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

Lecture -17
Kinematics System of Centre Lathe & It's Operations

Good after noon! Our subject is Manufacturing Processes II. Now today, we are going to start the fourth module is a new module, new topic General Purpose Machine Tools.

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Till the last lecture we continued on machining and manufacturing today we shall start with the general purpose machine tools. The first lecture under this module will be the Kinematic system of centre lathe and their operations. So what are the contents of the lecture today?

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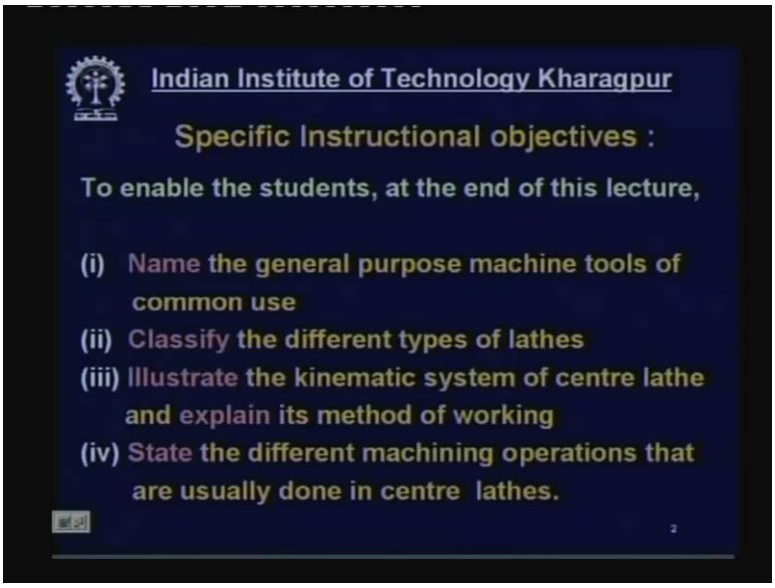

These are; this lecture will enable the students name the general purpose machine tools of common use. Classify the different types of lathes. Illustrate the Kinematic system of centre lathe and explain its method of working and last and fourth, state the different machining operations that are usually done in centre lathe. So today our topic is centre lathe amongst the conventional or general purpose machine tools onward we shall cover other kinds of machine tools like milling machines, shaping machines and so on. Now what are the general purpose machines tools?

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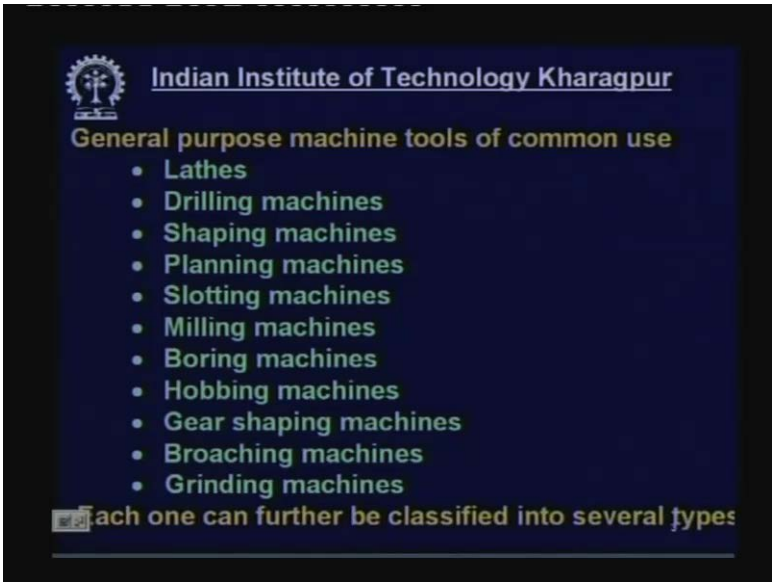

General purpose machine tools are those which are commonly used and widely used in all sorts of machine manufacturing shops or machine shops is a common machine tools which were introduced or developed long back and are still used in small, medium and heavy industries lathes, lathes are used to produce cylindrical jobs, internal cylindrical surface and external cylindrical surface rod like. Drilling machine; in which holes cylindrical holes are originated or some time existing hole is enlarged. These are small machine not that very big holes are made. Shaping machines; shaping machine is a primitive machine which produces flat surfaces and the flat surface can be horizontal, vertical, inclined like that but the shaping machines are becoming gradually absolute and less used. Planning machines also produce the flat surfaces like shaping machines but planning machines are made for big jobs, large size of work pieces.

Slotting machine; slotting machine is basically a vertical shaping machine were the cutting reciprocates vertically and it makes internal surfaces say holes or slots or key way in holes and so on. These slotting machines are also not very widely used for batch of mass production only for repair and maintenance work slotting machines are often used in small scale industries. Milling machines; yes milling machines are widely used milling machines are generally used for making flat surfaces. Now vertical, horizontal, inclined flat surfaces resulting say grooves, slots some time they are used for parting a piece into two parts. Milling machines are also used for making some form type of machining like say cutting the teeth of gear. Sometime threads are also cut in milling machines. Wire wheel or the teeth wire wheel gears are also cut sometime in milling machine.

If it is a small production boring machines are similar to drilling machines boring machine can be you know vertical type like drilling machine which are normally smaller size but precision and horizontal boring machines are very large size for the large jobs boring machines are normally used for enlarging and existing hole or making a hole accurately in dimension and finish hobbing machines. Hobbing machines is the machine for mass production of gear teeth in cutters external say external gear teeth of external gears can be cut in large quantity very fast every heaving machine by generation method gear shaping machine is another gear teeth cutting machine were the teeth of both external gear and internal gears can be cut. Beside that the teeth of spline shafts internal external can also be cut in gear shaping machine.

This is slightly less productive than hobbing, but produces better quality. Broaching machines are really is a cutting tool which is used for making flat surface or other than flat surface for making holes or key way. Sometime small gears spline shafts are also manufacture be broaching. The broaching tool is very expensive and the process is very fast and the quality of the product is also good. Grinding machines that is the slow process of metal removal but it provides it is used only for high accuracy and finish particularly when the works material is very hard cannot be done by machining. Now the classification of lathes:

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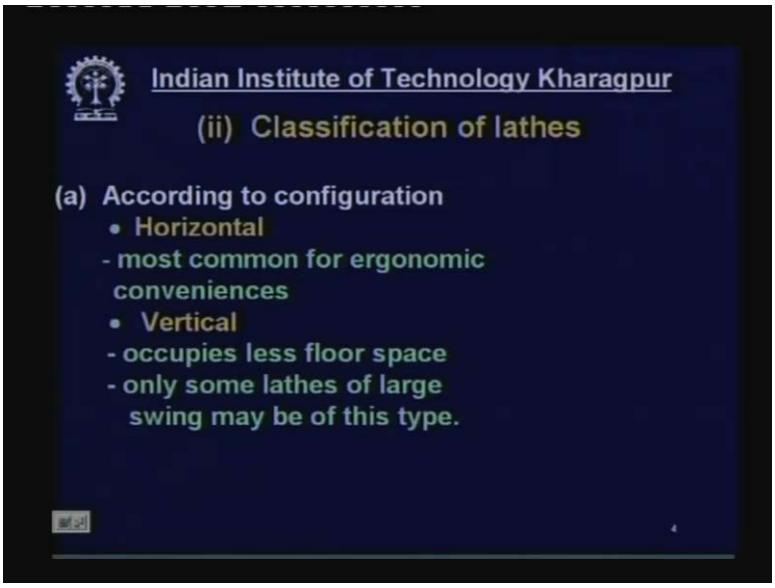

