Thread manufacturing

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

1• Casting: characteristics;

1- Only a few threads over short length
2- Less accuracy and poor finish
3- Example – threads at the mouth of glass bottles, spun cast iron pipes etc.

2. Forming (Rolling): characteristics;

1- Blanks of strong ductile metals like steels are rolled between threaded dies
2- Large threads are hot rolled followed by finishing and smaller threads are straight cold rolled to desired finish
3- Cold rolling attributes more strength and toughness to the threaded parts
4- Widely used for mass production of fasteners like bolts, screws etc.

3• Removal process (Machining)

1- Accomplished by various cutting tools in different machine tools like lathes, milling machines, drilling machines (with tapping attachment) etc.
2- Widely used for high accuracy and finish

3- Employed for wide ranges of threads and volume of production; from piece to mass production.

4• Semifinishing and finishing (Grinding) : characteristics

1- Usually done for finishing (accuracy and surface) after performing by machining or hot rolling but are often employed for direct threading on rods

2- Precision threads on hard or surface hardened components are finshed or directly produced by grinding only

3- Employed for wide ranges of type and size of threads and volume of production

5• Precision forming to near – net – shape: characteristics

1- No machining is required, slight grinding is often done, if needed for high accuracy and finish

2- Application – investment casting for job order or batch production– injection moulding (polymer) for batch or mass production

6• Non conventional process (EDM, ECM etc) characteristics:

1- When conventional methods are not feasible

2- High precision and micro threads are needed

3- Material is as such difficult – to – process

(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 :

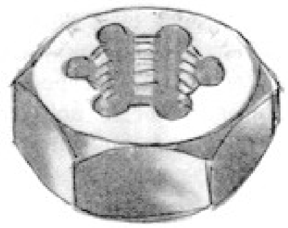
1-Thread cutting by hand operated tools

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

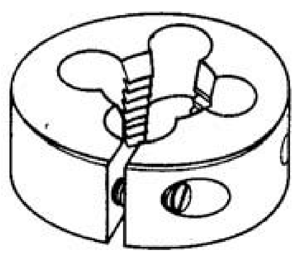
1.1 External screw threads

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. shows the hand operated dies of common use, which are coaxially rotated around the premachined rod like blank with the help of handle or die stock.

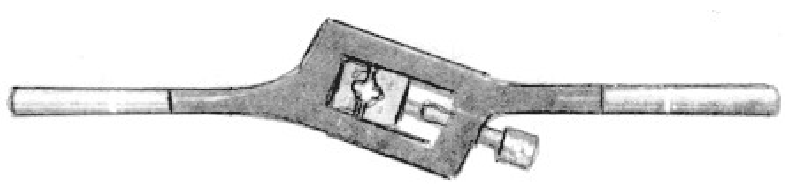
a- **Solid or button die:** used for making threads of usually small pitch and diameter in one pass.



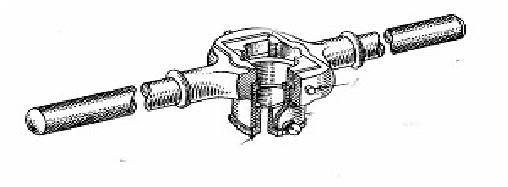
b- **Spring die:** the die ring is provided with a slit, the width of which is adjustable by a screw to enable elastically slight reduction in the bore and thus cut the thread in number of passes with lesser force on hands.



c- **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.

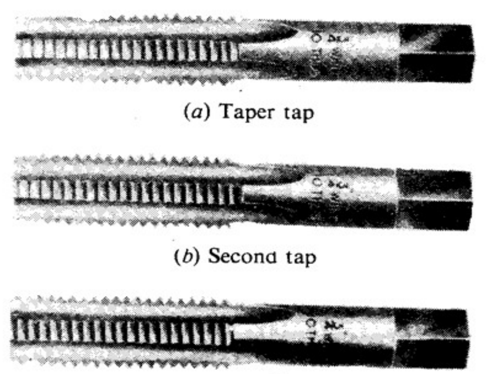


d- **Pipe die:** pipe threads of large diameter but smaller pitch are cut by manually rotating the large wrench (stock) in which the die is fitted through a guide bush.



1.2 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 Figure. 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.



