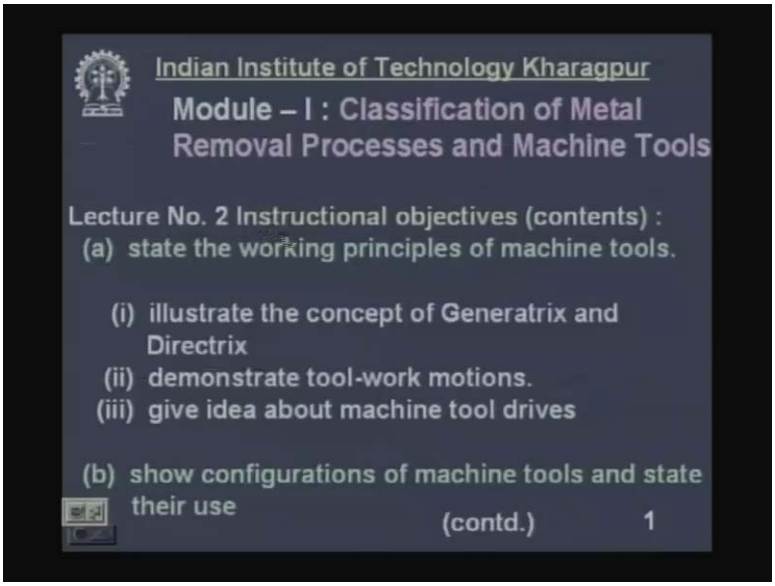
Manufacturing Processes II
Prof. A.B Chattopadhyay
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture No. 2

Instructional objectives – II

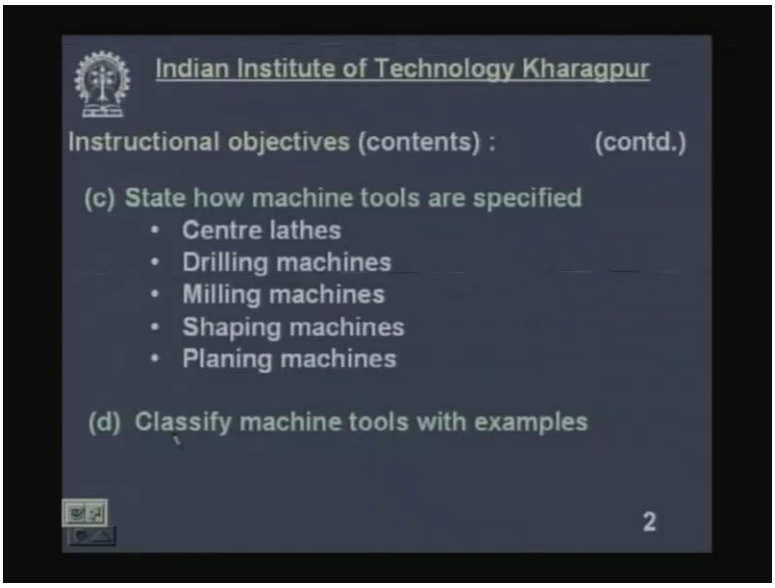
Friends our subject is Manufacturing Processes II and we are continuing Module – I:

(Refer Slide Time: 01:11)



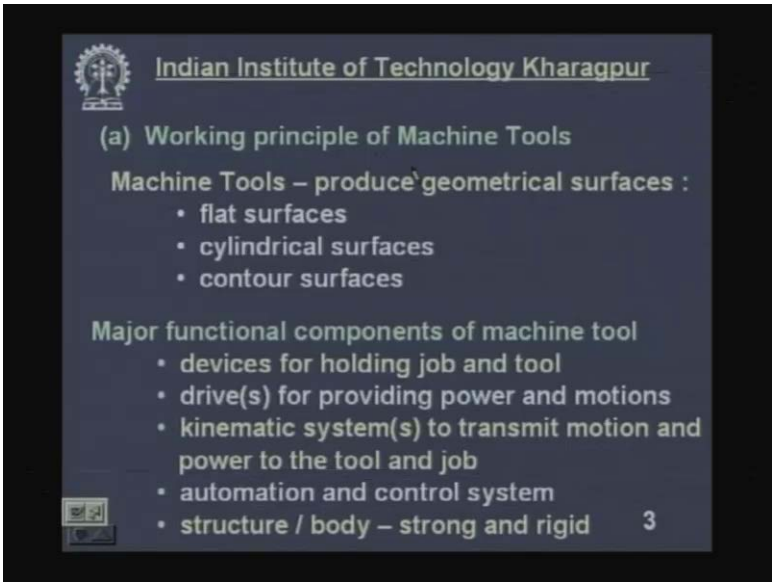
Classification of Metal Removal Processes and Machine Tools and this is the second lecture under the Module - I and the content or instructional objectives of this Lecture 2 are state the working principles of machine tools. The basic principles under that (i) illustrate the concept of Generatrix and Directrix. (ii) demonstrate tool- work motions (iii) deep idea about machine tool drives.
(b) show configurations of machine tools and state their uses

(Refer Slide Time: 01:55)



(c) State how machine tools are specified. The convention of the machine tools, centre lathe, drilling machines, milling machines, shaping machine and planing machines.
and last (d) Classify machine tools with examples.

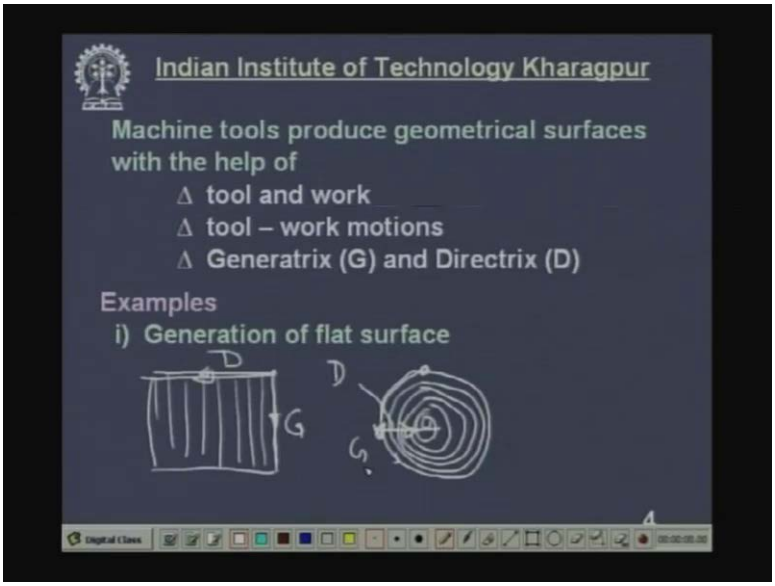
(Refer Slide Time: 02:14)



Now see the working principle of Machine Tools. I remind you the machine tools - they produce geometrical surfaces. This was mentioned in the previous class also. Now when you say geometrical surfaces we mean flat surfaces, cylindrical surfaces and contour surfaces which can be mathematically expressed and redrawn according to program. Only those will be called geometrical surfaces.

Now major function, functional components of machine tools. A machine tool is comprised all machine tools will be comprised of some common features which are devices for holding the job and the tool. For example in lathe, the jobs are held in chuck or the driving plate. Tool is a tool holder or tool post. Next drives, all machine tools require power drive for moving the tool and the job. Now the kinematic systems means the change of mechanisms to transmit motion and power from the source that is motor to the tool and job, and these mechanisms comprising the system can be belt pulley system can be change in sprocket, can be gears, worm and worm wheel ratchet, paul and rack pinion and so on. Next is automation and control system. Some machine tools are semiautomatic or automatic. So some automatic features are there and control system to control the process parameters, speed, and feed depth of cut etcetera. Now the structure or body of the machine tool that is a big housing remains stationary and that should be strong and rigid.

(Refer Slide Time: 04:10)

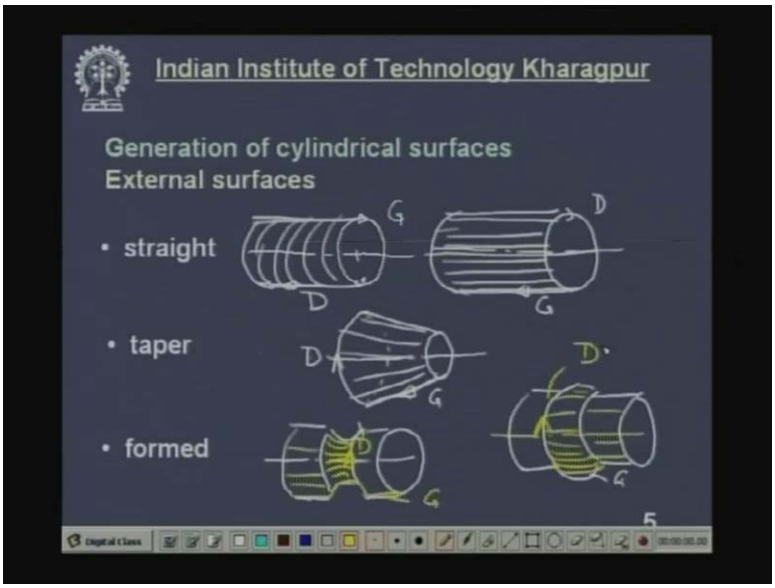


Now machine tools produce geometrical surfaces on the job with the help of the tool. To accomplish that some motions tool work motion are necessary and there are generatrix and directrix. These are two vectors and we have to just understand conceptually and with the help of generatrix and directrix we can explain lot of activities of the machine tools. For example, such generation of flat surface. How this flat surface can be generated? Say we take a point on a plane all right and then it is moved in along a straight path along a straight path up to this much and this is say an arrow.

Let us take a point. Now you take a point and then let it move along a straight line along a straight path and then this straight line will be traversed in a perpendicular direction suppose it is moved in this direction. So this straight line now precedes goes like this along this direction. So the resultant of this moment of the straight line along this path will be the flat surface. This straight line is called generatrix and the other direction along which this straight line or generatrix travel is called directrix simply D directrix. This is one way of making flat surface there can be another method.

