

Fundamentals of Manufacturing Processes
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Lecture – 46
Material Removal Processes: Grinding Operations

Hello, I welcome you all in this presentation related to the subject fundamentals of the manufacturing processes and we are talking about the grinding process, the last few lectures we have talked about the fundamentals related to the grinding and today we will see the grinding operations or these are also termed as a grinding processes.

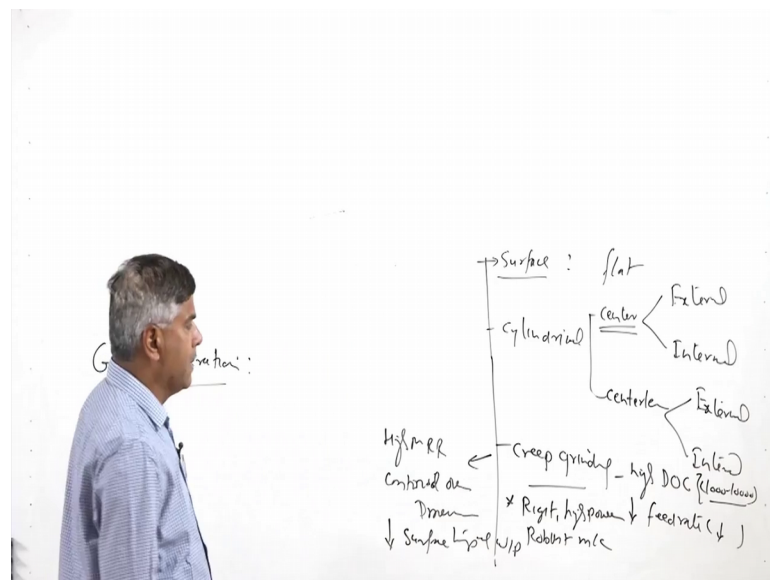
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The grinding is used for giving the desired finish as well as the control over the dimensions. So, that accurate size production can be made, but this is used for a smoothing or finishing of the flat surfaces, cylindrical shaped components like contour in form of threads, may be holes and gears etc and various such kind of the geometries can be processed by the grinding process and for that purpose the different types of the grinding is used like, one is surface grinding which is used for primarily the flat surfaces. Then cylindrical grinding it has a very large a range of the varieties, one is like center type where the work piece is held in the centers and along the particular axis and another is center less process, both can be external and internal cylindrical grinding.

So, this also center less also comes in the external and internal cylindrical grinding. So, internal cylindrical grinding means, the cylindrical hole like this exist in an external cylindrical grinding means the external surface of the cylinder will be processed. So, in the center less means, there will be one chuck on that work piece will be held and then it will be subjected to the grinding. In case of the center less, the work piece is simply placed on to the rest like this and then with the help of the supports from the 2 sides, 1 with the help of a regulating roll and the grinding wheel the that the work piece is placed in position for the external grinding. In likewise we have arrangement for the internal center less grinding, in addition to the surface and the cylindrical grinding.

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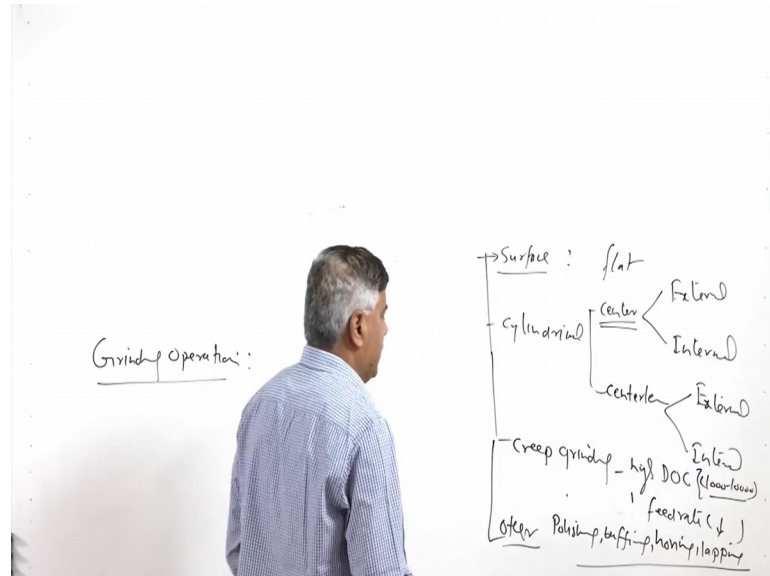


There are other grinding approaches like 1 is a called creep grinding, where in the very high depth of cut and very low feed rates are used.

