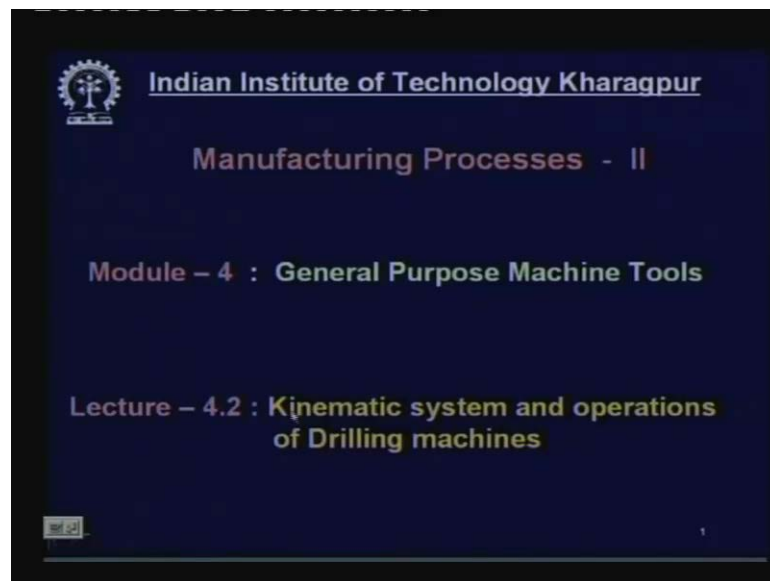


Manufacturing Process II
Prof. A.B. Chattopadhyay
Dept. of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture No.18
General Purpose Machine Tool Drills & Drilling Machine

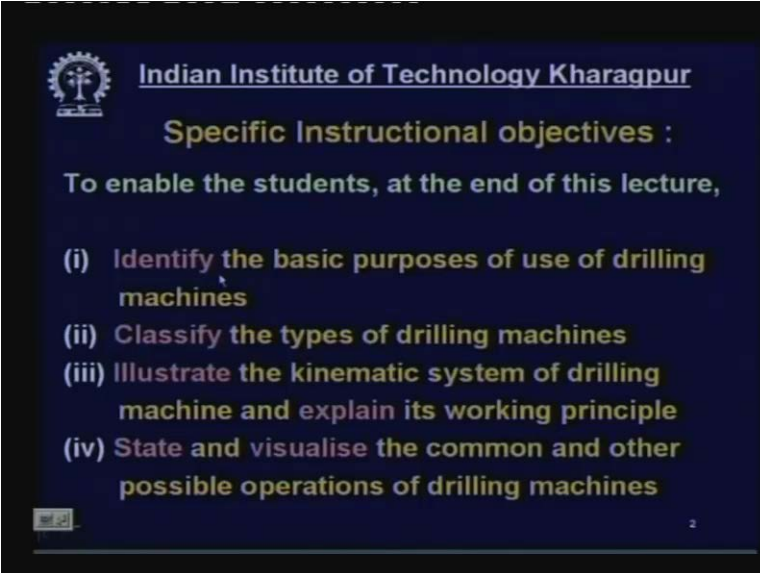
Good morning to all of you. Now let us come to our subject Manufacturing Processes – II. We are continuing Module - 4 which deals with General Purpose Machine Tools and today our

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lecture will be dealing with Kinematic system and operations of Drilling machines. It is a very common machine tool.

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Specific Instructional objectives :

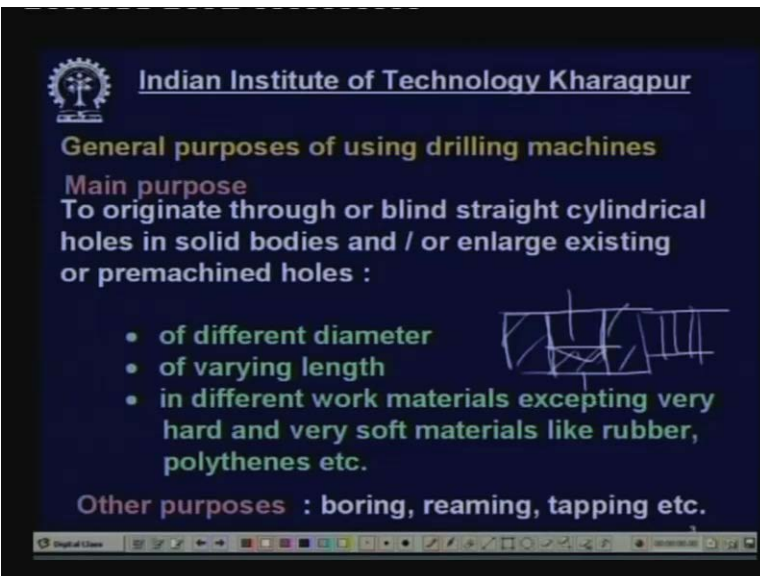
To enable the students, at the end of this lecture,

- (i) Identify the basic purposes of use of drilling machines
- (ii) Classify the types of drilling machines
- (iii) Illustrate the kinematic system of drilling machine and explain its working principle
- (iv) State and visualise the common and other possible operations of drilling machines

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Now the Specific Instructional objectives of lecture today: This lecture after completion will enable the students to identify the basic purposes of use of drilling machines. What are the main and other purposes of using drilling machines, then classify the different types of drilling machines available and used. Illustrate the Kinematic system of drilling machine and explain its working principle. State and visualize the common and other possible operations of various types of drilling machines.

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General purposes of using drilling machines

Main purpose
To originate through or blind straight cylindrical holes in solid bodies and / or enlarge existing or premachined holes :

- of different diameter
- of varying length
- in different work materials excepting very hard and very soft materials like rubber, polythenes etc.

Other purposes : boring, reaming, tapping etc.

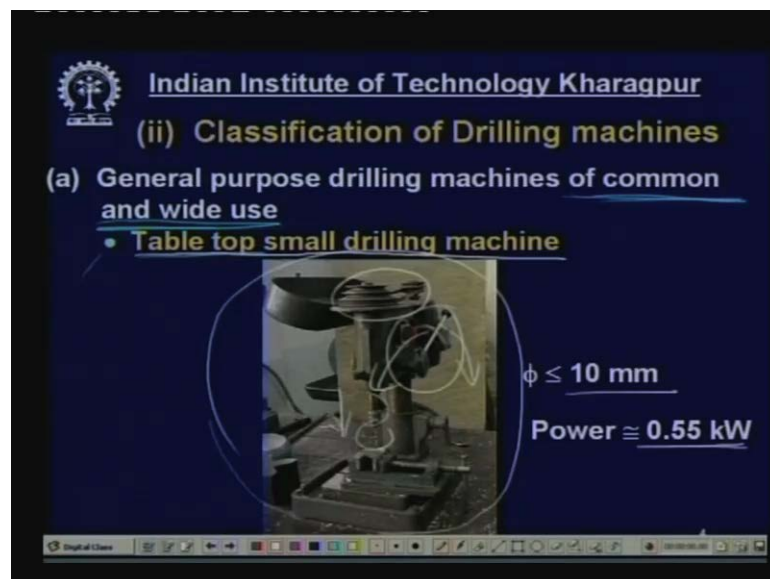
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Now let us start with General purposes of using drilling machines. What are those? Main purpose of drilling machines is to originate through or blind straight, cylindrical holes in solid bodies or

enlarge existing or pre machined holes. Now let me emphasize to originate through or blind holes the originate hole that means there is no hole at all in a solid body. For example, say here is a solid body plate and there is no hole at all, we want to make a hole like this. Now this hole can be through or this can be part like this, it is called blind hole and this holes are generally straight **straight** cylindrical hole in solid bodies.

