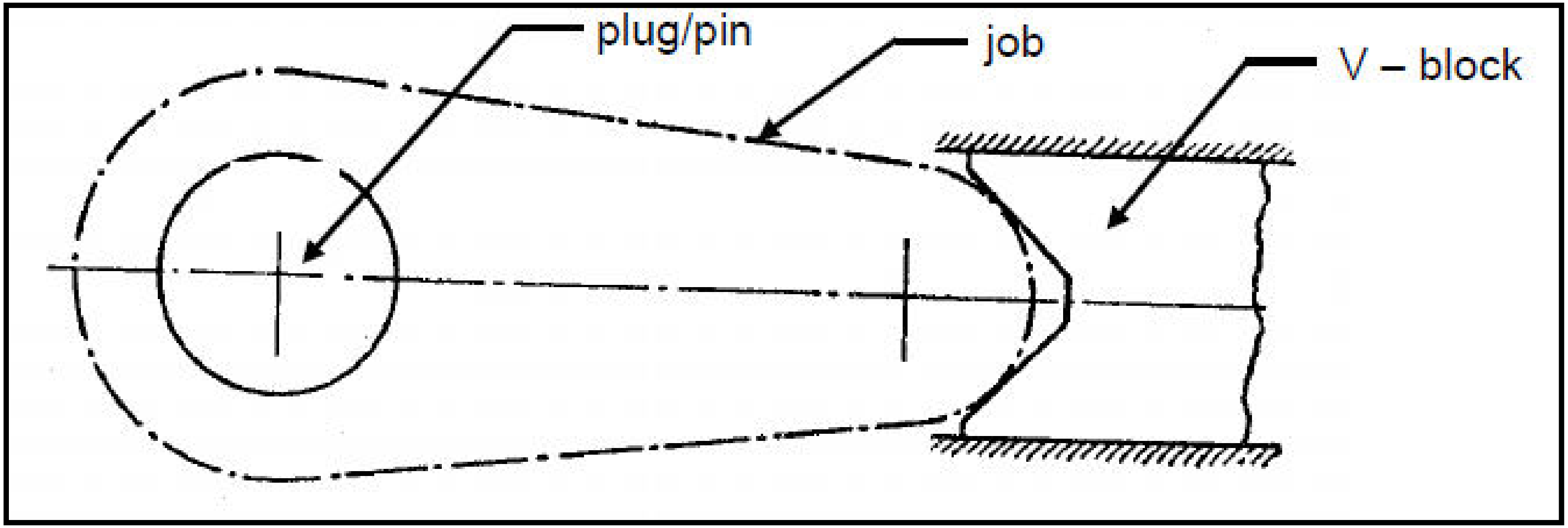
Locating by holes



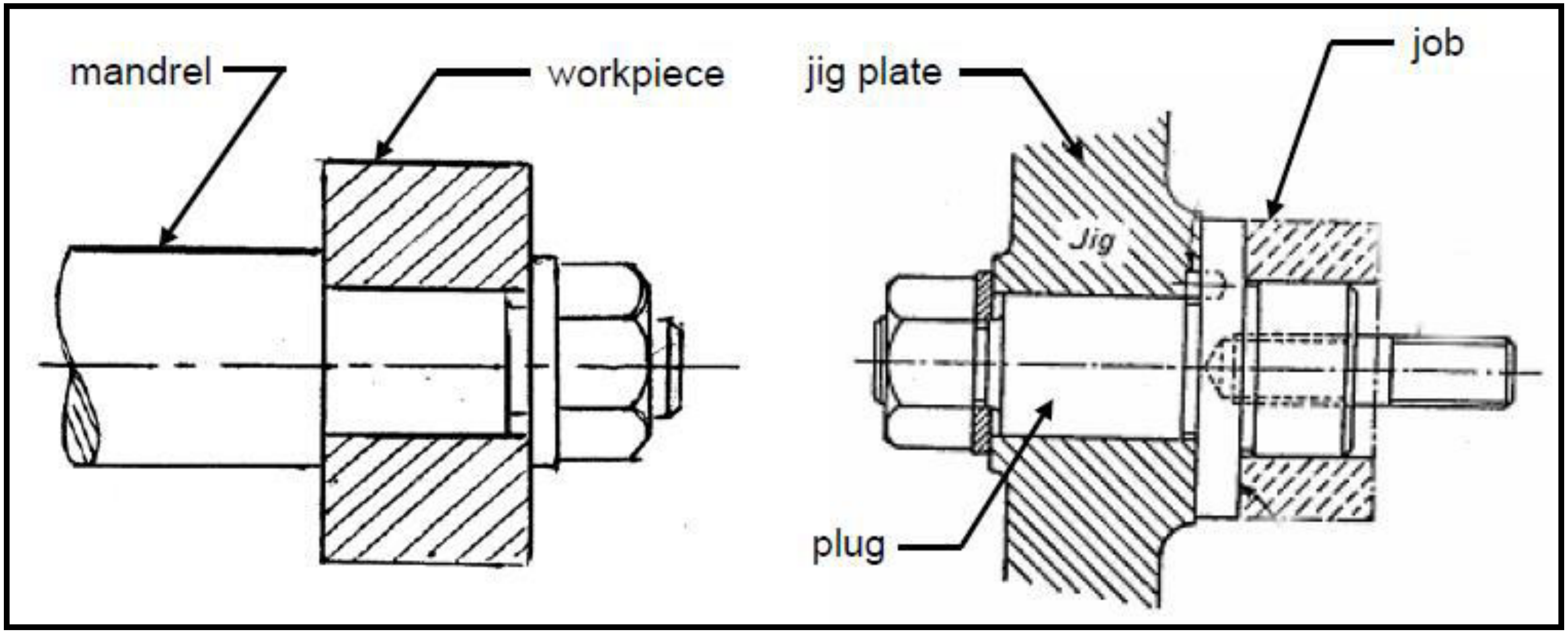
(a) locating by two holes

(b) locating by one hole

Locating by holes



Locating on mandrel or plug

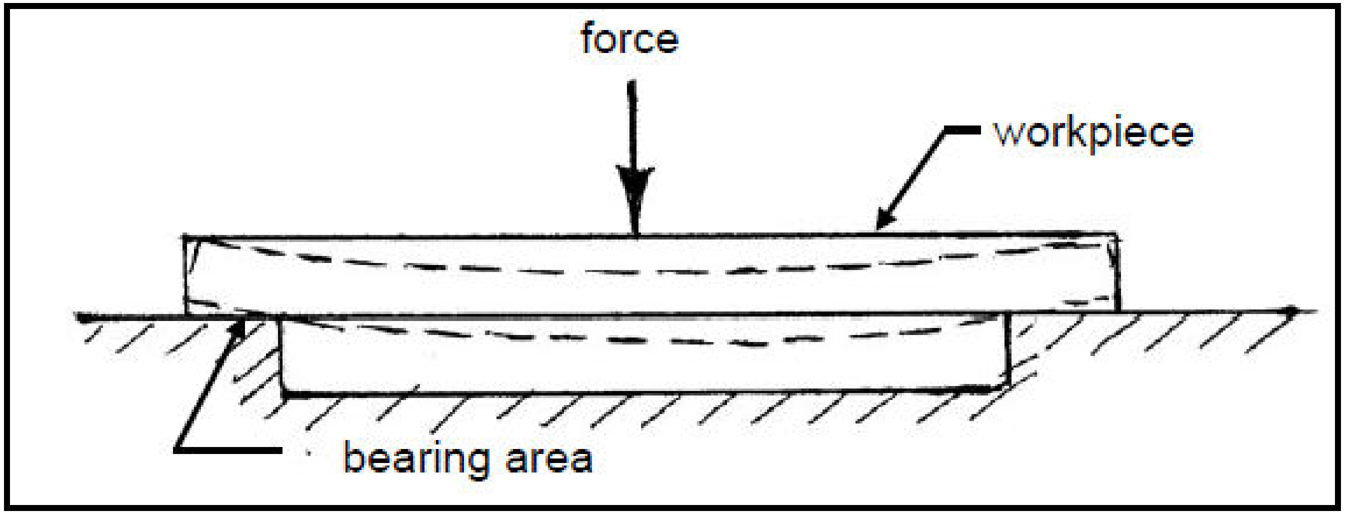


Supporting – principles and methods

- A work piece has to be properly placed in the jig or fixture not only for desired positioning and orientation but also on strong and rigid support such that the blank does not elastically deflect or deform under the actions of the clamping forces, cutting forces and even its own weight.

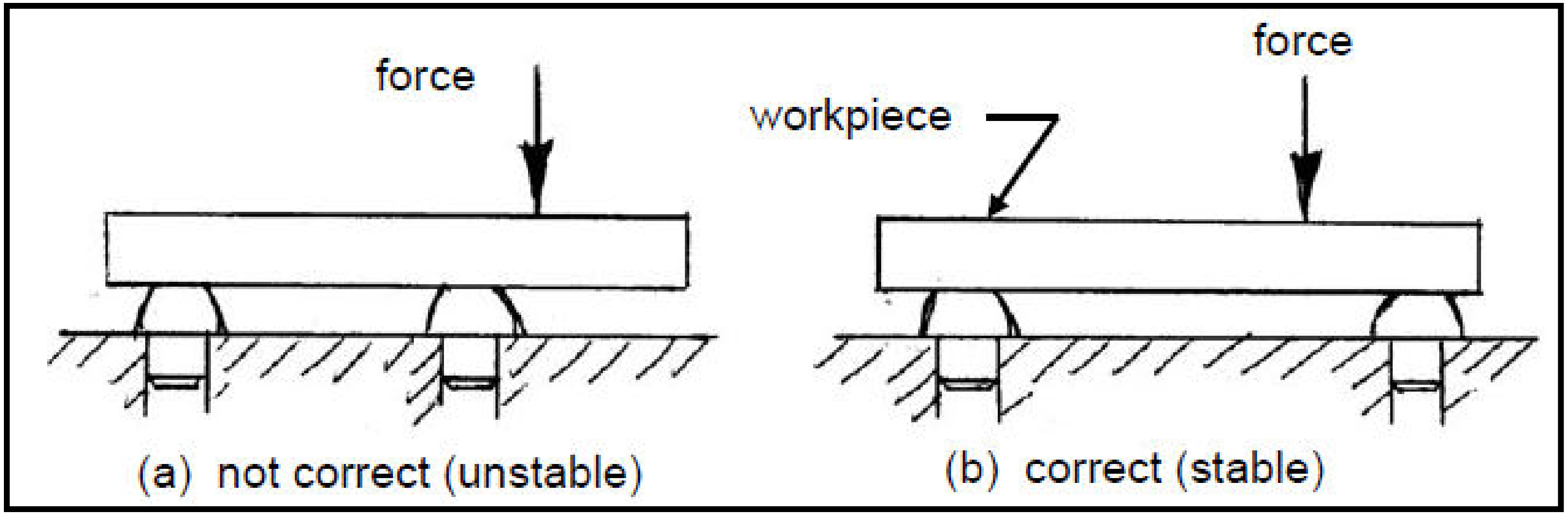
Basic principles or rules to be followed while designing or planning for supporting

- supporting should be provided at least at three points
- supporting elements and system have to be enough strong and rigid to prevent deformation due to clamping and cutting forces
- unsupported span should not be large to cause sagging as indicated in fig.



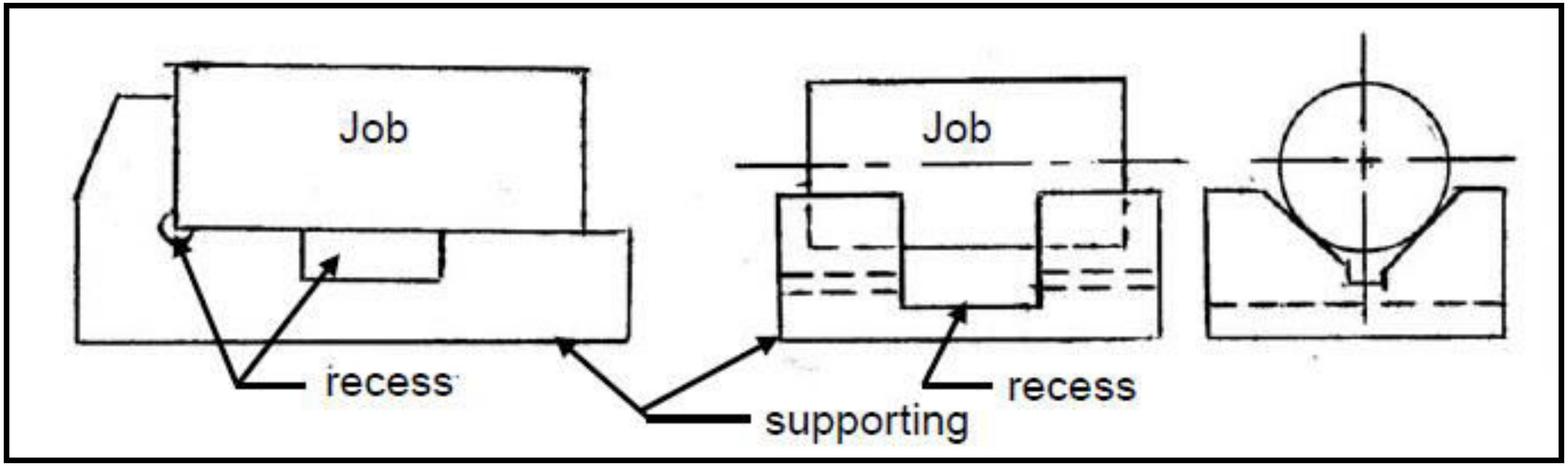
Basic principles or rules to be followed while designing or planning for supporting

- supporting should keep the blank in stable condition under the forces as indicated in fig.



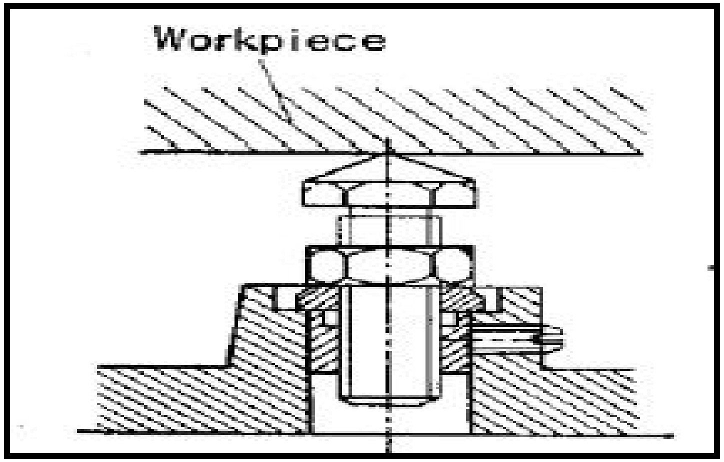
Basic principles or rules to be followed while designing or planning for supporting

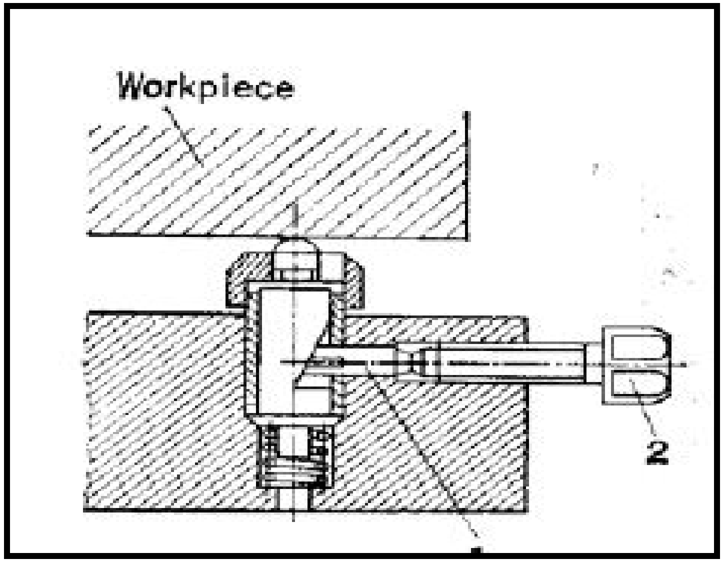
- for supporting large flat area proper recess is to be provided, as indicated in fig, for better and stable support.
- round or cylindrical work pieces should be supported (along with locating) on strong v - block of suitable size



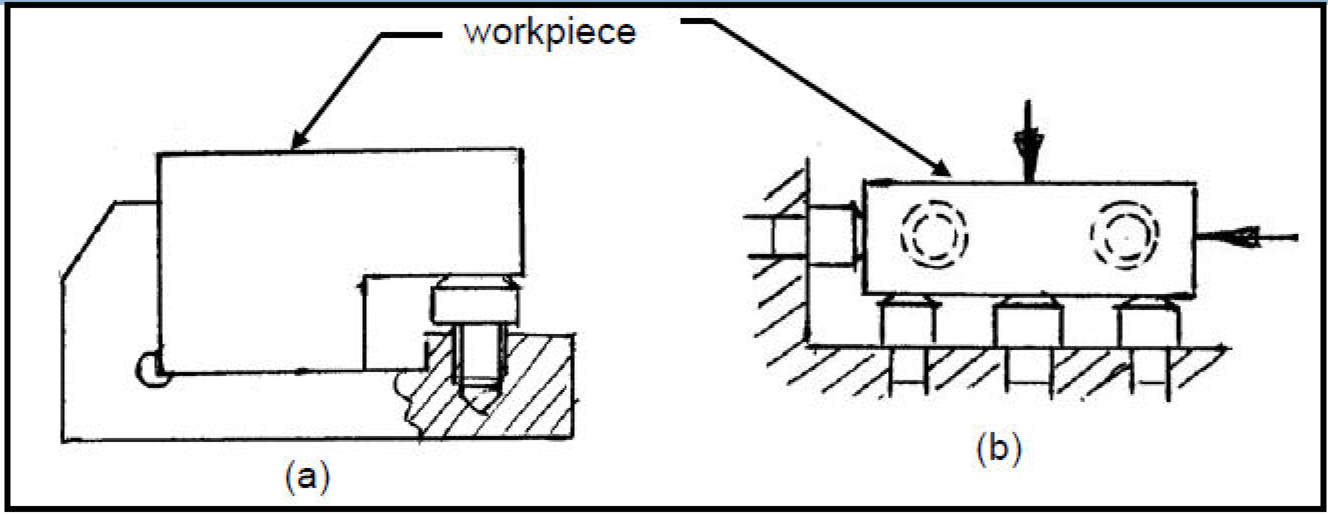
Common methods of supporting job in fixtures

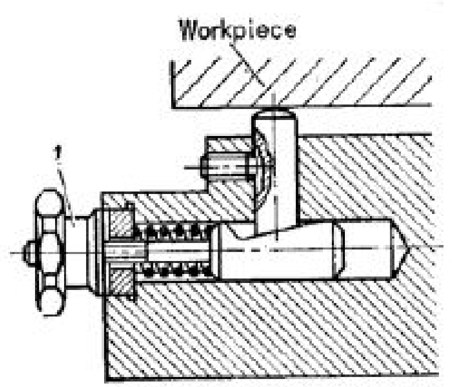
- supporting on vices
- supporting on flat surfaces / blocks (fig.)
- supporting by fixed pins (fig.)
- additional supporting by adjustable pins and plugs or jack screws as shown in fig.
- supporting (and locating) on V - blocks and mandrels (fig.)

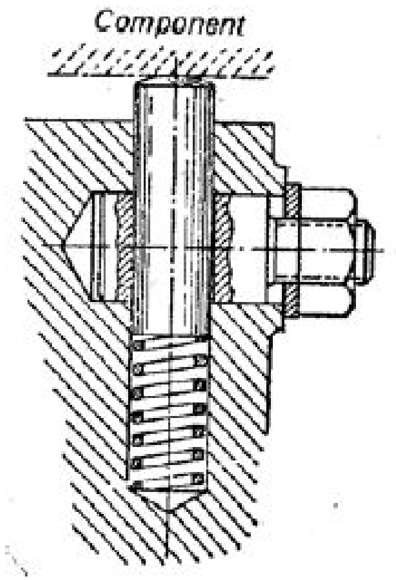




Common methods of supporting job in fixtures







Clamping of work piece in fixtures

- In jigs and fixtures the work piece or blank has to be strongly and rigidly clamped against the supporting surfaces and also the locating features so that the blank does not get displaced at all under the cutting forces during machining.