So, depth of cut maybe like thousand to 10,000 times higher than, what is normally used in the conventional grinding while the creep, while the feed rate is proportionally lower means thousand to the 10,000 times lower than the conventional field rate. So, which are used another important requirement for creep grinding, is that it a very rigid high power and a robust machine is needed for this because very high cutting forces are generated during the grinding. But at the same time it offers the advantage of the high mrr and good control over the control over the dimensions and surface finish, as well as the surface

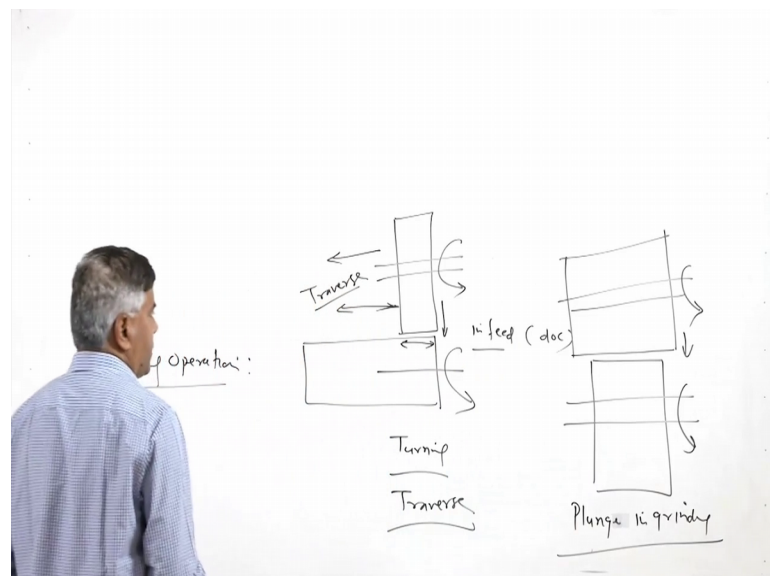
temperature of the work pieces also the surface temperature of the work piece is also low when the creep grinding is used.

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So, these are some of the grinding processes, apart from this there are other grinding processes. Which are which may be termed as other grinding operations, which includes like polishing buffing, then we have a honing and lapping, all these are used for producing very high lustrous surfaces. So, that they can be used for the purpose they are being developed.

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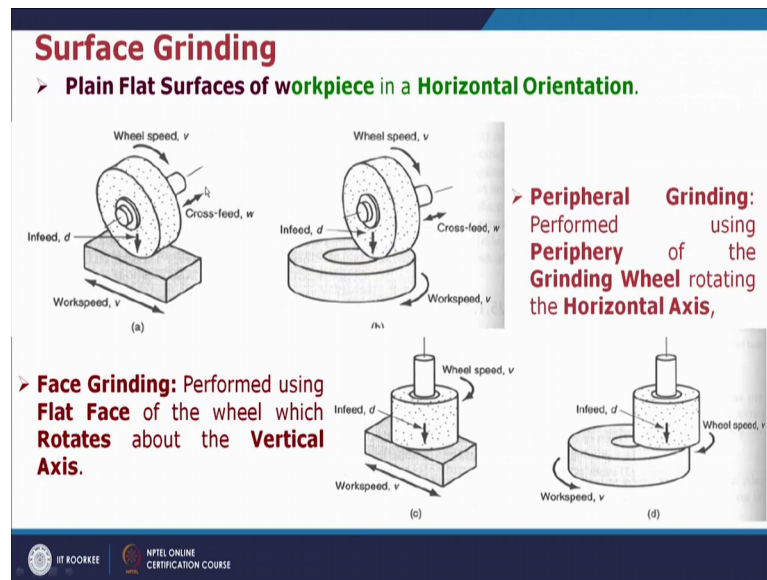
For the cylindrical grinding there is one more classification, wherein like this is the work piece length and this is the grinding wheel grinding, wheel is rotated about it is access and read really it is fed in. So, this is called in feed that will be deciding the depth of cut the work piece is also rotated and so to but during this situation of the grinding, when the grinding wheel interacts with the work piece only. This area will be processed, so in order to cover the entire length of the work piece is fed traverse wise also.