Sometimes there may be a small hole existing we want to enlarge the hole that is also done in drilling machine. So the main purpose of drilling machine is to originate through or blind holes which will be straight cylindrical in solid bodies and sometime enlarge some existing holes or some pre machined holes of different diameter. So this can do drilling on different diameters of varying length or depth in different work materials in different metals and nonmetals also but expecting very hard and very soft materials like rubber, polythene etcetera. Now there are many other purposes of using these drilling machines which are boring, reaming, tapping threads and many others which will be discussed later on. Now the classification of drilling machines:

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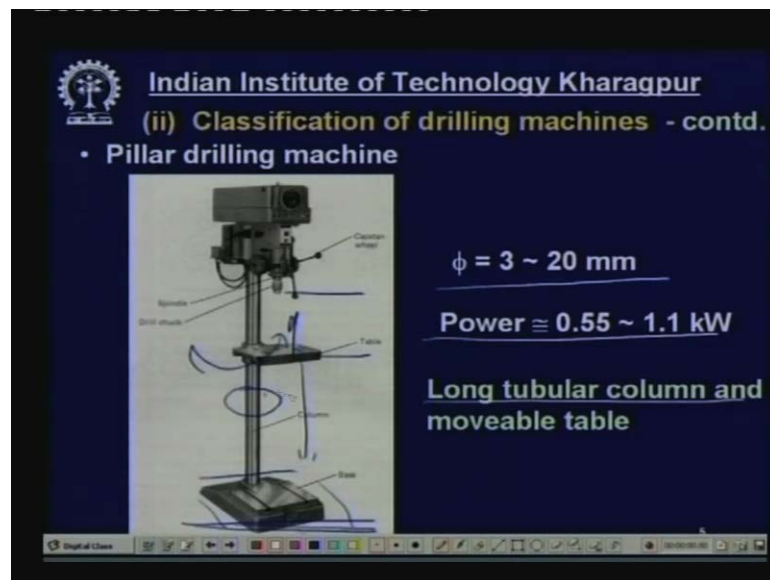


The drilling machines normally produce holes through holes and the single straight holes but even then there are lot of types, different types of drilling machines for different purposes for different size and shape and all these things. Now let us have a glance on the different types of drilling machines and then we shall see subsequently the applications of those drilling machines. Now, the general purpose drilling machines of common use: Here you see that we are talking about general purpose drilling machines of common use and why they use? That is first, then we shall discuss on the drilling machines which are general purpose but used for some specific applications. Now let us have a look into the common and wide use of general purpose drilling machines. Here you see this one is a table top small **table top small** drilling machine.

Now this drilling machine here you see the diagram this is a small drilling machine of size around say 1 feet 2,3 feet and these are mounted on the table either mounted or clamped or

bolted on the table for rigidity and this spindle. This is the drill which is mounted on the spindle and the spindle is rotated by belt pulley system and the speed can be change from say one. There can be 3 speeds low, medium and high speed and the feed motion of the drill that is the downward motion is imparted manually by operating this lever either this direction or that direction. So this feeding and withdrawal of the drill is done manually without any control of the feed rate and this is used normally for small diameter holes say up to 10 millimeter diameter and power obviously is less because it is manually operated, maximum half kilowatt or 0.55 kilowatt or may be maximum 1horse power in case of HP. These are used for repair work or one or two piece job order product and all these things and small pieces and simple jobs of say softer grades, very hard metals or odd shapes are not machined in this process and it is not a lot production batch mass production machine. It is very ordinary piece production general purpose drilling machine. Next is pillar drilling machine:

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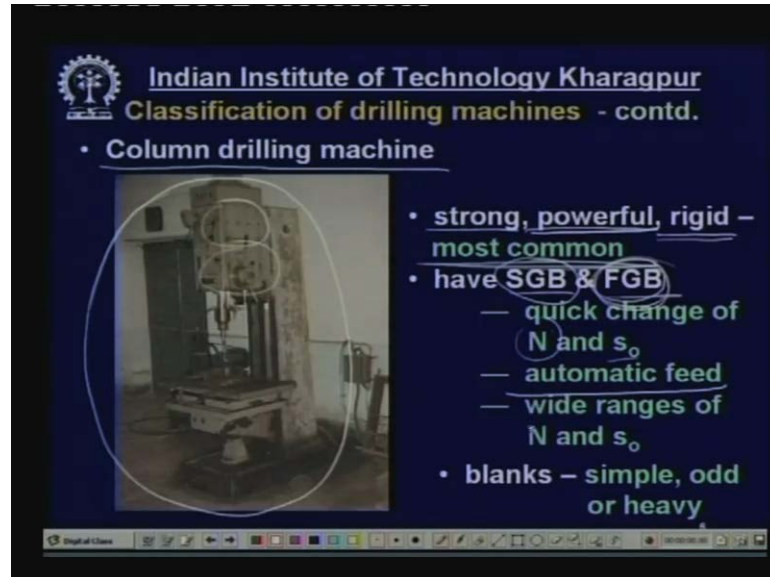


Now this looks a pillar drilling machine, it looks like a pillar. Here you see this is the pillar. This is pillar which has got a circular section that is a tubular section. So this is not very strong nor very rigid. So this is basically an extension of the table top machine. It is taller and fitted on the ground mounted on the ground or the floor or some foundation may be okay. So these are light working machine. The difference between table top machine and this machine is the wide gap between the drilling machine and the table also the table can be moved up and down to accommodate larger or different types of jobs and this table can be swiveled also around this tubular column to accommodate different types of jobs of different length.

So this is slightly bigger or larger in size, then the table top machine and is obviously not a mass production lot production type of drilling machine is a very ordinary drilling machine for one or two pieces of light work. Diameter may vary from 3 to say 20 millimeter, not beyond that. Power may be say up to 1 point 1 kilowatt and since a long tubular column job this is not very rigid. So

accuracy is not excepted and there may be chances of vibration and the table is moveable as I told you already. Now what is the next type?

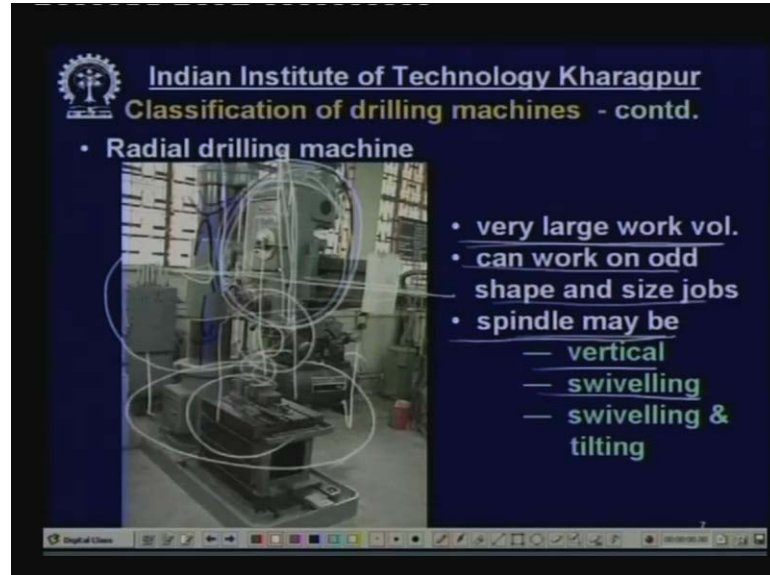
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Here is a type called Column drilling machines. This is column drilling machine shown over here. This is very rigid, rugged machine and quite big size and now lot of work can be done in this drilling machine and of different diameter of drill, different depth of drill, and we can machine different job of material, but it is a general purpose drilling machine with a very low production rate very ordinary production rate. It is not a mass production or best production machine. The characteristics of this machine is strong, because that the structure you see is very strong structure. Very powerful machine to allow high speed drilling by larger diameter drills in say moderately or medium strong materials. It is rigid for high accuracy and this kind of drill is most common.

We will find in industries these drills are most common. These drills have speed gear box and feed gear box. The speed gear box and feed gear box are confined with the drilling head. To enable selection of speed, you can vary the spindle speed and you can also vary the feed depending upon the requirement and the speed and feed can be changed, quick change of speed and feed with the help of this speed gear box and feed gear box is possible and this feed gear box also enables automatic change of feed which is not possible in the previous drilling machines I discussed wide range of speed and feed are available in the speed gear box and feed gear box and the blanks, the blanks here is a rigid and large table the bed on which there may be may not be a table but large bed very strong rigid were but a simple to very odd and heavy type jobs can also be mounted and comfortably machined. So this is very common type. What is next type?