While designing for clamping the following factors essentially need to be considered :

- clamping need to be strong and rigid enough to hold the blank firmly during machining
- clamping should be easy, quick and consistently adequate
- clamping should be such that it is not affected by vibration, chatter or heavy pressure
- the way of clamping and unclamping should not hinder loading and unloading the blank in the jig or fixture
- the clamp and clamping force must not damage or deform the work piece
- clamping operation should be very simple and quick acting when the jig or fixture is to be used more frequently and for large volume of work

While designing for clamping the following factors essentially need to be considered :

- Clamps, which move by slide or slip or tend to do so during applying clamping forces, should be avoided
- O clamping system should comprise of less number of parts for ease of design, operation and maintenance
- O the wearing parts should be hard or hardened and also be easily replaceable
- O clamping force should act on heavy part(s) and against supporting and locating surfaces
- O clamping force should be away from the machining thrust forces
- O clamping method should be fool proof and safe
- O clamping must be reliable but also inexpensive

Various methods of clamping

- General clamping methods of common use :

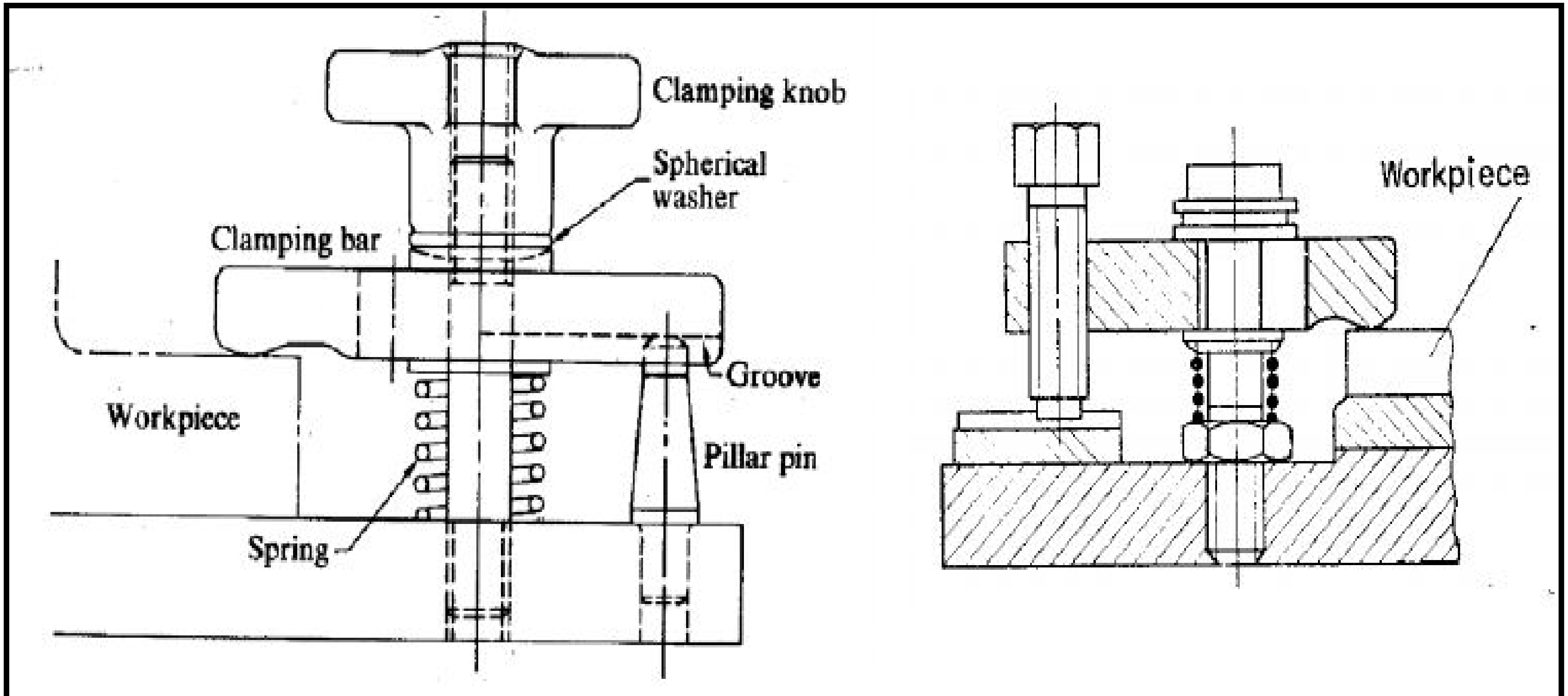
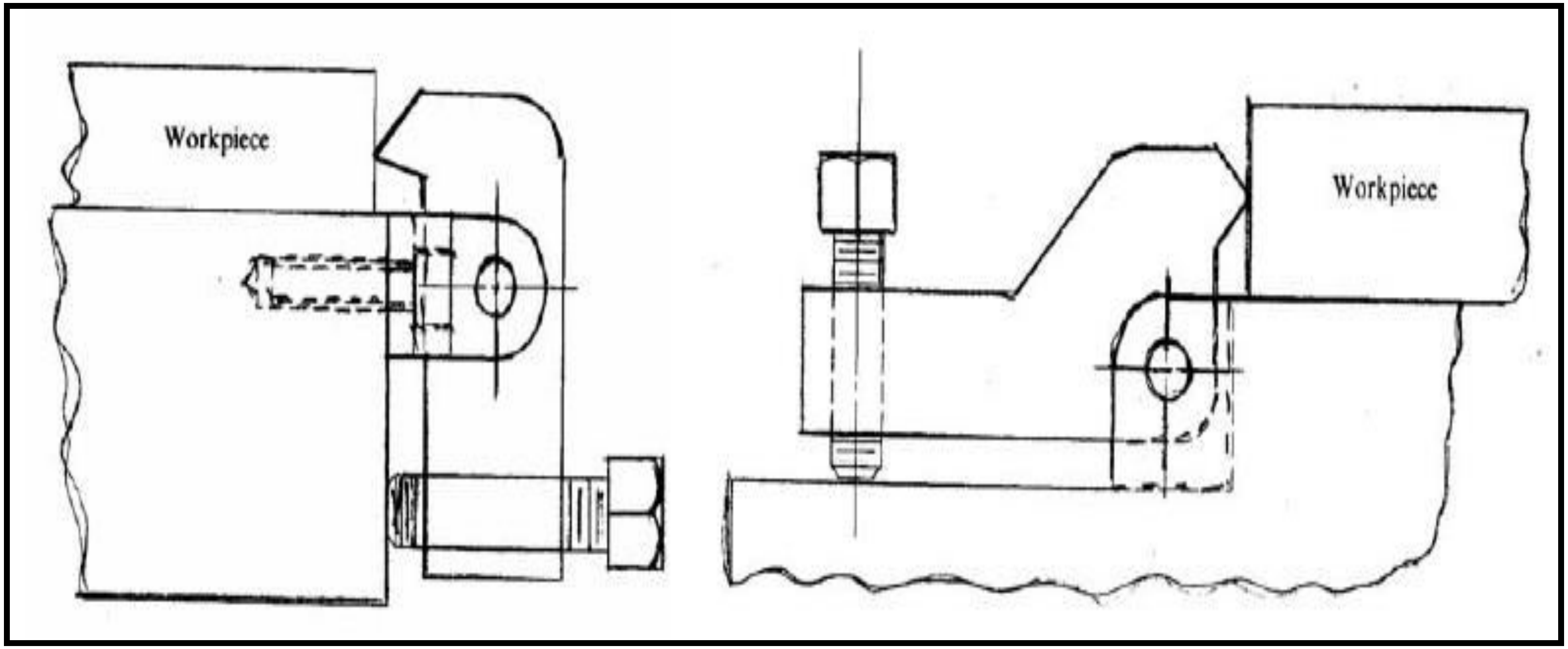


Fig. 8.1.17 Common strap type clamping.

Various methods of clamping

- **General clamping methods of common use :**



Clamping from side for unobstructed through machining (like milling, planning and broaching) of the top surface. Some commonly used such clamping are shown in Fig

Various methods of clamping

- General clamping methods of common use :

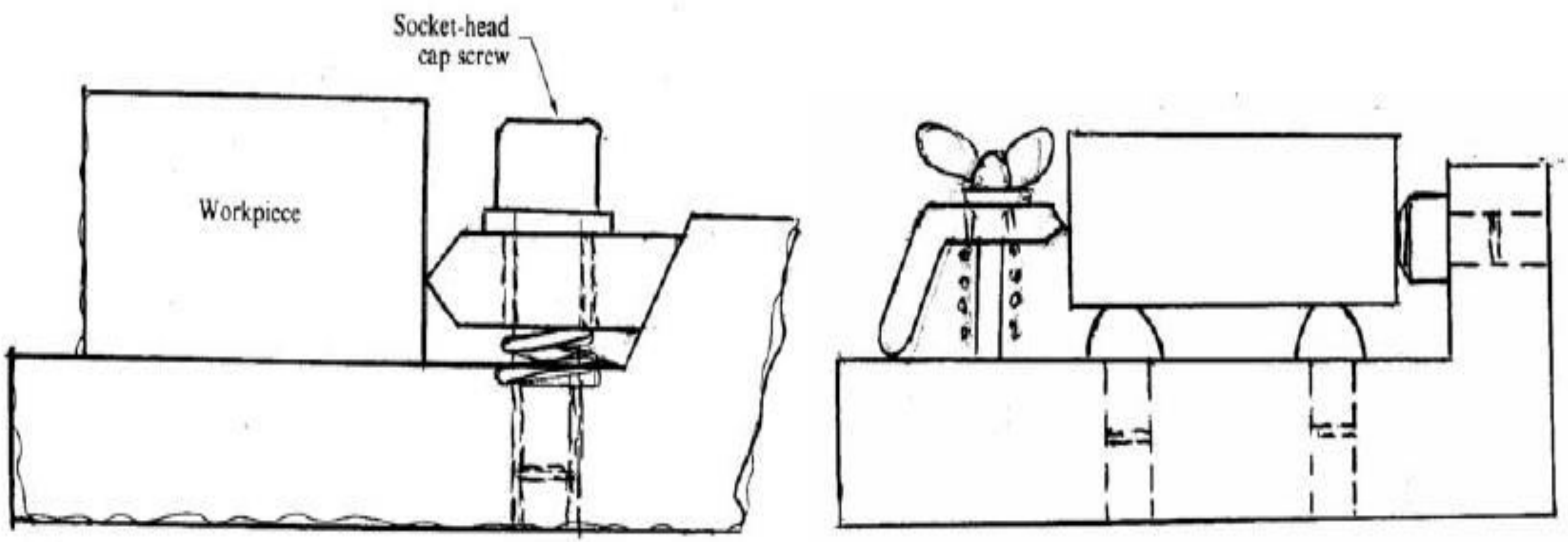
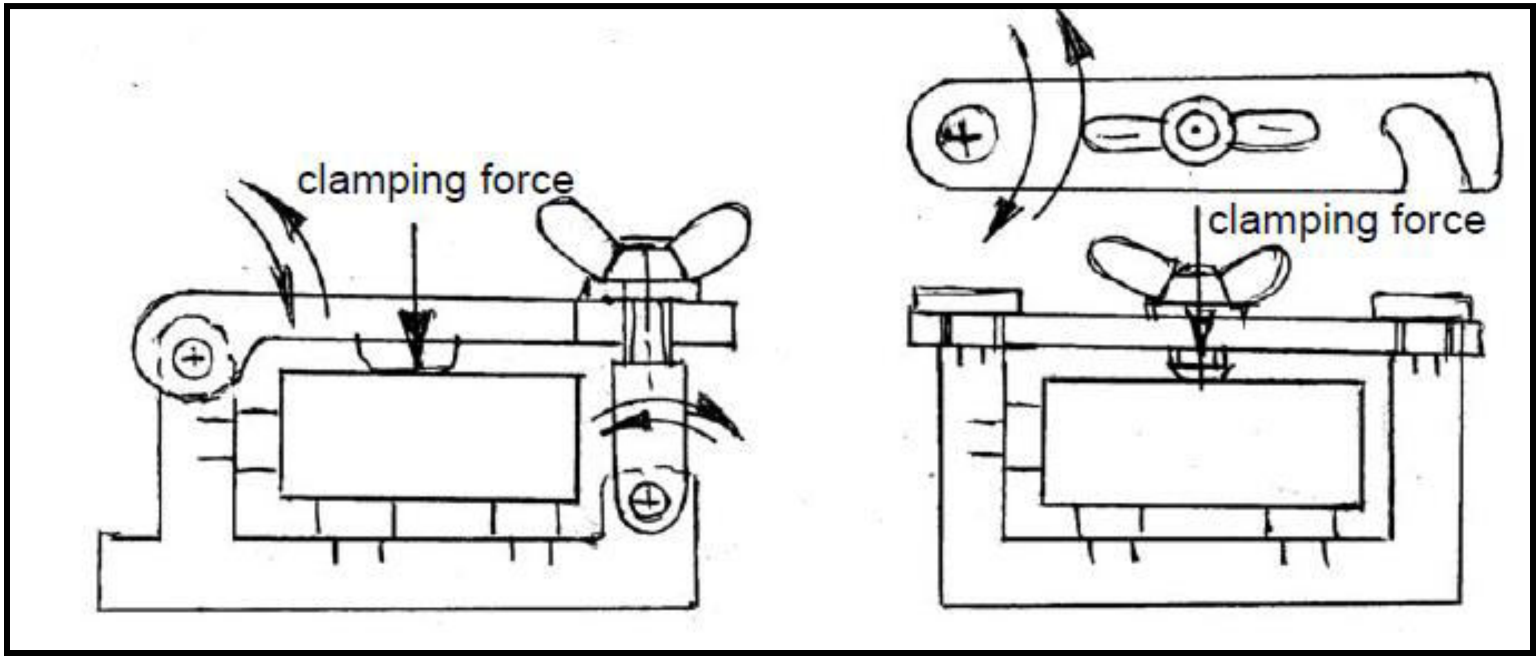


Fig. 8.1.18 Clamping from side for free machining of the top surface.

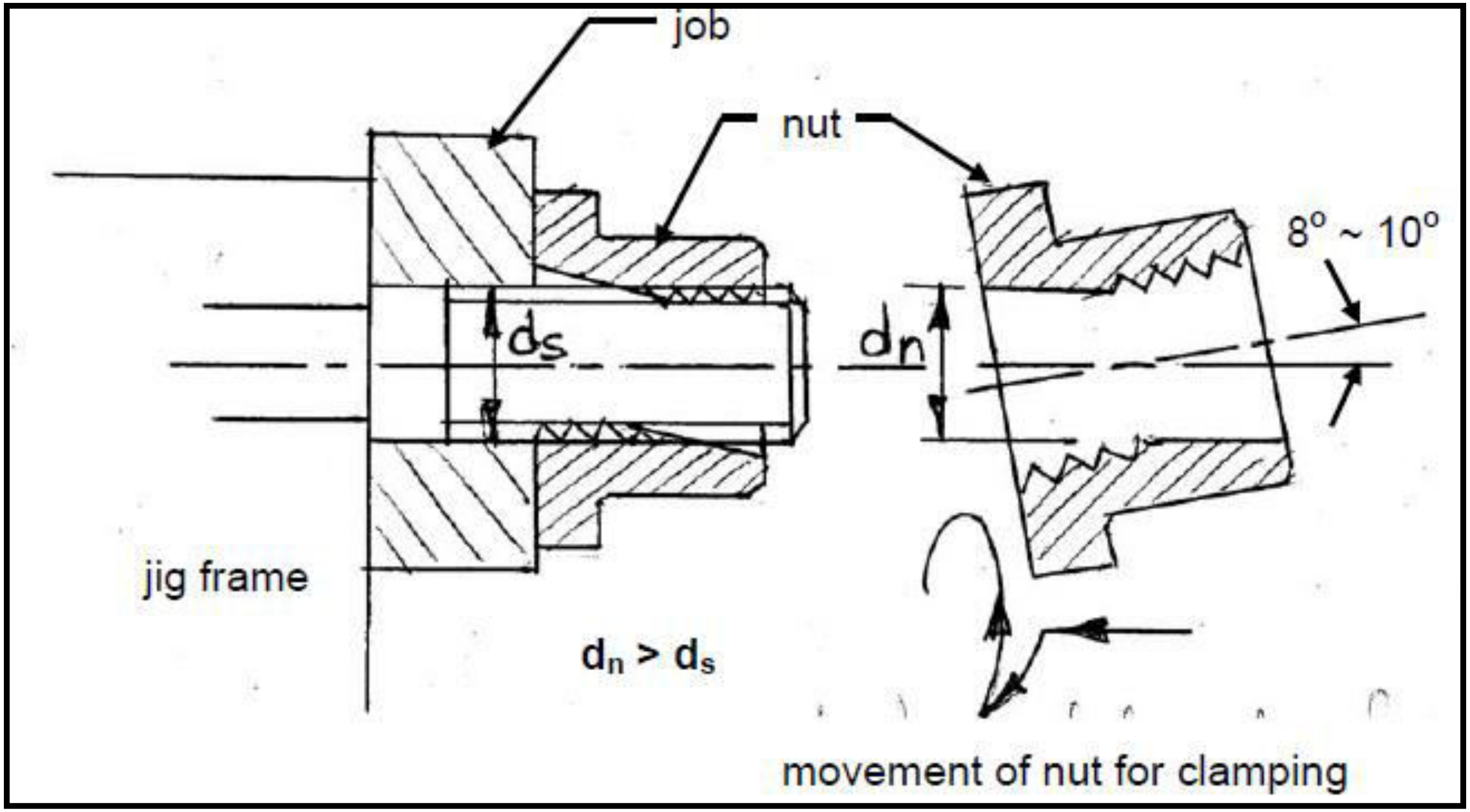
Clamping by swing plates

- Such clamping, typically shown in Fig. 8.1.19, are simple and relatively quick in operation but is suitable for jobs of relatively smaller size, simpler shape and requiring lesser clamping forces.