Now before that we should consider the classification of machine tools. Now if we really someone tries to classify machine tools there are can be 1000 types or at least few 100 types. So instead let us start one by one first of all with the lathe. Now lathes are the most common and widely used machine tools most primitive machine tool and these machine tool some most widely used along all the machine tools and most versatile. So lathes have been this can be classified in number of ways, in number of respects according to configuration. Actually the machine tools like lathe can be classified in different aspects. So what are the aspects according to which will be classified that has to be mentioned.

For example, according to configuration basic shape or standing horizontal. Most of the lathes are horizontal axis that is for ergonomic convenience, whatever be the size, high and the length and power of the lathe horizontal lathes. The height of the centre should be at the west height of a man of common of height. So that he can very comfortably and conveniently work on that but vertical lathes now there is few lathes normally big size which are kept vertical. Now main purpose to it occupies less floor space but for ergonomic convenience these machines are kept vertical and the chucks are kept under the ground so that the worker can work conveniently. This occupies less space and this is used for large swing like boring mill and so on and so these are not very common. Classification of lathes continued. Now next is according to purpose of use.

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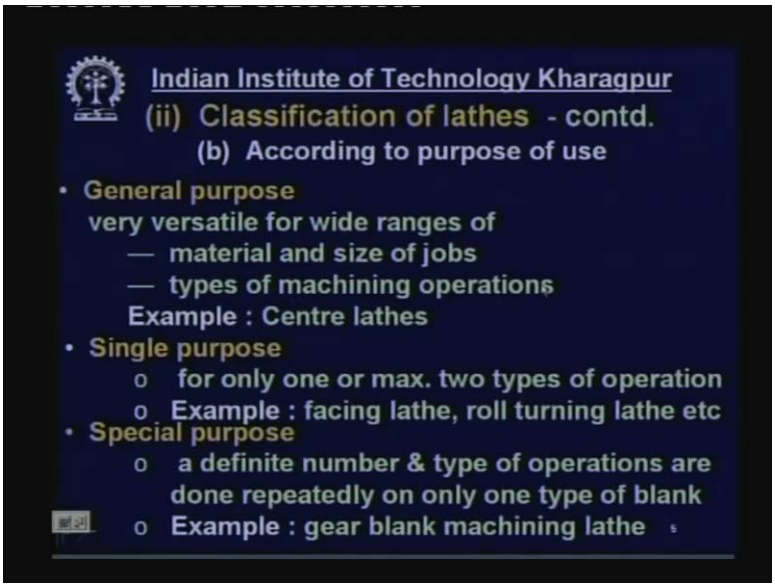

What are the purposes of use? Three categories: General purpose, Single purpose and Special purpose. What is General purpose which is most versatile and widely used. This is a very versatile for wide range of material jobs of different material, different size of jobs, different shapes of jobs can a machined then various types of machining operations can be done. For example, centre lathes. These centre lathes are so versatile. These are called modern machine is very most versatile but this is used for general purpose work. Any kind of work on any type of job will be done in this versus but this possess is generally manually done.

Single purpose-in single purpose from the main it understood that only one type of operation may be occasionally maximum two operations like say terming and facing or only facing or facing and chamfering or turning and grooving. So only one or maximum two types of operations, will be done on different job material and job size within a limit. For example, facing lathe the facing lather here the chucks are very big where job disc type jobs are faced. You know the on the facing operation is done. So jobs are of large diameter but short length roll turning lathes where the rollers of the rolling mills are only finished by turning and may be some grooving and chamfering work can be additionally done. But basically these lathes are main for turning the roller of rolling machines.

Similarly say copying lathe can be one single purpose machine and other other machines. Say now special purpose special purpose machine tools were these are for a special type of job a particular type of job will be a machine over a long long period repeatedly a definite number and type of operations say 6 or 7 operations of the definite type say few like drilling, boring, thread cutting and milling operations are done repeatedly saving work. Same set a work will be done machining operations will be done repeatedly over a long period may be a months after months or years on a particular type of blank. For example, gear blank machining lathe were the blanks of gears may be spar gear or swivel gear will be machined over a long long period. Another example say the sewing machine.

The body of the sewing machine it needs some machining operations like drilling, threading, boring, facing at different locations and this work the set of machining work will be done by the same set of tools over a long period. For that a particular type of machine tool will be utilized that is dedicated which cannot be used for other kind of job. What are the next classification criteria according to size and capacity?

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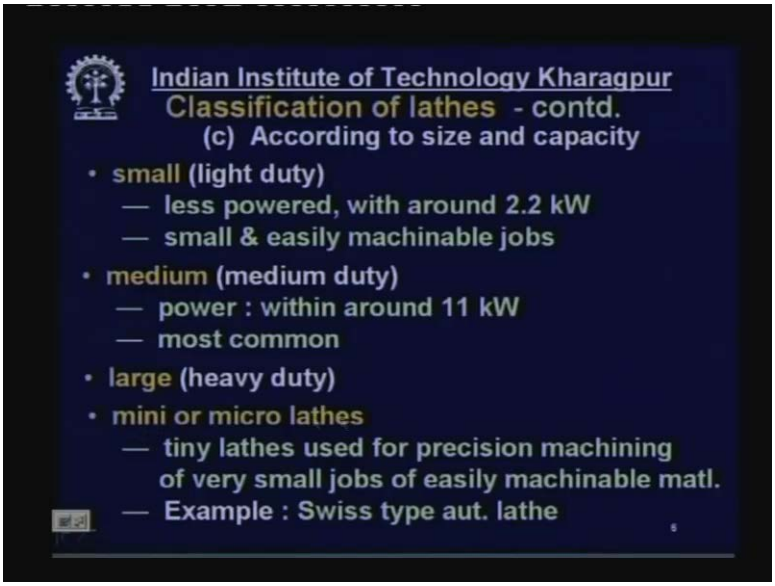

Size which is visible and capacity is measured in terms of power, depth of cut, cutting velocity feed and so on small category. There is no really harden first line of demarcation with a small medium large or micro but generally we call it small, medium, large a very large mini or micro lathes. Now small lathes; they are also called light duty lathes were depth occur speed feed etcetera less and the power consumption will be less powered with around max say maximum 2.2 kilowatt not more than that. Small and easily machinable jobs. So here the jobs will be a small size commentiated to the size of the lathe and power of edibility and here the cutting force should not be very high. So material should be should not be very exotic type which produces or difficult to machine.