Suppose we draw a point and then draw a circle on the plane and this is the generatrix all right and then you reduce the diameter of this circle gradually that means the circle is gradually concentrating towards the center that means it is moving in this direction. So this is the directrix. So combination of this generatrix, the circle original circle and the directrix together will constitute the circle or the surface.

(Refer Slide Time: 06:57)



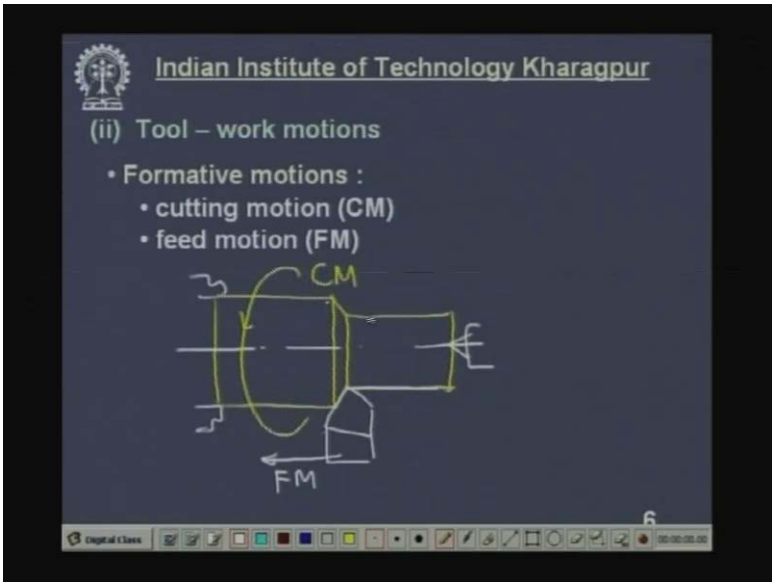
Now see the generation of cylindrical surface. Now cylindrical surface can be straight, taper or formed. Let us take straight surface you take a point. See here a point. Now you rotate this point about an axis. Just imagine an axis and above this axis the point is rotated to form a circle a circular path. This is elliptical because I have shown in the two D. So the generatrix is a ring like circle. Now this ring will be traversed in a direction parallel to this axis and around this axis. So what will happen if this ring is traveling in this direction?

So this surface that we produced by this ring while traveling in this direction say this is called directrix, this will produce the cylindrical surface. Another method we can take a straight line simple a straight line say this is generatrix and now this straight line will be rotated about a parallel axis. Now this will be rotated about this axis like this and this is the direction along which this straight line will be rotated. So what will be the result? So this straight line is now rotating about this axis and this will produce this cylindrical surface. This will be straight because this straight line taken generatrix parallel to the axis. Now taper, if we take this axis of rotation this is the axis of rotation and the generatrix in an inclined fashion this is the generatrix. If the generatrix is rotated above this axis then this will be the rotation of this point and this will rotate like this.

So what will be the result when this straight line will rotate about this axis in the fashion shown then this will produces taper cylindrical surface and this is the directrix along which this straight line generatrix is rotated .Now formed, this is an axis and you take line like this and you rotate this line around this axis and then what will happen? This will form like this. So this will

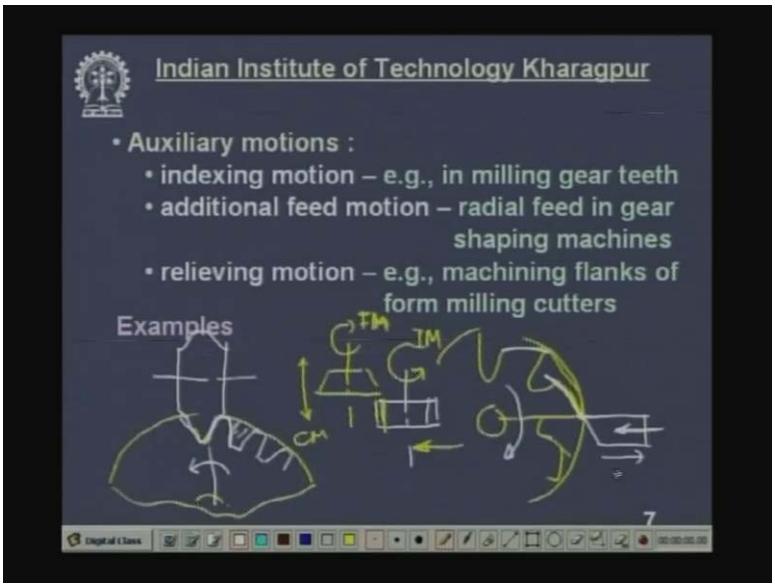
produce a surface like this,that means this is the generatrix. This is the generatrix which is rotated about this axis along this path circular path. So this is the directrix. Now you produce this surface a formed surface. Another example you take a center line and then its line like this. So this kind and now you rotate. So this is the generatrix you rotate about this axis so this will be formed like this. So this will produce this surface so this is generatrix and this is directrix this is how various type of cylindrical surface straight taper formed can be produced.

(Refer Slide Time: 10:58)



Now come to tool work motions. In machine for machining work the cutting tool and the work piece will interact. There should be always relative moment and so both the tool and the work will be subject to motions relative motions. Now there are two kinds of motions essential for machining purpose. One is formative motions. One is cutting motion simply CM other one is feed motion. I also show you what it is. Say for example in turning, suppose here is a rod and this is the center line. Now this is the tool cutting tool it is a turning operation. This side it is held in a chart and this side may be now what are the motions involved. So this job will be rotated about its axis so this is cutting motion and the cutting tool will be moved along this axis of the job this is called feed motion. So combination of this cutting motion and feed motion results this surface by viewing the axis material and this is the finish surface, produced is the finished surface.

(Refer Slide Time: 12:49)

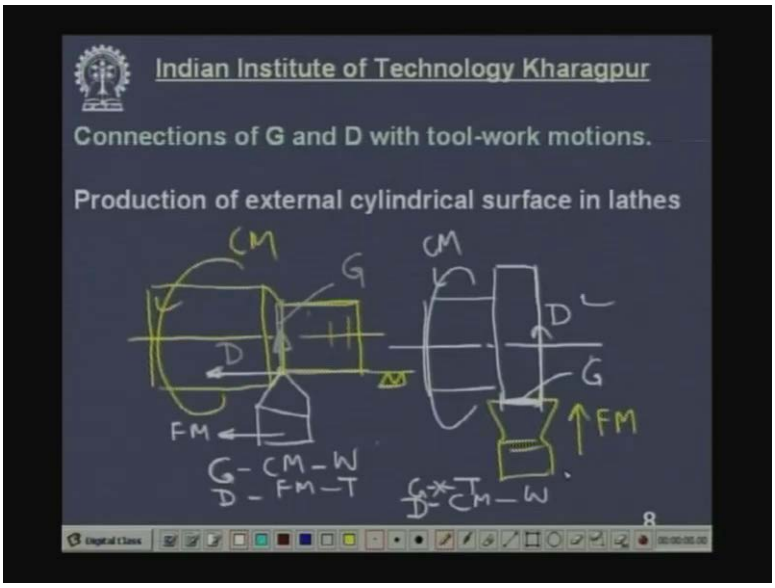


Now next is Auxiliary motions. Another set of motions which may not be compulsory but it may be required sometime. For example, indexing motion. For example - in milling gear teeth. So this is say a gear blank, you take a gear blank, a cylinder all right and now you cut a tooth gap like this with the help of a milling cutter. So you produce this one. So one tooth gap after producing one tooth gap then this will be shifted and this blank will be rotated by another tooth gap and then this will produce another remove material from here. So leaving a cutting a gear teeth in between so this way, this will produce number of teeth by one by one indexing it is called indexing motion. Then say additional feed motion.

If you consider the gear shaping process cutting the gear teeth in gear shaping machine this is the gear flank in which teeth have to be cut and then this is the cutter gear shaping cutter. Now what are the motions involved. First of all the cutting motion the cutter will reciprocate and then this cutting motion, this will rotate feed motion then this will rotate in opposite direction, this is the called indexing motion. In addition to these four motions this work piece has to be flank has to be continuously fed or move towards the cutter so that the full depth of the gear teeth can be cut. So this is call additional feed motion.

Now coming to relative relieving motion. For example machining flanks of form milling. Just imagine, this is the disc we are making manufacturing a milling cutter a form milling cutter so what will be the form of the tooth. This is one tooth, then this is another tooth, then this is another tooth. Now how to cut this profile on the disc? Originally this is a disc now this has to produce so you take one cutting tooth cutting tool like this and this will be rotated in this direction and the cutting tool will be moved in this direction. Resultant of this feed motion and this rotation will produce this point will move along this path this is the locus and this one after completing this path up to from here to here this will come where again then again it will cut this one. So there will be reciprocating motion this is called relieving motion and the lathe in which this kind of work is done is called a relieving lathe.

(Refer Slide Time: 16:12)

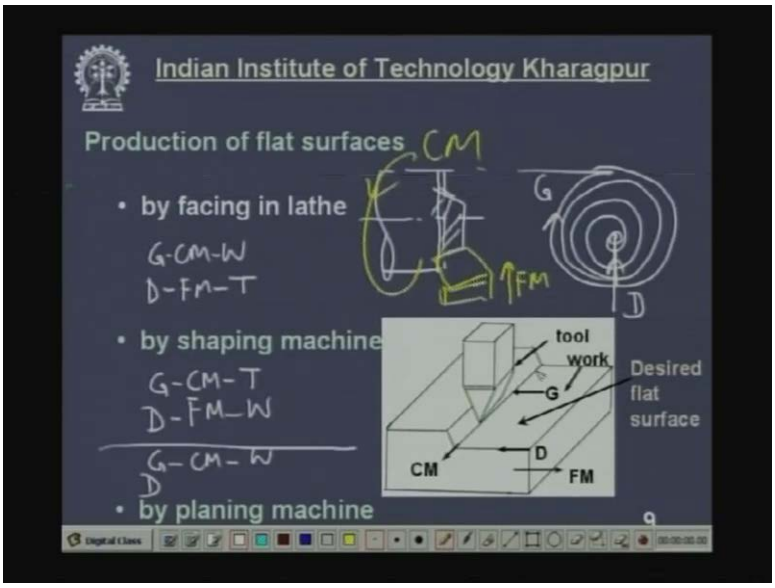


Now connections of generatrix and directrix with tool work motions production of external cylindrical surface in lathe. Now you see where the cutting motion and feed motion will be connected with the generatrix and directrix and this produces cylindrical surface. Now say there is a blank, a rod undergoing turning operation. Now what are the motions? This is feed motion. Cutting motion rotation of the job and this is cutting motion.