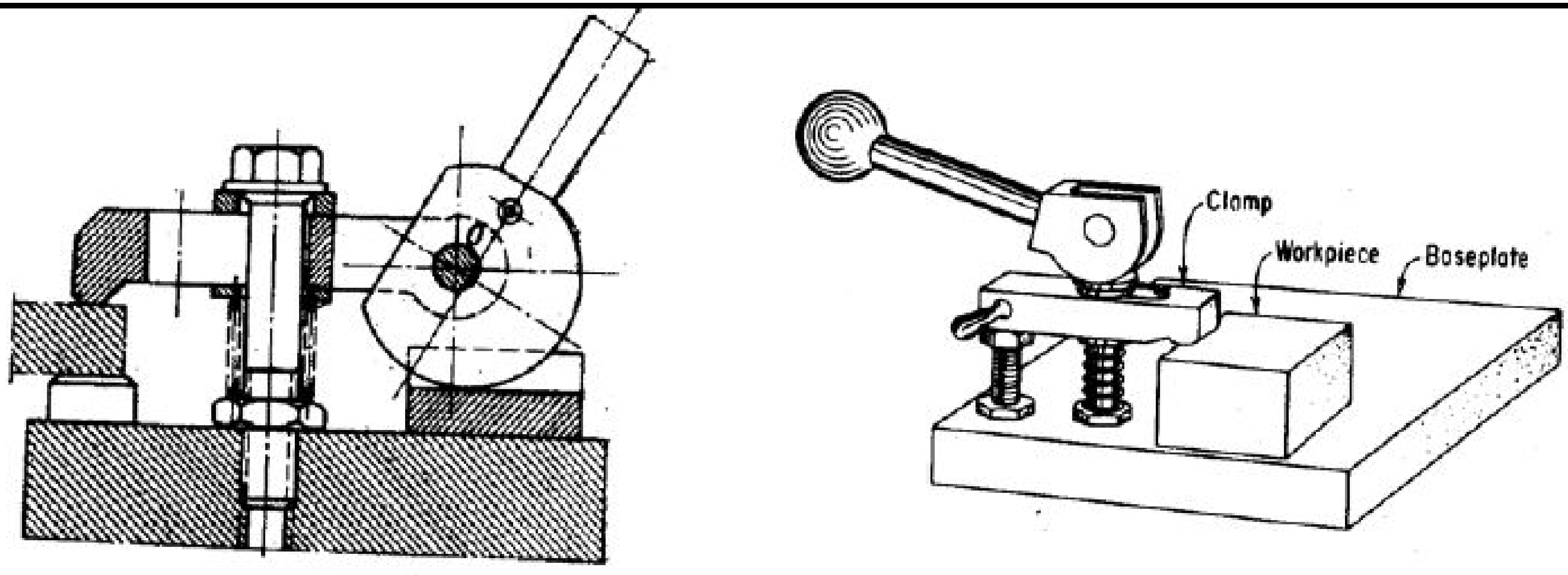
Quick clamping methods and systems

- **Use of quick acting nut**



Quick clamping methods and systems

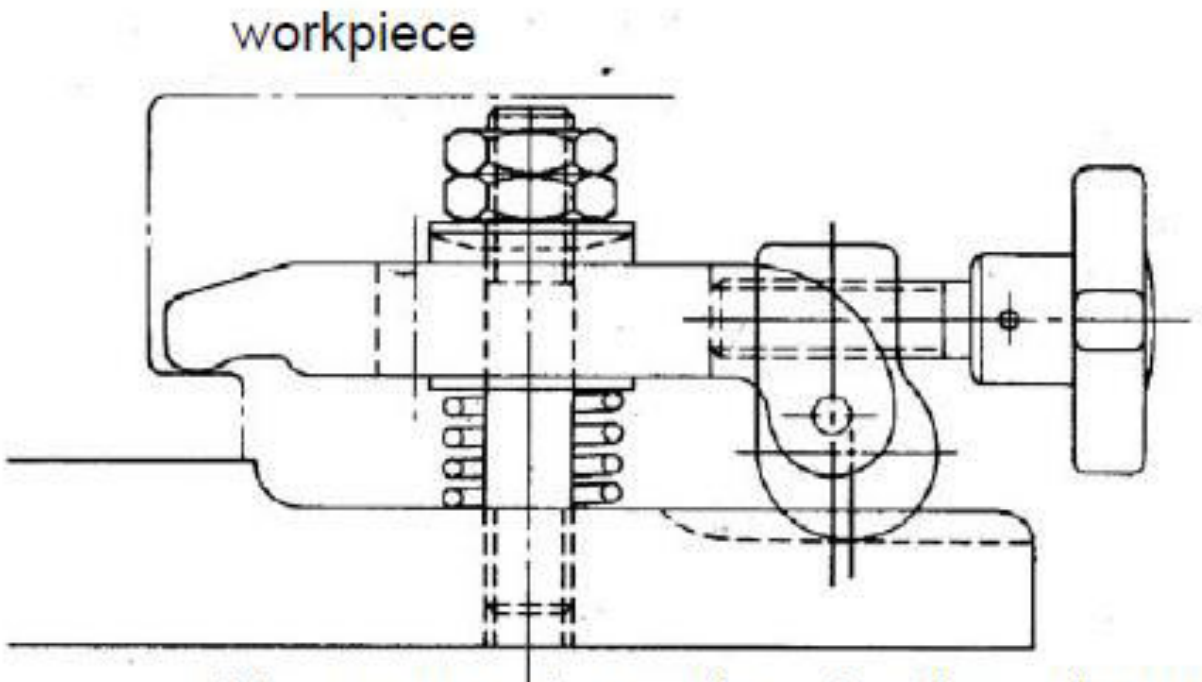
- **Cam clamping**



(a) clamping by cam

Quick clamping methods and systems

- **Cam clamping**



(b) screw and cam clamping from distance

Quick clamping methods and systems

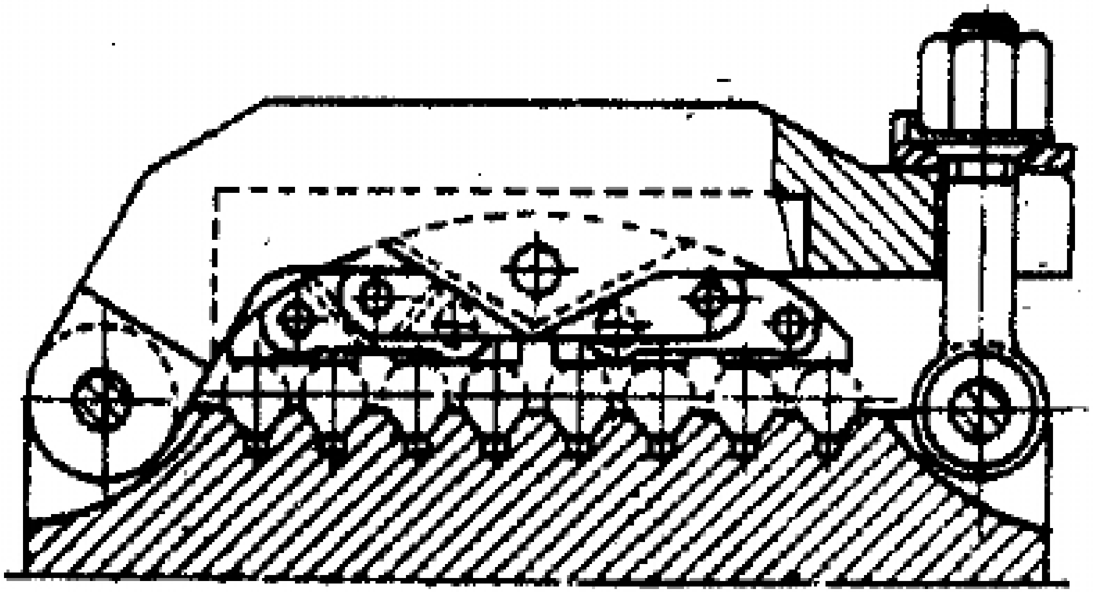


Fig. 8.1.22 Quick multiple locating and clamping of cylindrical jobs.

Drill – jig bushing

- **The factors to be considered while designing for jig – bushing, are :**
- The bushes, used to guide and properly locate drills, reamers etc. are generally made of carbon or alloy steel and made wear resistive by hardening to RC 60 and above. Often bushes are also made from grey cast iron for antifriction and protection of the tools.
- The hardened jig bushes are finished outside by grinding and inside by grinding and lapping if high precision is insisted.

The factors to be considered while designing for jig – bushing, are :

- The bush's length should be sufficient (≥ twice drill diameter) and its diameter should be slightly larger than the drill diameter
- o Design and construction should enable easy and quick proper fitting and removal or replacement of the bushes
- o Bushes should not come out from its seat along with the drill during its return.

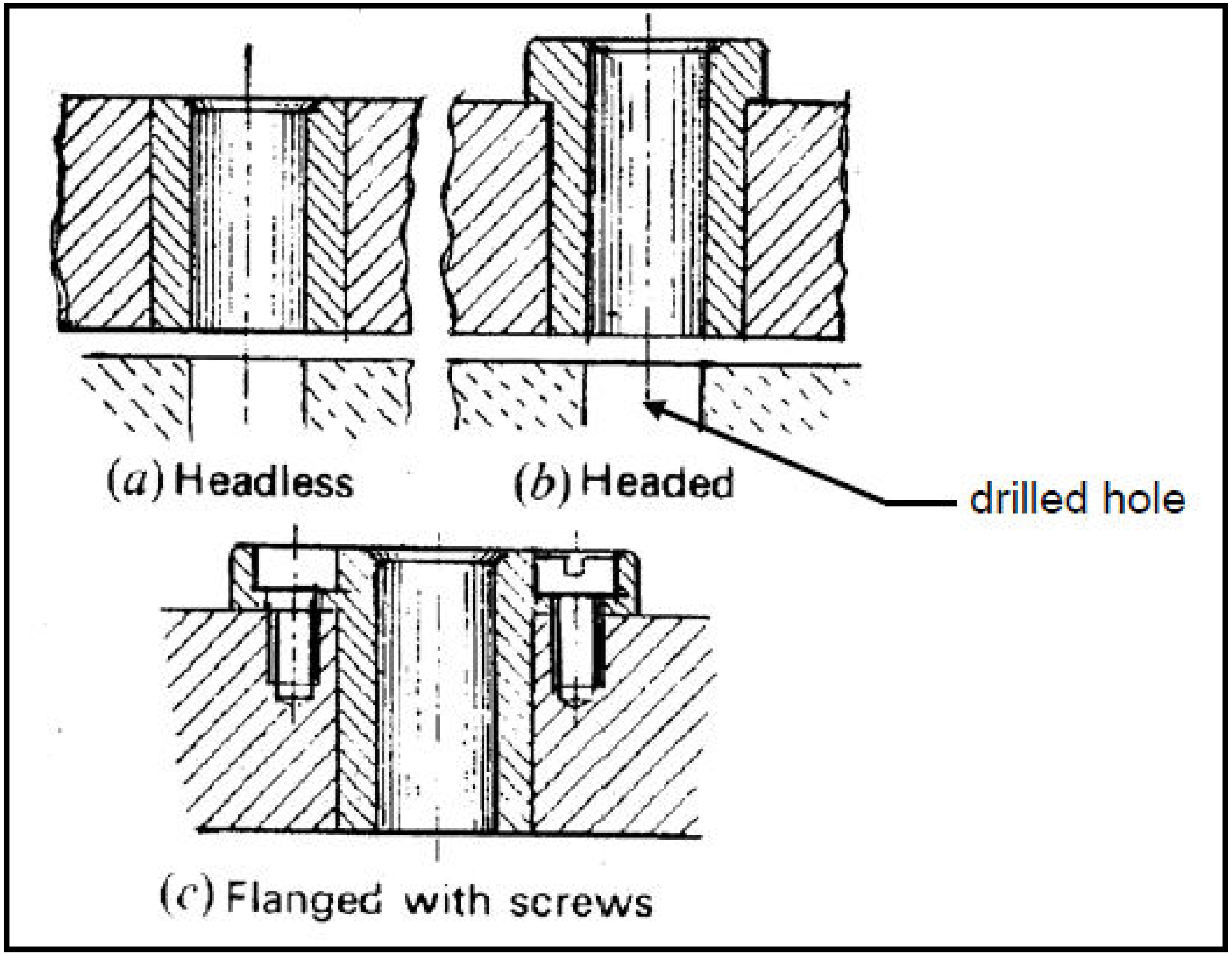
Types of jig bushes

- Depending upon nature of fitting, quick mounting and replacement, job requirement etc. jig bushes are classified into several types.
- • Bushes may be
  - – Press fitted type
  - – Slip type
  - – Screwed type

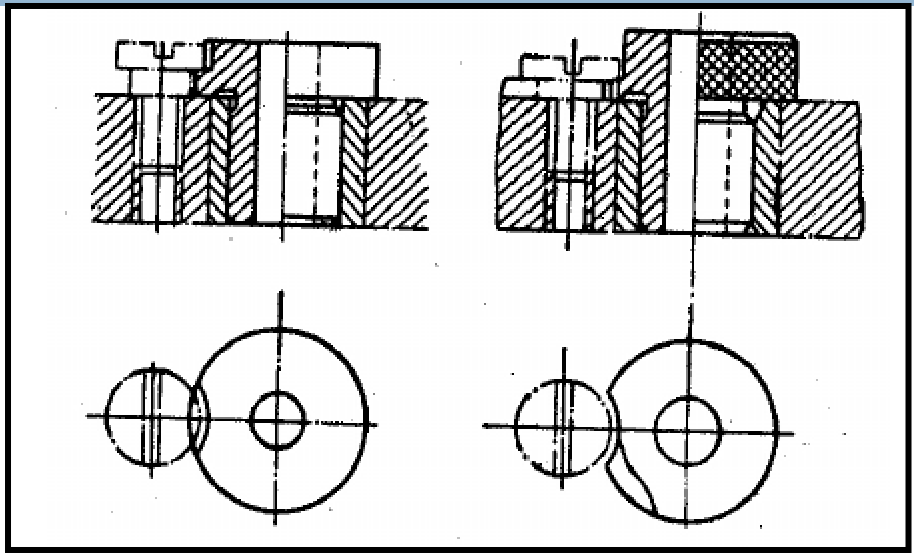
Types of jig bushes

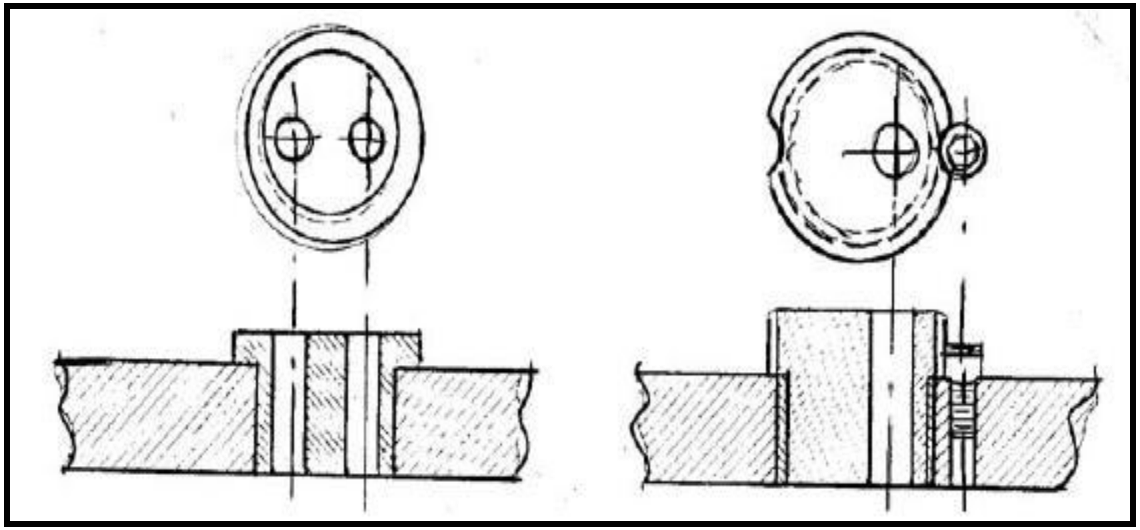
- Press fitted thin sleeve type bushes are generally used for shorter runs and are not renewable. Renewable type slip bushes are used with liner. But screw bushes, though renewable may be used without or with liner.
- • Bushes may be
  - – Without head
  - – With head
  - – With a flange being screwed on the bracket

Types of jig bushes



Types of jig bushes





Gear and Thread Manufacturing

Gear and Thread Manufacturing:

Gear manufacturing

- Classifications of methods,
- Generating methods,
- Gear hobbing,
- Gear shaping
- Gear finishing processes and
- Quality of gear.

Thread manufacturing

- Thread milling,
- Thread grinding and
- Thread rolling,
- Thread rolling machines and
- Quality of thread.

Gear Manufacturing:

Introduction:

- Gears are basically wheels having, on its periphery, equispaced teeth which are so designed that those wheels transmit, without slip, rotary motion smoothly and uniformly with minimum friction and wear at the mating tooth – profiles.
- To achieve those favorable conditions, most of the gears have their tooth form based on involute curve or cycloid.

General Applications Of Gears:

- Gears of various type, size and material are widely used in several machines and systems requiring positive and stepped drive.

- **The major applications are :**
  - Speed gear box, feed gear box and some other kinematic units of machine tools
  - Speed drives in textile, jute and similar machineries.
  - Gear boxes of automobiles
  - Speed and / or feed drives of several metal forming machines.
  - Machineries for mining, tea processing etc.
  - Large and heavy duty gear boxes used in cement industries, sugar industries, cranes, conveyors etc.
  - Precision equipments, clocks and watches.
  - Industrial robots and toys.

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.

Preforming Gear Blanks:

Casting:

Gear blanks and even gears along with teeth requiring substantial to little machining or finishing are produced by various casting processes.

- **Sand casting:**

The blanks of large cast iron gears, if required to be made one or few pieces, are produced by sand casting. Then the blank is prepared to appropriate dimensions and the teeth are produced by machining that cast preform.

Complete gears with teeth can also be directly produced by such casting and used at low speed in machineries like farm machinery and hand operated devices where gear accuracy and finish are not that much required.

- **Metal mould casting**

Medium size steel gears with limited accuracy and finish are often made in single or few pieces by metal mould casting. Such unfinished gears are used in several agro-industries.

For general and precision use the cast preforms are properly machined.

Preforming Gear Blanks (Cont..):

- **Die casting**

  Large lot or mass production of small gears of low melting point alloys of Al, Zn, Cu, Mg etc. are done mainly by die casting. Such reasonably accurate gears are directly or after little further finishing are used under light load and moderate speeds, for example in instruments, camera, toys.

- **Investment casting**

  This near-net-shape method is used for producing small to medium size gears of exotic materials with high accuracy and surface finish hardly requiring further finishing. These relatively costly gears are generally used under heavy loads and stresses.

- **Shell mould casting**

  Small gears in batches are also often produced by this process. The quality provided by this process lies in between that of sand casting and investment casting.

Gear Manufacturing (Cont..):

- **Centrifugal casting**

  The solid blanks or the outer rims (without teeth) of worm wheels made of cast iron, phosphor bronze or even steel are preferably preformed by centrifugal casting. The performs are machined to form the gear blank of proper size. Then the teeth are developed by machining.

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 as shown in Fig. shown in next slide.
- 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.

Gear Manufacturing (Cont..):

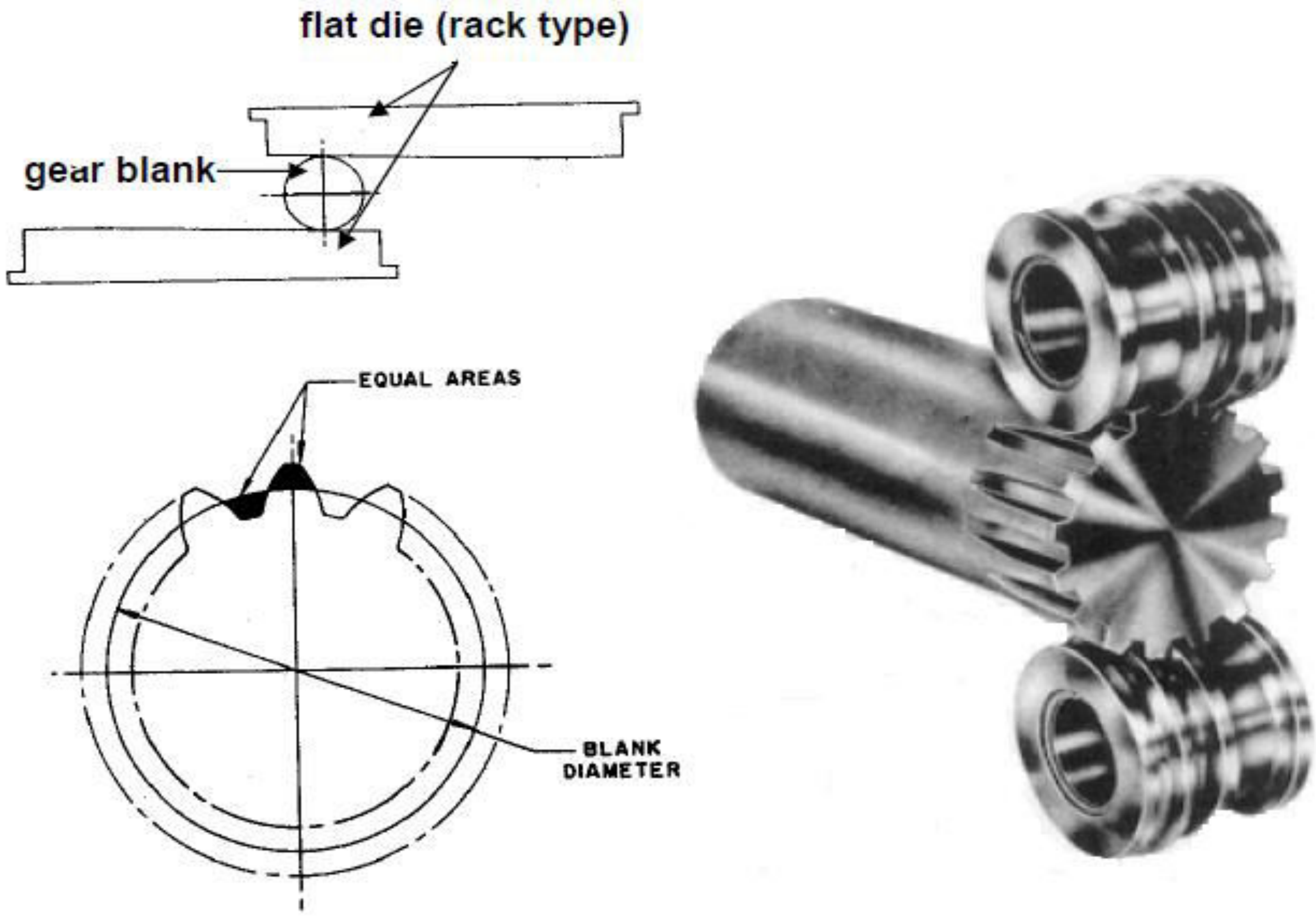


Fig. *Production of teeth of spur gears by rolling.*

Gear Manufacturing (Cont..):

- **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.