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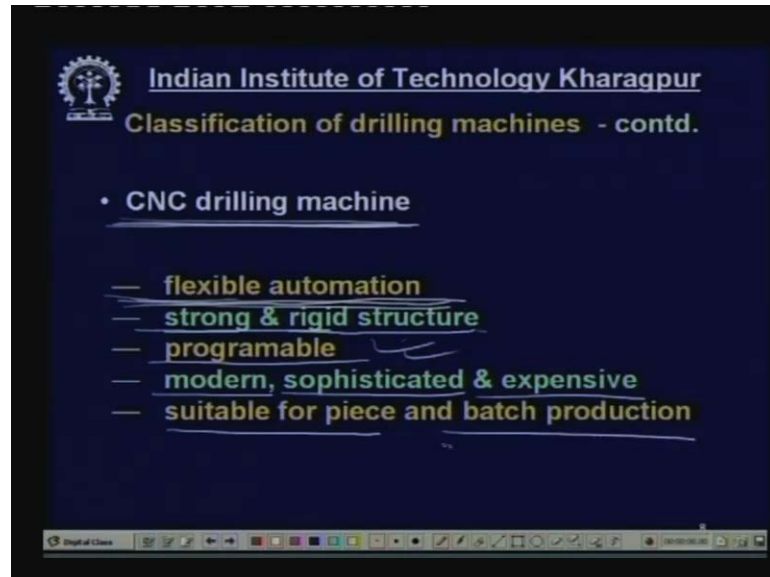
It is a radial drilling machine. The radial drilling machine here you see that, this is the tubular column. This is the tubular column this one but here the tube is very thick and large diameter and valve thickness is also quite large, this is very rigid okay. This on that this is the arm here is an arm radial arm which moves up and down manually or it can powered movement then the drilling head the drilling head here this is called drilling head which holds the drill spindle here in which the drill is mounted and is subjected to rotation. The entire head is mounted on the radial arm and this can move inward and outward from the drill axis. Not only that, as this along with this radial arm the drilling head moves upward and downward to have large gap between the to drill and job or there is a stroke length. Not only that further this radial arm can be rotated about the column rotated about the column, say about 300 degree. Theoretically 360 degree but it can be rotated 300 easily.

Now you understand because of ability of the drilling head to move over up and down over a long distance inward and outward radially and then swinging around the column. This allows very large work volume, a large work space were the position were the drill spindle can be position for doing the work can work on odd shape and size jobs. Even if the job is very large and odd shape and cannot be mounted on the bed itself it is outside. Suppose it is so large that some work has to be done elsewhere then the drills the drilling head will be shifted either upward downward or radially or say swinging and you can do the work. Again, this spindle **this spindle** may be actually the versatility of this machine can be enhanced further by looking into the spindle by having different types of spindle. The spindle may be vertical and fixed. Only vertical okay and this can be swiveling type that means this spindle can be rotated. It can be rotated **this can be rotated** like this to get some inclined hole.

If one we want to make and tilting is also there. Now this is called swiveling and tilting is this direction. So the drill can be straight the spindle it can be swiveling type and it can tilted type that enhances the versatility of the drilling machine. So this drills is radial drilling machine so

used mainly for batch production or piece production of large jobs or shape jobs. Now CNC drilling machine:

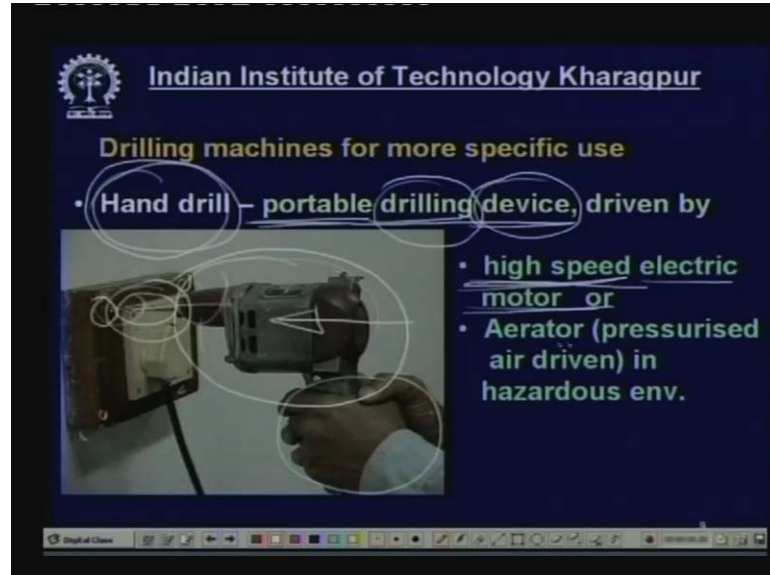
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What is CNC? Computer numerical control: It is very modern machine machine tool concept that since 1970 and 75 onwards, this concept of computer numerical control in machine tools have come up. You now to cope up with the demand for batch production or what is called flexible automation. The present trend is batch production which needs flexible automation that means the automatic system should be capable to change quickly, easily, quickly and inexpensively to meet the requirement of a new product okay. Normally in fixed automation, this is very difficult. Now the CNC drill machines different types of machine tools can be CNC control say lathe CNC lathe, CNC milling machines, CNC drilling machines, CNC grinding machine, CNC broaching machine. Now drilling machines are also can be CNC. What are the characteristics of this flexible automation that is speed, feed and movements.

All the movements can be programmed and controlled very easily quickly as simple by simple program unlike say other kind of conventional machine tools, these machine tools are very rigid and strong made a strong structure. So the process capability is high. This kind of drills produces very high accuracy and less vibration. It is programmable, so that you can easily change from one product to another. This machine tool is really very modern. Came only recently or very sophisticated and obviously expensive. Now these machines are very much suitable for piece production and batch production which is the trend of the present and future. So CNC drilling machines are coming up in that way the very useful machines. Now so far we talked about the drilling machines which are of very common use of wide application.

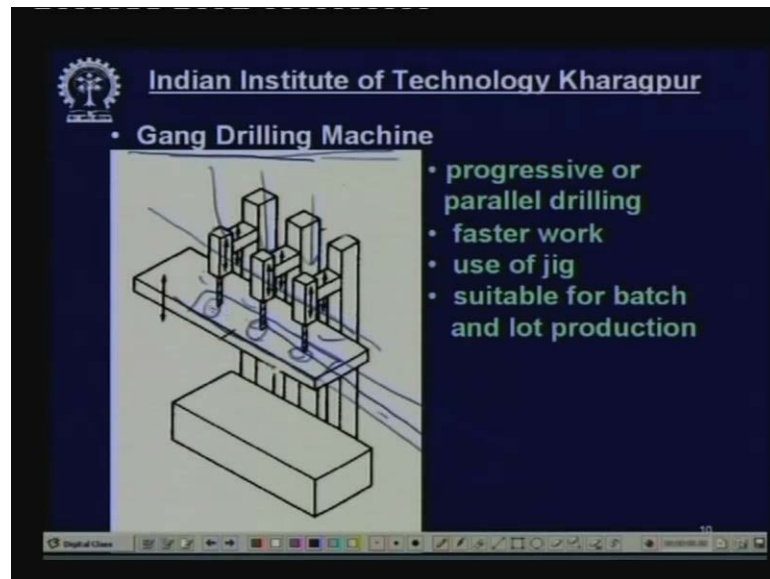
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Now we shall the drilling machine general purpose but those are used for little more specific applications. It is not regularly done but sometime and as and when required it is done and for specific application as and when required. For example, say hand drill **hand drill** that means the drill is held in hand. Now this is a portable drilling device. Now here we see, we cannot call it a drill machine it is actually a small device okay which can do drilling work and the entire set up shown over here, this is the drilling. This is drill bit okay. Suppose we want to make a hole in a switch board some holes here. Now it cannot be taken to the drilling machine nor drilling machine can be taken to this spot. So into the hole has to be made as a few holes and then this drilling device called hand drill you know held in a hand normally it is a brought in position and then the hole is made okay by pressure the feed is given by pressure now what the characteristics.

These are portable number one, these are small so small, it should not be called machine tool but it can be a device. Now this is high speed. Here the rotation should be high speed so that the force that come on to the spindle is much less, high speed now this high speed can be accomplished by high speed electric motor or where there is a chance of you know hazards or some chemical gases which can burn because of some electrical spark inside if there are any then, this spindle is rotated by aerator system. Aerator is simply just like a turbine operated rotated high speed by pressurized air. This is called aerator and this cannot give high torque but it is at high speed it can rotate and make holes and this is very necessary for hazardous environment because there is no electric spark or electricity anywhere okay.