Now what we are producing? We are producing this surface, this cylindrical pre surface and this is pre cylinder so what is needed? Rotation of this job that is related to a job this point of the tool tip. So this will create a rotation along this path so this is the generatrix this is a generatrix and because the feed motion this point is also moving in this direction so this is the directrix. Now here you observe that, the generatrix is obtained from the cutting motion. So generatrix is connected with the cutting motion it is imparted to the job work whereas the directrix is connected with the feed motion of the tool feed motion and imparted to the cutting tool.

So this is the indication how this generatrix and directrix are connected with the tool and work as well as cutting motion and feed motion. Now the cylindrical surface can be produced in another way. Suppose there is a rod here is a surface or a disc collar and this is the rod now you put the cutting tool in this fashion. The job w will give the feed motion and the job will rotate this is cutting motion. Now here how do you get it. So this is the generatrix with the part of the cutting tool and now this is traveling along this path the circular path. So this is the directrix and this is the generatrix from here to here. So generatrix is connected with the tool and directrix is connected with the job and this is connected with. So generatrix is not connected with any motion is connected with the tool. So there is no motion but it is connected with the tool say tool and what about directrix? Directrix is connected with the cutting motion and the work piece. This is how the cylindrical surface is produced.

(Refer Slide Time: 19:47)



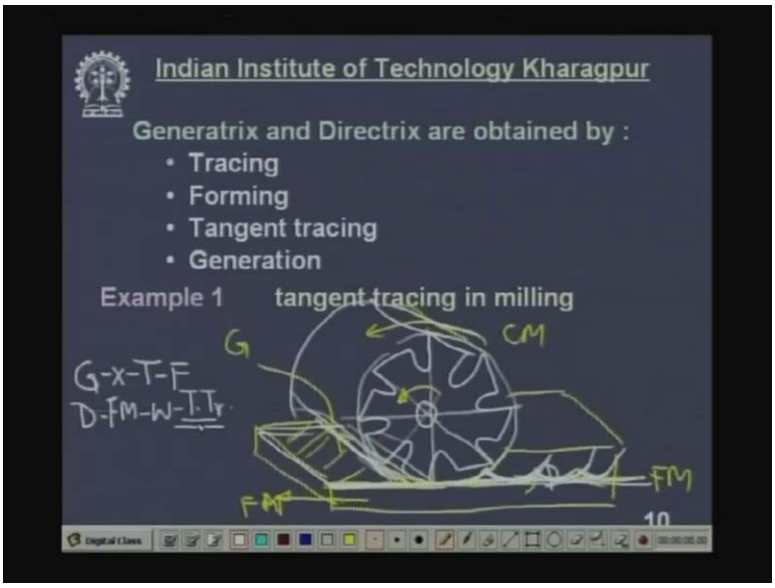
Now production of flat surfaces by facing in lathe. The people believe that lathe produces only cylindrical surface but flat surface can also be produced in lathe how? This is a rod and this layer of material and this is the cutting tool. This cutting tool travels in this direction. So this is feed motion and then the job rotates that is cutting motion. So if you look see from this side here this is the work piece outer periphery. So when this point is fixed the job rotates this locus of the contact point. So this is generatrix. Now the tool moves inside and remove this material gradually so this moves inside that means the diameter of the circle is gradually reduced and the metal is totally removed so this is the directrix.

So directrix is connected with the feed motion and the tool and generatrix with the cutting motion with the job and directrix with the feed motion imparted to the tool this is how flat surface can be produced in lathe. Now next in shaping machine how flat surface are producing shaping machine? Now in shaping machine this is the cutting tool, this is the work piece, this is the flat surface which is being produced and this is the excess material which has to be removed gradually. Now what are the motions involved. The cutting tool reciprocates in this direction. So tip of the tool moves along this path. So that is a cutting motion and the work piece moves in this direction slowly so this is the feed motion. Now come to this point. So this surface flat surface has to be produced. So this cutting motion which is a straight line is equivalent to the generatrix so this is the generatrix and this generatrix moves along this path the directrix path which is parallel to feed motion.

So this feed motion produces the directrix and the cutting motion impart with the tool produces the generatrix and we get the flat surface. So here the generatrix this one is connected with cutting motion imparted to the tool and directrix it is obtained from the feed motion imparted to the job. Now come to planing machine. Planing machine is very similar to shaping machine. Only difference so far as generatrix and directrix concerned in shaping machine the tool reciprocates produces cutting motion but in plaining machine the tool remains almost fixed the job reciprocates and that gives the cutting motion.

So cutting motion is obtain by the traveling of the work piece and that produces generatrix and directrix the cutting tool travels slowly instead of the job. So in case of plaining machine in case of plain machine generatrix connected with the cutting motion obtained by reciprocation of the job work piece and directrix this most this directrix will be accomplished by slow moment of the tool in this direction so this is feed motion and this is tool. This is how is produced a shaping and plaining machine. Now come to production of flat surfaces.

(Refer Slide Time: 24:02)



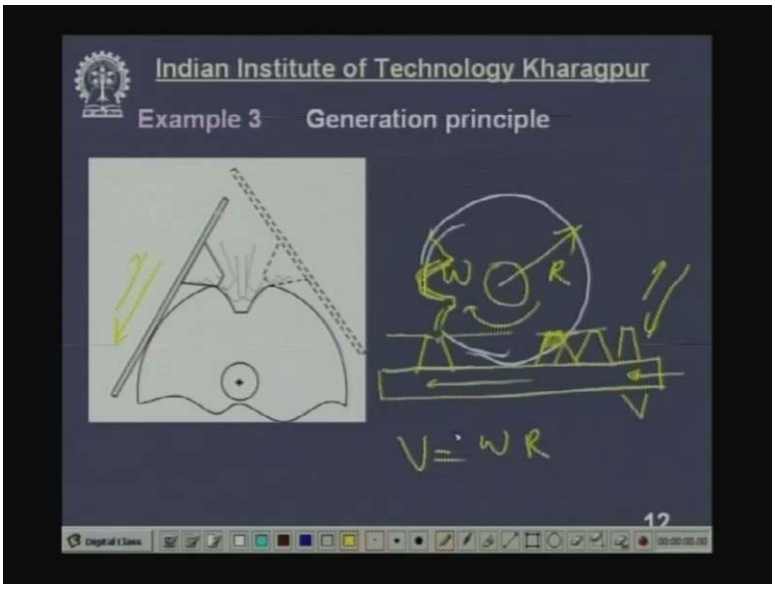
Now the generatrix and directrix are obtained by now. Here you see the generatrix and directrix are nothing but two lines. They can be straight line or they may not be straight line they can curved line but how are the obtained? Tracing, the examples are shown in case of turning shaping there that generatrix and directrix are obtained just as a locus of a moving point that is by tracing. So that gives an example of tracing, forming the form of the tool will give the generatrix. Then tangent tracing is another method and generation. Now I shall show you the different method. Say example, tangent tracing. How that generatrix or directrix especially directrix will be obtained by tangent tracing in case of milling. Say, suppose this is the milling cutter, a slab milling cutter which has got number of teeth and this removes material from the work piece this is the blank.

Now this rotates in this direction. So this is cutting motion and the job moves in this direction that is feed motion and what does it do? It produces flat surface, finished surface and this produces this flat surface. Now this is slab milling cutter which has certain length so this has got a length and the work piece. So this is the flat surface which is getting produced. So when this cutter which is like a roller rest on the flat surface is a line contact this line of contact this line of contact is generatrix. Now here since it is a straight roller. This will be a straight line but if it is a curved surface a peculiar shape then this will be also a non straight line curve I am coming to that one later on.

but so this is generatrix and because of the feed motion this point is moving in this direction so this is the directrix .So result of this directrix and this generatrix so this straight line is moving gradually in this direction a resulting this flat surface. Now what we can write so generatrix now here again you just observe this cutting tool removes the material along this path.

Now next cutting tool will follow this path the next cutting tool will follow this path it will go like this so this is the actual path but the directrix is straight line that means if you just imagine a straight line tangent to this curve path or the locus of the tip of the tool then this is the directrix which is nothing but tangent to the instantaneous locus of the tip and this is the example of tangent tracing this is called tangent tracing. Therefore we obtain generatrix as it is not connected with any motion so no connection with motion it is connected with a tool so tool the form of the tool and we obtain by the form of the tool form of the tool it can be straight line it can be curved like this and then directrix it is connected with the feed motion of the work piece and it is obtained by tangent tracing TTR which stands for tangent tracing. This is an example tangent tracing.