Medium size when you call it medium size the power will be within 2.2 kilowatt to 11 kilowatt. Most of the centre lathes those are used in industry are of this category medium size and these are most common obviously then large heavy duty. Now the heavy duty lathes that can be even highly powerful may be up to 120 kilowatt and it will be very rigid and high speed machine tools. They are not very regularly used these are used for you know special applications. Mini or micro lathes, this mini lathe like switch type automatically came into being long back but micro CNC lathes have come a very recently for making very very small parts of different ah systems in the small jobs. So it is said that tiny lathes these are very tiny small lathe table it up mounted on the table may be 6 inches long or 4 inches long, even smaller used for precision machining of very small

jobs of easily machinable material that is soft material which are not very difficult like carbides or a high alloy steels like that.

Now very small jobs now for example the components of wrist watch suppose. Now wrist watch is a very small device. Now it has got plenty of mechanical systems like pins, gears, shafts, hobs which have to be machined all right. So this lathes would be very small and another set of lathe call CNC lathe which will be computerized that can those are also used for making the small parts of mini robots or mini machines. The robot size or the machine size can be say 1 centimeter cube and it may have 100 parts all the small parts will be machine in this micro lathe which are you know it is numerical control and computerized.

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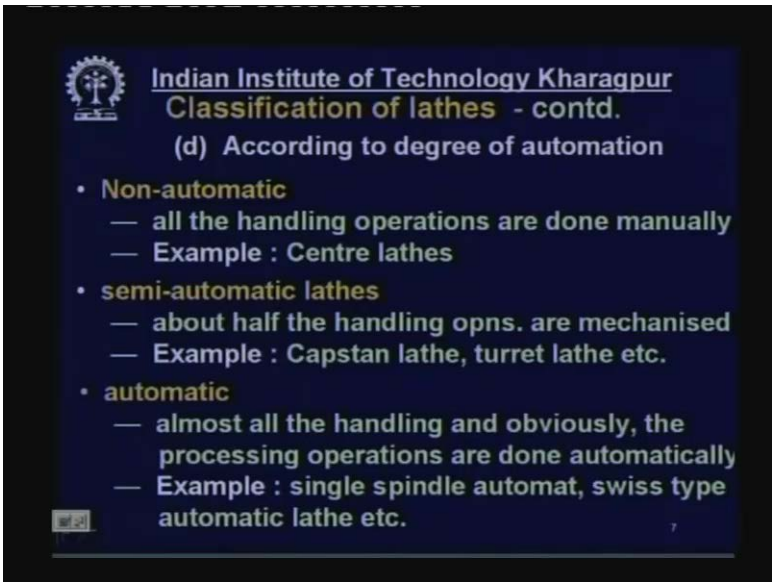

Now according to degree of automation, now we know what is the purpose of automation? Automation is a system or a device or a mechanism that enables very quick production, easy production with huge amount of jobs with consistently high accuracy. So this is the purpose of automation. Get the work done quickly, accurately and consistently without human intervention or with minimum human intervention. So this is very economic process for mass production. Now the machines like lathes also categorized with respect to the degree of automation.

Many lathes are automated and mechanized. Non - automatic, semi-automatic and automatic. Now how are they classified? Non -automatic. Now you know that in machining operation say for turning a rod which has to be turn in a lathe okay. Now before we machine or remove the material lot of preparatory work has to be done. The job has to be mounted on lathe. The cutting tool has to be mounted on lathe. Speed, feed, depth of cut have to be adjusted. Cutting fluid has to be put off and on then motor has to be off and on all these preparatory works are not directly connected with the chip formation but these are essential you cannot avoid and these are called individual

operations. These operations apparently non-productive are called handling operations. And another set of operations called processing operations which are directly associated with chip removal like say facing, turning, drilling, boring, finishing, parting like that. Now whether a machine tool is called automatic or non automatic or the degree of automation will be decided by to what extent the handling operations are done automatically.

It does not depend upon what extend you know this processing operations are done. It may be say all the processing operations are done automatically, but all the handling operations are done manually then the machine will be called non-automatic. So the degree of automation will be decided by to what extent the handling operations are done in mechanized way. Now come to the definitions Non-automatic; All the handling operations are done manually irrespective of these processing operations. For example; centre lathes. Semi-automatic; About half the handling operations are mechanized. There is no mention about processing operations not necessary when around 50 percent of the handling operations are done automatically are in mechanized fashion, then this machine will be called, this lathe will be called semi-automatic. For example, capstan lathe turret lathe relieving lathe then copying lathe these are all semi-automatic lathes.

Now automatic; you understand that it will be called automatic only when all the handling operations or almost all the handling operations and obviously the processing operations. When all the handling operations are automated processing operation have to be automated there is no way out. So almost all the handling operations and obviously the processing operations are done automatically. Then this kind of lathe or any machine tool will be called automatic. For example, single spindle automatic, swiss type automatic lathe automatic cutting of lathe like this. Now the characteristics of this machines are they are very compact, very complex in shape in design and operation is very simple just push button type, maintenance is difficult if there is any fault and these machines are expensive. Advantage: these machines work very fast, very fast production rate is very high and the quality is also good and maintained consistently over a long long period but these are costly.

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Now according to the type of automation, previously we observed according to degree of automation okay degree of automation. Now you see according to the type of automation. Now the kind of automation we are familiar with till 19 say 65 are all fixed automation. These are called fixed automation. These are very conventional often called hard automation why these are called hard automation or ah fixed automation because this automation is achieved by incorporating lot of system additional devices of systems those can be mechanical device even electronic device, electrical device, electromechanical device, hydraulic device computers and all these things. But when all these components are mechanical type, hardware type. Then these are called fixed automation or hard automation because if there have been change in the job or the product then lot of changes have to be incorporated into the machine.

Lot of components have to be replaced thrown away new components have to be design and brought in. So the change over cost of one product to another will be tremendous a very big amount and is very rigid. So the changing to for a new product will be very difficult very task. Now example; single spindle automatic lathe, swiss type automatic lathe. These were invented may be about 150 years back. So these are all hard automation or fixed automation. So these are all driven by mechanical devices another category has recently come up targeting batch production. You know fixed automation is very good economically applicable for mass production or huge production because initial cost is very high change over cost is very high but the present trend and future trend is batch production instead of mass production.

So when there is a batch production the products size shape or category changes rapidly or frequently. So the machine should be capable to coup up with the change over of the job from one design to another one shape to another one dimension to another okay. So the flexible automation is such which can easily coup up the change. This is very modern and suitable for batch production for low change over cost. Yes change over cost is very

low because whenever the job changes on in the program in the computer has to be changed.