So, traverse movement of the grinding wheel is given parallel to the axis of rotation of the work piece. So, movement of the grinding wheel parallel to the axis of rotation of the grinding wheel. So, this situation is similar to that of the turning, where tool remains fixed, but here grinding wheel is a tool which is rotating, rest of the moments are same as that of the turning. This kind of the grinding is termed as traverse grinding; here the width of the wheel is smaller than the length of the work piece. Which is to be processed on the other hand, if the width of the wheel is this is the say work piece and this is the grinding wheel.

So, grinding wheel will be rotating in feed will be given, since in this case the width of the wheel is a bigger than the width of the work piece or the length of the work piece. So, just a radial in feed is needed for giving the depth of cut and no traverse movement is required for this purpose and this kind of grinding is called plunge grinding, plunge in grinding or plunge cut grinding is also it is termed as. So, this is the 2 broad these are the 2 broad classifications, for the grinding cylindrical grinding with regard to the size of the grinding wheel and the length of the work piece which is to be processed.

So, now schematically there are so many kinds of the arrangements for the grinding, which are used for different types of the grinding operations. So, that is what we will see now with the help of the PPT.

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So, here what we can see here, like say this is the surface grinding. So, in case of the surface grinding, there are 2 possible things flat surface work piece is subjected to the grinding. So, in 1 case in both the cases work piece remains flat, this what we can see for surface grinding; generally the work piece remains flat and horizontal position, but the axis of the work grinding wheel can vary.

So, in this kind of arrangement where the periphery of the grinding wheel is working this is called peripheral grinding and in this case that there are 2 types of the options for let us see first the movement of the grinding wheel. So, grinding wheel is rotating as well as crosswise movement is given and the radial in feed is also given to give the depth of cut, but the work pieces reciprocated in this horizontally in order to cover the entire surface area. While in another arrangement the work piece is flat rotational movement is given to the work piece, transverse movement is also given to the transfer's movement or cross feed is also given to the wheel to cover the entire area or the surface of the work piece and the in feed is given to control the depth of cut.

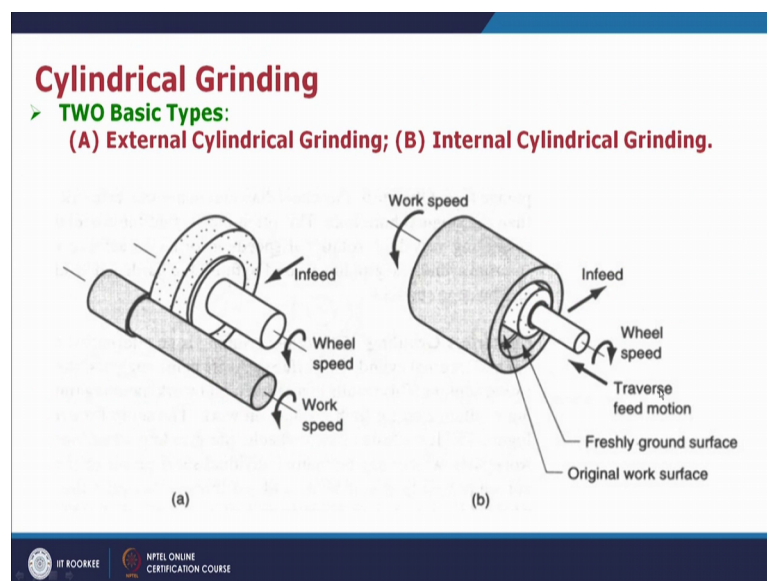
But instead of the reciprocating movement here the rotational movement is given to the work piece. So, that it can it is all surfaces are can be covered under the grinding wheel and it they can be processed. So, this both these are examples of the peripheral grinding, where periphery of the grinding wheel is being used for performing the grinding and

another grinding is face grinding, where the face of the wheel like this, is the face of the wheel this is being used for the grinding purpose.