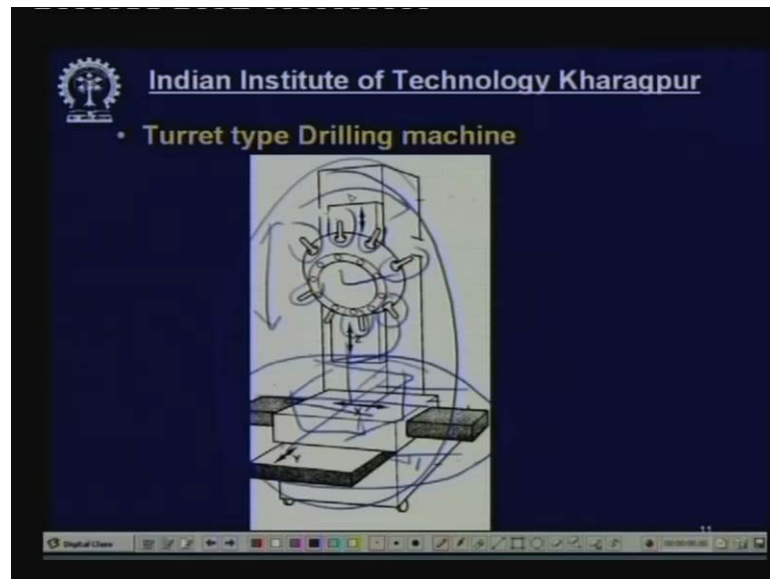
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Now the gang drilling machine: now the gang drilling machine from the name itself you understand that a number of drills, **a number of drills** are used simultaneously. So this is little more productive than the conventional machine tools, general purpose drilling machine I already discussed. The gang drilling machine is a little more productive. It can do work faster. Now look the principle here instead of one spindle, there are 3 spindles 1, 2 and 3. So there are more than 1 2 3 even it can go up to 6 spindles and they will be generally in a row in a general row and a work is suppose a plate, you place under here and then all these spindles will move simultaneously okay will move simultaneously and this spindles can be used in 2 ways progressively and parallel. Parallel means suppose you want to make some holes of same diameter and it is a long bar. So you place the bar first here under the drill and you move the drill simultaneously. So you get 3 holes. After that you shift the bar or the job, so that 3 more holes can be made that means productivity is made 3 times.

Now this can be used in another way that is called progressive. How? Suppose you want to make a bigger hole of diameter like this. So if this is so big you should you may be say 40 millimeter or 30 millimeter. So ideally, we should make a small hole, then enlarge the hole and then finally enlarge the hole in 3 or 4 stages. So this drill will be very small and this will be little larger and this is the largest final. So you take its bar to be drilled and then push bring it here. Make the small hole then you push it here. This will make this hole will come over here that will be enlarged and this will make another new small hole then, you shift it here then this will make the final larger size and this small size will be bigger and this one will make another fresh, small hole. So the productivity will be here also 3 times. But here, we have to remember that for this kind of job one jig has to be yet on the job. There should be a plate like called jig has to be used to keep the location same and the tool guidance and all these things accuracy. So what are the characteristics? Progressive or parallel drilling is a faster production because 3 drills works simultaneously. Use of a jig is necessity and suitable for batch production and lot production that is productivity is higher.

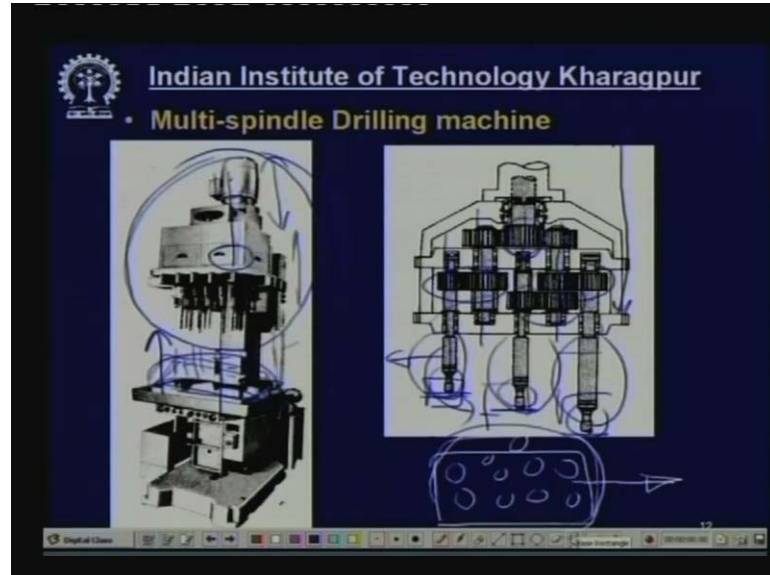
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Now this is another little high productive drilling machines is called Turret type Drilling machine. You know turret lathe. Now turret lathes can be horizontal normally some but sometime the turret lathes are made vertical to save space and particularly when the job is very large diameter or the chuckle very large diameter, the turret lathes are the boring mills are made vertical. Here also this shows a drilling machine. Drilling machines are as such vertical. So this is also vertical axis and there is a turret and the turret has got number of holes may be 6, 5, 6 up to 10 holes and in to the holes in the holes, the cutting tools like drills are mounted. Not necessarily there are all drills. There can be drill some similar tools like a boring tool or a say ream cutter or say counter sinking tool can be mounted and a job will be mounted on this table. This table will move either in x direction or in y direction and the entire turret will move vertically up and down along will the drill.

Now after one tool is used say small drill, then it will go back, then this will rotate little bit and called indexing and next tool will come in position and do the subsequent operations. In this way if in any job say 4 or 5 operations are needed say small drill, then secondary enlargement, thrust enlargement, then boring, then reaming and then finishing further. So many tools will be used consecutively, so this kind of turret is best suitable for that purpose. Now the table moment can be you know mechanical or hydraulic or electrohydraulic or now a days these are driven by numerical control and the entire machine is controlled by computer. So the whole thing becomes computer numerical control or CNC drilling machine. So this turret type drilling machine in short is a vertical axis, it possess a turret which moves up and down along with the cutting tools and it is time to time indexed to bring the tools in position sequentially and it can be ordinary type or it can be CNC type.

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Now Multi-spindle Drilling machine: This is really a special purpose drilling machine, not exactly special purpose. This is single purpose and combination of single purpose that is the only drilling and may be slightly different than drilling slightly boring or counter sinking kind of operation and this is used for large lot production. So this is in between say batch production and mass production and this is single purpose to special purpose machine tool. Here multi spindle that is large number of spindles may be you say up to 10 or 12 spindles all are vertical you know and they are working. Suppose you want to make number of this is a plate, this is a top view, you want to make number of holes of different size okay different size at different location say 8holes. It can be of different shape also circular shape. Now this plate so this will require large number of holes of different diameter, a different location may be a different depth all right and this is a large number of pieces have to be produced repeatedly. The same job has to be produced repeatedly and this is called mass production and this plate has to be mounted first on this.

First has to be mounted on this table and then there should be a jig. This will be covered by a jig having some holes already all right according which will be prime. According to the job to be made for each job type of job there should be a separate jig to be made which is also resembles the same job. Now if this jig has got number of holes and bushes through which all the drills you know, they come inside and do the necessary drilling operation. Now here you see how it is accomplished? There is a central gear. Now this is the motor which rotates a central gear here. This is a central gear and there some planetary gears which rotate which are shifted around this circle and this can be rotated about the axis and this is one those spindles and these spindles again transmit rotation to this spindles through another set of pair of gears.