So it does not take much time. It can be done very quickly, easily and in expensively or low cost. Example is a modern machine tool CNC computer numerical control lathes turning centers, nc dnc, fms, cim, computed indicated manufacturing system. These are all example of flexible automation which maintained the advantage. It is very flexible very quickly, easily and economically change from one product to another with simply programs and these are very accurate also maintain accuracy maintenance is simpler but the problem is it is suitable for batch production not for mass production and if the total cost is really high compared to hard automation if not more. Now the classification of lathes according to the job configuration:

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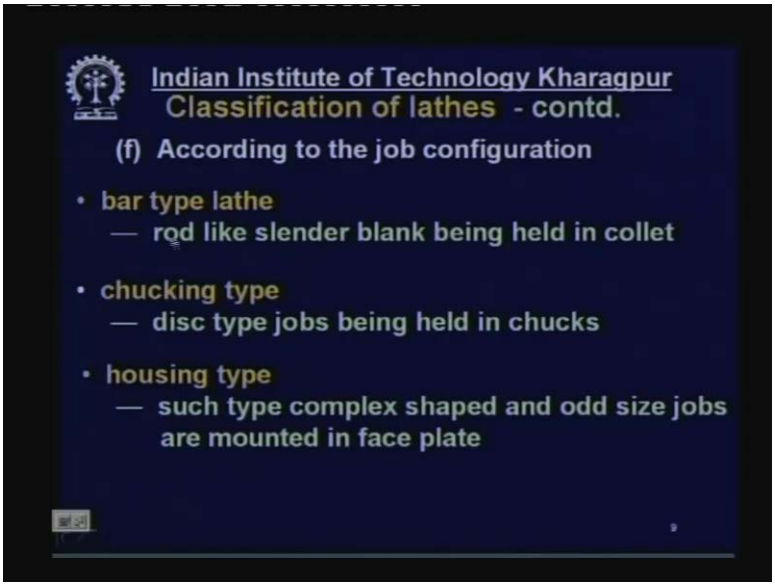

Now what kind of job? What kind of configuration of the job the lathe handles that is another category or aspect of classification of machine tools. Normally here this kind of classification is appropriate for automatic machine tools. Automatic lathes say one class of lathe, automatic lathe they handle bar type job say rod like slender rod like, rod like slender blank being held in the collet and jobs are made one by one and cut to size and dropped into the beam, then this rod is fade again for the next job to be done. Chucking type - chucking type that deals with disc type job normally, and this disc type jobs say you have to manufacture the blanks of the gears, pulleys, shafts, rims, etcetera not shafts pulleys gears clutch and like that these type.

These are held in chucks. There can be one chuck or there can be chucks. So these are bar type is a most common that is swiss type automatic lathes. Single spindle automatic lathe multi spindle lathe, bar type these are very common. Chucking type is less common housing type. Now some time the jobs are very complex just like housing or box like of irregular size, shape and all these things which cannot be held either in collect or in chuck

all right and they are mounted on large face plate, large face plate which has got number of slots radially and in tangential and this face plate is mounted on the lathe spindle and on this face plate is odd shape jobs are fixed by clamping and this is not very common is only for few occasions and complex shaped jobs. Now the classification of lathes, according to the precision or process capability:

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Process capability actually machine tools are accessed in terms of productivity that is the rate of production and process capability. How how it can maintain accuracy of the product? There can ability to produce and maintain accuracy. According to that lathes are categorized in two groups. One, which are ordinary called common ordinary. Most of the lathes are ordinary which is not that precision and dimensional accuracy will vary from 10 to 50 micron and these are very common precision lathes are occasional you know these are very special and very expensive and only when it is required it is used. These are characterized by capable to provide high dimensional accuracy and good surface finish and these are costly only event is required it is used. So that these jobs can be finished to complete dimension and finish without grinding. Now the classification of lathes according to number of spindles:

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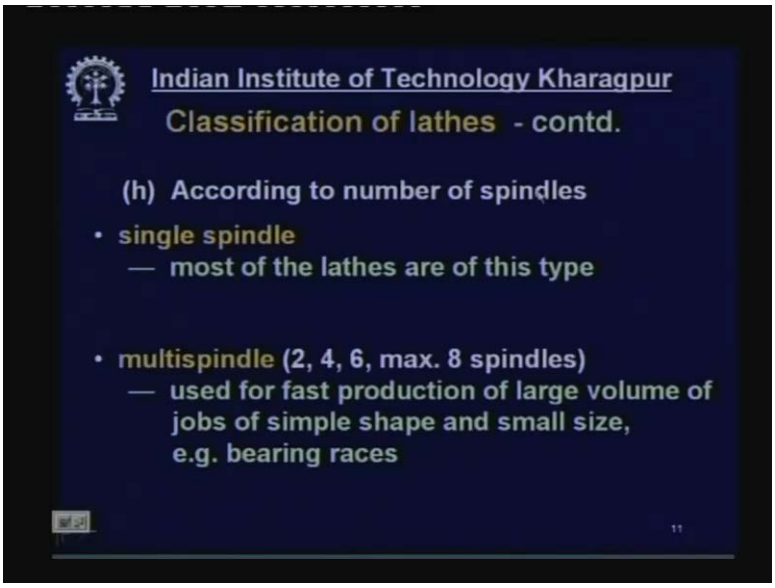

Now in our whole body you see there is only one head. So one head thinks and the whole body does the work. Now suppose if we have two more hands on the back side. So from the front two hands front side you can do some work and two hands on the backside we can do some more work. So the productivity can be improved. So this is just a guessing or an analogy but in machine tools some time in the more number of spindles can be provided any way but most of the lathes are single spindle. Single spindle lathes most of the lathes are of this type were there is only one machine, one spindle and in the one spindle one job is machined at a time until it is finished.

In multi spindle lathe were the machine tool is quite large and powerful and a job to be produced in huge quantity at the large number over months or say years and the job requires very small number of operations, few operations and the jobs are simple, jobs are small but produced to be produced in huge quantity, then for such repetitive type of work of limited number of operations and all these things here, instead of one spindle the machine can be provided with more than 1, 2 ,4, 6 or maximum 8 spindles can be provided and that the productivity will be proportionally increased not exactly proportionally but definitely it will increase with the number of spindles. Now example; these are used for past production, rapid production, of large volume of jobs of simple shape and small size and requiring small number of machining operations. For example; say the bearing races.