(Refer Slide Time: 28:44)

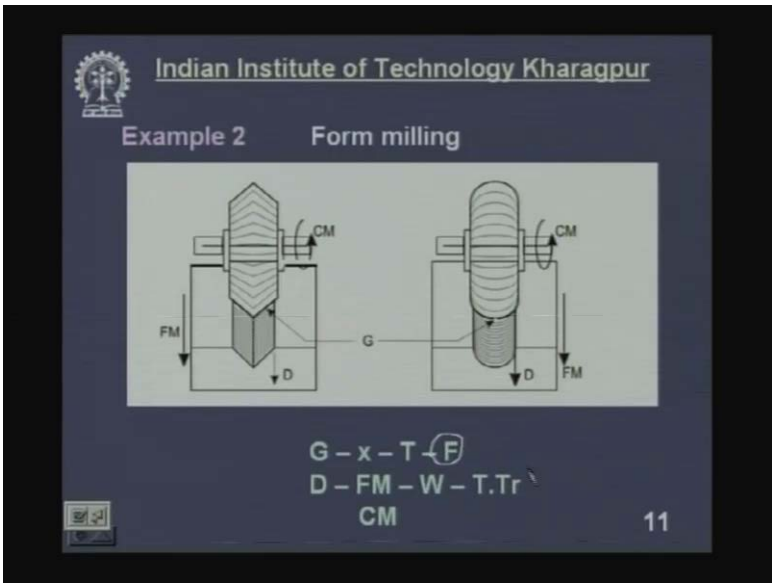


Next you will see generation process. In generation process, we get complicated surface we get complicated surfaces by simpler form of the tool that is the unique characteristics of generation.
For example, we want to produce teeth of gear and then these are the tooth gap. Here is a cutter fitted on a flank. Now if you rotate this flank or roll on the surface this cutting protruded portion will gradually penetrate into this material and then gradually get out and with a continuous rolling and finally this will leave an impression like this or cavity. So this form of the cavity is not exactly same as the cutting tooth. Now here how it can enter this cutting tooth actually reciprocates perpendicular to the board here or parallel to the axis of the gear blank. So this is the cutting motion. This reciprocates like this perpendicular to the plate and then it we get this one it can be understood by another method.

Suppose this is the disc for a gear blank on which the gear teeth have to be produced and this is the plate or flank resting tangent to the surface just like this tangent to the surface. Now this one is moving in this direction with the velocity V and this one is rotating with an angular velocity omega and radius is R such that it is a rolling action. So for rolling, V must be equal to omega R. At this point there is no steady moment. Now if we have one protrusion like this and now this is reciprocating perpendicular to the board or parallel to the axis of the gear blank that is cutting motion now it is gradually moving in this direction this is also rotating. Now this will gradually come close to this and then penetrating to this. When this will penetrate, this will remove this material and finally when this cutter with these protrusion or cutting tooth will reach here by this time a tooth gap will be produced. So this material will be removed so we get tooth gap.

Now if we have another tooth side by side say two tooth, then we will get two tooth gap simultaneously and in between two tooth gap, we get one gear tooth. So this is example of generation with the help of very simple type of tool you get a complex shapes in volume.

(Refer Slide Time: 32:15)

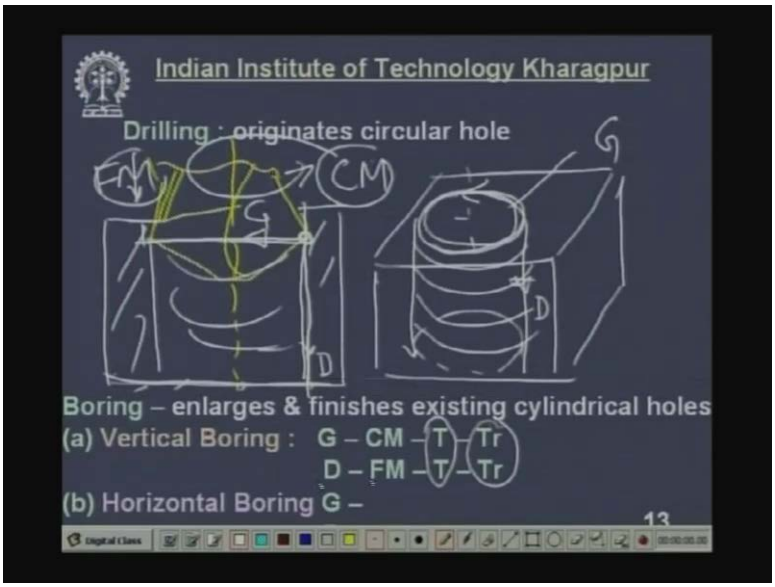


Now here you see Form milling. In this case of Form milling what we are actually producing this is the milling cutter. This shows the milling cutter and this is the work piece a chemical block in which a slot has to be cut. A group a V group has to be cut. Now we take the cutter with the V group V shape so getting this particular shape of the group metal removal. So this portion is the generatrix and now these generatrix when it travels along this path the directrix we get this slot.

Similarly in this case if we want a circular group so this is the generatrix and this will travel along this direction that is the directrix we get this profile. Now what are the motions involved? The cutter is rotating cutting motion job is moving in this direction feed motion the form of the tool gives the generatrix and traveling of the feed motion of the job gives the directrix. So in this is similar here. So you get this is the generatrix. In this case the form of the tool is nothing but the generatrix. This is the generatrix. Now, in this case generatrix is not connected with any

motion it is connected with the form of the tool and but this form of the tool but what about the directrix? Directrix is with the feed motion imparted to the work piece and this is obtained by tangent tracing because it is milling process and the cutting motion is not connected with either generatrix or directrix this is called Form milling.

(Refer Slide Time: 34:11)



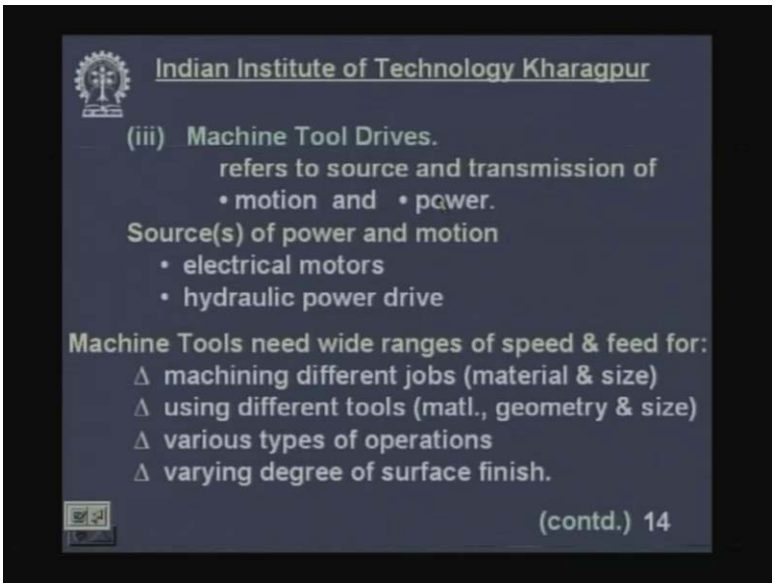
Now come to drilling operation. In drilling operation what is what does drilling do? Drilling or drills produces or originate circular hole or straight cylindrical hole in solid body in a machine tool called drilling machine. So it is a hole, hole means a cylindrical surface. Now here, suppose you want to make a hole, this is the upper surface and you are producing a hole in a solid body like this and then this is the generatrix a circular ring like. So this is the generatrix and this ring will be traveled along this direction travels to the plane parallel to the axis and then you get the hole inside.

So this is the generatrix and this is the directrix. Result of these two is internal cylindrical hole. Now practically, it is like this say this is the drill bit and it is axis of rotation of the drill bit. Now it is producing hole in a block. So what are the motions? First motion is the cutting motion. The job rotate, the cutting tool rotates, no the cutting tool rotates not the job and the cutting tool moves downward that is feed motion and the job remains stationary it does not move at all. The cutting motion given to the tool and the feed motion result is now this is the point or contact. Now when this is subjected to rotation now this point will trace a circle so this is a circle. This is a circle this is the generatrix and the feed motion that the cutting tool gradually moves downward. So this is the feed motion and this is the directrix what is the result? Result is the hole we make this cylindrical internal surface.

Now what is boring, vertical boring? Now boring can be similar to drilling, but difference is drilling originate soil in salt body but boring enlarges and finishes existing cylindrical hole. So it gives more finish and enlarges hole. Now boring machine may be two types. Vertical boring and Horizontal boring. In vertical boring, the configuration that is generatrix is connected with the

cutting motion imparted to the tool and obtained by tracing. Feed motion is also connected to the sorry directrix is connected to the feed motion and tool. So you see both are tool and obtained by tracing. But in horizontal boring, only difference will be the feed motion will be given to the work piece. So this will be W in case of horizontal boring.

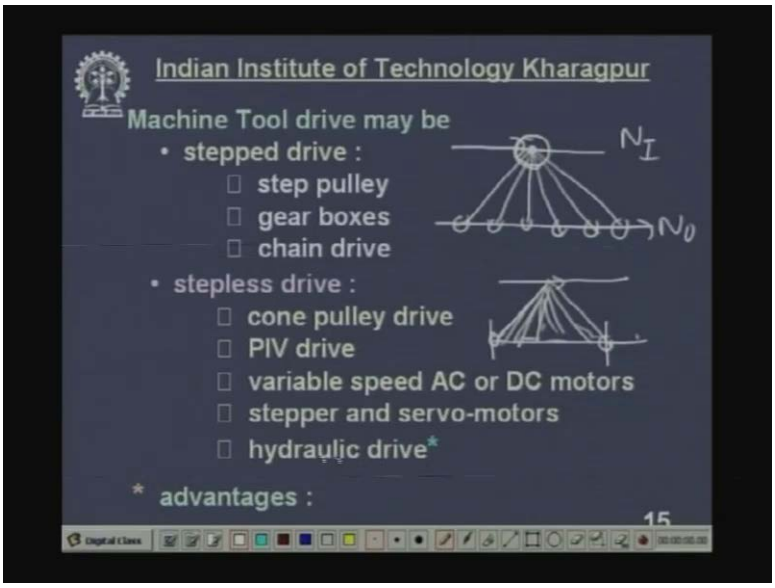
(Refer Slide Time: 37:36)



Now, Machine Tool Drives. Machine tool requires drive, if the machine tool drive refers to source and transmission of motion and power say electric motors that transmit power and motion both to the cutting tool and the work piece. The sources of power and motion can be electrical motors different types for hydraulic power pack, hydraulic drive and most common is more common is electrical motors. Now beside this sources of power drive also include some devices. For machine tools need wide ranges of speed and feed cutting velocity and feed why for machining different jobs say material different materials are machined at different speeds.