- **Blanking in Press tool**

  Mass production of small and thin metallic gears requiring less accuracy and finish are often done by blanking from sheets by suitably designed die and punch. Such gears are used for clocks, watches, meters, toys etc. However, quality gears can also be produced by slight finishing (shaving) after blanking.

- **Plastic molding**

  Small to medium size plastic gears with or without metal core are manufactured in large quantity by injection molding.

  Such moderately accurate and less noisy gears, both external and internal types, are used under light loads such as equipments, toys, meters etc.

Gear Manufacturing (Cont..):

- **Extrusion process**

  High quality small metallic or non metallic external gears are often produced in large quantity by extrusion. Number of gears of desired width are obtained by parting from the extruded rod of gear – section.

- **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) as shown in Fig.

Fig. *Production of teeth of external and internal spur gears by Wire-Electrodischarge machining (EDM)*

Gear Manufacturing (Cont..):

Production of Gear Teeth by Machining

- It appears from the previous discussion that gears are manufactured in several routes ;
    - The preformed blanks of approximate shape and irregular surface are machined to desired dimensions and finish and then the teeth are produced generally by machining and occasionally by rolling.
    - Full gears with teeth are made by different processes and then finished by further machining and / or grinding
    - Accurate gears in finished form are directly produced by near – net – shape process like rolling, plastic molding, powder metallurgy etc. requiring slight or no further finishing.
- The most commonly practiced method is preforming the blank by casting, forging etc. followed by pre-machining to prepare the gear blank to desired dimensions and then production of the teeth by machining and further finishing by grinding if necessary.
- 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 Manufacturing (Cont..):

Methods of production of gear teeth by machining on Forming principle

- **Shaping** required at all, for making teeth of large gears whereas slotting, generally, for internal gears.
- **Milling** Gear teeth can be produced by both disc and end mill type form milling cutter as shown in Fig.
- Gear teeth can be produced **, planning and slotting**
- Fig. schematically shows how teeth of straight toothed spur gear can be produced in shaping machine, if necessary.
- 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.
- In principle planning and slotting machines work on the same principle. Planning machine is used, if by both disc and end mill type form milling cutter as shown in Fig.

Gear Manufacturing (Cont..):

- Production of gear teeth by form milling are characterized 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.

Gear Manufacturing (Cont..):

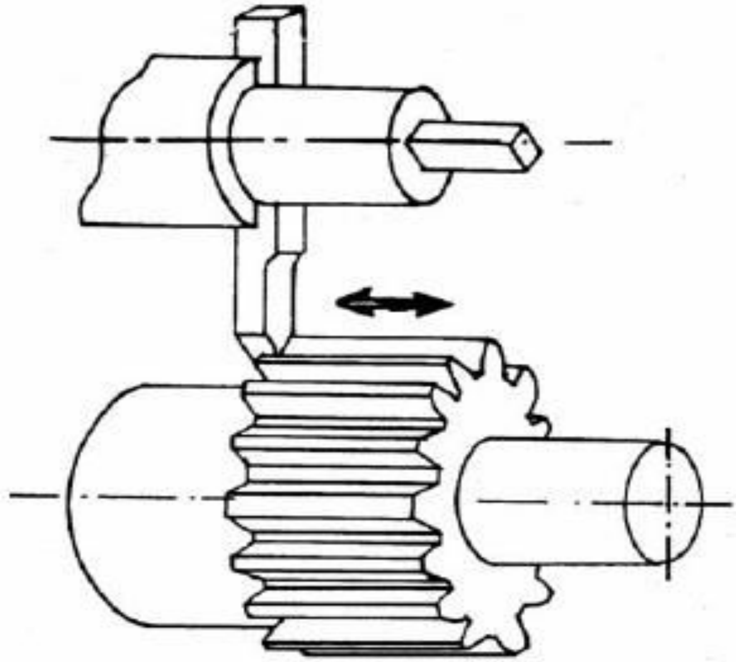


Fig. Gear teeth cutting in ordinary shaping machine.

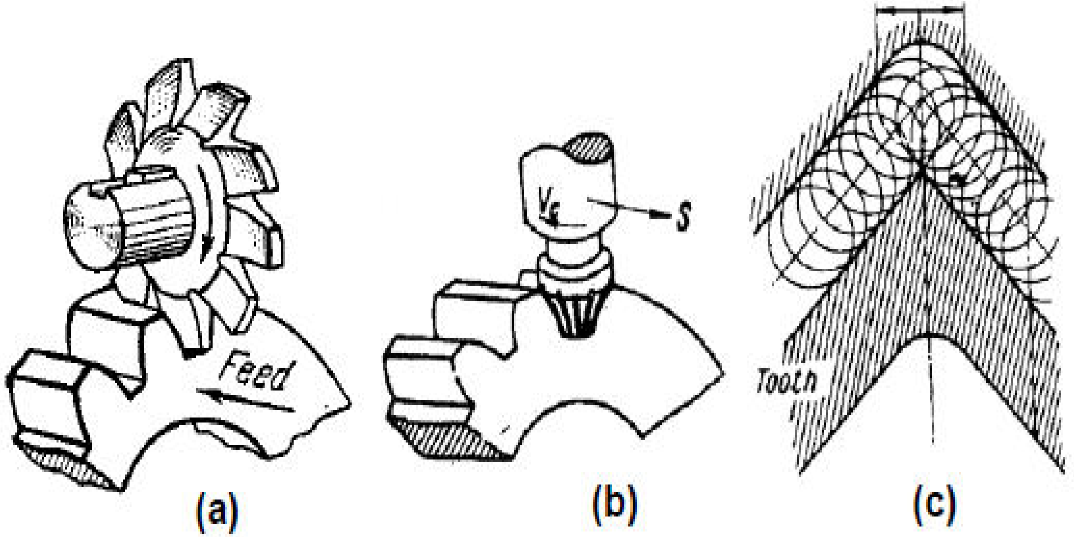


Fig. Producing external teeth by form milling cutters (a) disc type and end mill type for (b) single helical and (c) double helical teeth

Gear Manufacturing (Cont..):

Fast production of teeth of spur gears

- **Parallel multiple teeth shaping**
- In principle, it is similar to ordinary shaping but all the tooth gaps are made simultaneously, without requiring indexing, by a set of radially infeeding single point form tools as indicated in Fig. (a).
- This old process was highly productive but became almost obsolete for very high initial and running costs.

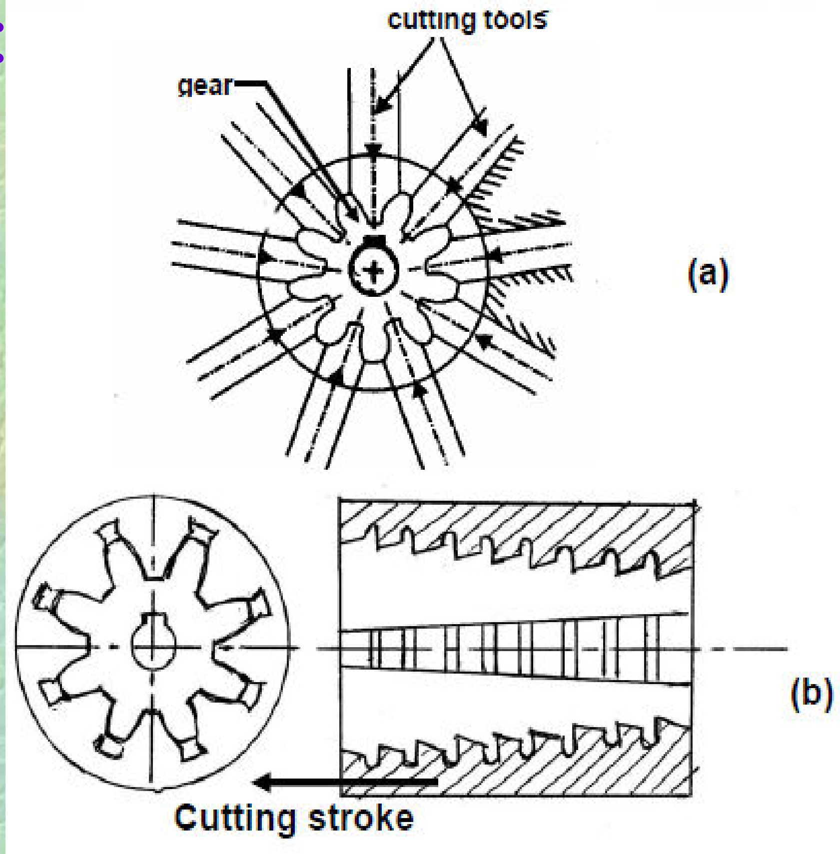


Fig. High production of straight teeth of external spur gears by (a) parallel shaping (forming) and (b) broaching

Broaching

Teeth of small internal and external spur gears; straight or single helical, of relatively softer materials are produced in large quantity by this process. Fig. (b) schematically shows how external teeth are produced by a broaching in one pass. This method leads to very high productivity and quality but cost of machine and broach are very high.

Gear Manufacturing (Cont..):

- **Production of gear teeth by machining on Generation principle**
- Generation method is characterized 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.
    - o **Sunderland method using rack type cutter**
- Fig. schematically shows the principle of this generation process where 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. The favourable and essential 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 Manufacturing (Cont..):

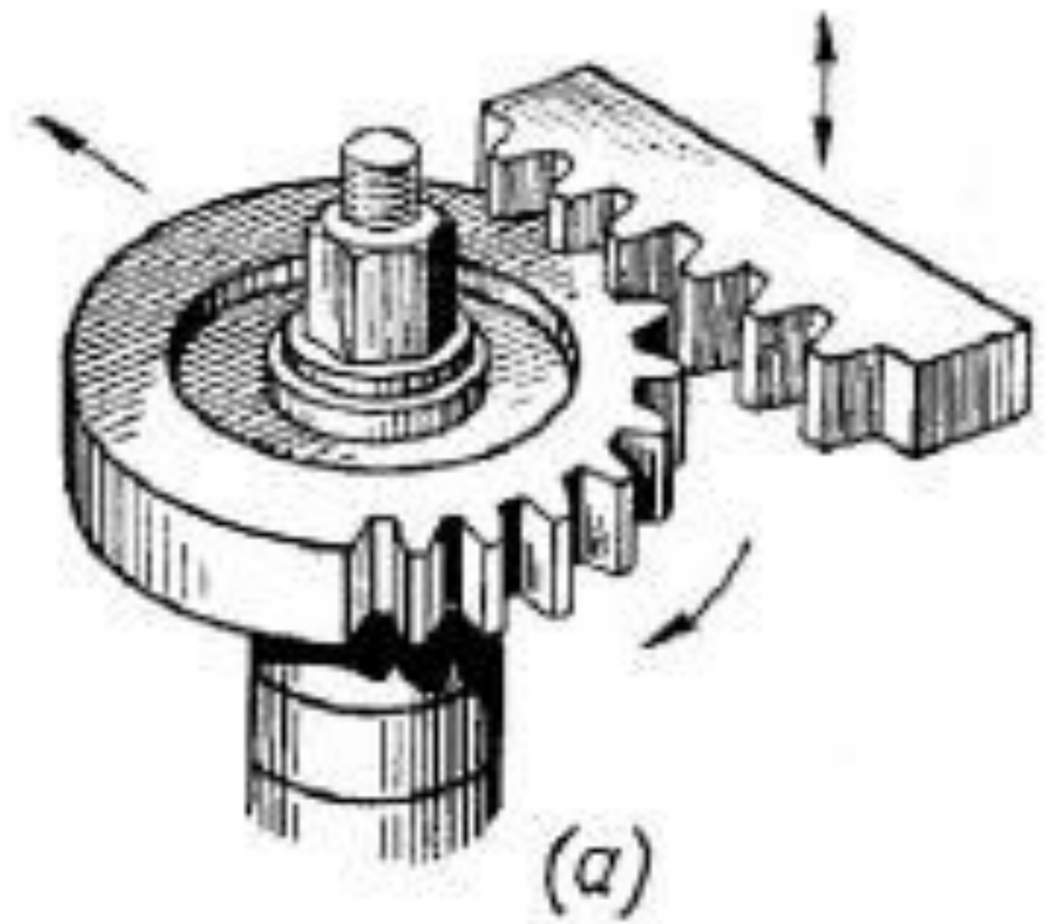


Fig. *External gear teeth generation by rack type cutter (Sunderland method)*

Gear Manufacturing (Cont..):

Gear shaping

- In principle, gear shaping is similar to the rack type cutting process, excepting that, the linear type rack cutter is replaced by a circular cutter as indicated in Fig. where both the cutter and the blank rotate as a pair of spur gears in addition to the reciprocation of the cutter.
- 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 Manufacturing (Cont..):

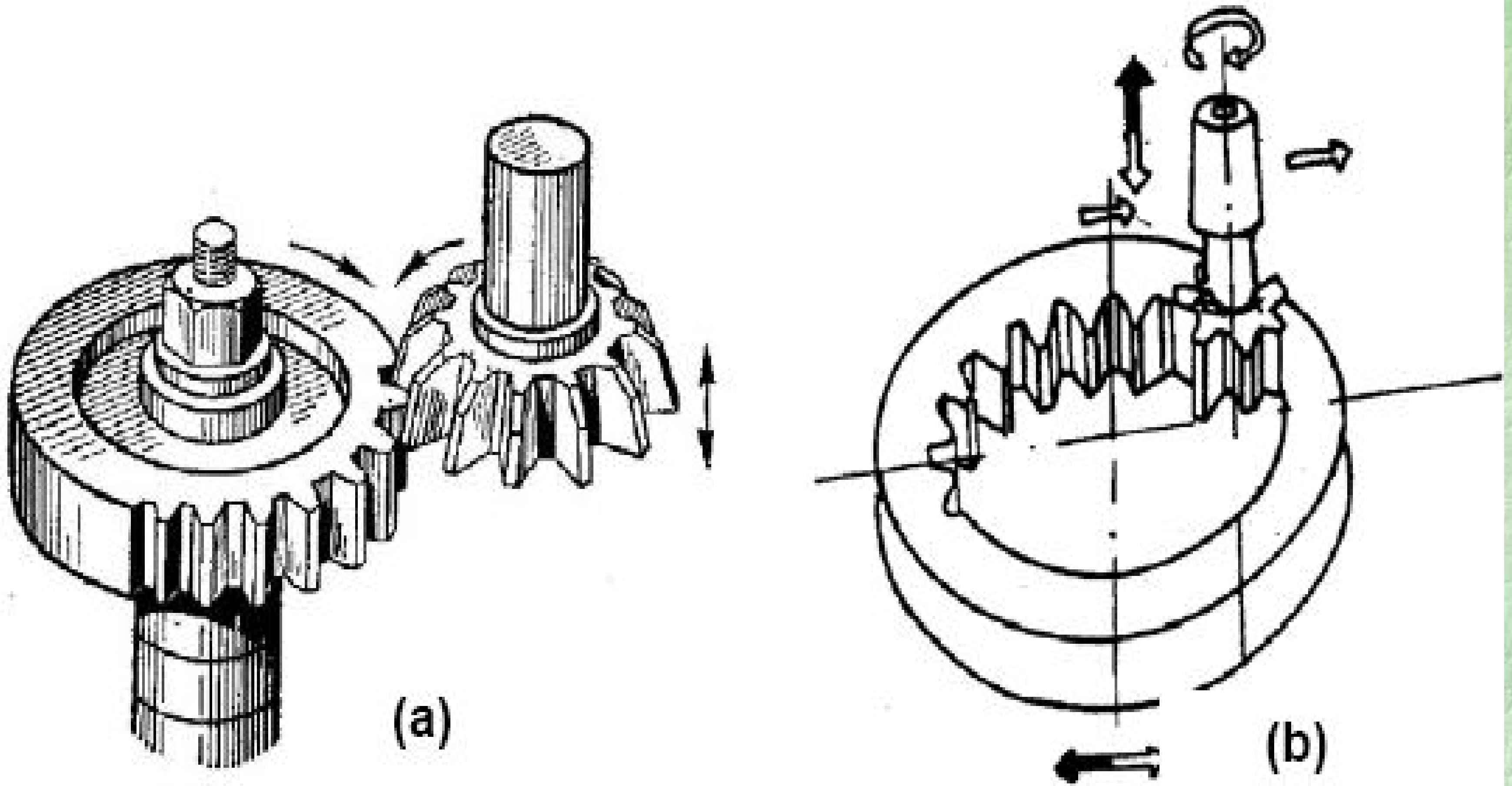


Fig. *Gear teeth generation by gear shaping (a) external and (b) internal spur gear*

Gear Manufacturing (Cont..):

Hobbing

- The tool-work configuration and motions in hobbing are shown in Fig. where 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 worm.
- 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.

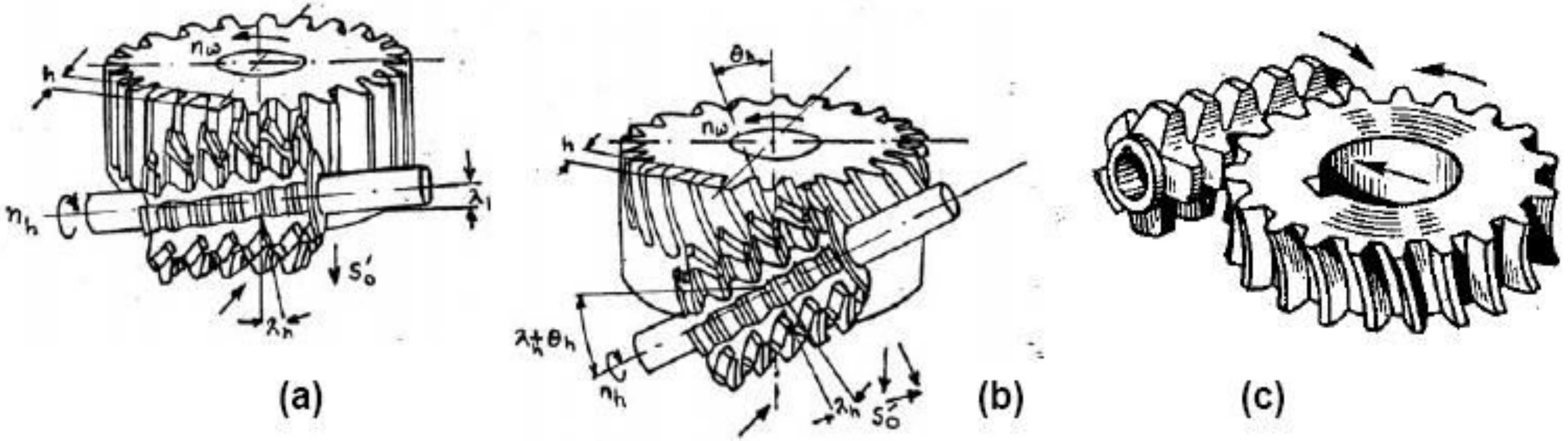


Fig. *Generation of external gear teeth by Hobbing :*
(a) straight tooth (b) helical tooth and (c) worm wheel

Gear Manufacturing (Cont..):

ADVANTAGES AND LIMITATIONS of Shaping & Hobbing:

- Racks can not be hobbed, but can be shaped.
- Length of rack shaped depends upon table length of gear shaper.
- Gears with shoulders adjacent to it can not be hobbed, but can be shaped.
- Internal gears can be shaped easily than hobbed.
- Double helical gears can be only be shaped.
- Cams, polygons can also be shaped.
- Worm and worm wheels can not be shaped.
- On return stroke no cutting taken place.
- Reversal of motion required large forces specially at high speeds.