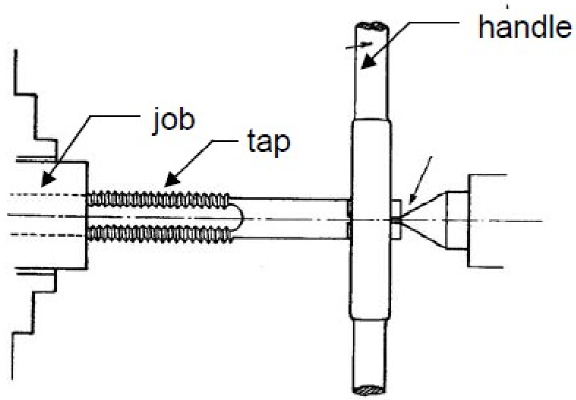
(a) Taper tap

(b) Second tap

(c) Plug tap

Hand operated taps for cutting internal threads.

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.



Hand operated tapping in centre lathe.

2-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.

2.1 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 centres.

2.1.1 External threads :

External threads are produced in centre lathes by various methods:

1- 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

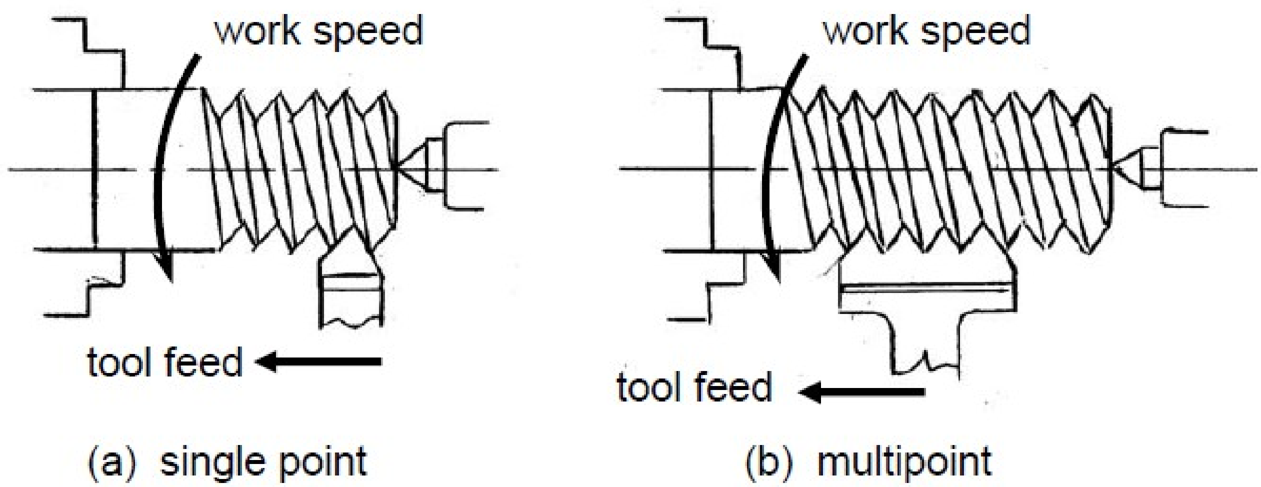


Fig. External threading in lathe by chasing

2- Thread milling: 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;

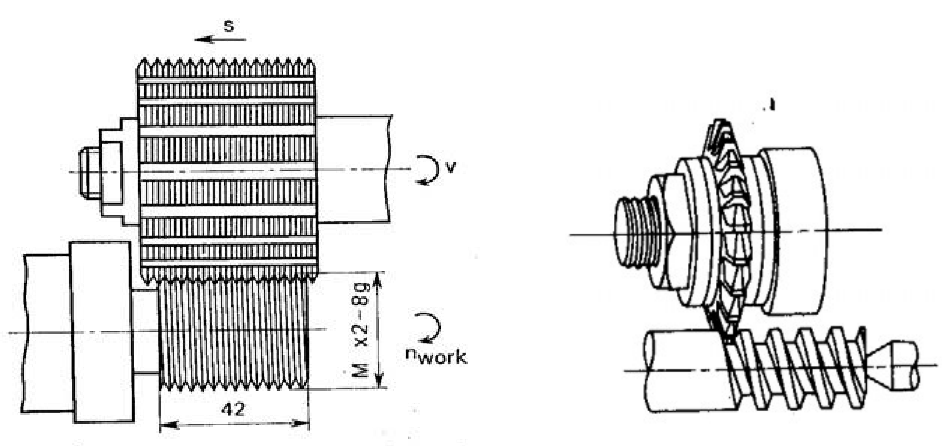


Fig. Thread milling by attachment in centre lathes.