Strong materials, hard materials at low speed, low velocity and softer materials at faster speed.
If the job diameter is very large so speed should be low, RPM should be low and if the job diameter is slow then RPM should be large. Using different tool materials now, when you use very good tool material like carbide we can machine at high speed but if the work tool material is high speed steel, then speed has to be maintained low. Now various types of operations:
Turning operation, finishing operation are done at high speed but, operations like reaming, thread cutting should be done at low speed. So the machine tool should be able to provide all these range of speeds varying degree of surface finish. If we want very good surface finish, the speed should be very high and so on.

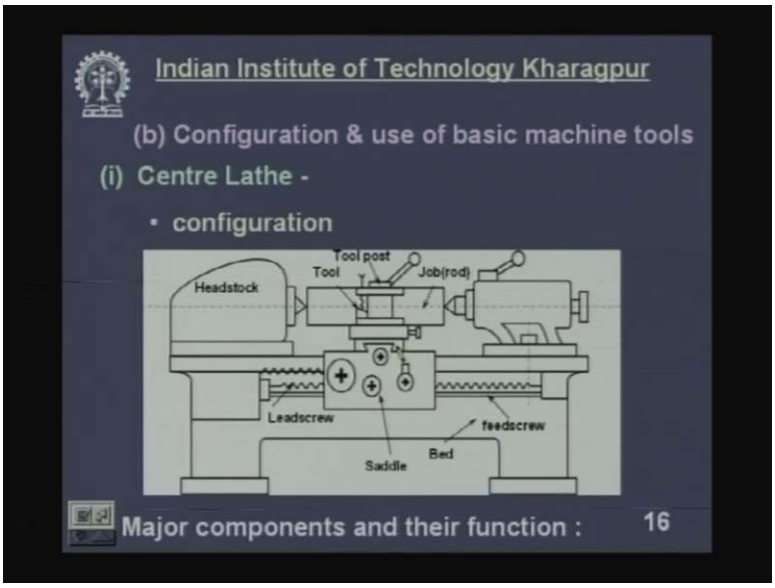
(Refer Slide Time: 39:14)



Now the machine tool drive may be two kinds: stepped drive and stepless drive. What is the stepped drive? Stepped drive means suppose this is the input shaft which is rotating at a particular RPM, now this is the output shaft from one input motion we need large number of motions or speeds or RPM say one, two, three, four, five, six it can be twelve, eighteen, twenty-four like that. This is called stepped drive that means from one input speed we get few discrete definite number of and values of speed, this is called stepped drive. It is more economic. It is obtained by step pulley system, gear boxes, chain drive and so on.

But in another case we discussed stepless drive, where from inputs simple one input speed we need speed to the output shaft minimum or maximum or any speed in between in finite number of speeds this is called stepless drive. Say five hundred RPM, five hundred one RPM, three hundred ninety-nine RPM, any RPM from in between these two ranges. Now this can be obtained by cone pulley drive, PIV drive Positive Infinitely Variable speed drive, variable speed AC and DC motors, stepper motors and servomotors, now hydraulic drive has got certain advantages and disadvantages over electrical drive. Disadvantage is it occupies lot of space leakage problem and more floor space occupied, but there are advantages first of all it is smooth operation, it is stepless drive, and it gives self - lubrication. Anyway even then the motor drives are more common.

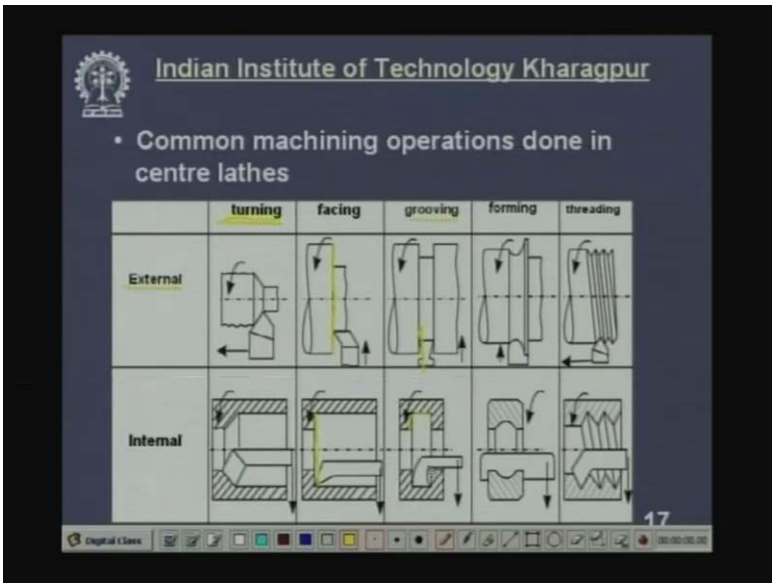
(Refer Slide Time: 41:18)



Now come to configuration and use of some basic machine tools. There are hundred types of machine tools or thousand types but now we are taking about basic machine tools. So central lathe, again lathes are of twenty-four types, we are talking about centre lathe which is most common and this is the configuration of a centre lathe. Now what are the major components? before going to the component let us see the work piece. This is the work piece and this is the cutting tool which produces which moves parallel to the axis feed motion and the job rotates about its axis. So job is such a rotation and tool actual motion.

Now this called head stock. Function of the head stock is to hold the job as well as transmit power and motion from this motor from here to this job. This is the tail stock. What is function of the tail stock? It gives support to the job, it also sometime hold some cutting tool like drill or reamer for doing that kind of work reaming and drilling and the cutting tool is mounted on the tool holder which is on the tool post, tool post on the compound slide, compound slide on the cross slide, cross slide on the carriage. This carriage which travels along this bed. So the first important part is headstock, then tailstock, then carriage. This travels over the bed. So this is the bed and the bed is standing on two columns and the two columns rest on what is called foundation.

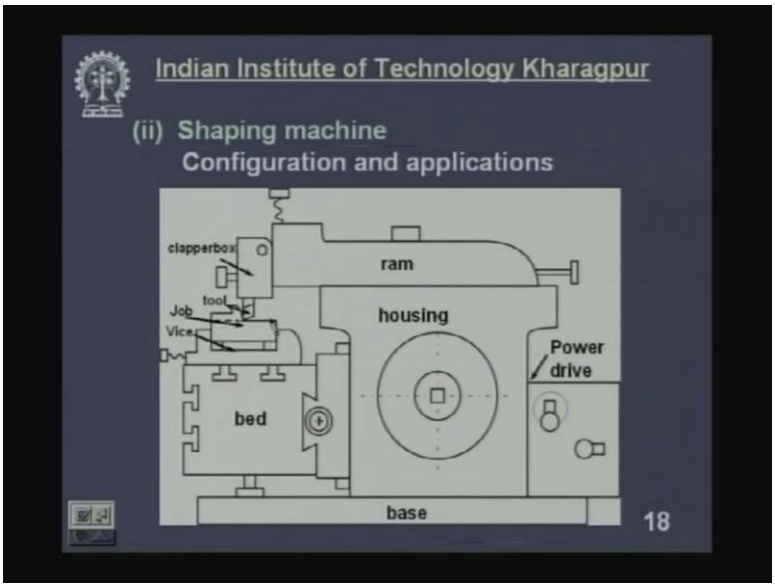
(Refer Slide Time: 43:02)



What are the operations? Common operations are turning. Now the turning can be external or it can be internal. Now this external turning, job is subject to rotation and the tool is given the feed motion. Internal turning is similar to boring like this. Now facing this surface is getting produced flat surface. So the job rotates and the tool moves. This is the internal facing. This surface is getting faced then grooving we produce a groove this is the cylindrical surface by moving the tool inside radially like this feed motion and job rotates cutting motion we get this groove and this is internal groove produced in a cylindrical surface.

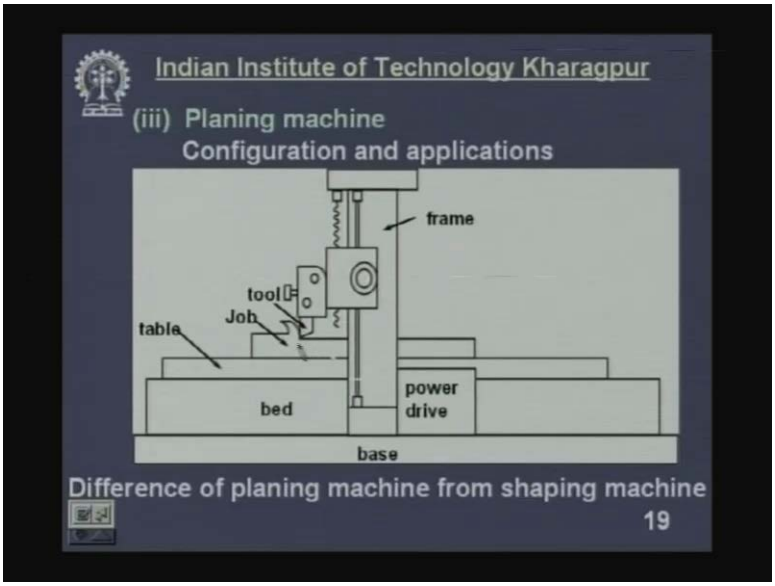
Now we want a particular form of the job particular form like this. This is called forming for that the cutting tool should pass at the same form for the profile replica of the form of the job. So this is external forming and this is internal forming. So we want an internal form like this and this is the cutting tool which has also got similar form. Now, when the job rotates and this is moved in this direction called feed motion we get this particular profile and thread cutting threading so this is a number of threads are cut by for the moment's rotation of the job and faster feed of the tool and this is internal thread cutting.