So the location the circular angular rotation, position and radial position of the spindles can be varied by moving this axis and all these are done according to the job to be done for the location of the holes and this has to be decided and depending upon the diameter of the hole to be made, different size of drills are mounted on the different spindles and depending upon the depth of the hole to be made, these drills are used at different height because the entirely moves

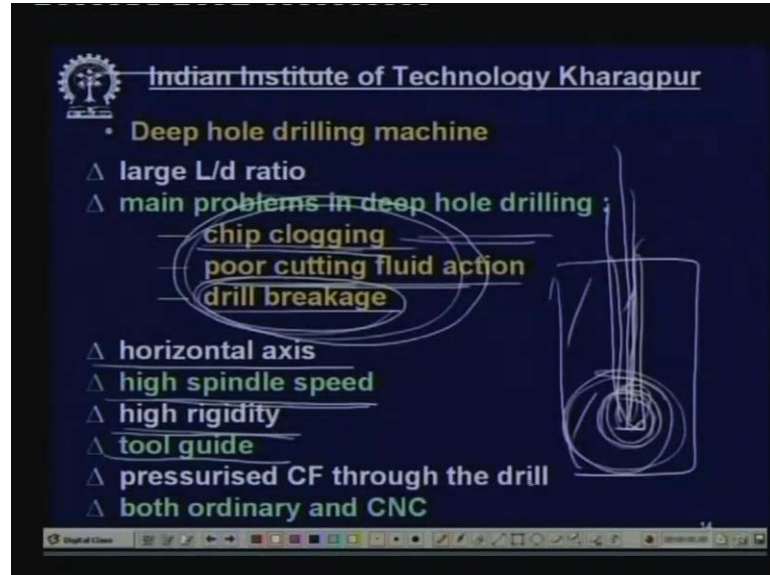
simultaneously downward and this will be at different height so that, the holes of different size different depth can be made and entirely moves up downward the powered. But sometime, you know this machine is so big that moving the entire head upward downward may be little difficult and not economy. In that case, the job that is mounted on the blank along with the fixed jig is moved upward for the feed motion for the cutting action and after cutting action it is moved down and the spindle head remains in one place which is quite heavy and large. So this is machine tool, multi spindle machine tool, were the number of spindles may vary from say 4 to 12 even more and this is used for mass production or large lot production.

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Now Micro drilling machine: now micro drilling machine it is not really micron or micro size. Micro here means very small drill, very small may be say about maximum 1 foot height or even say 6 inches 6 inches 1 foot height and this looks like this. Here you can see that, this is the base. On this is the base okay heavy base which can be directly placed on the table or it can be grounded on the table to make it is a fixed and then there is a rod like column and this is a drilling head. This drilling head can be moved up and down **moved up and down** with a help of a lever that is necessary for the feed motion. Now here is the motion is transmitted belt pulley system and normally one or two speeds are available one high speed, one low speed accomplished by this motor comes through the belt pulley which has got two pulleys of two groups to give two different speeds but this rotates at high speed normally because if the speed is increased, then the force on the drill comes down the thrust force comes down torque and thrust so speed should be high because it is operated manually and the small jobs of this kinds of job can be mounted here with the help of small vice and you can do the drilling of the manually operation. It is just like a table top drilling machine but comes much smaller size and this is used for very very fine work thus very small work say one or two pieces have to be make or one hole has to be made. So this is related to repair work or electrical work, electro fitting work like that.

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Now the Deep hole drilling machine: now making deep hole is a problem it is not easy. Now when we call it a hole a deep. Now the hole has got two dimensions. One is the diameter and other one is a length length and diameter. So if the length is too large compared to the diameter, then it is called deep hole say L by d , L is a length and d is a diameter if L by d ratio exceeds say 10 even 8 we call it deep hole and the lot of problems arise. Now when we require such kind of deep hole where we need? We deep holes in case of say barrel of guns, barrel of rifles, sorry and the oil holes in crank shafts oil holes in bearing housing, then we need very long holes length is very long and high and diameter is very small. This is called large LYD ratio. Now the main problems in deep hole drilling as I have already told that, main problem is chip clogging.

Now when we make a deep hole inside a body say this is a drill bit it comes up to this much then the chips that form here that may be clogged here may be jammed and if the chips are jammed in the flute, then there will be no cutting action and then the cutting will be action will be very defective and the cutting flute that is normal used for pulling and lubrication that may not reach the cutting zone. If the chip gets clogged, so the poor cutting flute action that hampers cutting action and as a result finally because of the clogging of the chip and absence of cooling and lubrication and the drill as such is very slender, very weak slender drill may easily break. So this is very frequent phenomena or regular phenomena in deep hole drilling. The main problem that chip breaks due to chip clogging and poor cutting fluid action.

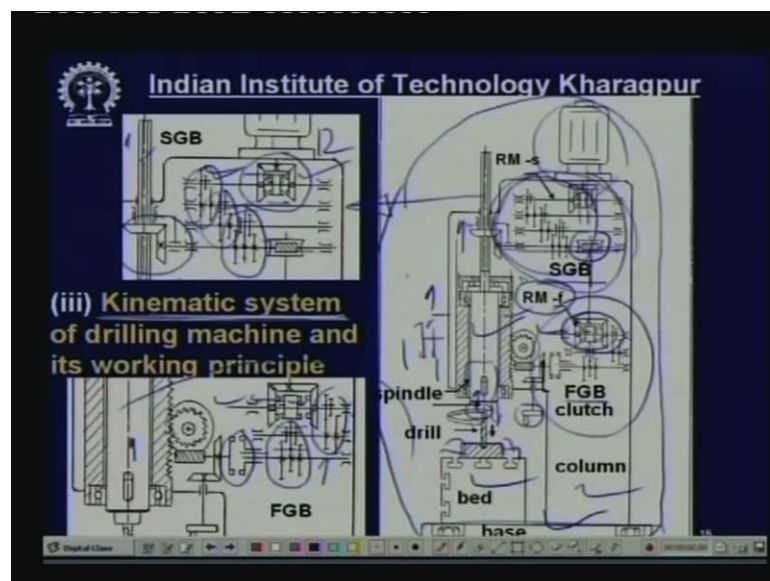
Now these machines are normally so this problem has to be solved okay. How? By chip clogging, this drills will have to be with a large helix angle large helix angle and the drilling as to be done intermittently first you just proceed little bit say 1 centimeter you withdraw the drill, clean all the chips and all these things then you again push it again lift it then you again push it again lift it. So you keep on cleaning the chips do not allow the chips to clog. Secondly the cutting flute as to be applied profusely all right and not only that under pressure and sometime to reach the cutting fluid at the end drill tip. This has to go through the drill is made hollow through

the hole pressurized flute is pass through to reach the cutting zone. So then this problem will be overcome.

Anyway these drilling machines are normally horizontal; horizontal axis because the hole is weak, the drill is big and the whole spindle is big. So if it is vertical, then it will be too slender the whole machine will be too slender and that means the lack of rigidity. So accuracy analysis will be lost. So these are made horizontal. High speed spindle to reduce the cutting force because if the force is large, this slender drill may buckle or break. High rigidity so that is no chance of any vibration or buckling tool guide since the guide tool is very long and slender some the tool has to be guided the tool has to be guided through the guide the tool will move so that, this lateral movement is prevented. Pressurized cutting fluid through the drill one or two holes are made through the drill through that the hole is the while is passed and both ordinary and CNC machines are visible. But nowadays, these deep hole drill are converted or made in with CNC control for accuracy and productivity.

So in defense, they use lot of say CNC deep hole drilling machines for boring and drilling the guns barrels or antiaircraft, gun rifles and so on. Now let us come to very important aspect of lecture today that is Kinematic system. Just now you have heard, so many types of drilling machines, very small to very large. Manual to automatic control and up to CNC control, very resilient to very rigid okay horizontal vertical drilling with the different types of drills and diameter but the Kinematic diagram is more or less say in say where there is feed gear box and speed gear box. Here you can see, this is the speed gear box and feed gear box that means the

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speed and feed or can be changed frequently depending upon the requirement and feed can be changed or adopted automatically like radial drilling machine, column drilling machine and automatic drilling machine turret head and so on. So this is the Kinematic structure of very common type of drilling machines, basically column type drilling machine and to some extent

radial drilling machine. Now what are there inside? Now the Kinematic system, the Kinematic system as I told you earlier also in our previous lectures that is, this arrangement the Kinematic system of when a machine or machine tool deals with only motions. Transfer of motion and transformation of motion like say from rotation to rotation, rotation to translation, translation to rotation, rotation to oscillation and so on and transfer of motion from one point to another point from the source to the drill cutting point. So this is called Kinematic system. Now let us go into this Kinematic system.