3- 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. The tool is rotated fast but the blank much slowly. This intermittent cut enables more effective lubrication and cooling of the tool.

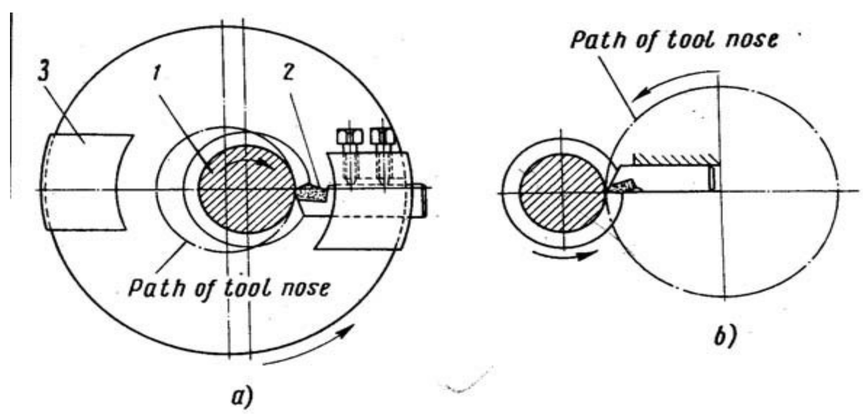


Fig. Thread cutting in centre lathe by rotating tools.

2.1.2 Internal threads:

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

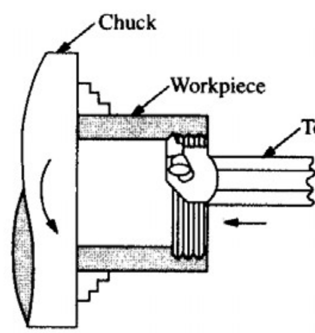
a) Single point tool

b) Machine taps

c) Internal thread milling

a) 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.** Multipoint flat chaser is often used for faster production.

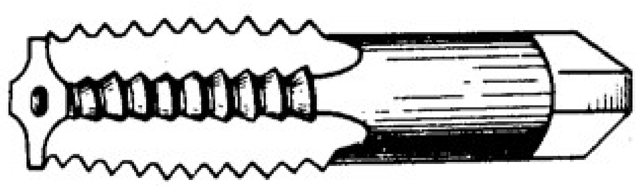


b) Internal threading by taps Internal threads of small length and diameter are cut in drilled holes by different types of taps;

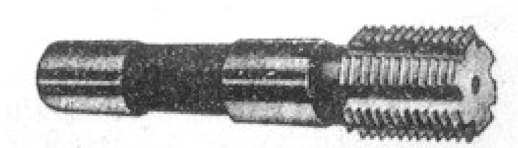
1- Straight solid tap (**Fig.** used for small jobs

2- Taps with adjustable blades – usually for large diameter jobs

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



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



(b) Production of screw threads by thread rolling

In production of screw threads, compared to machining thread rolling,

1- Is generally cold working process

2- Provides higher strength to the threads

3- Does not cause any material loss

4- Does not require that high accuracy and finish of the blank

5- Requires simpler machines and tools

6- Applicable for threads of smaller diameter, shorter length and finer pitch

7- Enables much faster production of small products like screws, bolts, studs etc.

8- Cannot provide that high accuracy

9- Is applicable for relatively softer metals

10- Is used mostly for making external screw threads

11- Needs separate dies for different threads

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

1- 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:

a) **Horizontal:** most convenient and common

b) **Vertical:** occupies less space and facilitates cleaning and lubrication under gravity

c) **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.

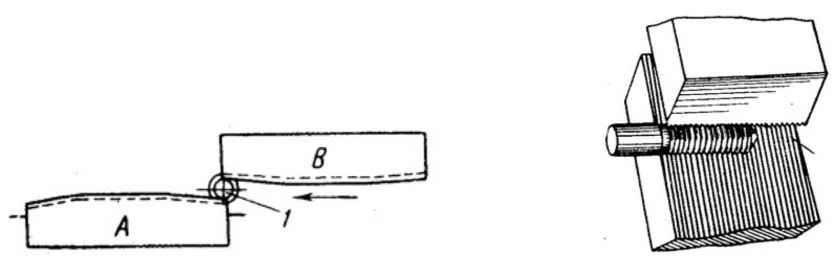


Fig. Principle of thread rolling by flat dies.