So, here in this case the rotational movement is given to the grinding wheel and then radial in feed is given while work pieces are reciprocated like this case and the similarly here work piece given a rotational movement and the radial in feet is given to the grinding wheel, in order to give the depth of cut and then additional rotational movement is given to the work piece.

So, the rotational movements there are 2 types of work movements which are given to the work piece one is a reciprocating movement, another is rotational movement. So, in both the cases whether it is face grinding or the peripheral grinding, that 2 types of the motions are being given. While the work piece move, while the movement of the grinding wheel is a rotational as well as in feed. It involves in case of the face grinding operation.

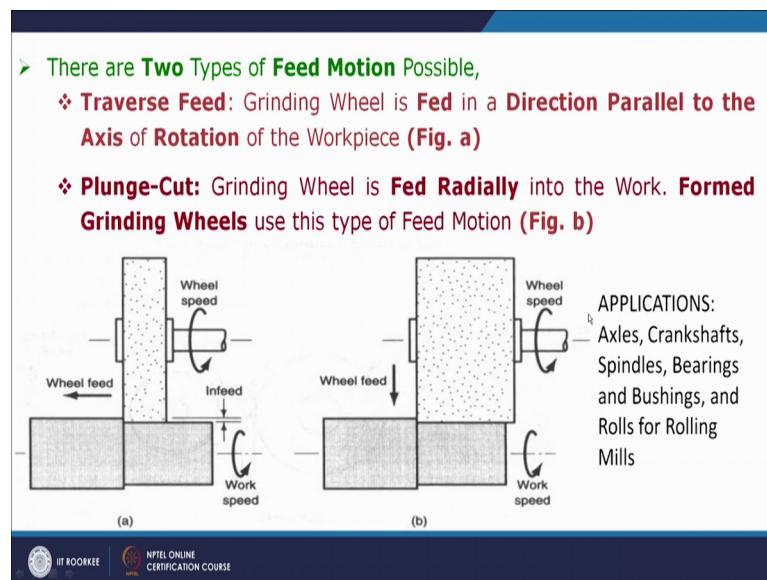
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Now, coming to the cylindrical grinding in case of the cylindrical grinding like this, is the work piece which is being subjected to the grinding, like say it is cylindrical shaft and this is the grinding wheel. So, length of the shaft is more means surface of the work piece, which is to be subjected to ground, is much greater than the width of the wheel. So, apart from the rotational movement to the wheel and the rotational movement of the work piece, we need the traverse movement of the grinding wheel also.

So, this will be the case of the Travers's grinding and a radial in feed is given to the grinding wheel. So, that required depth of cut can be obtained and this is an example of the internal cylindrical grinding where work-piece inside the cylindrical hole of the grinding wheel is subjected to be grinding, then this grinding wheel is inserted inside the grinding wheel and then it is a radial in feed is given. So, that the wheel surface comes in contact of the surface of the, internal surface of the work-piece in order to perform the grinding. So, here what we can see traverse movement to the grinding wheel as well as radial in feed is given. So, that required depth of cut can be achieved, at the same time; work-piece is also rotated and wheel is rotated in order to perform the internal cylindrical grinding.

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As I have just explained there are 2 types of the motions which are which can be given as per the length of the work-piece as well as the width of the grinding wheel. This is the case when the length of the work-piece to be processed is bigger than the length of the grind width of the grinding wheel, then we need Traver's feed. So, the travers speed is given in the direction parallel to the axis of rotation of the work-piece while another case where the width of the wheel is bigger than the length of the work-piece which is to be processed. So, we need simply the plunge cut or the plunge in is needed.

So, we just radial grinding wheel is to be fed radially into the work-piece so that the required cut can be made to achieve the desired size and shape. The this type of the

cylindrical grinding is performed for finishing the products like axle crankshaft spindles bearings bushing and rolls for the roller mills.