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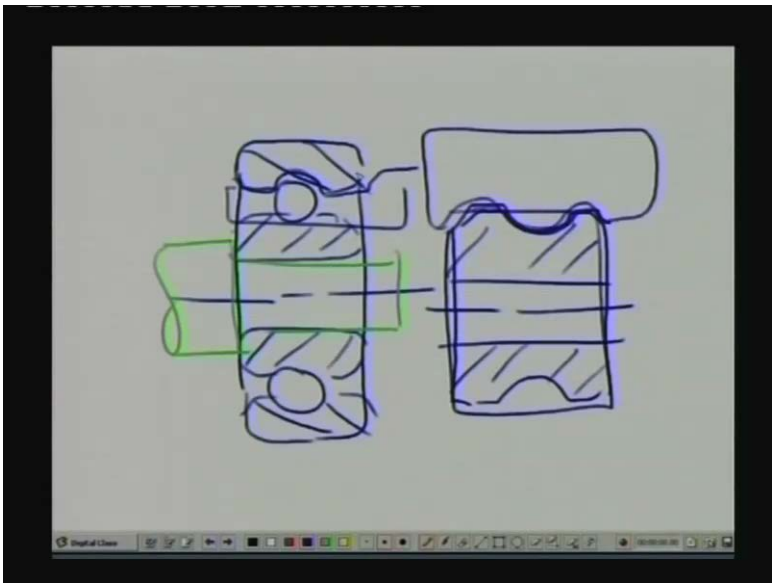

Say let me draw a bearing a ball bearing. This is the center and this is the ball balls and this is the inner race in which the job is fitted okay. This is the job or shaft, this is the shaft on which this bearing is fitted. Now here this is the inner race and this outer race okay. Now let me draw the say inner race. What is shape of the inner race? Like this, now here this is the forming form tool by which this particular form will be machined. Similarly this form will be machined by another form tool. So these are the form tools okay and just one form tool will produce this. So you start with a small ring or a rod then this part will be part of and then this particular form be produced by form tool. So this kind of bearings inner race and outer race are produced in huge quantity very rapidly by multi spindle lathes. This is one example is this case there can be large severe most several more other applications of multi spindle lathes. Now come to now come to the next topic that is next article Kinematic system of center lathes.

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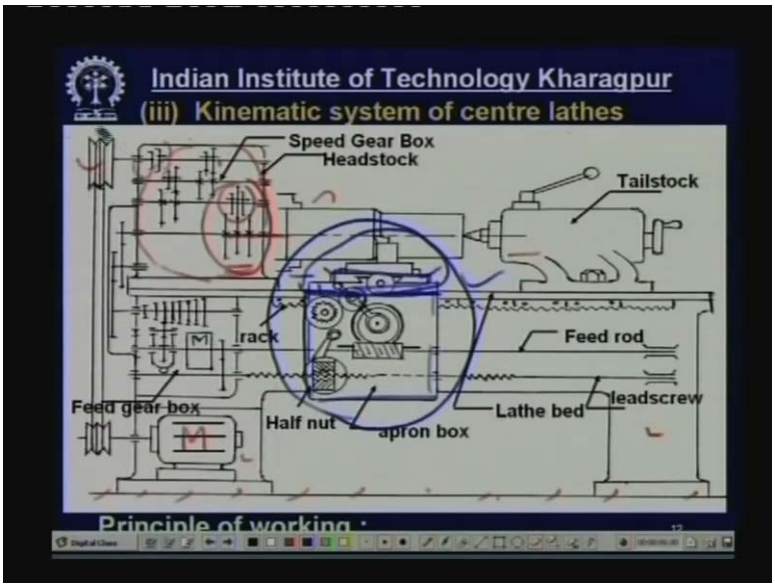

So today we are discussing centre lathe only all right and the Kinematic diagram in detail because this centre lathe as I told you is the most common type and widely used lathe and if one understand the Kinematic system or Kinematic arrangement of this machine tool then he can learn easily the Kinematic system of other machine tools all right. Now let me tell you what are the configuration, the basic part into this. Kinematic system means the arrangement or the system of the mechanisms or the chain of structure of mechanisms which enable um providing motions to the job and the tool. So this Kinematic system deals with transmission and transformation of motion at the cutting tool and job. So this is the work piece. So this is the job which is mounted in between the chuck and the tailstock center. This is the cutting tool this is the cutting tool that is the mounted on the compounds like compounds like and then what the main. So first we identify where is the job and where is the tool and the relative position.

So first you identify the job is a rod like which has to be finished to a particular diameter and held in a chuck on one side at and tail stock is a support and there is a cutting tool and the cutting tool will travel in this direction that is called feed motion and this job will rotate like this. So this is called cutting motion and this is the feed motion which you learn in my previous earlier lectures. Now what are the measure parts? This is the lathe which has got the headstock. This is called headstock which possesses the speed gear box inside comprising of large number of gears and shafts, then there is a tailstock for supporting the jobs as well as for mounting some cutting tool as and when required like drills, reamers etcetera. These two headstock and tailstock are mounted on the lathe bed is a rectangular piece lathe bed which has got guides at the top lathe guides two lathe guides and this lathe bed is mounted or a integral part has got two legs. This is one leg and this is tool another leg. So these two legs are then in integral body are resting on the floor or on the concrete foundation. This was the con general configuration and there is another moving part of sliding this part called carriage. This carriage slides along the lathe bed and this is carrying the cutting tool to impart the feed motion.

Now let us see what are the what are the motions and how the motions are transmitted and what are the functions of different part shown over here and all the results. First of all the job has to rotate. So it has to derive rotation and torque that is the power because when this will be machine the cutting force will be there the cutting force multiplied by the velocity will produce the power requirement. So the power and motion rotation have to be derived from a source and this is the motor say single source. So the mu power and motion goes from the motor to the job in the form of rotation through the bell pulley system. It is bell pulley system, then it comes through a clutch a friction clutch for safety and then a number of gears, cluster gears say there are 4 gears. Here there has two and four three and this is really this has been shown for 12 speed gear box you know that in lathe or same the other machines like drilling, boring number of spindle speeds are required for different type of our machining comfortably different type of work material different type of tool material different type of operations, different size of job or tool and different finish or say rough surface.

So we need number of spindle speeds. So this is a function, this is called a speed gear box comprising of number of gears called cluster gears within the headstock. This will split the speed coming from the motor in to a number of spindle speeds from for a low speed say high speed and medium speed like that. So this job can be rotated any one of the twelve bar eighteen speeds available. Now this cluster gears has got say this is a stage. So this is called cluster and these are called fixed gears. So by shifting these gears cluster, we can get three speeds multiplied by two multiplied by two. So 3 into 2 into 2 so there may be 12 speeds available. Now this is the tailstock which this is the center tailstock center which can be static or which can be revolving and this gives the support. Sometime the cutting tools like drills or reamers can also a mounted here and this will be moved gradually to get the work in the work piece.

Now then this is the saddle or carriage. These are cutting tool which a travels in the direction. Now the feed the movement of the tool is called the feed. It can be longitudinal feed that is along the axis of the job along the axis of the job. So the tool will move that is called longitudinal feed or usual feed. Another feed will be perpendicular to job. There is in this direction radial radial feed or cross feed. Now this cutting tool is mounted on the tool post. The tool post is mounted on the compound slide. The compound slide can be traveled by a screw manually by operating this screw manually this slide can be moved forward and backward. So you can give the feed manually, then this compound slide is resting on the cross slide. This is the cross slide is a cross slide. Now this cross slide has got ductal guides. So it is resting on another plate. Here this is another plate.