2- 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:

a) 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 .

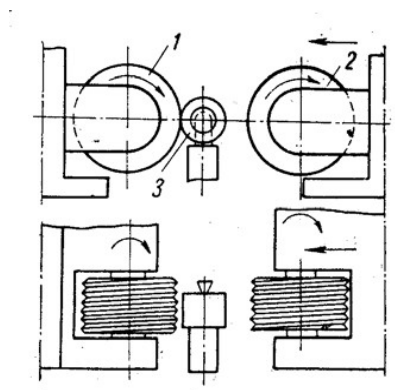


Fig. Principle of thread rolling by circular die with plunge feed

b) 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 archemedian spiral over an angle on one of the dies as indicated in **Fig.** This makes the system simpler by eliminating a linear motion.

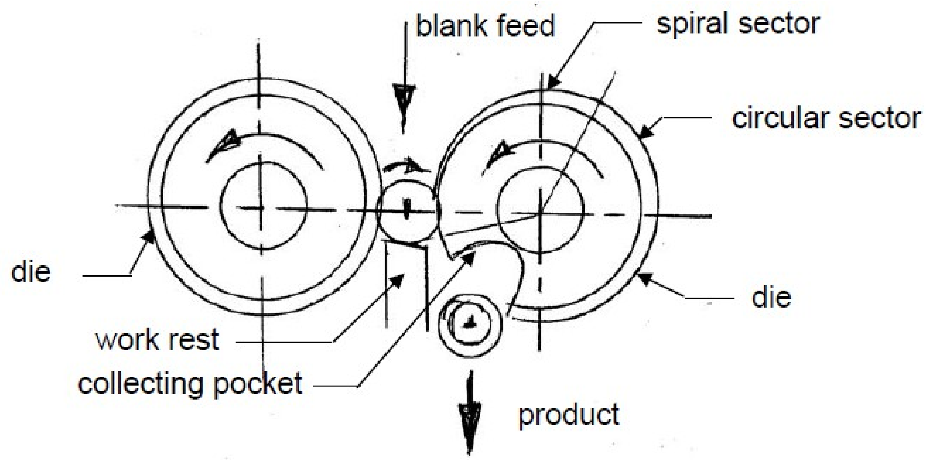


Fig. Thread rolling by spiral feed circular die.

c) 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.

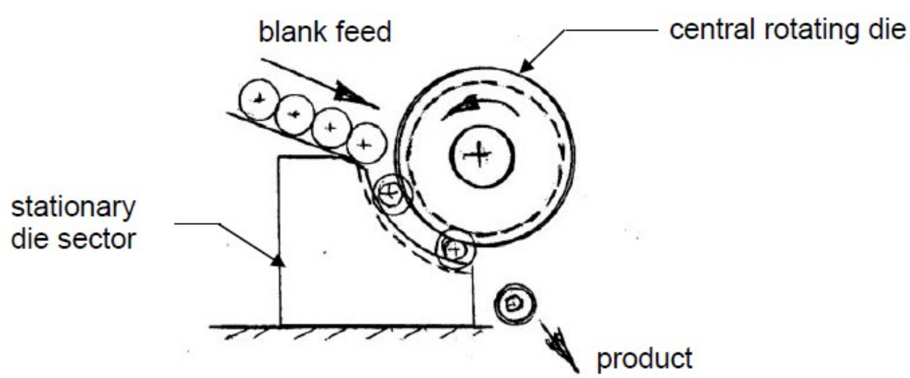


Fig. Thread rolling by sector circular die

(c) 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

1- High dimensional and form accuracy as well as surface finsh are required, e.g., screw threads of precision machines and measuring instruments

2- The threaded parts are essentially hardened and cannot be machined or rolled further, e.g., leadscrews 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

However screw threads are ground in several methods which include;

a) **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.

b) **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.