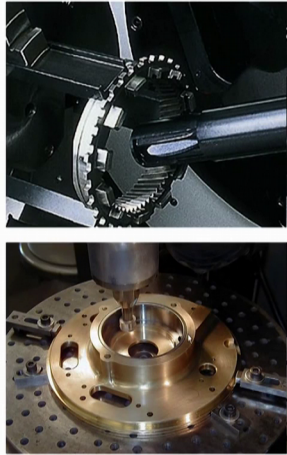
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Internal Cylindrical Grinding

- The Workpiece is **Usually held in a Chuck and Rotated**
- **Wheel Diameter** must be **Smaller than the Original Bore Hole** so needs **High Rotational Speeds** in Order to **Achieve the Desired Surface Speed.**
- **Grinding Wheel** is **Fed** in either of Two Ways: **Traverse Feed** or **Plunge Feed**

APPLICATIONS:

- **Finishing the Hardened Surfaces of Bearing Races and Bushing Surfaces.**

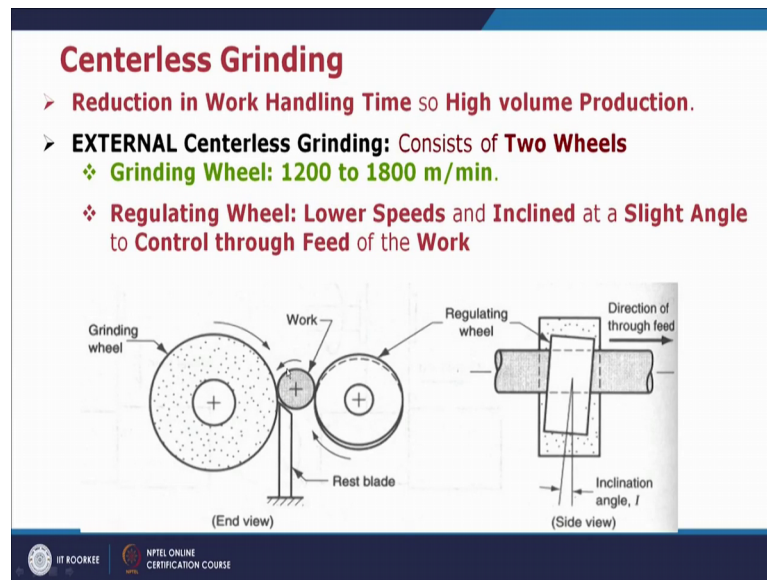




These are the photographs of the internal cylindrical grinding, wherein workpieces are held in the chuck and the work-piece is rotated. This is the internal surface of the hollow cylindrical object, and the internal surface of the work-piece is being processed by the grinding wheel, which is in contact with the internal surface of the grinding wheel.

This kind of operation is normally done for inner bearing races and the bushing surfaces for the finishing purpose, and the surfaces which have been hardened. Then coming to the centerless grinding process: in the centerless grinding process, there is no need to put the work-piece on the chuck or on the center, but it is simply placed on the rest blade.

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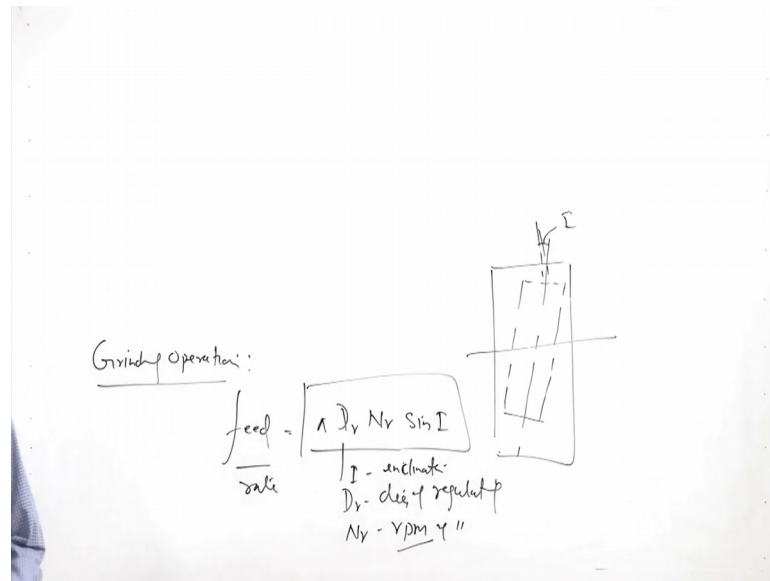