On this plate, this cross slide moves radially with the help of a screw and nut and this is the screw on which gear is mounted. So when you operate this screw, then this cross slide moves forward and backward radially towards and away from the work piece. For cutting for facing grooving similar for similar work this cross feed is needed and then this compound slide is mounted on the cross slide cross slide is mounted on a plate which travels on the lathe bed to ensure and this is fixed with this is called saddle so this part is called saddle. This is mounted on fix with an apron box a box like which hangs in front of the lathe and that comp that consists lot of mechanisms inside okay and the all these

things together is called carriage which moves along with tool as a whole in the in the the left or right and some time this cross slide can move forward and backward in a direction perpendicular to the axis of the job that is cross feed. Now let us see how these movements are accomplished. This cutting tool so this is the carriage. This is were from it gets the motion. It gets the motion the cutting tool gets the motion from the rotation of the job. So the job rotates. It is mounted on the spindle this is called spindle. These are shaft like is a hollow shaft called spindle. From the spindles backside there is a compound gear the one gear two gear reduction there another gear another gear.

So these four gears together is called gear quadrant and they are fixed placed in a cover for safety. Now this quadrant gear ultimately transmits motions into this shaft and this is called Norton drive and this is the tumbler so by fixing the gear with anyone of these gears on Norton we can have say 8 different or 9 even up to 11 different speeds. Now again that each of the 11 speeds will be divide into 4 or 5 speeds by a mechanism called mender drive. These mender drives can be of different form which splits one speed into four or five numbers. So if there are 9 gears into the Norton drive and there are 5 steps in the minder. So ultimately we get 9 into 6, 30 is 9 into 4 say 36 speed into this feed rod. This is called feed rod. This feed rod rotates very slowly. Now the power is also transmitted from this shaft from this shaft to this shaft. This is called feed rod is a rod like which has got only a long key way and this is transmitted to another shaft fixed gears that is called lead screw. So this is called this is the lead screw okay.

It is screwed lead screw and on the lead screw, there is a nut called half duct which can be engage and disengage. Now come to this feed rod. The feed rod receives motion from this feed gear box. This gear box is called feed gear box which has got large number of feeds or speeds and then on this feed rod, there is a worm. This worm rotates and its worm will move along this direction. So there is spline or key long key. This worm is engaged with the worm wheel. So the shaft rotates on the same shaft there is a gear on the back side. On the gear there is another gear in mesh. Now this gear is a mesh with another gear on the same shaft there is a pinion. This pinion is nothing like a gear nothing but a gear which rolls along the rack. So this is the rack okay. These racks are in segments. These rack segments are fitted on this wall or under the bed under just under the bed and this pinion rolls along this rolls means rotate make to rotate by engagement of the set of gears. So when this pinion will be rotated and roll on the surface this shaft along with the whole body will be moving this way or this way. So this is how the motion is transmitted from the feed rod from the feed rod from the feed rod to the pinion from the pinion it rolls on the rack. So the entire cutting tool holding this and mounted on the carriage moves in this direction or in this direction depending upon the direction of rotation of this feed rod.

Now come to the lead screw. Now the feed rod is engaged for slow feed motion used for turning operation. Ordinary turning operation or say radial turning, facing. All kind of work but when we need cutting precision threads were the feed motion and the cutting motion need to be synchronized and the feed motion should be accurately maintained then this lead screw is used which gives the positive drive. Now the lead screw before that let me tell you how we get automatic cross feed. Now this gear is in mesh with this

gear. But this shaft of this gear mounted on lever. So by swinging this lever, this lever we can engage this gear with this gear or with that gear. This is the gear which is mounted on the lead screw of the cross feed cross drive, cross feed drive.

So when these gears will be rotated, this cross slide will travel perpendicular to the axis of the job giving what is called cross feed. Now this can be automated and here this will be with their will be one friction touch to engage otherwise this wheel can be rotated manually or this also can be rotated manually to give manual feed but which is not very common practice. Now come to the thread cutting. This is a lead screw. There are two nuts. On the lead screw there are two nut segments all right they are threaded. So when these two are brought closure then they will grip on to the threads of lead screw. So the rotation of the lead screw will be transmitted to this nut combined nut and then the combine nut at the parts of this entire carriage. So, when the nut will travel along this screw this entire carriage will also move. But this is the first motion required for thread cutting but arrangement is makes such that both this feed ordinary feed and this lead screw cannot be engaged simultaneously either this or that. So this full proof arrangement has to be there to save the machine from disaster that is the full proof arrangement and as I told you that. So the cutting tools can also be mounted here.

(Refer Slide Time: 42:20)

Now let us come to the machining operations that can be done in Centre lathes. As I told you that centre lathe is a very versatile machine tool amongst lathes also the centre lathe is the most versatile most versatile in the sense that large number of operations can be performed in centre lathes over different size or diameter and length of the work piece and of different material. So the most versatile and huge kind of operations can be done. Now you can see, what are those operations which can be performed in centre lathe? Generally these are the operations which are now telling will be are done. For example, the centering face first is facing. What is facing. It was told in my previous lectures now I

have shown you the facing. Suppose there is a rod, this is a rod. This is a rod this surface is irregular.

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I want to finish this surface by removing this material. How this will be done? So we shall put a cutting tool in this face of this type and this cutting tool will be moved gradually in this direction radially and the job will be rotated as usual. So then how this will be done? So this was the intermediate position this is the rod and this is the cutting tool which is already got into that and certain amount of material are yet to be removed. So this amount of material is already been removed. Now it move further and this material will be also removed. So this is called facing. Then comes say Centering: Centering means making a hole.

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Suppose this is a rod end. This has to be supported in say tail stock before that a hole has to be made like this a hole has to be made like this. So that the centre a centre can be fitted here the tailstock centre this is called centering. This is centering is done by a drill called centre drill is one operation. Next comes rough and finish turning.

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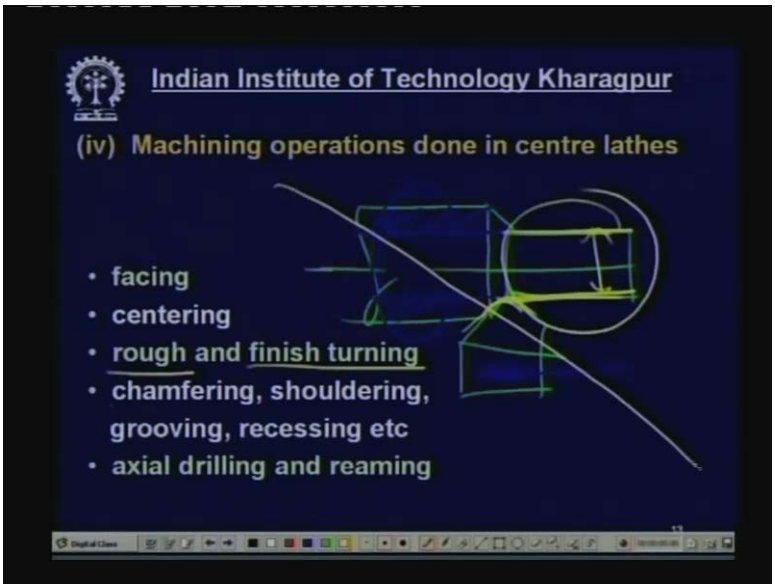

Turning you know, this is most common work. So this is the rod and so this is the cutting tool okay and this is the work piece which is subjected to rotation. It rotates and the tool moves in this direction is called feed motion and this is the this is the material which is going to be removed and this is the finished surface. This is the finish surface. Now this

can be this is called rough turning as well as finished turning. Rough turning means you know the surface the dimension not that be accurate and surface will be rough but when we need finishing, we just take care of the speed and feed and the tool shape specially download the tool and we do it by finishing then chamfering. What is chamfering?