Now this is the drilling machine okay. This is column drilling machine. What is the main part? This is a power source say motor only motor. We are excluding at this moment, we are not discussing at this moment this lubrication or other kind of drive only power drive that is the single motor. This is the cutting tool drill. Here is only machine tool where both the cutting motion and feed motion are given to the tool. So the drill bit here that is made to rotate and same drill is made to move down. The work piece **the work piece** remains completely stationary in such kind of drill now. So this drill is mounted in a drill socket **the drill is mounted in a drill socket here**. The drill socket is fitted into this spindle, this is called the drilling machine spindle which has got a long bar at the tail end which is plain, I am coming to that why now this spindle is partially hollow here? So the drill is or the drill socket is fitted into this taper hole.

Now the drill spindle has to be rotated to rotate the drill where from the drill spindle achieves or attains the motion? The drill spindle is connected to the motor through a gear box called speed gear box. This is a speed gear box okay, where the speed is not only transferred or transmitted **transmitted** to the drill. It is also splitted, motor rotates at the constant RPM. But drill may require different RPM very slow, very large, or very high depending upon the work material, tool material, tool diameter, machine tool condition. So there is a provision that is called speed gear box which enables splitting or reducing or increase the motor speed to a high or low value and with the help of some cluster gears. So this is how the spindle is made to rotate. Now this is the enlarged view of the speed gear box. So the power comes from the motor, this is a reversal mechanism which really converts say the rotating motion from clockwise to anticlockwise or may be anticlockwise to clockwise.

So when we need clockwise motion, so the clutch will be operating in this direction. When we need say anticlockwise when say for producing threads by tapping, we need this anticlockwise rotation. So, the clutch will be moved and we can get clockwise and anticlockwise motion. Now the speed comes to first shaft. Now through these gears with split to tube, two then again it is splitted into two. Now again finally splitted into three: So how many speeds we get. So 2 into 2 into 3. So this is a 12 speed gear box and the power comes from the final shift through the pair of gears through the gears this spindle goes. Now the spindle is plane why because this spindle will move up and down.

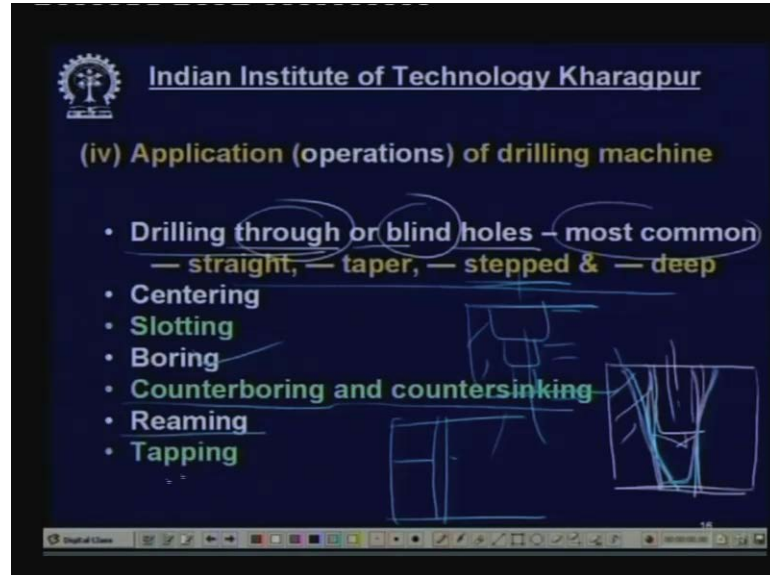
So this will move up and down along while it is rotating, so this spine shaft will allow the movement of the spindle up and down through the gear without hampering the transmission of rotation. So transmission of rotation will continue, but the drill spindle can be moved up and down through this gear with the help of this plane then the feed motion, the drill has to be moved up and down. This is actually done this spindle is mounted in a quill or barrel. These are box type which moves up and down okay and this has got a rack on its wall and on the rack, there is a

pinion when the pinion is mounted on the shaft. When the shaft is rotated the pin is rotated clockwise or anticlockwise along accordingly this quill along with this spindle will move up or down okay. So this shaft is rotated by another worm wheel that is rotated by one worm and that can be rotated a wheel manually.

So by operating this wheel manually, you can rotate this pinion and make this spindle move up and down. So manual drilling is possible. Now if you want it to automatic, then the speed comes from you have to use this feed gear box. This is the feed gear box. **This is the feed gear box okay.** Now explaining; the power is coming from this spindle final a spindle shaft through a reduction because feed motion is very slow. It is brought to the shaft through a feed reduction mechanism. So that is called this can enable the movement upward or movement downward that means the pinion has to be rotated upward sorry clockwise or anticlockwise to move this spindle downward and upward. So to change this direction of rotation of this pinion, this clutch is operated, this system is operated, this clutch is operated. This clutch can be moved either this way or that way that will make this spindle rotate either clockwise or anticlockwise.

Now that will be transmitted to this shaft in this two that will be again splitted into three. So this shaft can be rotated at any one of the 6 speeds and that will convert into feeds. Now if you engage this clutch, now this rotation reduce rotation will be transmitted to this pinion through this worm wheel and this worm okay and this will be done then defined. Now you can change this feed by operating the cluster shift in the cluster gears. So you can have any one of the 6 different feeds okay and this is a bed on which the job is clamped either in a vice or directly by clamping and rigidly mounted and this is a column which is very rigid and this is base of the drilling machine and the base is fitted, clamped on the foundation concrete foundation. So this is the Kinematic structure of drilling machines. Now it varies machine to machine or manufacture to manufacture. Here we have shown 12 speed gear 12 speed gear box that means the spindle can rotate at 12 different speeds, but they are drilling machines if wanted it can be 18 speed it can be 24 speed. Similarly the feeds can be increased from 6 to 8 to 12 and so on by having different cluster gears.

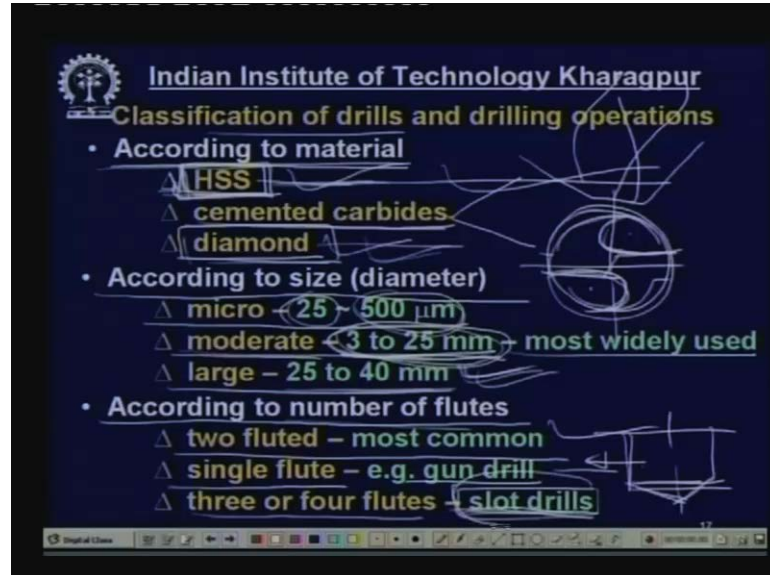
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Now the application of drilling machines applications or operations the various kinds of operations or applications possible in drilling machine. Now this is very important because those who will use the drilling machine they should know about it. Now the drilling through the primary is drilling through or blind holes. Now what is I am reminding you that, if you want to make a hole suppose this is a rod, it is plate or say block, you want to make a hole up to this much by a drill okay. Then this is called blind hole. If you want to make full length up to bottom then this is called through hole. So drilling machines are mainly used for drilling holes all right which can be through which can be blind and this is the most common application of drilling machines and this whole again this whole as I have shown this is straight hole okay.