(Refer Slide Time: 44:54)



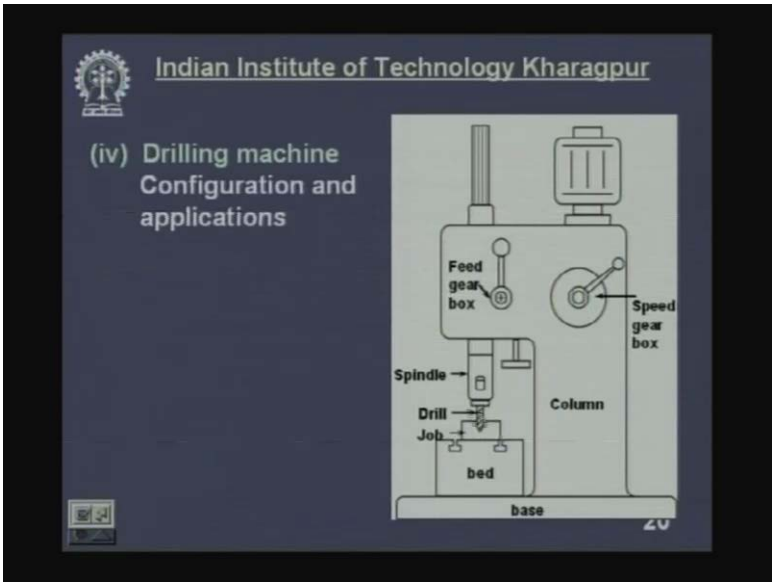
Now come to shaping machine. Shaping machine produces flat surface. Flat surface may be horizontal, vertical or inclined. This is the cutting tool, the cutting tool tip that cutting tool is mounted on the clapper box which is fitted into the ram. The ram reciprocates with a last stroke length on the housing or the bed or structure. So this traveling of the tool reciprocation gives the required cutting motion. What about the work piece? This work piece is mounted on the vice. Vice is fitted onto the table and the table moves along with the job in a perpendicular in a direction perpendicular to the cutting motion in this direction. So here along this axis perpendicular to the plane of this diagram and then we get flat surface. This is the flat surface here and this produces flat surface.

(Refer Slide Time: 45:57)



Now, the plaining machine. As I you told earlier the plaining machine and shaping machine are basically same. In shaping machine the tool reciprocates, in plaining machine the job, this is the work piece which is mounted on the table that reciprocates onto the bed. This is the bed where as in plaining in shaping machine the feed motion the transverse feed motion is given to the job it moving perpendicular to the plane horizontally slowly but in shaping in plaining machine the feed motion the slow feed motions given to the tool. So this will move in this direction perpendicular to the cutting motion. So what is the difference of plaining machine from shaping machine ? First difference is that in generatrix and directrix or the cutting motion is given to the job in plaining machine onto the tool on shaping machine. Feed motion is given to the tool in plaining machine and job in shaping machine. Another big difference is the shaping machine is used for small jobs low duty small jobs, but plaining machine is used for heavy duty jobs heavy jobs.

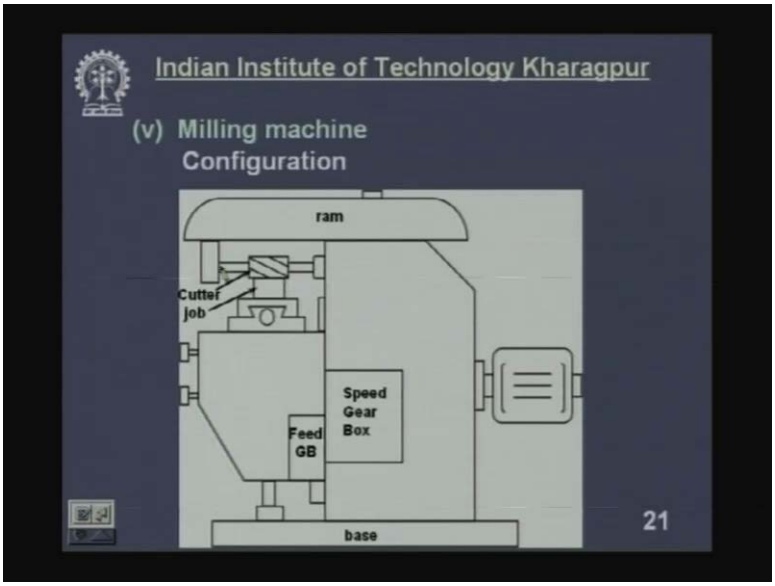
(Refer Slide Time: 47:11)



Now come to drilling machine. What is the configuration? This is the drill bit which rotates about its own axis and it moves downward gradually that is called feed motion. So both the feed motion and cutting motions given to the drill bit. Job remains stationary onto the bed resting on the base and this is called the structure or body of the drilling machine and this is the spindle which moves up and down. It rotates as well as it moves up and down and this is the power source and this is the gear box which changes the rate of speed the RPM of the spindle as well as the rate of travel of the feed motion.

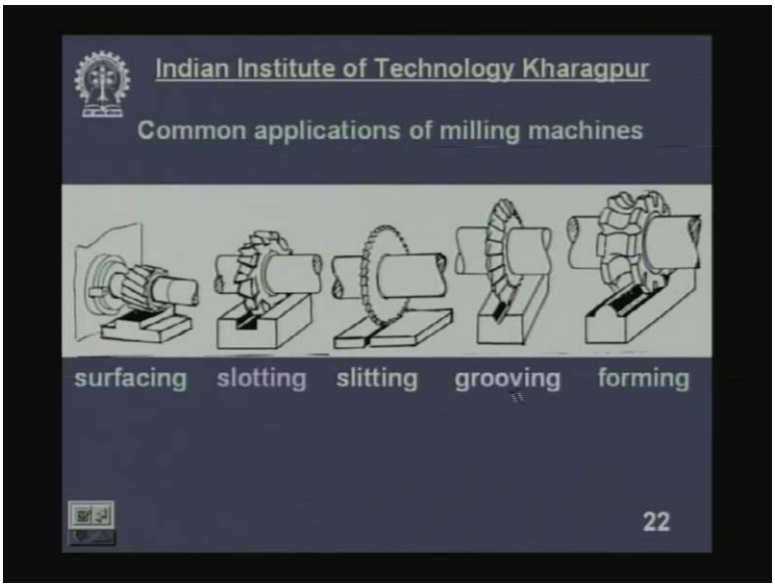
This produces what for the applications. An application is generally to produce cylindrical state, cylindrical hole of different diameter. This can be also used for counter boring, counter sinking and some similar operations like taping with a special taping attachment like that.

(Refer Slide Time: 48:13)



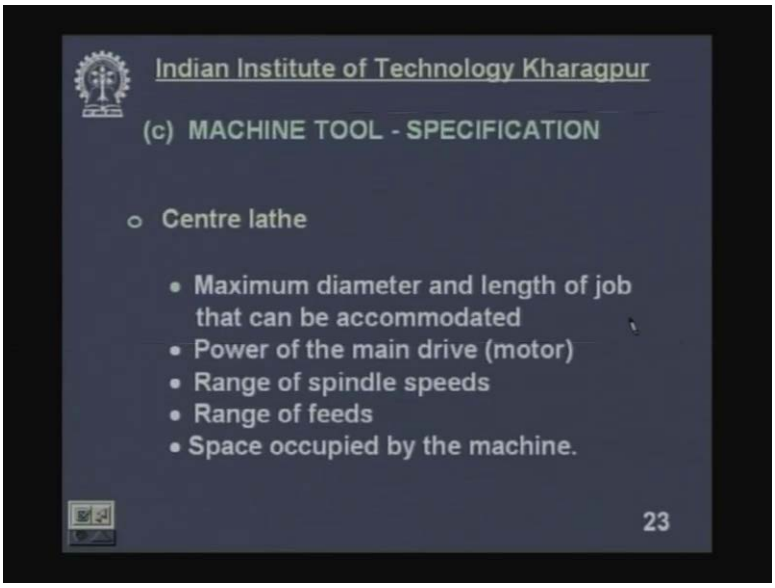
Now come to milling machine. In milling machine this is the cutter and this is the work piece. So this rotates about this or on this arbuor. The arbuor is receiving motion from this source and there is a gear box inside and this is the ram which can be adjusted time to time, the position can be adjusted the work piece is mounted on the table and table is fitted onto the bed the bed has got three moments - the work piece along with the table and bed can move axially perpendicular to this plane of the plate and the transverse motion in this direction and vertical moment upward and then downward resulting various surfaces and this is the speed gear box which you know splits the speed into number as this is a speed gear box. Now what are the functions it does?

(Refer Slide Time: 49:17)



It does various kinds of operations. Common applications of milling machines. Now common there can be some uncommon applications also. For example, surfacing. This is the milling cutter, this is the work piece producing flat surface. Here slotting this cutter produce a slot a straight slot. Slitting a plate is cut into two pieces by a slitting cutter. Now here you make a group a V group called operations called grooving by a grooving cutter and now produce a form contour and that is called forming and a cutting tool has also got the similar configuration here which will be the replica of the profile of the job to be developed. So this is milling.

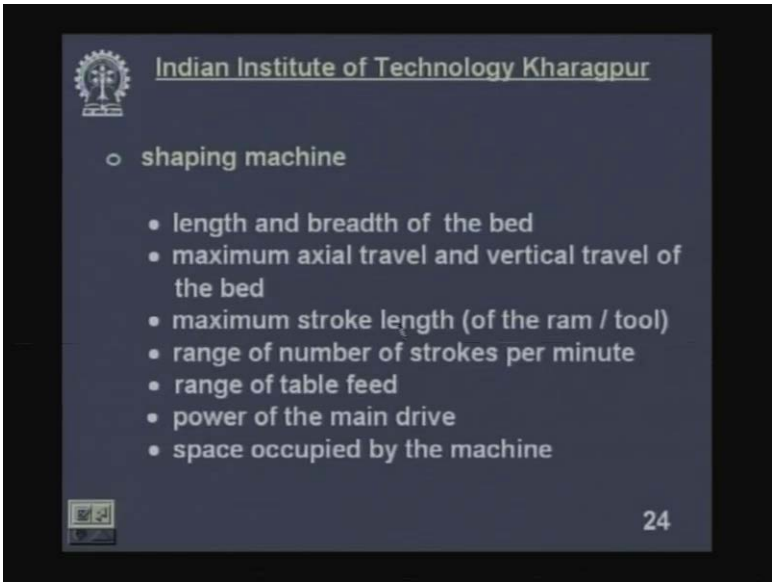
(Refer Slide Time: 50:02)



Now come to machine tools specification. How to specify machine tools? When you go to market for purchasing a lathe, you have to tell what kind of lathe you want, what amount of power, what kind of lathe, then what should be the size of the lathe, and what can and all these things you should be very clear you should very clearly mention. Otherwise you cannot purchase it procure it.