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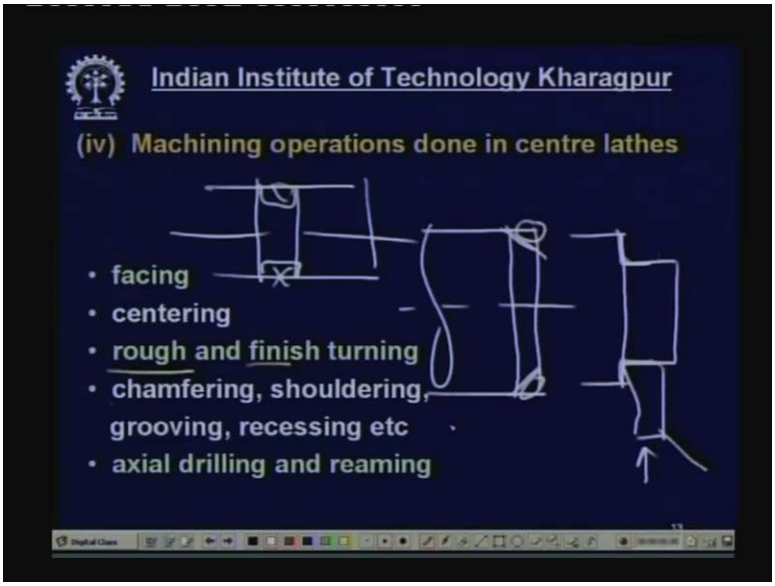

Chamfering means, suppose this is the rod. This is the rod end we want to make it like this. This part will be removed. So this is called chamfering, then what is called shouldering. Shouldering means here is one surface we want to make step. So this end this kind of step is called shouldering and that is done by cutting tool like this which will move in this direction. Grooving; what is grooving? Here is a job rod. Now we want to make a groove by removing this material. So this is groove grooving. Similarly recessing kind of work can be done. Next is another set operation called drilling. Axial drilling and reaming. So here the drill is fitted into the tailstock and the reamer for finishing is also held in the tailstock quill and the tail stock is gradually moved. These are not very common practice this is for you know repair and small lot of work. Small few pieces is a not very you know mass production type. Next comes taper turning:

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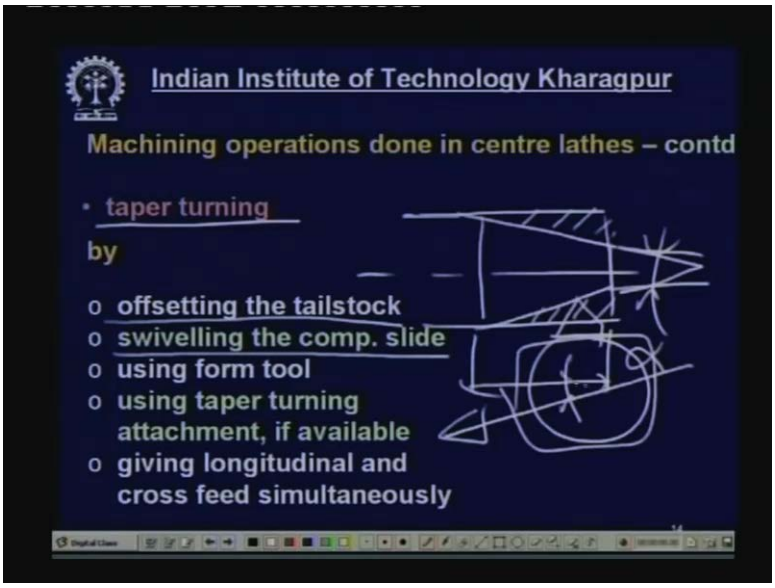

The turning taper: What is taper? You know that, this is the rod which has to be tapered that is this material has to be removed this is the length of taper and this is the angle of taper say alpha okay. Now this type of jobs are very much required for many purposes and this taper, cutting taper in lathe is called taper turning is called taper turning. This can be done in number of ways in a lathe. What are those methods by offsetting the tailstock? The tailstock will be slightly shifted radially and that will enable the production of you know small taper angle over a large length say longer length but short angle that is that can be possible by offsetting the tailstock by swivelling the compound slide. This is for you know medium small tube medium angle and medium length. Here the cutting tool will be moved in this direction. So this tool is mounted on the compound slide and that will be tilted by tilting by manually you can move in an angle parallel to the job to be reduced. Now using form tool. Here the form tools are used for small tapers. For example; say we want to produce a small taper like this.

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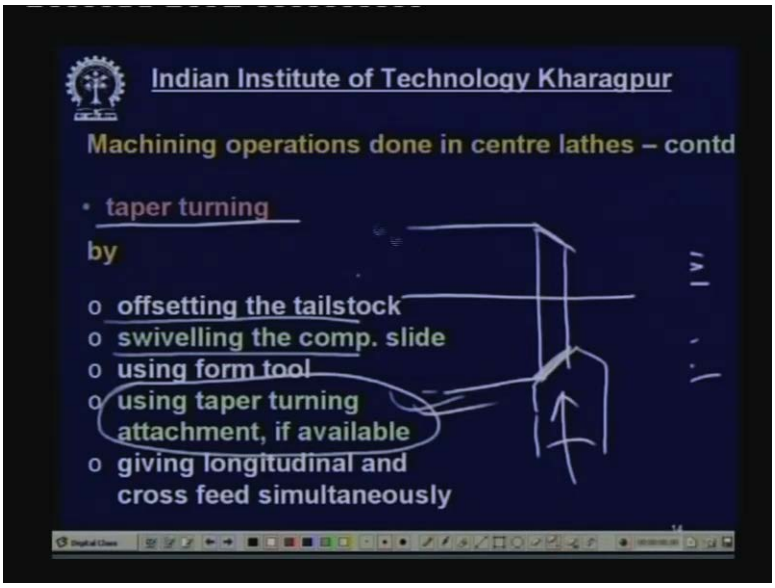

Then we can use a tool like this and the tool if feed in this direction then this taper will be produced. So large taper with short length will be produced by you know using tape a using form tool. Now the taper turning attachment is a very good attachment which is time to time attached to the machine tool for turning the taper jobs is very versatile but it has attached and purchase separately. Now this is also possible in some lathes were you can give.