Now this can be taper, this can be taper hole but taper hole is very rare very occasional; now by it has done it as to be done by special drill but straight hole is most common and sometime stepped hole is also made. Stepped hole means say this is the work surface, we make a one diameter hole then another diameter, then another diameter final. So the diameters are varying at different position of the portion of the hole okay. This is called stepped hole and sometime I already told this hole is made very deep okay of the small diameter but very large depth. So this is a various kind of holes. Now in addition to making holes what else can be done? Centering- that is done for making small holes and the job to be turn in the lathe. Boring- for enlargement of holes, then counterboring and countersinking. This will be discussed more detail, then Reaming- for finishing by reamer and tapping for cutting threads, internal threads in nuts and so on. So all these things will be discussed now:

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Classification of drills and drilling operations: For different drilling operations, different types of drills are obviously required. Now the drills have to be classified, different types you know few dozen types of drills are available. How do you classify? This can be this classification can be made in different aspects according to size according to length according to aspect ratio according to material and so on. Now let us go in systematically. According to the classification of drills according to material now the drills can be made of different material. High speed steel okay. You know the high speed steel was introduced in 1905 by F.W.Taylor which contains about 18 percent tungsten and 4 percent chromium vanadium. Sometimes little bit cobalt is also added and later on as high speed steel and these are very tough and strong. Since drills are very slender tool and geometry is very complex.

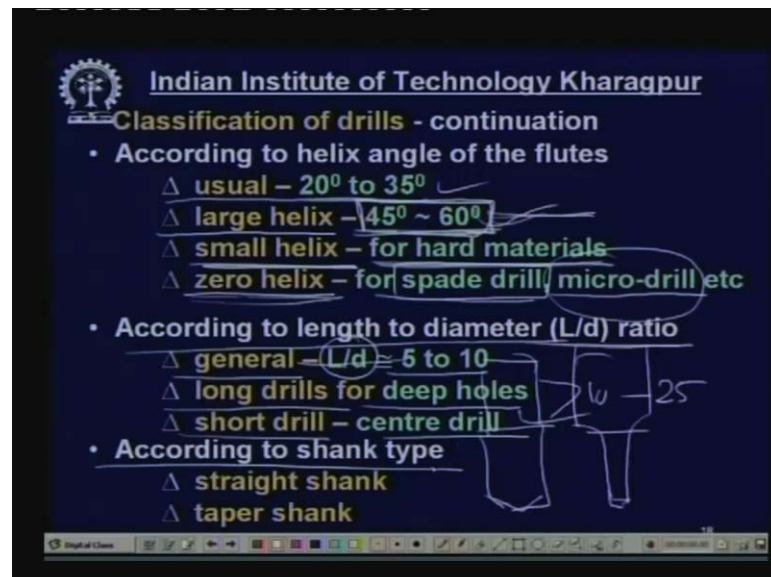
So high speed steel with its toughness, formability and strength tensile strength and transverse obturator strength are mostly appropriate. So most of the drills or the tools those are used in drilling machines are made of high speed steel. Even today, through the cutting speed is not that high possible then comes cemented carbides which are produced powder metallurgically this carbides can be uncoated can be coated tools. The diamond-sometime for making very small holes in exotic materials diamond is used where other tools cannot do work, because of hardness of the material or special to the material and size of the hole etcetera. So diamond is very occasional very rarely used only for very special application like very find holes or for very exotic material. But diamonds again I remind you that, diamond tools are never used for machining steels like material then the diamond will be graphitized.

Now we can classify the drills according to size. Not very clear cut demarcation is available or used but anyway there is a generally people call it micro micro drill. What is the micro drill or micro drilling? When the size of the driller size of the hole will be around 25 five micron to 500 micron 500 micron means I remind you the half of millimeter. Now you can imagine what is the size 25 micron to that small size drilling is possible and is called micro drilling for that special drills called micro drills are available made available. Moderate-that is 3 to 25 millimeter really

most of the drilling work we do in industries, they are within 3 to 25 millimeter. So this is the most widely used region and with this size of drills are used in plenty in the work shop and market Large - Occasionally we drill large holes. Normally if the hole is too large say bearing or something or bearing housing have to be made then hole is made by drilling originated then it is enlarged by boring operation. So drilling if to be done to a large extent then maximum 40 millimeter occasionally may be 45 millimeter some manufacturers or some users may be using but normally 25 to 40 millimeter. We call it large diameter and this means that there will large force large torque some machine tool that is very powerful rigid all right.

So this is not a mass production machine. Now the classification according to number of flutes. Now this is you know the drill has got fluted the drill this is a drill this is actual view, this is one flute and this is another flute and this flute continuous **along this flute continuous along this flute continuous** helically sorry and then how many flutes are there. The flutes actually provided for removal of the chip or because this cutting edge will produce a chip how this will be removed from the hole through this cavity or flute. These chips will pass out and secondly the flute angle the helix angle the flute angle that governs the rake angle of cutting tool. Now according to number of flutes two fluted most common very ideal and most common single flute very rare this is used to make the drill bit very strong and rigid. For example; gun drill, deep hole drill, crank shaft hole drill etcetera. Sometimes 3 or 4 flutes are also used. These are called slot drill okay. Slot drills to reduce the load path tooth sometime this slot drills are make or use for making holes will flat end like this normal drills make a tip or a cone type but this makes a flat. Sometimes this slot drills are also used to make some slots this slot drills look like sometime to some extent end mill cutter.

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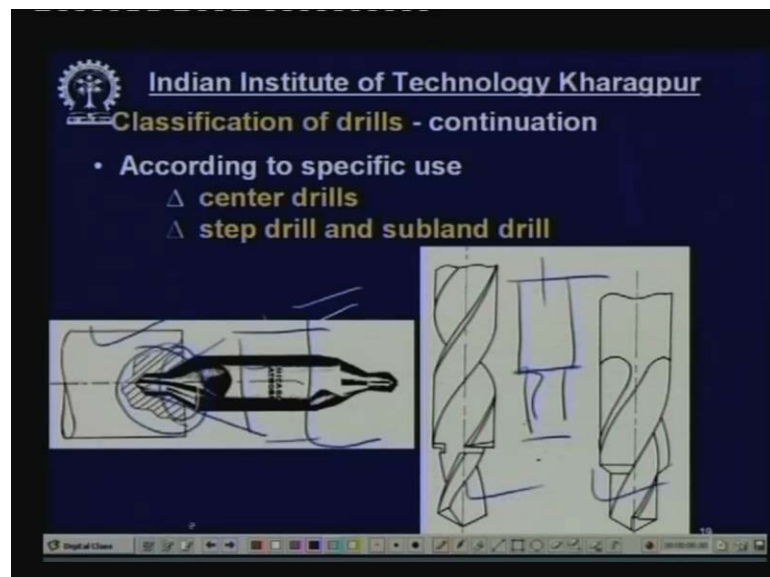


According to helix angle of the flutes, normally it varies from 20 degree to 35 degree. I already told that this helix angle really represents also governs the rake angle. You know for cutting ductile material with a long chip large rake angle is necessary. So the helix angle should also

very large. So this will not only enable very good removal of the chip, but also help reduce the cutting force by virtue of large **large** helix angle. The usual helix angle up to 35 degree. What is the large helix angle 45 degree up to 60 degrees. These are used suitable for long drills for deep hole drilling in soft materials or yes or for making holes in very soft material like aluminium, copper other alloys. So the helix angle, large helix angle means lesser force. But if we increase the helix angle, the rake angle will increase. Chip disposal will be better but the strength of the drill will decrease. So this will be used for long drills and soft materials small helix where large helix is prohibited for harder material. When you make hard machine harder materials, so the core of the drill as to be made harder strong and that means this small helix will be there zero helix. Yes when the work piece is really very very hard or we want to do spade drilling. Spade drilling means you know this is the rod and then this is the drill bit is a plate like is a plate like okay.