Gear Manufacturing (Cont..):

- **Manufacture of worm**

  The screw like single or multi-start worms (gears) made of steel are generally made by machining like long thread milling or by cold rolling like thread rolling followed by heat treatment for surface hardening and finishing by grinding.

- **Manufacture of bevel gears**

  In manufacture of bevel gears, first the blanks are preformed by casting or forging followed by machining to desired dimensions in lathes or special purpose machine.

  Then the teeth are produced in the blank by machining. The way of machining and machine tool are chosen based on the form of teeth and volume of production as follows :

- Straight toothed bevel gear

  - Forming by milling cutter – low productivity and quality hence employed for production requiring less volume and precision

  - Generation – high accuracy and finish, hence applied for batch to mass production.

Gear Manufacturing (Cont..):

- Fig. schematically shows the principle of forming and generation of teeth of straight toothed bevel gear. In generation process, the inner flanks of two adjacent teeth are developed with involute profile by the straight teeth of the cutters under rolling action.
  - Teeth of spiral and hypoid bevel gears are produced by almost the same generation principle but the cutter resembles face milling cutter as shown in Fig.

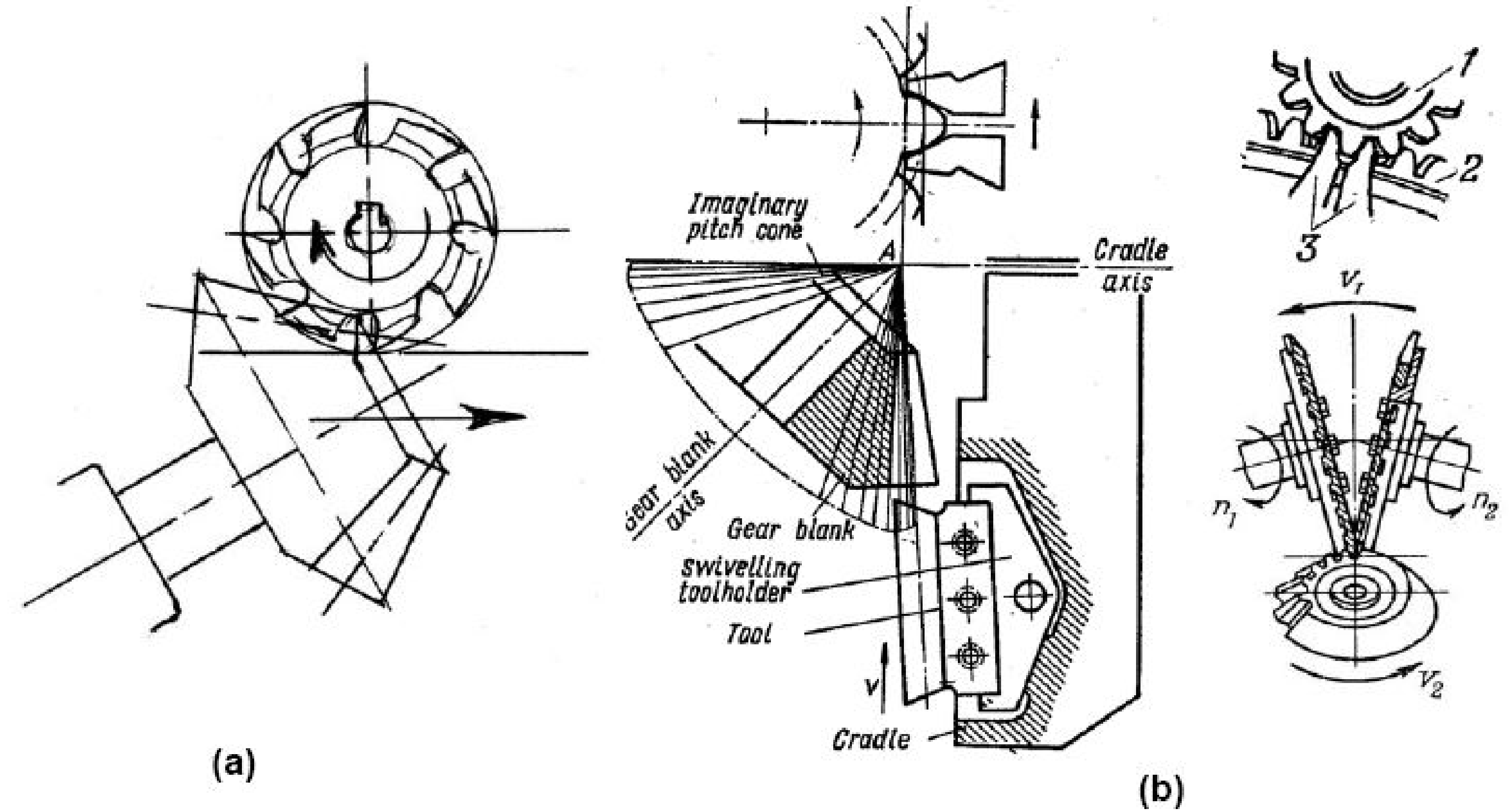


Fig. Production of teeth of straight toothed spur gear by (a) forming and (b) generation

Gear Manufacturing (Cont..):

Finishing of Gear Teeth

- For smooth running, good performance and long service life, the gears need
  - to be accurate in dimensions and forms
  - to have high surface finish and
  - to be hard and wear resistive at their tooth flanks

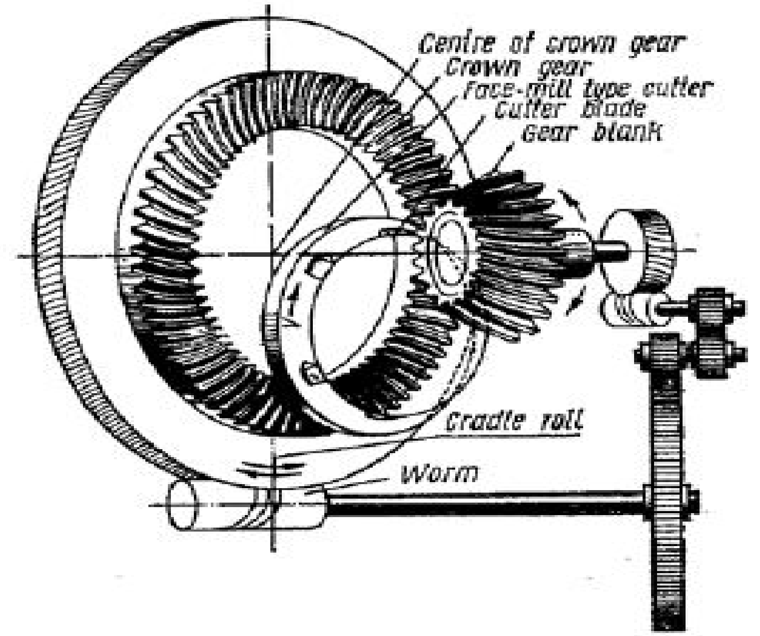


Fig. Generation of teeth of spiral and hypoid bevel gear.

Above requirements are achieved by some gear teeth finishing work after near accurate preforming and machining.

Small gears made by cold rolling generally do not require further finishing. If a rolled gear needs further surface hardening only then little finishing by grinding and / or lapping is done after hardening.

Gears produced to near-net-shape by die casting, powder metallurgy, extrusion, blanking etc. need little finishing.

Machined and hardened gear teeth are essentially finished for accuracy and surface finish.

Gear Finishing:

Common methods of gear teeth finishing:

- Gear teeth, after preforming and machining, are finished generally by;
  - For soft and unhardened gears
    - gear shaving
    - gear rolling or burnishing
  - For hard and hardened gears
    - grinding
    - lapping
  - For soft but precision gears
    - shaving followed by surface hardening and then lapping

Gear Finishing:

Gear shaving:

- The teeth of straight or helical toothed external spur gears and worm wheels of moderate size and made of soft materials like aluminum alloy, brass, bronze, cast iron etc. and unhardened steels are mostly finished by shaving process.
- Fig. shows the different types of shaving cutters which while their finishing action work apparently as a spur gear, rack or worm in mesh with the conjugate gears to be finished.
- All those gear, rack or worm type shaving cutters are of hard steel or HSS and their teeth are uniformly serrated as shown in Fig. (a) to generate sharp cutting edges.
- While interacting with the gears, the cutting teeth of the shaving cutter keep on smoothening the mating gear flanks by fine machining to high accuracy and surface finish.
- For such minute cutting action, the shaving teeth need an actual or apparent movement relative to the mating teeth along their length as indicated in Fig. (b).

Gear Finishing:

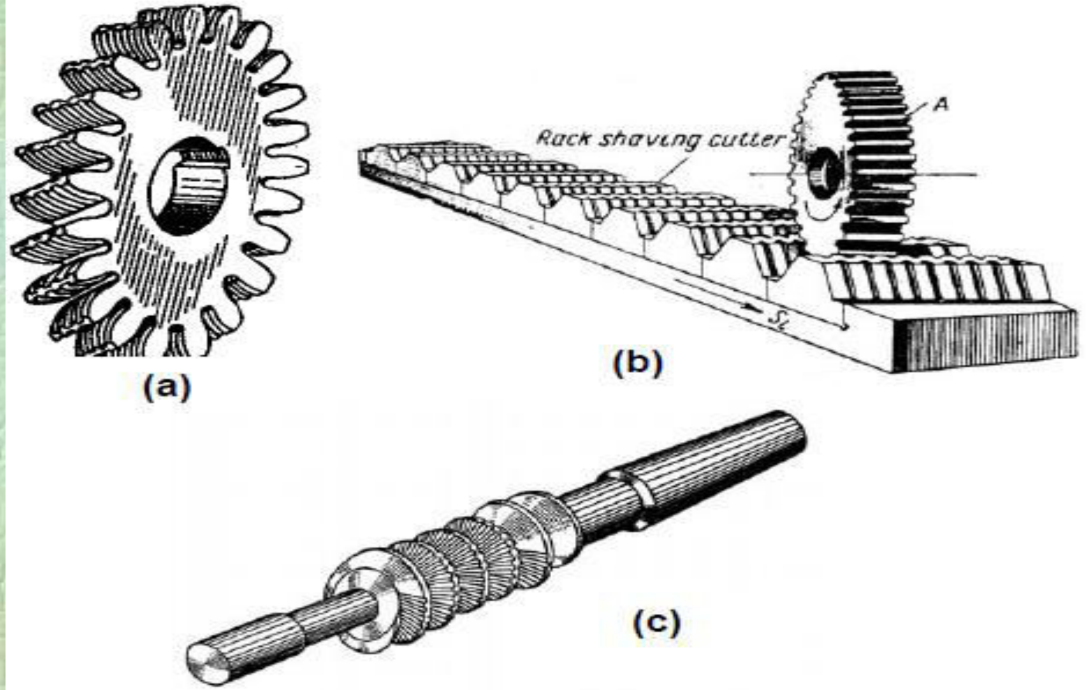


Fig. *Gear shaving cutters of (a) spur gear type (b) rack and (c) worm type*

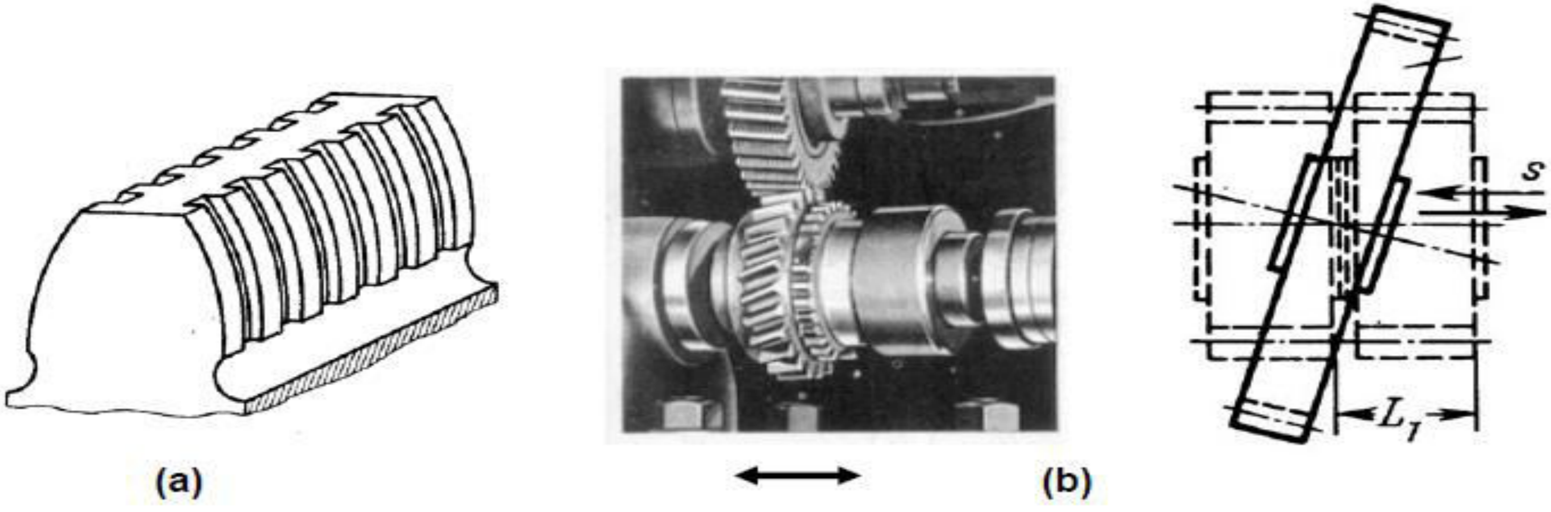


Fig. *Cutting teeth of gear shaving (a) cutter and its (b) action*

Gear Finishing:

Gear rolling or burnishing:

- In this method the machined gear is rolled under pressure with three hardened master gears of high accuracy and finish. The minute irregularities of the machined gear teeth are smeared off by cold plastic flow, which also helps in improving the surface integrity of the desired teeth.

Gear teeth grinding:

- Grinding is a very accurate method and is, though relatively expensive, more widely used for finishing teeth of different type and size of gears of hard material or hardened surfaces. The properly formed and dressed wheel finishes the gear teeth flanks by fine machining or abrading action of the fine abrasives.
- Like gear milling, gear grinding is also done on two principles
    - Forming
    - Generation, which is more productive and accurate.

Gear Finishing:

Gear teeth grinding on forming principle:

- This is very similar to machining gear teeth by a single disc type form milling cutter as indicated in Fig. where the grinding wheel is dressed to the form that is exactly required on the gear.
- Need of indexing makes the process slow and less accurate.
- The wheel or dressing has to be changed with change in module, pressure angle and even number of teeth.
- Form grinding may be used for finishing straight or single helical spur gears, straight toothed bevel gears as well as worm and worm wheels.

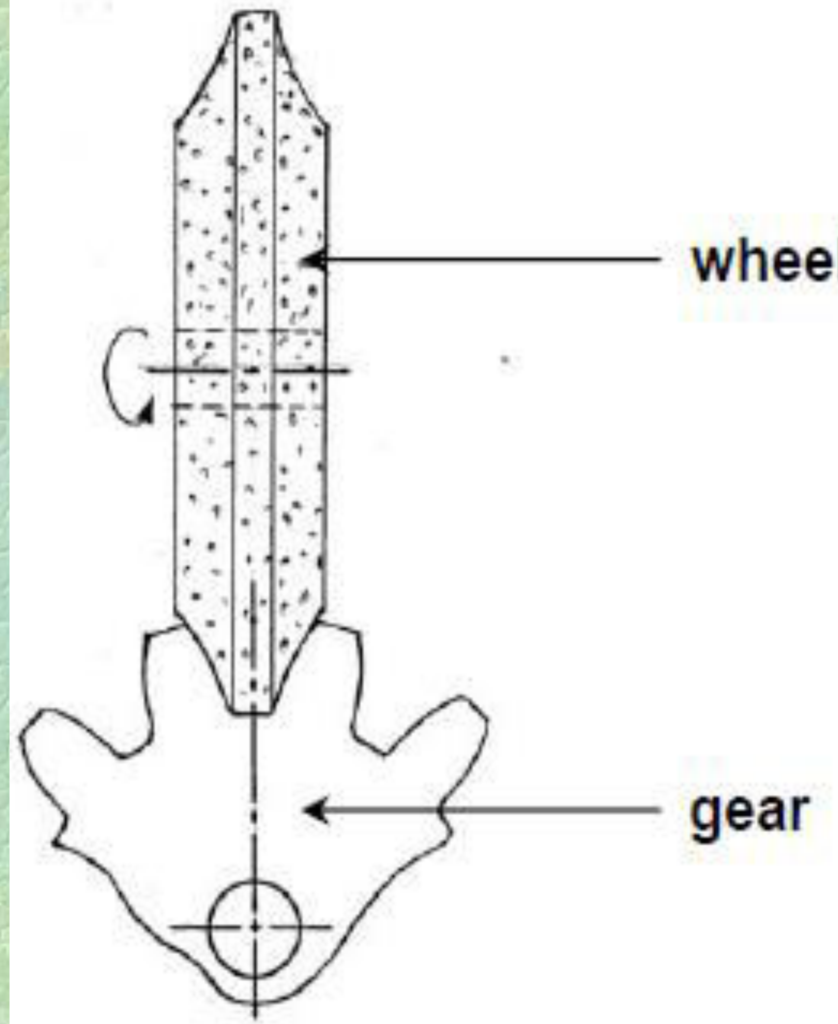


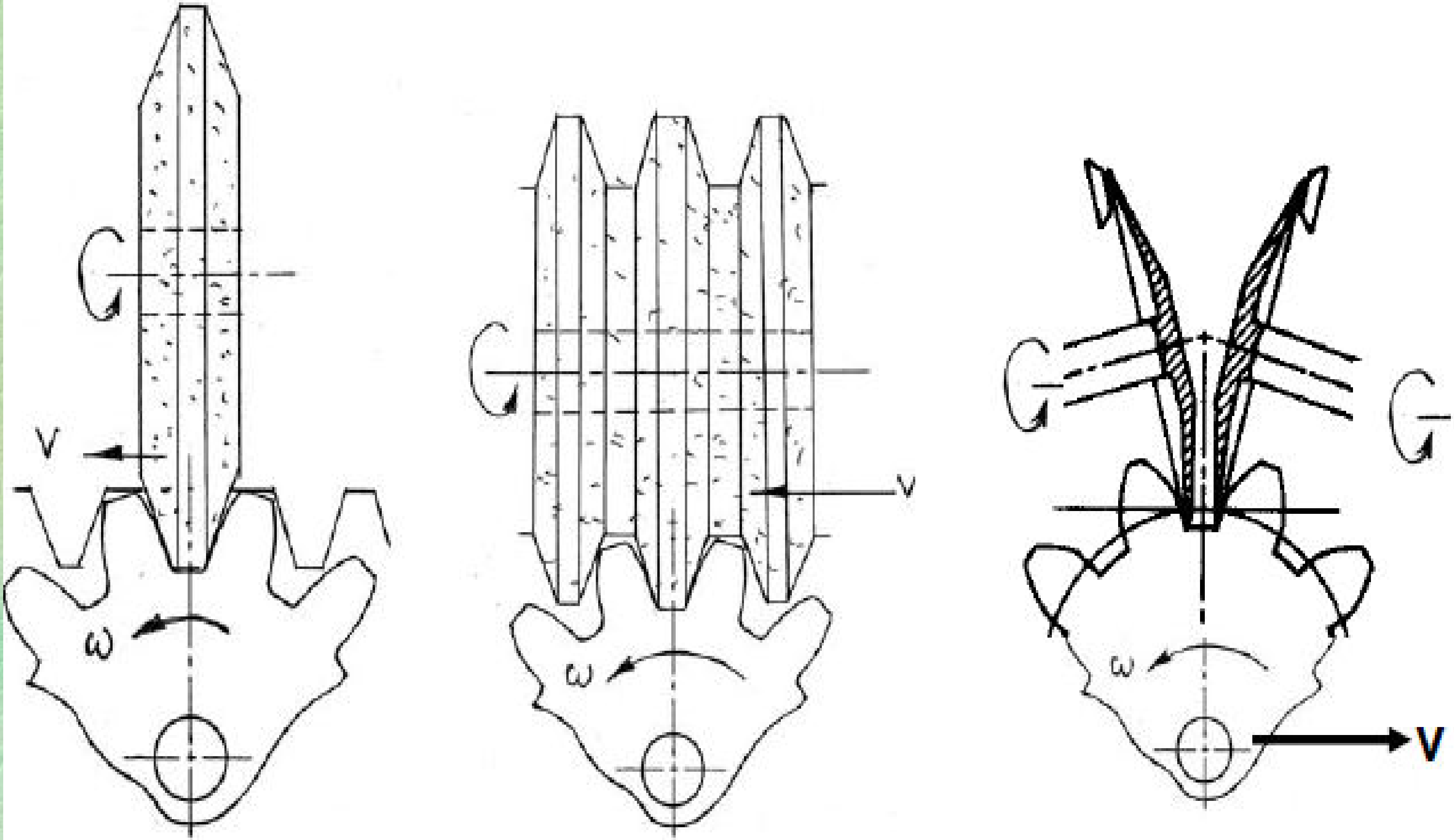
Fig. Gear teeth finishing by form grinding

Gear Finishing:

Gear teeth grinding on generation principle:

- Fig. schematically shows the methods of finishing spur gear teeth by grinding on generation principle.
- The simplest and most widely used method is very similar to spur gear teeth generation by one or multi-toothed rack cutter.
- The single or multi-ribbed rotating grinding wheel is reciprocated along the gear teeth as shown. Other tool – work motions remain same as in gear teeth generation by rack type cutter as indicated in gear generation by rack cutter.
- For finishing large gear teeth a pair of thin dish type grinding wheels are used as shown in Fig. (c).
- Whatsoever, the contacting surfaces of the wheels are made to behave as the two flanks of the virtual rack tooth.