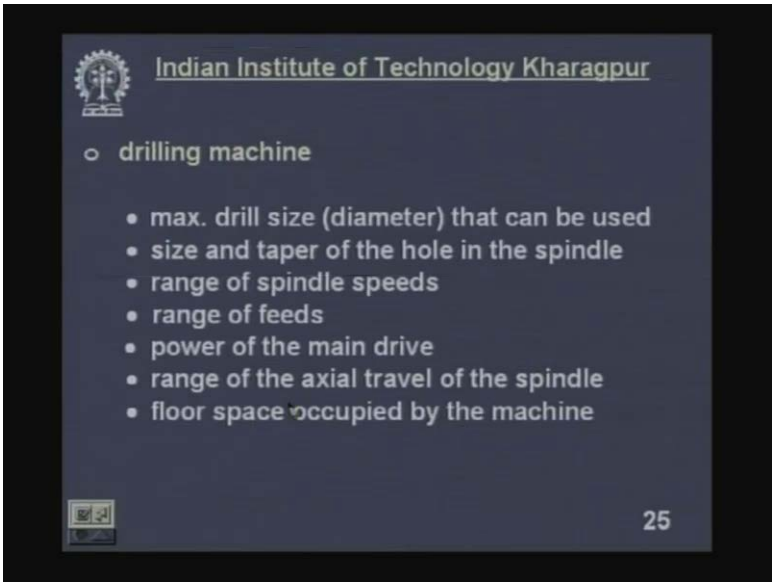
Now how lathes are specified? For example, centre lathes maximum diameter and length of the job that can be accumulated. Earlier days the lathe was specified by length of the bed, length of the bed is not that important but what is more important maximum length of the job and maximum diameter of the job that can be accumulated the most important part that you have to mention power of the main drive that is called the kilowatt, then range of spindle speeds what is the minimum RPM what is the maximum RPM, what are the intermediate speeds then range of feeds rate of travel the millimeter per revolution different feeds are there slow feed high feed medium feed so range of feed has to be specified then space occupied by the machine. Earlier the volume of the machine or weight of the machine was considered as the specification but now it has been realized that is no the space occupied is very important and expensive should be considered.

(Refer Slide Time: 51:31)



Now say for shaping machine. In shaping machine the length and breadth of the bed will decide the length and breadth of the job will be first specified then, maximum axial travel and vertical travel of the bed. The length of the travel is in two directions. Maximum stroke length of the cutting tool, range of number of strokes per minute so the number of strokes per minute can be slow or can be fast range of table feed you know the feed motion given to the table so that should be fast slow and this range should be mentioned power of the main drive say eleven kilowatt or five point five kilowatt like that and similarly space occupied by the machine.

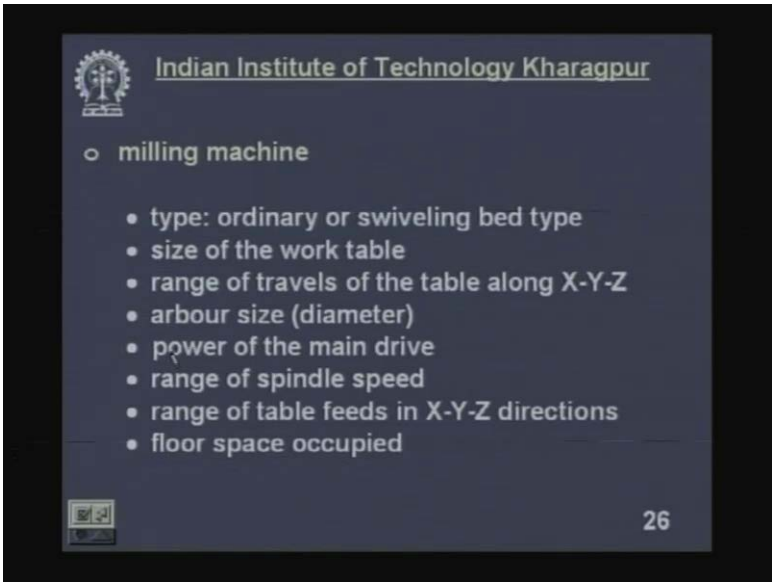
(Refer Slide Time: 52:13)



Coming to drilling machine, maximum drill size maximum is the diameter of the drill which will decide the maximum diameter of the hole that can be produced, size and taper of the hole in the

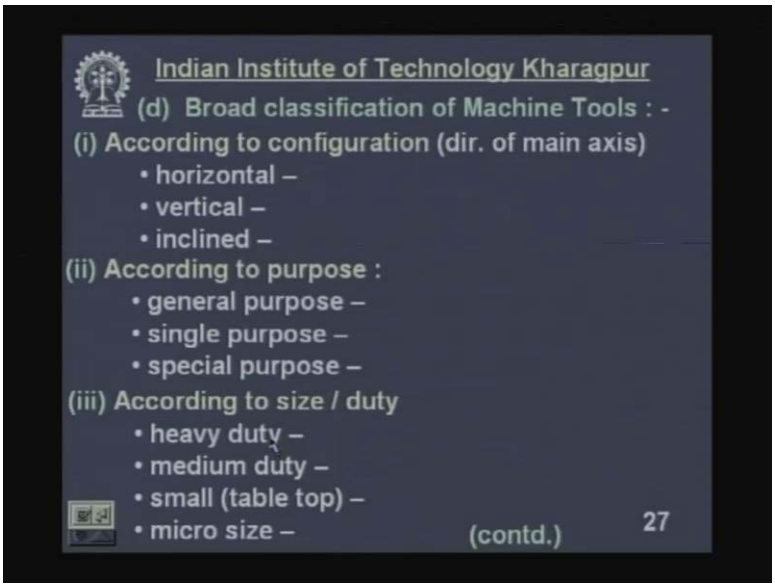
spindle say bore stepper. Range of spindle speeds, what is the minimum RPM? What is the maximum RPM? Number of speeds and what are the steps, then range of feeds of the tool travel power of the main drive, range of the axial travel of the spindle and floor space occupied.

(Refer Slide Time: 52:42)



Now milling machine, type - ordinary type or swiveling bed type. The bed can be rotated slightly in addition to xyz moment size of the work piece work table range of travels of the table along x direction, y direction, z directions. Arbour size, the diameter the board diameter of the cutter will be decided by the arbuor size. Power of the main drive say kilowatt range of spindle speeds or the arbuor speeds range of table feeds in the xyz directions and floor space occupied.

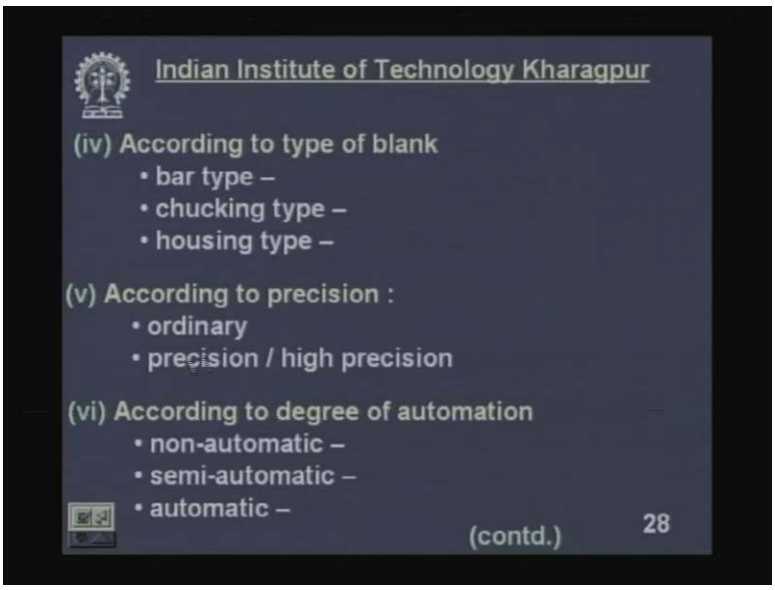
(Refer Slide Time: 53:17)



Now classification of machine tools. How many machine tools exist? How many types of machine tools? When we were student like you, we asked our teachers how many types of machine tools really exist. Our teacher told more than ten thousand types of machine tools exist but gradually the number is decreasing with the concept of group technology, with the help of group technology the total number of machine tools or the variations is gradually reduced for convenience.

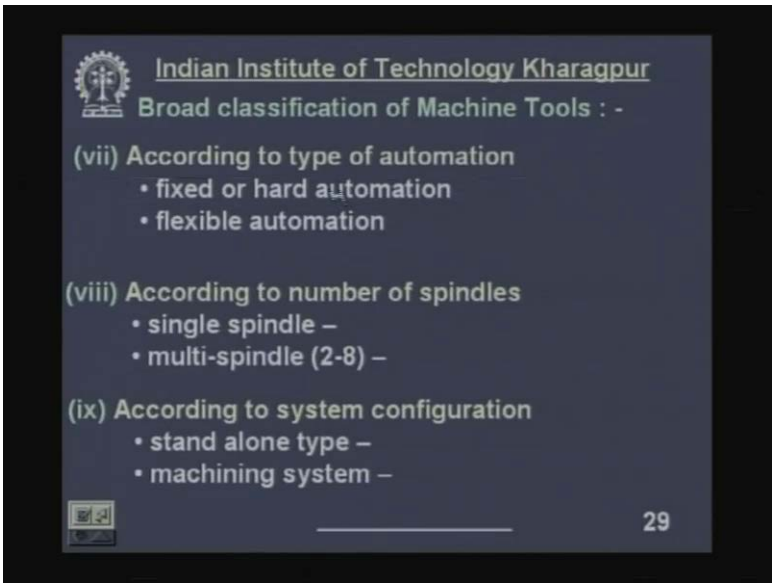
Now let us talk about broad classification of machine tools. Now with respect to what the classification has made? According to configuration so when you say classify the student, say classify according to what, according to height or weight or qualification or other caliber like that. Similarly, when you talk classification of machine tool that is according to what according to configuration direction of main axis horizontal that is horizontal lathe. There can be vertical lathe also. Milling machines may be vertical axis, horizontal axis, inclined. This is very special for transfer machine then according to purpose, general purpose any kind of work on any type of job, singles purpose which is the more productive that is only one operation say only turning or only facing will be done on different types of jobs. Special purpose a definite number of operations will be done on the one type of job repeatedly for mass production. Next comes according to size duty heavy duty say boring mill, plaining machine like that. Medium duty say milling machines, lathe small table top drilling machine, micro size micro drilling and so on.