So, this is the how work-piece has been placed on the rest blade, but it uses one side the grinding wheel another side regulating wheel. So, a regulating wheel is given some kind of the inclination which this is what we can see here this is the grinding wheel this is the regulating wheel. So, this inclination is given to the grinding wheel means vertically grain, regulating wheel is inclined vertically by an angle i . So, when this angle is given. So, rotation of the regulating wheel when it is in contact with the work piece under pressure with the grinding wheel, then it leads to the longitudinal feed to the work-piece because of this angular movement of the regulating wheel only the we will be in position to move the work-piece all along the width of the grinding wheel.

So, that entire length of the work-piece can be processed. For this kind of the external this is the external cylindrical grinding where external surface of the cylinders will be processed. So, thus this kind of it is a very quick process just we need to just place the work-piece on the rest blade and between the grinding wheel and the regulating wheel so it does not take much time. So, this is justified also for the high volume production purpose.

The speed of the grinding wheel which is used for this centerless grinding is can vary from 1200 to 1800 and the regulating wheel rotates at lower a speeds, but it is inclined at certain angle so that the feed can be controlled.

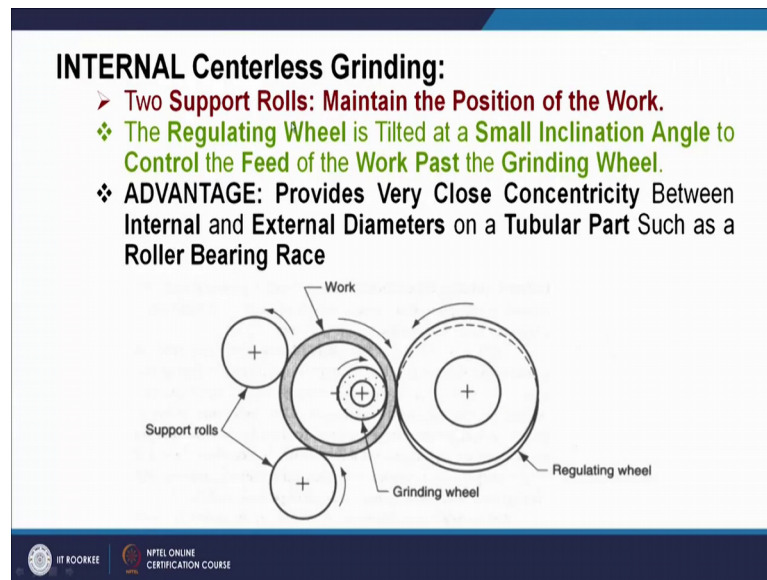
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So, feed rate which can be given to the work-piece in case of the centerless grinding can be obtained from the $\pi D_r N_r \sin i$. So, what these are D is r is the diameter of the regulating wheel similarly N_r is the rotationally speed rpm of the regulating wheel and i is the inclination which is given inclination giving to the regulating wheel.

So, by adjusting the diameter a rotationally speed and the is inclination of the regulating wheel with respect to the vertical plane like this say this is the grinding wheel. So, regulating wheel is inclined at a certain angle like this. So, this angle from the vertical plane is termed as I and it is rotationally speed decides the rate at which the work-piece moving par will be moving past the grinding wheel. So, the feed rate of the work-piece can be calculated for the centerless external grinding process a using this equation. So, we need to regulate the diameter rpm you know and the angle of inclination in order to have the desired feed rate.