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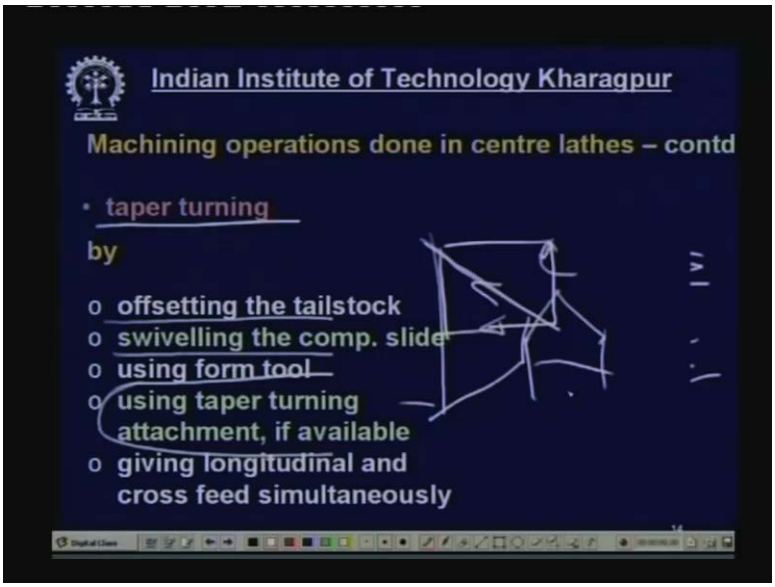

Here we have turning. Suppose this tool is here. So you give the longitude cross feed in this direction and longitudinal feed. So result of these two will be like this. So the tool will move simultaneous in this direction to produce taper. So this can help producing taper jobs by combining both. But is very risky thing and in very few lathes, this is provided. Otherwise there will there is a chance of accident. So these are very rare application. Next is boring.

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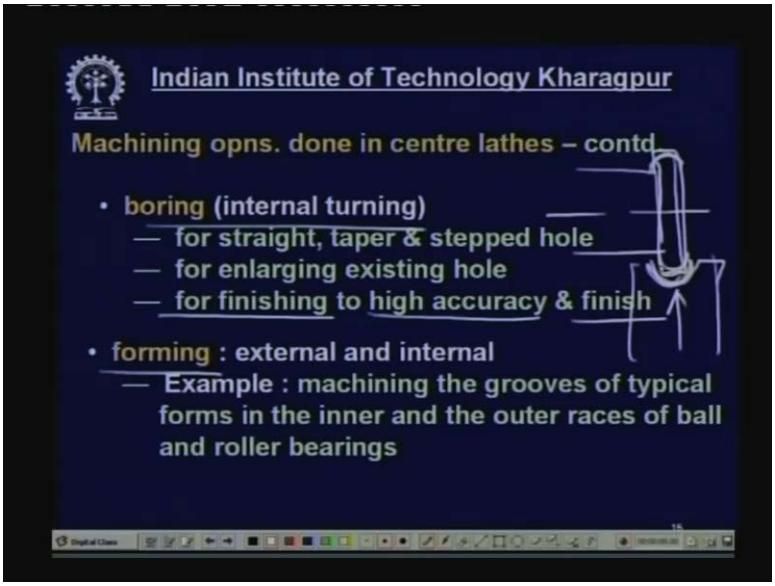

Machining operations for the boring: Now boring is an operation internal turning operation which is used for producing internal surfaces for straight stepper or stepper stepped holes for enlarging some existing hole which is already produced by casting or forging or some other method and this is boring is also used for finishing work for finishing work. Finishing means to approve a high accuracy and surface finished. So the boring machines are expensive forming several types of forming both external and internal are possible for example machine in the grooves of typical forms of the inner and the outer races of ball bearings, roller bearings I already explained to you. So this is forming. Forming for example, I can give you one example say here is a rod with a collar and you want to make it round. So you take a tool like this and feed in this direction. So this particular form of the tool will produce this kind of job. This is the forming. This can be external, internal and other ways.

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Now machining the other operations: Cutting screw threads-external screw thread, internal screw thread both are possible. These have been discussed with a lot of illustrations in the previous lectures. Now parting were a rod will be part into two pieces by parting tool and knurling for making the surface rough for the purpose of handling. This is the knurling and for that purpose a special suppose here is a handle of an

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instrument and for holding purpose, this has to be rough for gripping and this kind of grooves or this of surfaces made by knurling process. Last some beyond those operations,

beside these operations which are usually done. So, special operations can also be done by mounting special attachments. What are the attachments? A cylindrical grinding:

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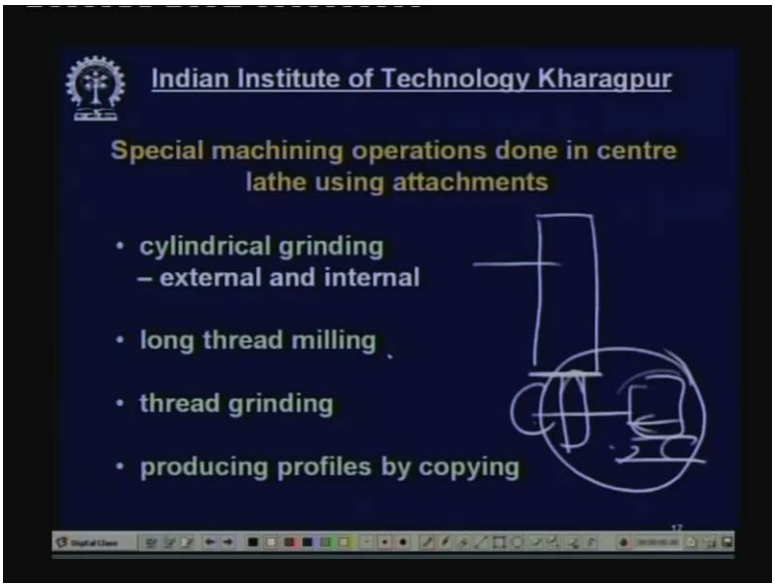

In cylindrical grinding, suppose this is a job and this has to be finished by grinding. So instead of a turning tool, you use a grinding wheel that will be mounted on a motor the motor will be mounted on the saddle. So this will move in this direction and this will rotate. So this is an attachment. Similarly thread milling say threads of long power screws are produced by milling process by milling cutter but that is driven by separate motor and mounted on the saddle of a lathe. Thread grinding, the threads are finished by grinding that is also done by an attachment and producing profiles by copying. So, some hydraulic copying. So hydraulic some copying attachment is available in the market which can be mounted on the lathe saddle or clamped and then it will be used for copying say the job to be produced has to be fixed at the bottom as a template and the stylus will copy it and be produced into the tool by hydraulic copying servo system. So beside that few more operations can also be done if challenged or if essentially required in lathe. So lathe is very versatile and maximum number and type of operations can be done in centre lathes unlike any machine tools.

Thank you