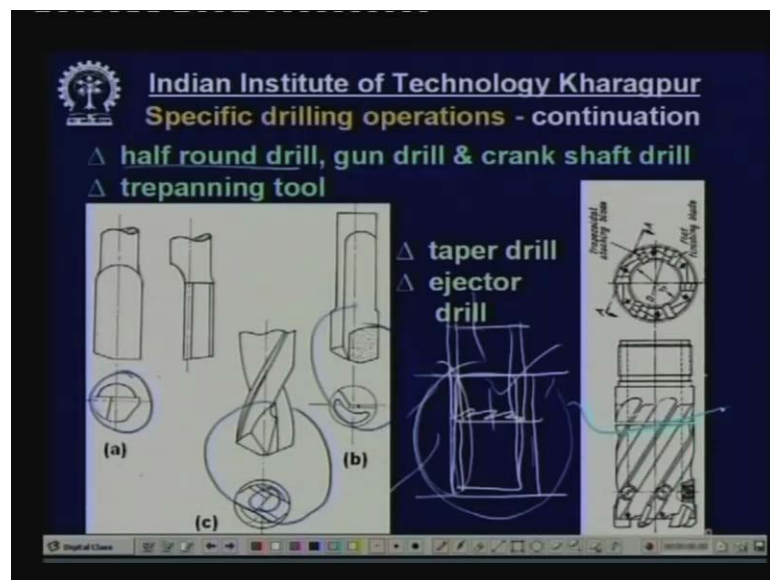
This is the spade drill. Now the spade drills are used for large production and harder materials. Sometimes micro drill for very small drills also; this helix angle is avoided because the micro drills are such very small in diameter and weak. So they have to be retained strong by zero helix. Next is according to length of diameter. length to diameter ratio, L by d ratio okay general normally L by d ratio should be within 5 to 10 that is maintained okay, neither very small nor very large. If the L by d ratio is too large, the drill becomes weak. If it is too small, the chip removal will be difficult. Long drills as I told you that this L by d ratio for deep holes. There the ratio should be more than 10. It can go up to 25 the ratio, short drills where the L by d ratio will be very small say about say centre drills like centre drills 2 or 3. According to the shank type, that straight shank and taper shank, sometime the shank of the drill is tapered to or sometime it is straight. When it is straight shank, then it is held in the chuck. Otherwise it is socket or directly into the spindle.

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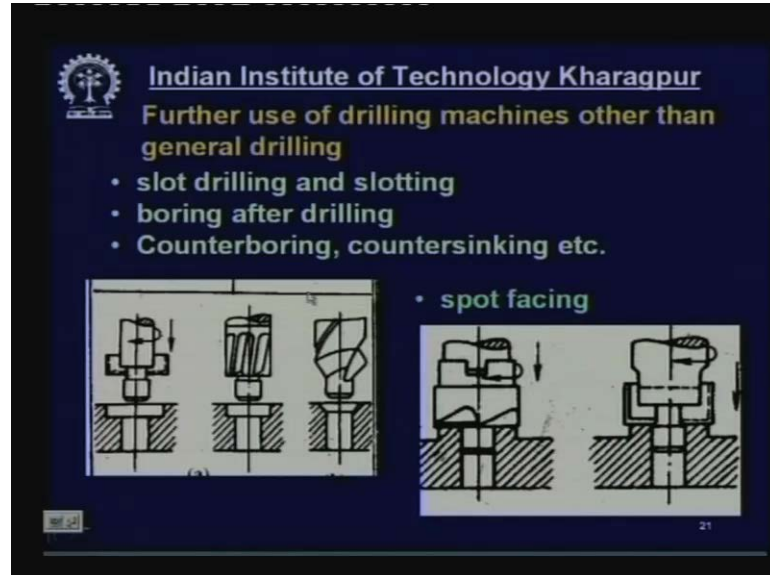
Now the classification of drills: again according to specific use this one shows a specific use this is a centered drill. This is called center drill very short drill and this makes this hole this makes the hole necessary they provide it at the end of the job to be turned and this hole is used to support this center which has to be mounted into the headstock or tailstock. This is called centered drill and one taper has to be made here, then comes you know step drill. So if you want to make step drill say one diameter, the hole has to be diameter has to be changed say up to this much. The diameter is this much and then diameter is reduced we can use as the step drill or subland drill. This is the drill which makes you know in one stroke to two type.

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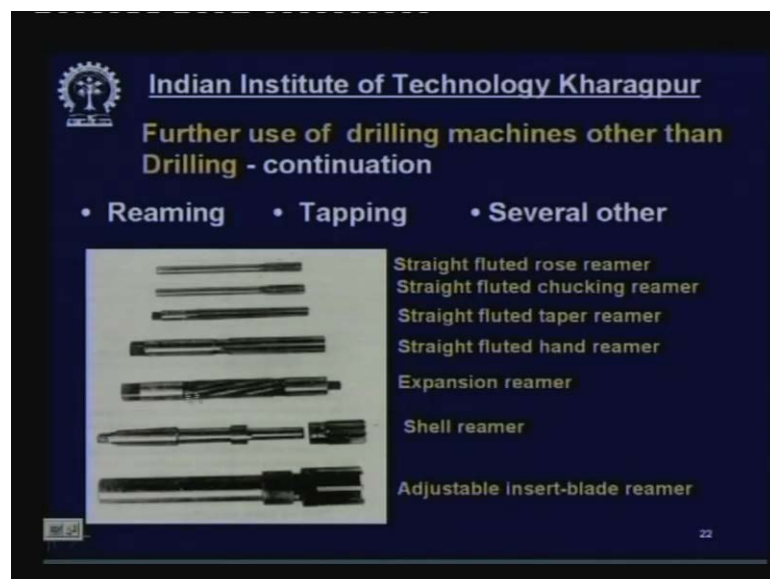
Then half round drill; half round this is half round drill. This is called half round drill this one half round drill, then gun drill. This is a gun drill and crank shaft drill this one. These are basically long drills where L by d ratio is very large and only one cutting edge is there, one flute is there and there may be two flutes. But the base is very strong and this is called half round various types of drills. Now this is a trepanning tool. Now what is trepanning tool? is a pipe like cutting tool is a pipe like cutting tool. Suppose you want to remove this material. This is hole has to be made. So what you do? You take a cutter pipe like okay. A pipe like cutter and then just gone cutting edges here. So when this will rotate this will remove material only from this region only from this material remove and this central material remains un-machined. So you can get an extra core. So this is one way of removal of making large hole by removing small material but this is feasible for softer material. So this is one piratical type of machine of such the cutter called trepanning tool.

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Now further use of drilling machines other than general purpose. So this is called slot drilling and slotting as I told you already, the boring after drilling enlargement of hole by putting a boring tool in the drill spindle instead of a drill, you can do boring. You can change the diameter of the both boring tool. Counter boring, this is the example of counter boring. So you made a hole then you enlarge the diameter at that top end to accommodate say then bolt head or some nut. Sometime it is tapered to put some screw and is called countersinking. Now spot facing; here is a surface at the top of the hole which as to be flattened. So this is called you know spot facing operation.

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Then comes Reaming: Reaming means finishing. There are various reamers which look like into some extent drills but there this has got a taper cone. These are just like long milling cutters and they are fitted into the drill after drilling because drilling does not give very good high accuracy and a finish. So this has to be finished sometime. Even after boring you do not get good enough say surface finish and accuracy. Then the finishing work directly after drilling or drilling and then subsequently boring finished by this cutters called reamers a rod like and they have got edges or ribs which are nothing but cutting edges. This is a small one. There are different types straight fluted reamers, this one. Straight fluted chucking reamer held in chucks slightly bigger straight fluted taper reamers is a slightly taper to finish the taper holes for taper gibs and all these things and this straight fluted hand reamer operated manually in a lathe sometime and expansion reamers where this diameter can be slightly adjusted within few microns. Shell reamer- this is a basic tool on which the reamer part can be removed and fitted. So this is engaged and this is engaged of different diameter.

You can choose it and fix it and the last one is adjustable insert blade. The blades there are separate blades available in the strips which are fitted into the grooves provided into the slot on to the body and this can help, enable, change in the diameter or replacement of the worn-out cutting tools. Now next is tapping. The tapping means cutting internal thread say nuts, the small nuts have got say the internal threads. How this thread will be made? You can make it in a lathe all right you make in drilling machine. If you want to make it in large lot production or mass production, then this has to be done in a drilling machine of course with the help of some drilling the tapping attachment. The tapping attachment is fitted first into the drill spindle and then the tap tool is fitted at the end.

Now here we need two motions during cutting motion the rotation and translation and during internal motion it should rotate in the opposite direction and gradually come up, the tapping attachment enables all this motions. So this tapping is accomplished in a drilling machine but with of an attachment. Similarly by using different types of attachments you can produce different types of jobs. There are a lot of examples. If there is real need or if there is a challenge then various kinds of job can be done even in ordinary drilling machines. But you have to use appropriate jig fixture, then some attachment like tapping attachment and different types of tools and so on. So these drilling machines are really quite versatile. It can do many many types of work from very job order production to mass production, to very less precision to very precision for small diameter to large diameter for very soft material to hard material, for very short length to high length. Next day we shall discuss on milling machine.

Thank you.