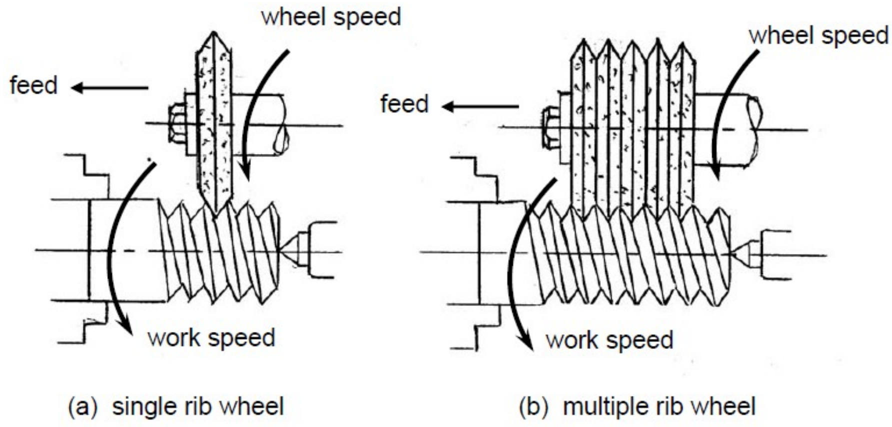


Fig. Grinding of external screw threads.

Change gears

Change gear is the function:

- To transmit motion to lead screw.
- To control the speed ratio between the lead screw and the spindle.

A standard set of change gears is provided from 20 to 120 teeth in steps of 5 and one extra gear (127).

There are two types of gears connection:

1- simple gear train

2- compound gear train

Example: calculate the change gears to cut a single start thread of 1.5mm pitch in a lathe machine having a lead screw of 6mm pitch.

Change gear ratio= $\frac{driver gear(s)}{driven\ gear(s)} = \frac{pitch\ of\ thread(mm)}{pitch\ of\ lead\ screw(mm)}$

$$= \frac{1.5*1}{6} = \frac{1}{4} x \frac{20}{20} = \frac{20}{80}$$ simple gearing

Example: calculate the change gears in a lathe to cut 12 thread per inch and the lead screw has 4mm pitch?

$$change\ gear\ ratio = \frac{drivergear\ (s)}{driven\ gear(s)} = \frac{pitch\ of\ thread(mm)}{pitch\ of\ lead\ screw(mm)}$$

$$\Theta\ pitch = \frac{1}{No.of\ thread\ /\ inch}$$

$$= \frac{\frac{1}{12}*25.4}{4} = \frac{254}{12*4*10} = \frac{127*20}{60*4*20}$$

$$= \frac{127}{80}x\frac{20}{60}$$

Compound gearing

Example: calculate the change gears for cutting 12 threads per inch on a lathe having a lead screw of 4 threads per inch?

$$change\ gear\ ratio = \frac{pitch\ of\ thread(mm)}{pitch\ of\ lead\ screw(mm)}$$

$$= \frac{\frac{1}{12}}{\frac{1}{4}} = \frac{4}{12} = \frac{1}{3}x\frac{20}{20}$$

$$= \frac{20}{60}$$

Simple gearing

Example: Find the change gear ratio for cutting a 4-start thread having a pitch of 1.25mm and the lead screw has a pitch of 4mm?

$$change\ gear\ ratio = \frac{pitch\ of\ thread\ \ xNo.of\ start}{pitch\ of\ lead\ screw}$$

$$= \frac{1.25x4}{4} = \frac{1.25x40}{40} = \frac{50}{40}$$

Simple gearing

Example: calculate the change gear ratio to cut a screw of 4 teeth per inch on a lathe machine having a lead screw of 8mm pitch?

$$\frac{driver}{driven}=\frac{pitch\,of\ screw\,to\,be\,cut}{pitch\,of\ lead\ screw}=\frac{\frac{1}{4}x25.4}{8}=\frac{25.4}{32}$$

$$=\frac{254}{320}=\frac{127}{160}=\frac{127}{80}x\frac{1}{2}=\frac{127}{80}x\frac{1x50}{2x50}$$

$$=\frac{127}{80}x\frac{50}{100}$$ Compound gearing

Example: Determine the value of conicity of taper job having the length of taper 200mm, larger diameter 100mm and smaller diameter 80mm?

$$K=\frac{D_l-D_s}{L}=\frac{100-80}{200}=\frac{20}{200}=\frac{1}{100}$$

Example: Find the angle at which the compound rest is to be swiveled or set with the following data:

Taper portion of the work=100mm

Smaller diameter =50mm

Larger diameter =75mm

$$\tan\alpha=\frac{D_l-D_s}{2L}=\frac{75-50}{2*100}=\frac{1}{8}=0.15$$

$\alpha = 7^{\circ}7`$