Gear Finishing:



(a) (b) (c)

Fig. *Gear teeth grinding on generation principle.*

Gear Finishing:

Gear teeth finishing by lapping

- The lapping process only corrects minute deviations from the desired gear tooth profiles.
- The gear to be finished after machining and heat treatment and even after grinding is run in mesh with a gear shaped lapping tool or another mating gear of cast iron. An abrasive lapping compound is used in between them.
- The gear tooth contact substantially improves by such lapping.

SCREW THREAD PRODUCTION

General Applications of Screw Threads:

- **Fastening**: screws, nut-bolts and studs having screw threads are used for temporarily fixing one part on to another part
- **Joining** : e.g., co-axial joining of rods, tubes etc. by external and internal screw threads at their ends or separate adapters
- **Clamping** : strongly holding an object by a threaded rod, e.g., in c-clamps, vices, tailstock on lathe bed etc.
- **Controlled linear movement** : e.g., travel of slides (tailstock barrel, compound slide, cross slide etc.) and work tables in milling machine, shaping machine, CNC machine tools and so on.
- **Transmission of motion and power** : e.g., lead screws of machine tools
- **Converting rotary motion to translation** : rotation of the screw causing linear travel of the nut, which have wide use in machine tool kinematic systems
- **Position control in instruments** : e.g., screws enabling precision movement of the work table in microscopes etc.
- **Precision measurement of length**: e.g., the threaded spindle of micrometers and so on.
- **Acting as worm** for obtaining slow rotation of gear or worm wheel
- **Exerting heavy force** : e.g., mechanical presses
- **Conveying and squeezing materials** : e.g., in screw conveyor, injection molding machine, screw pump etc.
- **Controlled automatic feeding** in mass production assembly etc.

Classification Of Screw Threads:

- **According to location**
  - o External screw thread (on bolts etc.)
  - o Internal screw thread (in nuts etc.)
- **According to configuration**
  - o Straight (helical) – most common, e.g., bolts, studs etc.
  - o Taper (helical), e.g., in drill chuck
  - o Radial (scroll) as in self centering chuck
- **According to the direction of the helix**
  - o Right hand (common)
  - o Left hand (occasionally)
- **According to form**
  - o Vee thread (60^0 or 55^0 angle) – most common
  - o Acme thread (29^0)
  - o Square thread (generally in power screws)
  - o Buttress thread (45^o)
  - o Worm thread ($29^0 \sim 40^0$)
  - o Semicircular (groove section) thread being used in re-circulating type bolls, screws.

Classification of Screw Threads:

- **According to standard**
  - o BSW (British Standard Whitworth); thread – size is designated by TPI (threads per inch)
  - o Metric thread; thread size is specified by pitch or lead (in mm)
- **According to number of start**
  - o Single start – most common
  - o Multi-start (2 to 4)
- **According to spacing of threads**
  - o TPI (no. of threads per inch), e.g. 12 TPI
  - o Pitch (or lead) – distance between two successive threads (or length of travel of the nut for one rotation of the screw), in mm
- **According to compactness or fineness of threads**
  - o General threads (with usually wide thread spacing), pipe threads (more densed desired)
  - o Fine threads (generally for leak proof)
- **According to segmentation**
  - o Full threads (common)
  - o Half turns as in half nuts
  - o Sector thread – e.g., in the jaws of lathe chucks.

Production Of Screw Threads – Possible Methods & Their Characteristics:

The various methods, which are more or less widely employed for producing screw threads are :

Casting characteristics;

- o only a few threads over short length
- o less accuracy and poor finish
- o example – threads at the mouth of glass bottles, spun cast iron pipes etc.

❖ **Forming (Rolling)** characteristics;

- o blanks of strong ductile metals like steels are rolled between threaded dies
- o large threads are hot rolled followed by finishing and smaller threads are straight cold rolled to desired finish
- o cold rolling attributes more strength and toughness to the threaded parts
- o widely used for mass production of fasteners like bolts, screws etc.

Production of Screw Threads – Possible Methods & Their Characteristics

- **Removal process (Machining)**
  - o accomplished by various cutting tools in different machine tools like lathes, milling machines, drilling machines (with tapping attachment) etc.
  - o widely used for high accuracy and finish
  - o employed for wide ranges of threads and volume of production; from piece to mass production.

- **Semi-finishing and finishing (Grinding)** characteristics :
  - o usually done for finishing (accuracy and surface) after performing by machining or hot rolling but are often employed for direct threading on rods
  - o precision threads on hard or surface hardened components are finished or directly produced by grinding only
  - o employed for wide ranges of type and size of threads and volume of production.

Production of Screw Threads – Possible Methods & Their Characteristics

- **Precision forming to near – net – shape** characteristics :
  - o no machining is required, slight grinding is often done, if needed for high accuracy and finish
  - o application – investment casting for job order or batch production
  - – injection molding (polymer) for batch or mass production.

- **Non conventional process (EDM, ECM etc)** characteristics :
  - o when conventional methods are not feasible
  - o high precision and micro threads are needed
  - o material is as such difficult – to – process

Processes, Machines & Tools Used For Producing Screw Threads:

(a) Machining

(b) Rolling

(c) **Grinding**

(a) Production of screw threads by machining

Machining is basically a removal process where jobs of desired size and shape are produced by gradually removing the excess material in the form of chips with the help of sharp cutting edges or tools. Screw threads can be produced by such removal process both manually using taps and dies as well as in machine tools of different types and degree of automation. In respect of process, machine and tool, machining of screw threads are done by several ways :

- **Thread cutting by hand operated tools**

  Usually small threads in few pieces of relatively soft ductile materials, if required, are made manually in fitting, repair or maintenance shops.

Thread cutting by hand operated tools:

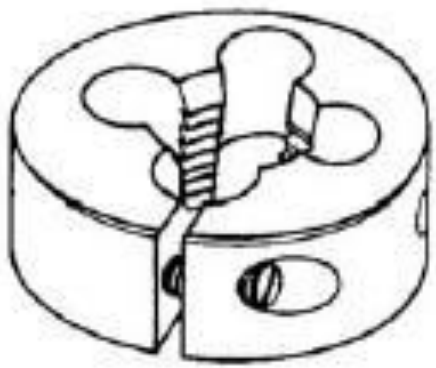
- **External screw threads** Machine screws, bolts or studs are made by different types of dies which look and apparently behave like nuts but made of hardened tool steel and having sharp internal cutting edges. Fig. 7.1.1 shows the hand operated dies of common use, which are coaxially rotated around the pre-machined rod like blank with the help of handle or die stock.

  - ∆ **Solid or button die** : used for making threads of usually small pitch and diameter in one pass.
  - ∆ **Spring die** : the die ring is provided with a slit, the width of which is adjustable by a screw to enable elastically slight reduction in the bore and thus cut the thread in number of passes with lesser force on hands.
  - ∆ **Split die** : the die is made in two pieces, one fixed and one movable (adjustable) within the cavity of the handle or wrench to enable cut relatively larger threads or fine threads on harder blanks easily in number of passes, the die pieces can be replaced by another pair for cutting different threads within small range of variation in size and pitch.
  - ∆ **Pipe die** : pipe threads of large diameter but smaller pitch are cut by manually rotating the large wrench (stock) in which the die is fitted through a guide bush as shown in **Fig.**

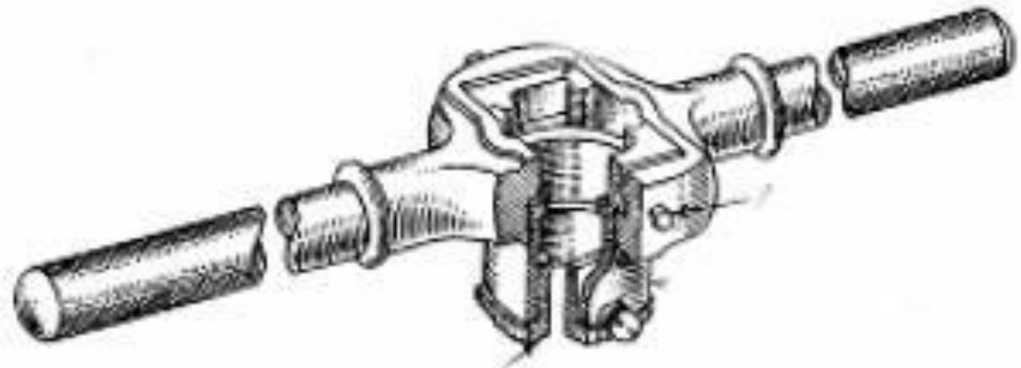
Thread cutting by hand operated tools:

(a) solid die

(c) split die



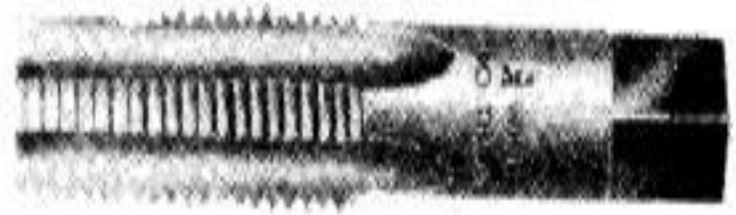
(b) spring die

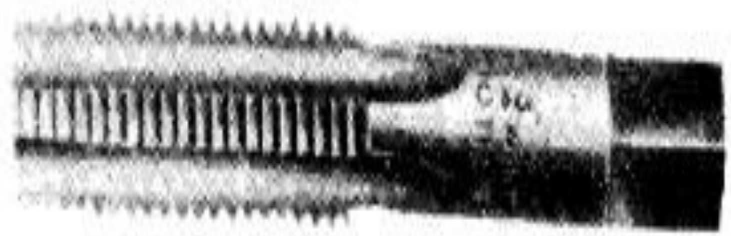


(d) pipe die

Thread cutting by hand operated tools:

- **Internal screw threads :**
- Internal screw threads of usually small size are cut manually, if needed, in plates, blocks, machine parts etc. by using taps which look and behave like a screw but made of tool steel or HSS and have sharp cutting edges produced by axial grooving over the threads as shown in **Fig.**
- Three taps namely, taper tap, plug tap and bottoming tap are used consecutively after drilling a tap size hole through which the taps are axially pushed helically with the help of a handle or wrench.


(a) Taper tap


(b) Second tap


(c) Plug tap

Hand operated taps for cutting internal threads.

Thread cutting by hand operated tools:

- Threads are often tapped by manually rotating and feeding the taps through the drilled hole in the blank held in lathe spindle as shown in **Fig.**

- The quality of such external and internal threads will depend upon the perfection of the taps or dies and skill of the operator.

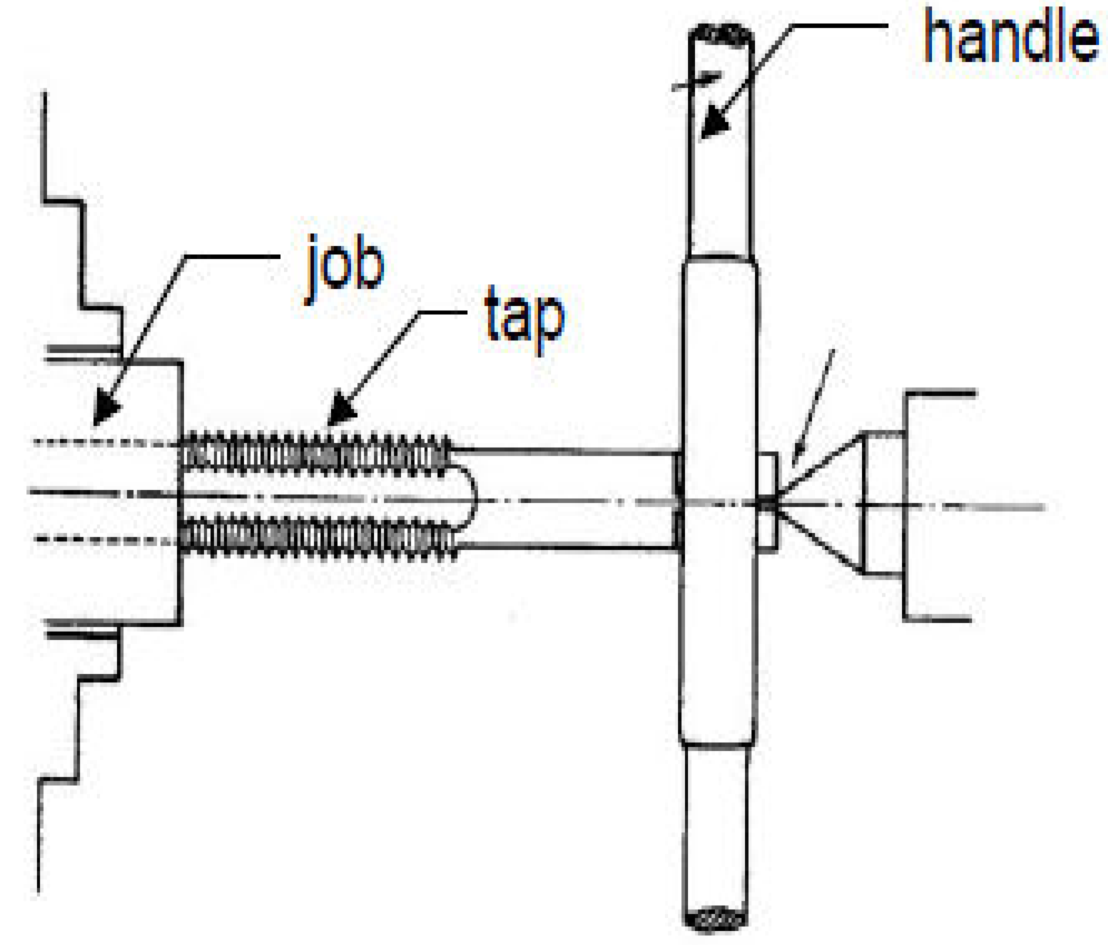


Fig. *Hand operated tapping in centre lathe.*

Machining screw threads in machine tools:

- Threads of fasteners in large quantity and precision threads in batches or lots are produced in different machine tools mainly lathes, by various cutting tools made of HSS or often cemented carbide tools.

  * **Machining screw threads in lathes**

    Screw threads in wide ranges of size, form, precision and volume are produced in lathes ranging from centre lathes to single spindle automats. Threads are also produced in special purpose lathes and CNC lathes including turning centers.

  • **In centre lathes**

o **External threads :**

External threads are produced in centre lathes by various methods :

External Thread Production on a Center Lathe:

- **Single point and multipoint chasing**, as schematically shown in **Fig.** This process is slow but can provide high quality. Multipoint chasing gives more productivity but at the cost of quality to some extent

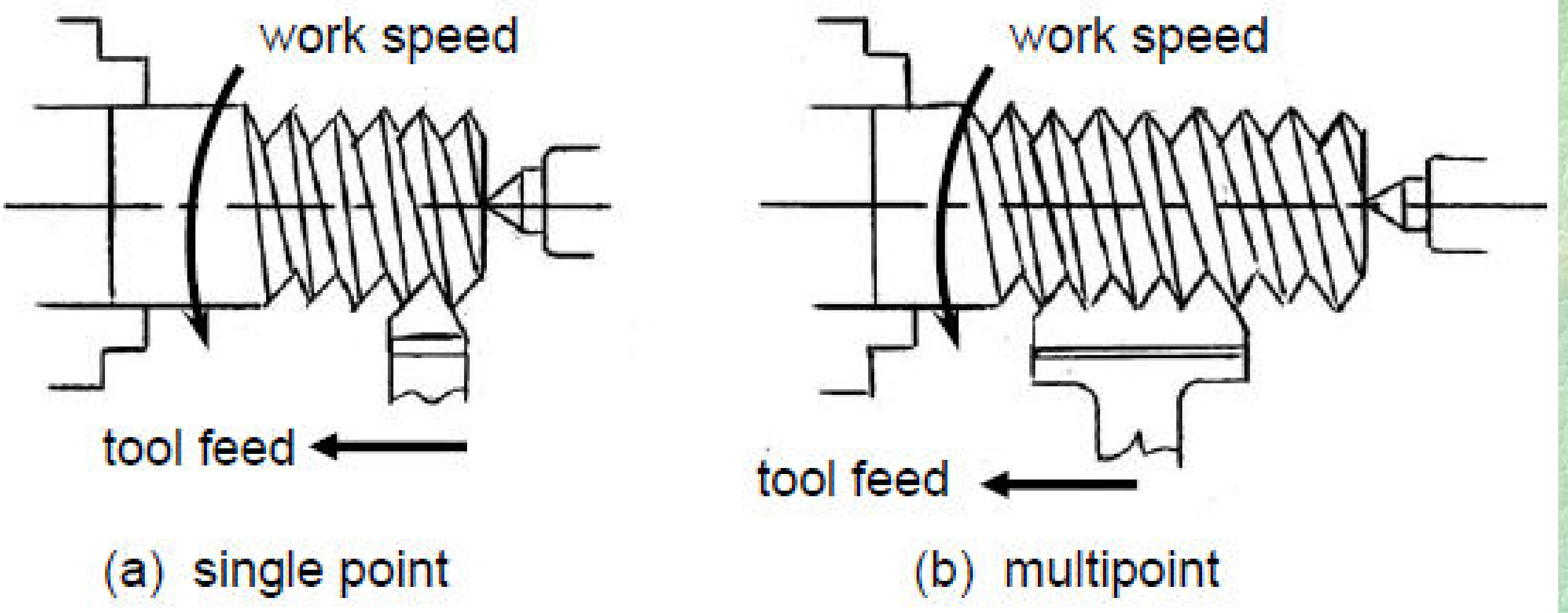


Fig. *External threading in lathe by chasing.*

Thread Milling on a Lathe:

- This process gives quite fast production by using suitable thread milling cutters in centre lathes as indicated in **Fig. The milling attachment is mounted on the saddle of the lathe.**
  Thread milling is of two types;

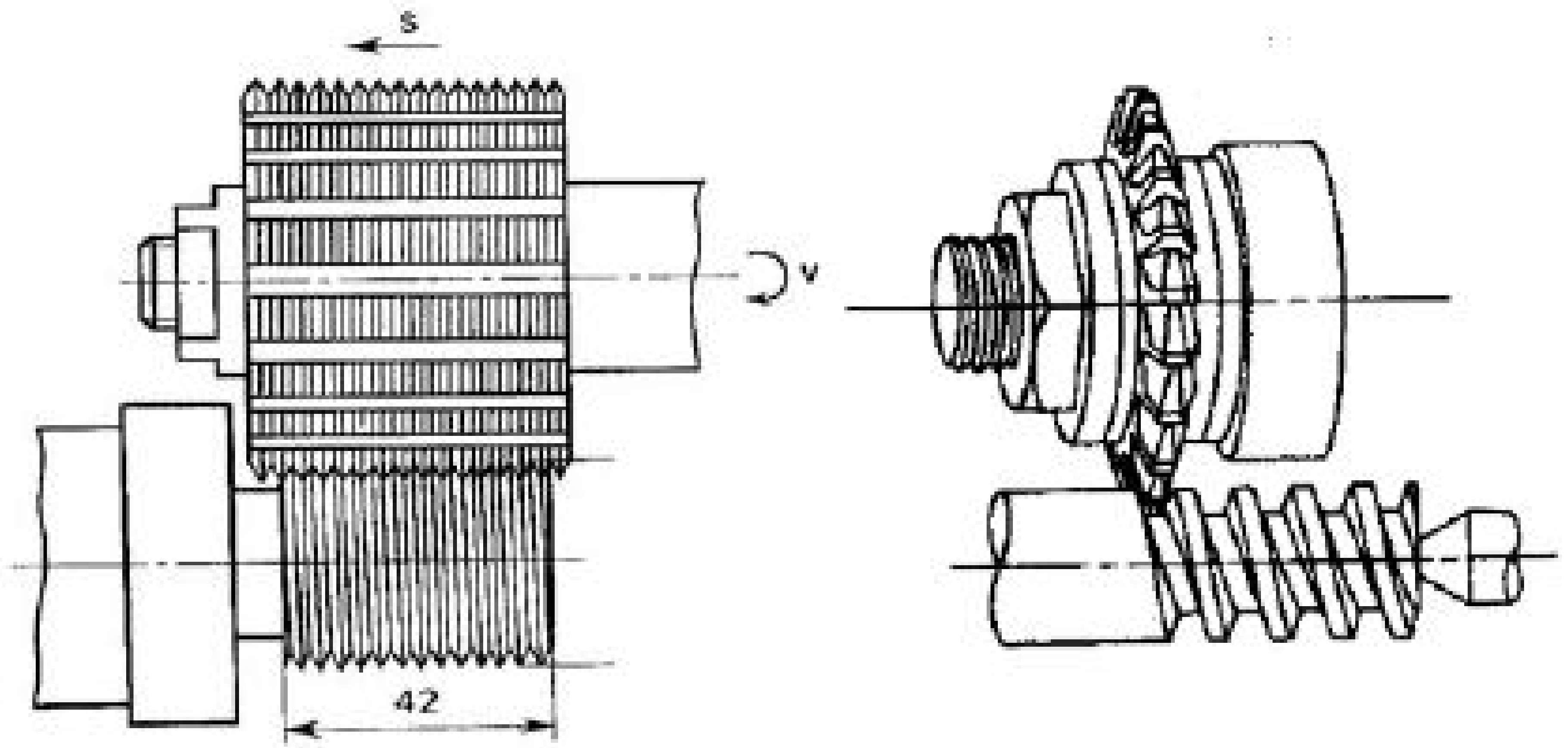


Fig. *Thread milling by attachment in centre lathes.*

Thread Milling on a Lathe:

- **Long thread milling**

  Long and large diameter screws like machine lead screws are reasonably accurately made by using a large disc type form milling cutter as shown in **Fig.** on earlier slide.