(Refer Slide Time: 55:02)



Then according to type of blank, blank may be bar type, chucking type and housing type. Housing type are generally big machine tools according to precision ordinary or precision even high precision. This way machine tools can be classified. According to the degree automation so machine tools need automation it can non automatic like centre lathes. Semiautomatic like capstan lathe, turret lathe, automatic like single spindle automatic lathe.

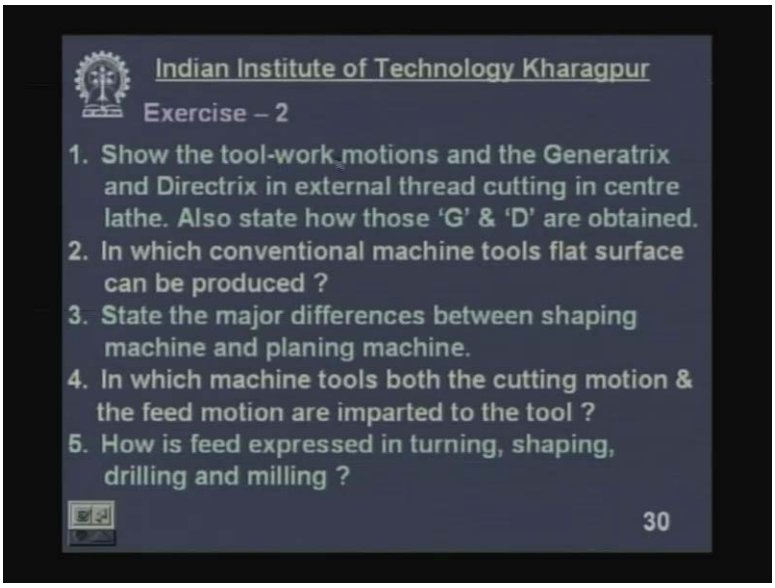
(Refer Slide Time: 55:31)



Then according to type of automation it can be fixed or hard automation. Most of the common machine tools that you see those are fixed or hard automation that which produces only one particular type of job if you change the job then lot of changes have to be incorporated into the machine tool. It is very expensive and this will take lot of time. Flexible automation is a modern concept where the changeover of the job can very quickly accommodated by using the computer or numerical control machine tool.

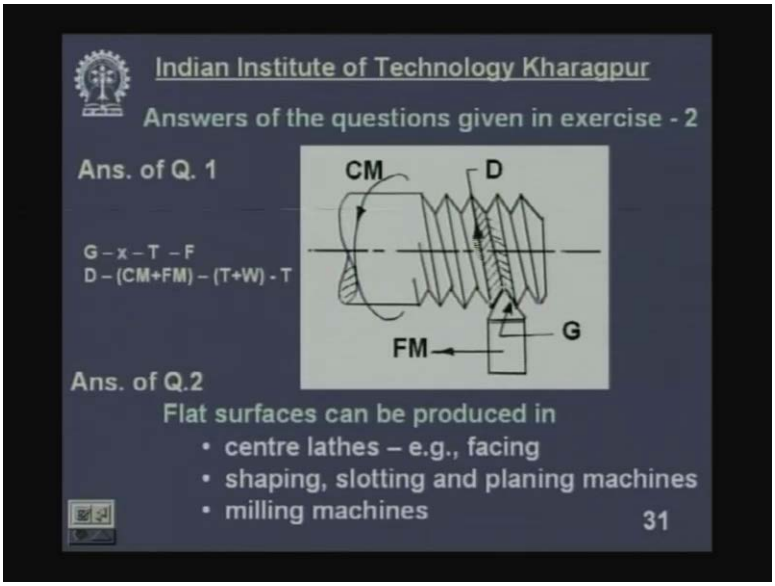
According to number of spindles, now most of the machine like lathe has got single spindle. Only one spindle is there why it can be multi spindle also, say two spindles or four or six or eight. They are called multi spindle lathe which gives more productivity and finally last according to system configuration, standalone type - most of the machine tools I talked about stand alone. Only one machine in one place or machining system say three or four machine tools will be amalgamated into one to carry out various types of work like drilling, milling, boring and so on. These are called machining system example machining center.

(Refer Slide Time: 56:38)



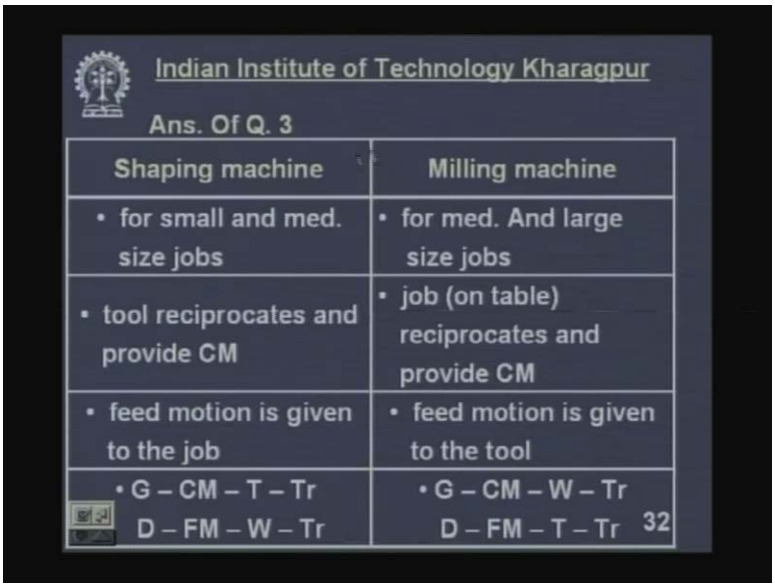
Some exercise for your practice.
1. Show the tool - work motions and the Generatrix and Directrix in external thread cutting in centre lathe. Also state how those Generatrix and Directrix are obtained.
2. In which conventional machine tools flat surfaces can be produced?
3. State the major differences between shaping machine and planing machine
4. In which machine tools both the cutting motions and feed motions are imparted to the tool?
5. How is feed expressed in turning, shaping, drilling and milling ?
See the answers.

(Refer Slide Time: 57:10)



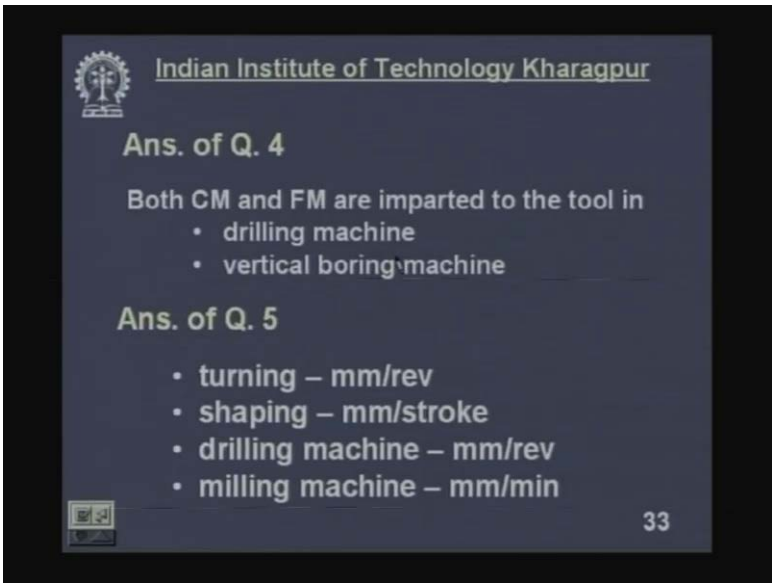
Now Answer of Question No.1.This is thread cutting. So thread is rotated at cutting motion, this is the feed motion. Now this is the generatrix and this is the directrix. So this combination of directrix and generatrix produce this surface this helical group. This helical group generatrix is connected with the form of the tool no motion but it is a part of the tool and the form of the tool so F what about the directrix. It is the resultant motion of the cutting motion and feed motion so this cutting motion and feed motion jointly produce the motion then is a combination of tool and job both and this is addressing. Now question number two flat surfaces can be produced in centre lathe for example by placing, shaping, slotting and plaining machines milling machines and so on.

(Refer Slide Time: 58:00)



Now this is answer for Question Number 3. Difference between shaping and plaining machine. We already discussed and you can see the size of the job the small and big. This is a plaining machine. It is a mistake this will be plaining machine. Tool reciprocates the job reciprocates feed motions given to the job feed motions given to the tool and this is the generatrix and directrix. Generatrix is obtained by cutting motion of the tool and by tracing directly by feed motion of the work piece and in case plaining machine, the cutting motion is given to the work piece feed motion to the tool.

(Refer Slide Time: 58:41)



Answer to Question Number 4. Both cutting motion and feed motion are imparted to the tool in drilling machine, vertical boring machine these are the characteristics these two machine tools only. As such of Question Number 5.How feed is expressed in different machine tools turning millimeter per revolution, shaping millimeter per stroke, drilling machine millimeter per revolution, milling machine millimeter per minute or centimeter per minute. So this is how different machine tools can be different like in broaching machine by tooth rise and so on.

Thank you.