- **Short thread milling**

Threads of shorter length and fine pitch are machined at high production rate by using a HSS milling cutter having a number of annular threads with axial grooves cut on it for generating cutting edges.

Each job requires only around 1.25 revolution of the blank and very short axial (1.25 pitch) and radial (1.5 pitch) travel of the rotating tool

Thread Milling on a Lathe:

- **Rotating tool:**

Often it becomes necessary to machine large threads on one or very few pieces of heavy blanks of irregular size and shape like heavy casting or forging of odd size and shape.

In such cases, the blank is mounted on face plate in a centre lathe with proper alignment. The deep and wide threads are produced by intermittent cutting action by a rotating tool.

A separate attachment carrying the rotating tool is mounted on the saddle and fed as usual by the lead screw of the centre lathe. **Fig.** shows schematically the principles of threading by rotary tools. The tool is rotated fast but the blank much slowly.

This intermittent cut enables more effective lubrication and cooling of the tool.

Thread Milling on a Lathe:

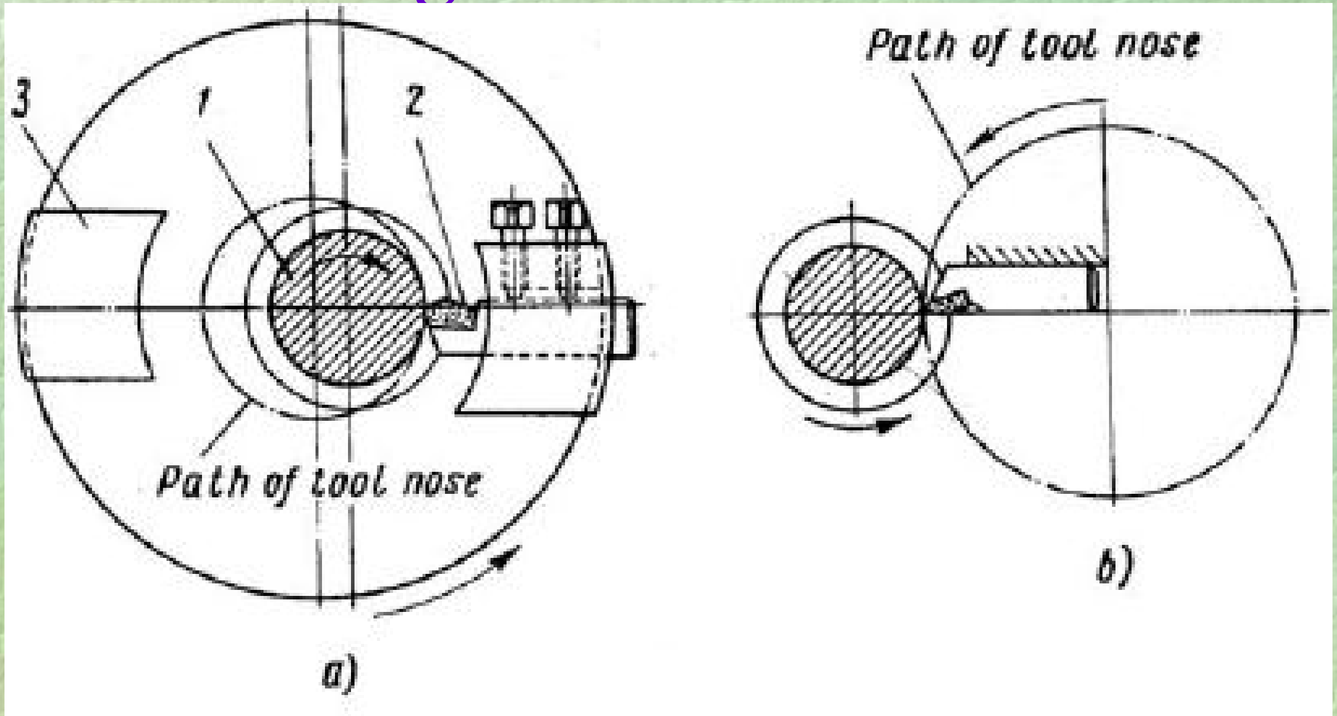


Fig. *Thread cutting in centre lathe by rotating tools.*

- **Internal threads** :

Internal threads are produced in centre lathes at slow rate by using;

Δ Single point tool

Δ Machine taps

Δ Internal thread milling

Internal threading by single point chasing:

- Internal threads in parts of wide ranges of diameter and pitch are accurately done in centre lathes by single point tool, as in boring, as shown in **Fig. (a)**.
- Multipoint flat chaser is often used for faster production.

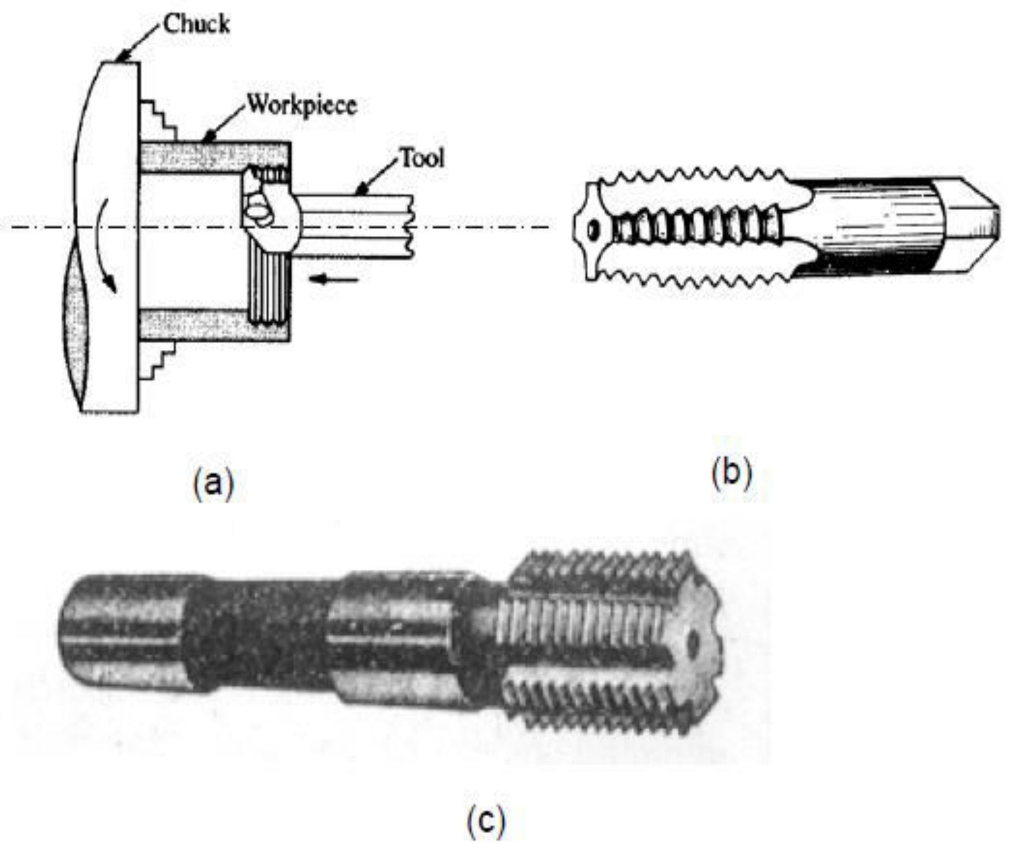


Fig. (a) single point tool , (b) solid tap and (c) milling cutter for internal threading in centre lathe.

Δ **Internal threading by taps** Internal threads of small length and diameter are cut in drilled holes by different types of taps;

Δ Straight solid tap (**Fig. (b)** – used for small jobs

Δ Taps with adjustable blades – usually for large diameter jobs

Δ Taper or nut taps – used for cutting threads in nuts.

Δ Internal thread milling cutter

Such solid cutter, shown in **Fig. (c)** produces internal threads very rapidly, as in external short thread milling, in lathes or special purpose thread milling machine.

Machining threads in semiautomatic lathes:

- Both external and internal threads are cut, for batch or small lot production, in capstan and turret lathes using different types of thread cutting tools;
  - Δ External threads in capstan lathe by self opening die and single or multipoint chaser in turret lathe
  - Δ Internal threads of varying size by collapsible tap.

  The self opening die, typically shown in **Fig. (a)**, is mounted in the turret and moved forward towards the rotating blank. At the end point, when the turret slows down and is about to stop or reverse, the front position of the die gets pulled and open automatically to enable free return of the die without stopping the job – rotation. The thread chasers may be flat or circular type as shown.

- In a collapsible tap, shown in **Fig. (b)**, the radially raised blades collapse (move radially inward) and the tap returns (along with the turret or saddle) freely from the threaded hole after completing the internal thread in one stroke.

Machining threads in semiautomatic lathes:

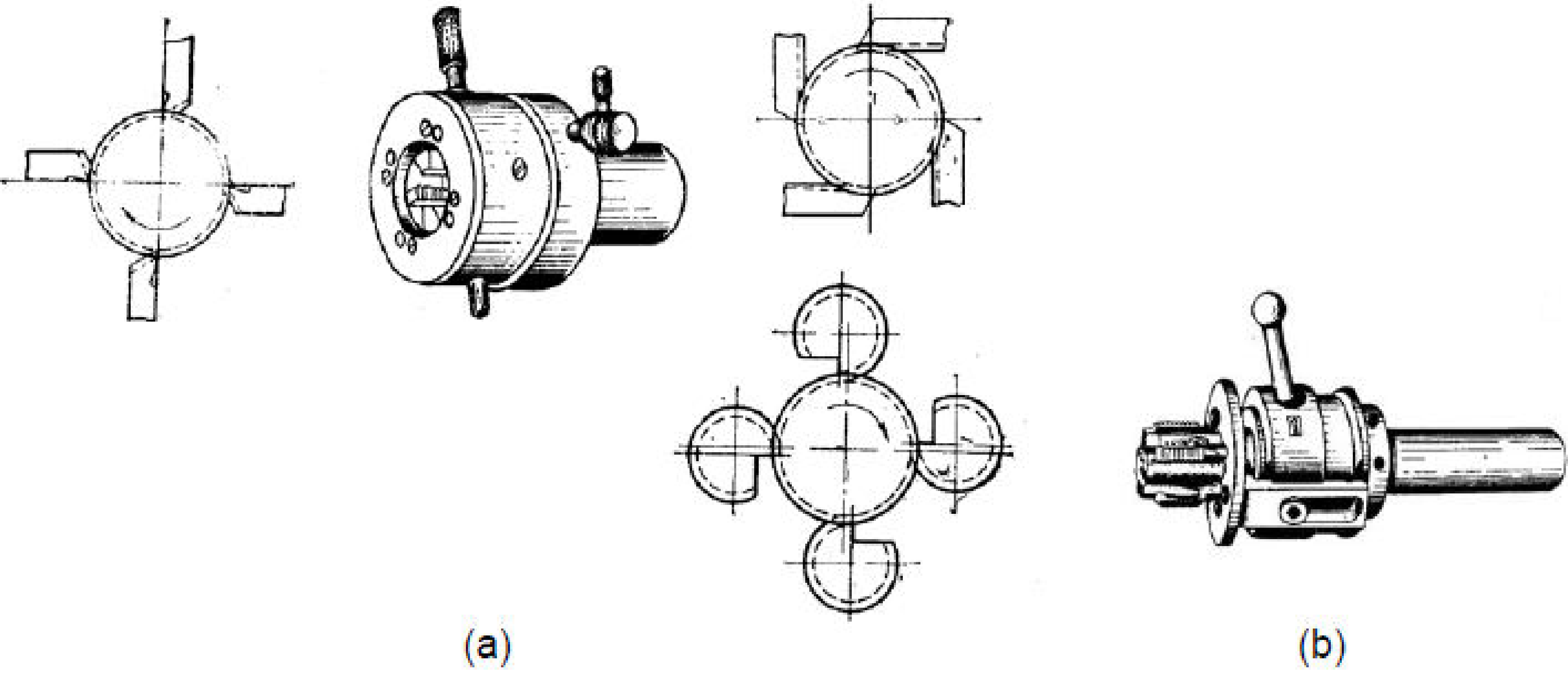


Fig. *Cutting (a) external and (b) internal threads in capstan and turret lathes.*

Machining Threads in Automatic Lathes:

- Small external threads for mass production of fasteners are produced by machining in single spindle automatic lathes or similar but special purpose (threading) lathes using solid die. The die is mounted on the coaxially moving turret or sliding attachment in turret lathes and SPM respectively.

- In turret lathe, the solid die is returned by reversing the job rotation, and in the special purpose machine, the die is freely returned by rotating the die slightly faster than the job and in the same direction.

Machining Screw Threads in Drilling Machine:

- Drilling machines are used basically for originating cylindrical holes but are also used, if needed, for enlarging drilled holes by larger drills, counter boring, countersinking etc.

- Internal threads of relatively smaller diameter, length and pitch are also often produced in drilling machines by using tapping attachment with its taper shank fitted axially in the spindle bore. **Fig.** typically shows one such tapping attachment.

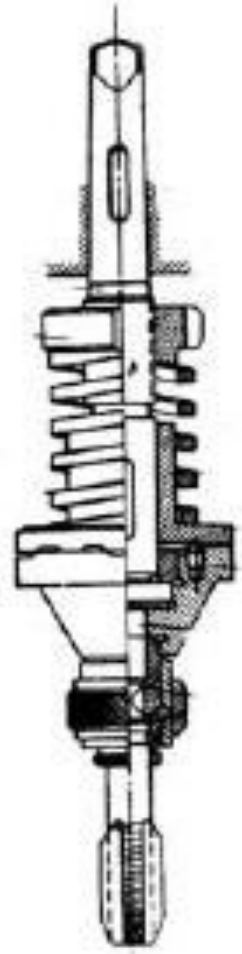


Fig. *Tapping attachment for machining internal threads in drilling machines.*

Machining Screw Threads in Drilling Machine:

- The tapping attachment is pushed slowly inside the drilled hole at low speed for cutting threads and at the end of this stroke, it is withdrawn slowly by rotating in reversed direction.
- Just at the point of start of return, the lower part of the attachments momentarily gets delinked from the upper part and is then up and rotated respectively by the spring and the clutch as shown in **Fig.** to move at per with the by using special attachment as shown in **Fig.**
- The taper tap is connected with a bent rod which is made to rotate at high speed upper part fitted into the spindle. This is necessary for the safe return of the tap without damaging the through or blind hole.
- Threading of small identical components like nuts for its mass production is also possible and done in general purpose drilling machines along with the spindle causing rotation of the tap at the same speed.

Machining Screw Threads in Drilling Machine:

- The blanks are automatically pushed intermittently under the tap and after threading the tap returns but along with the threaded nut.
- Finally the accumulated nuts are thrown out form the rod by centrifugal force to come out from the hopper as shown.

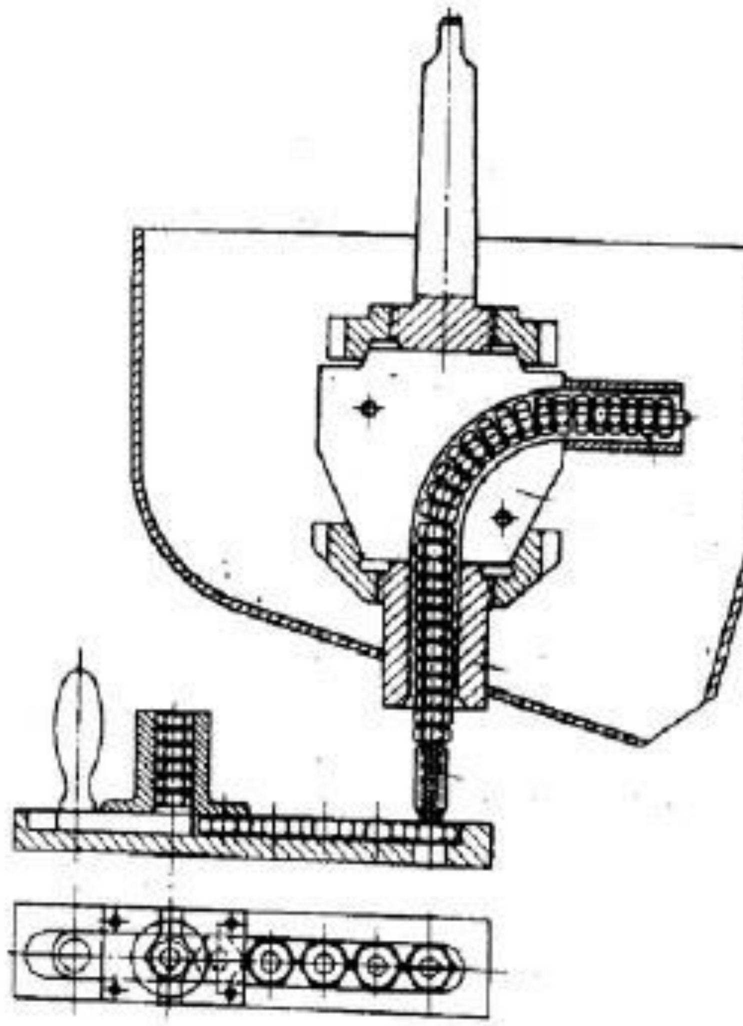


Fig. Threading of nuts in drilling machine by special tapping attachment.

Production of Screw Threads by Thread Rolling:

- In production of screw threads, compared to machining thread rolling:
  - It is generally cold working process.
  - It provides higher strength to the threads.
  - It does not cause any material loss.
  - It does not require that high accuracy and finish of the blank.
  - It requires simpler machines and tools applicable for threads of smaller diameter, shorter length and finer pitch.
  - It enables much faster production of small products like screws, bolts, studs etc.
  - It cannot provide that high accuracy.
  - It is applicable for relatively softer metals.
  - It is used mostly for making external screw threads.
  - It needs separate dies for different threads.

Production of Screw Threads by Thread Rolling:

- Thread rolling is accomplished by shifting work material by plastic deformation, instead of cutting or separation, with the help of a pair of dies having same threads desired.

- Different types of dies and methods are used for thread rolling which include,

  - Thread rolling between two flat dies
  - Thread rolling between a pair of circular dies
  - Thread rolling by sector dies.

Rolling of External Screw Threads by Flat Dies:

- The basic principle is schematically shown in **Fig.**
- Flat dies; one fixed and the other moving parallely, are used in three configurations :
  - Δ **Horizontal** : most convenient and common
  - Δ **Vertical** : occupies less space and facilitates cleaning and lubrication under gravity
  - Δ **Inclined** : derives benefit of both horizontal and vertical features
- All the flat dies are made of hardened cold die steel and provided with linear parallel threads like grooves of geometry as that of the desired thread.

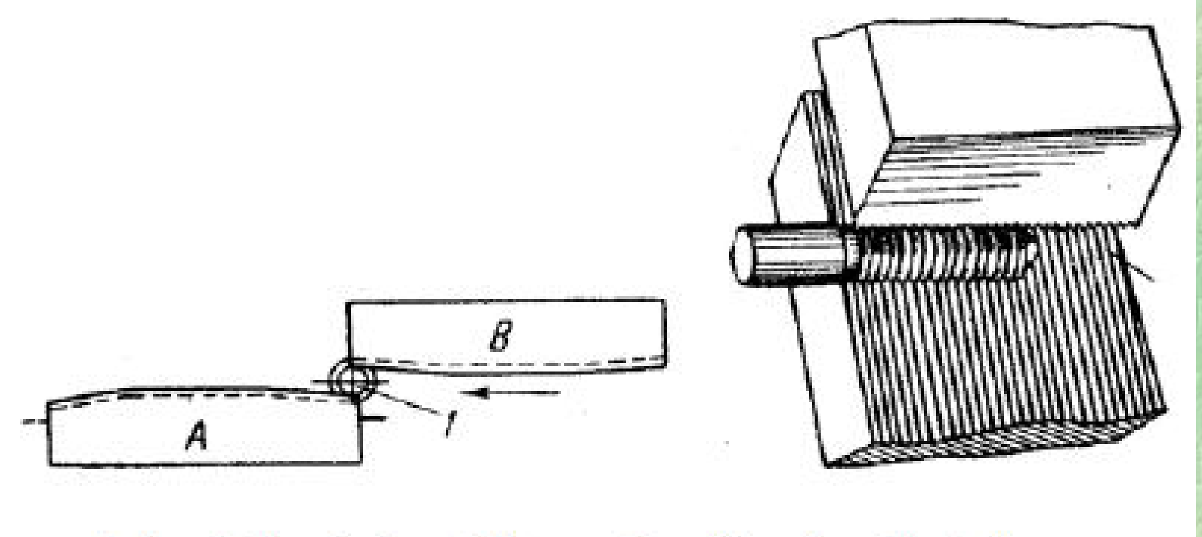


Fig. *Principle of thread rolling by flat dies.*

Thread Rolling by Circular Dies:

- Circular die sets occupy less space and are simpler in design, construction, operation and maintenance. The different types of thread rolling circular dies of common use and their working methods are :

  ∆ **Circular dies with plunge (radial) feed** :

  The two identical circular dies with parallel axis are rotated in the same direction and speed as indicated in **Fig.**

  One stays fixed in a position the other is moved radially desirably depending upon the thread depth.

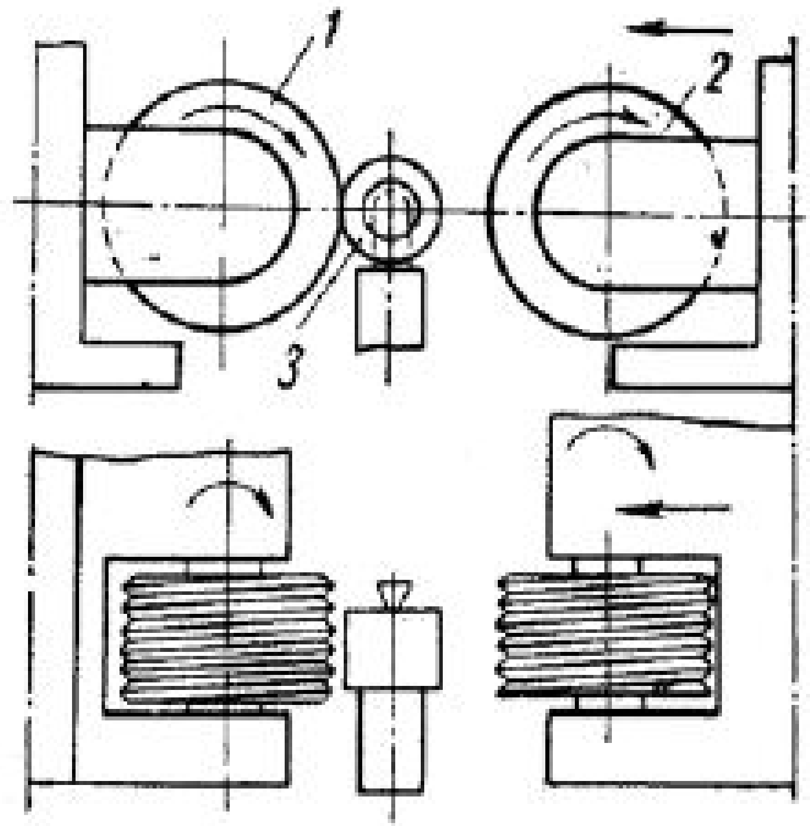


Fig. *Principle of thread rolling by circular die with plunge feed*

Thread Rolling by Circular Dies:

- **Circular die with inherent radial feed** :
- Here the forced penetration of the threads in the blank is accomplished not by radial shifting of one of the dies but gradual projection of the thread in Archimedean spiral over an angle on one of the dies as indicated in **Fig.**
- This makes the system simpler by eliminating a linear motion.

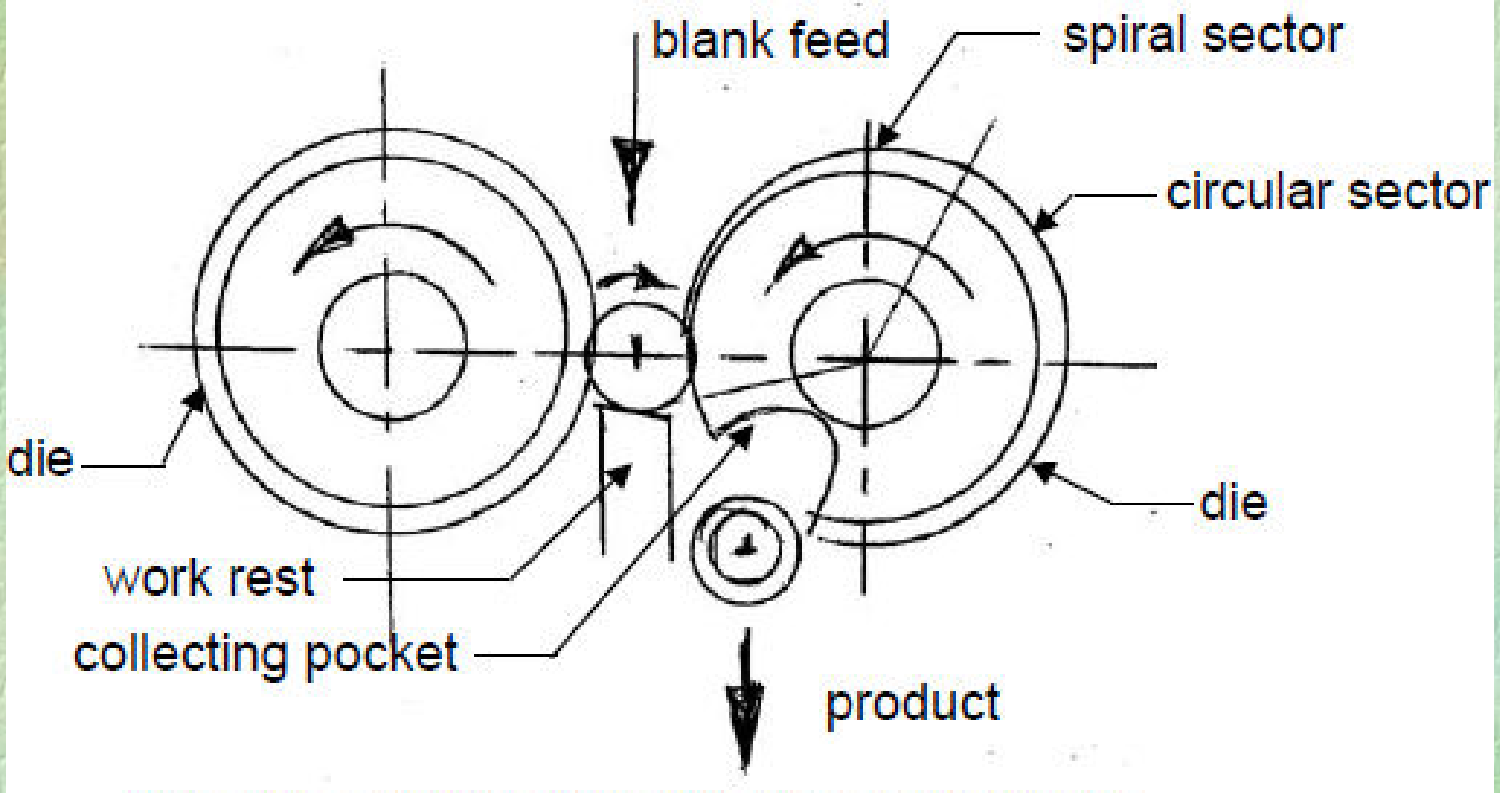


Fig. *Thread rolling by spiral feed circular die.*

Thread Rolling by Circular Dies:

- **Thread rolling in the annular space between two dies:**
- In this simpler system and process the outer die remains fixed and the inner one rotates as shown in **Fig.**
- Because of simple construction and motions, this method is more productive but limited to smaller jobs.

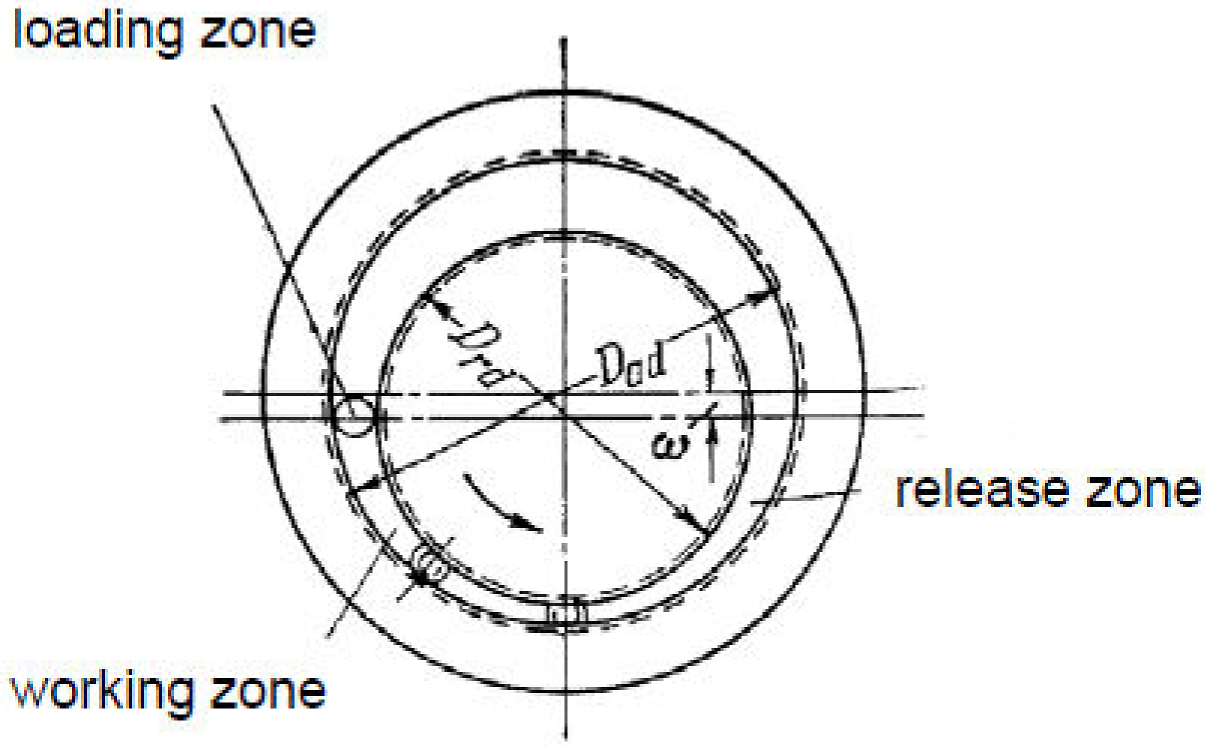


Fig. *Thread rolling in the annular space between two circular dies.*

Thread Rolling by Circular Dies:

- **Thread rolling by circular die sector** This method, schematically shown in **Fig.** is the simplest and fastest way of thread rolling enabling easy auto-feed of the blanks.
- Fine internal threads on large diameter and unhard metals may also be done, if needed, by using a screw like threaded tool which will be rotated and pressed parallely against the inner cylindrical wall of the product.

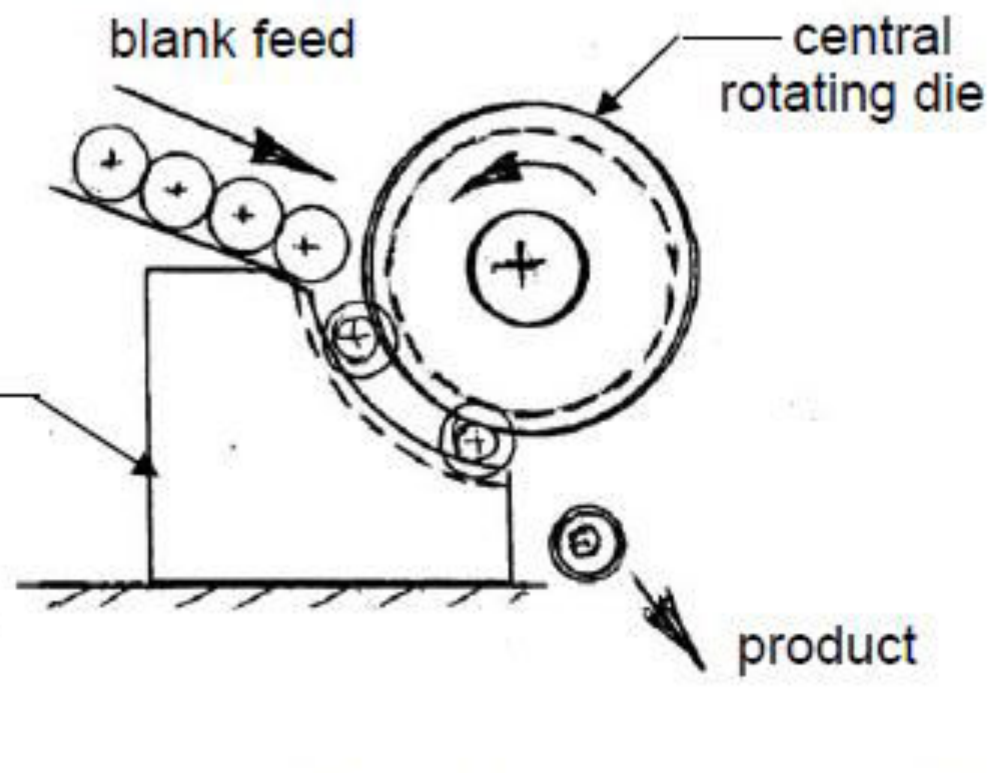


Fig. *Thread rolling by sector circular die*

Finishing and Production of Screw Threads by Grinding:

- In production of screw threads, grinding is employed for two purposes;
  - Finishing the threads after machining or even rolling when
    - o High dimensional and form accuracy as well as surface finsh are required, e.g., screw threads of precision machines and measuring instruments
    - o The threaded parts are essentially hardened and cannot be machined or rolled further, e.g., lead screws of machine tools, press – screws etc.
  - Directly originating (cutting) and simultaneously finishing threads in any hard or soft preformed blanks. This is employed generally for finer threads of small pitch on large and rigid blanks

- The screw threads are ground in several methods which include:

Finishing and Production of Screw Threads by Grinding:

- **External and internal thread grinding** by single ribbed formed grinding wheel as schematically shown in **Fig. (a)**. Such grinding is usually done in cylindrical grinding machine but is also occasionally done in rigid centre lathes by mounting a grinding attachment like thread milling attachment, on the lathe's saddle.
- **Multi-ribbed wheels** save grinding time by reducing the length of travel of the wheel but raises wheel cost. **Fig. (b)** shows such thread grinding with both fully covered and alternate ribbing.

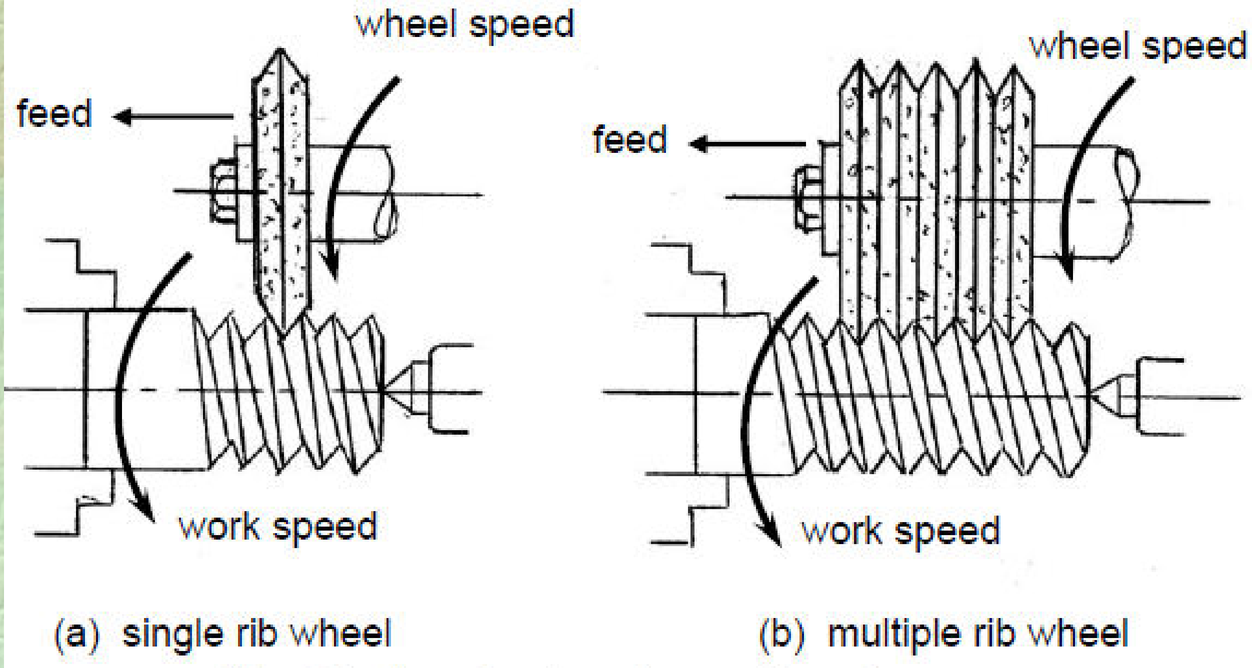


Fig. *Grinding of external screw threads.*

Finishing and Production of Screw Threads by Grinding:

- **External threads by centreless grinding:**
- Like centre less grinding of short and long rods by plunge feed and through feed respectively, centre less thread grinding is also done by ribbed grinding wheel using respectively parallel and desirably inclined plain guide wheels. Centre less grinding, if feasible, is more productive but at the cost of accuracy to some extent.

THANKS