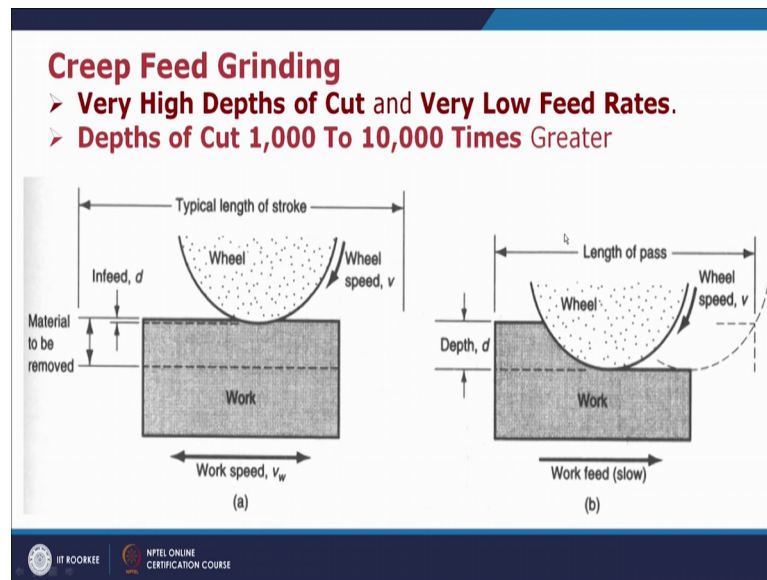
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Now, the internal centerless grinding process, it uses the 2 rolls 2 support rolls like this one another and between another one regulating wheel. So, regulate between the regulating wheel and to support rolls work-piece is placed and the rotation of the regulating wheel governs the rotation of the work-piece on to the support rolls. And a grinding wheel is brought in contact with the work-piece in side surface. So, rotation of the grinding wheel in this situation removes the material from the internal surfaces as well as a the inclination given to the regulating wheel helps to move the work-piece past the grinding wheel so that the entire length of the work-piece can be processed.

So, but the, but there is one additional advantage that this kind of the work-piece is when the internal centerless grinding is performed, it produces very concentricity between the internal and external diameters so that is especially useful for the roller bearing races.

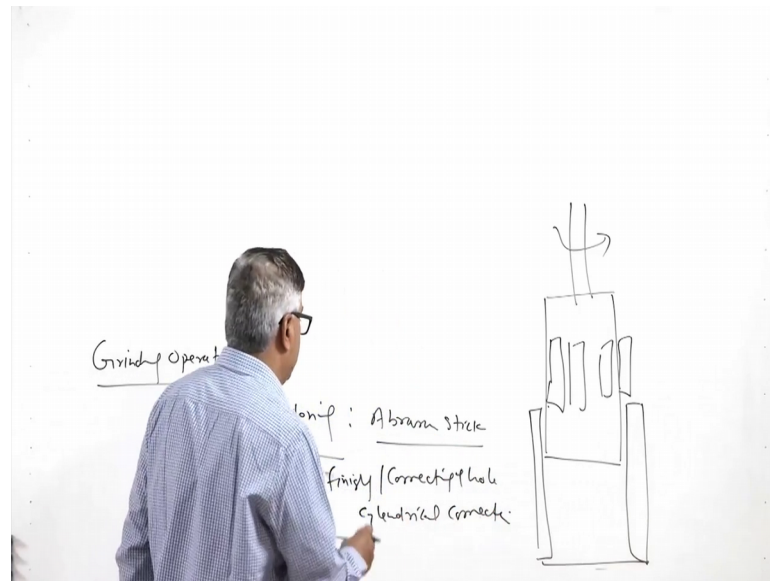
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Now, creep feed is another grinding process where in very high depth of cut and very low feed rates are used depth of cut can be as high as 1000 to 10000 times greater than the conventional than what is used in the conventional grinding processes, this what we can see is schematically shown in these 2 diagrams here this is the grinding wheel and the work-piece, and the in feed or the depth of cut is very little this what we can see while on the other hand for the creep grinding creep feed grinding, the depth of a cut is very high, but the translational speed which is used or the feed rate which is used for this condition is extremely low which is in proportionally means the whatever is the increase in the top cut proportionally the feed rate is reduced for the creep feed.

This kind of the process results in the very high metal removal rate and very good control over the dimensions and a very less temperature of the surface of the work-piece is achieved in this process. So, this is a very recently developed process, apart from this the creep feed surface grinding cylindrical and internal a cylindrical grinding which is like internal as well as external, there are few other grinding processes like the honing and lapping polishing etcetera.

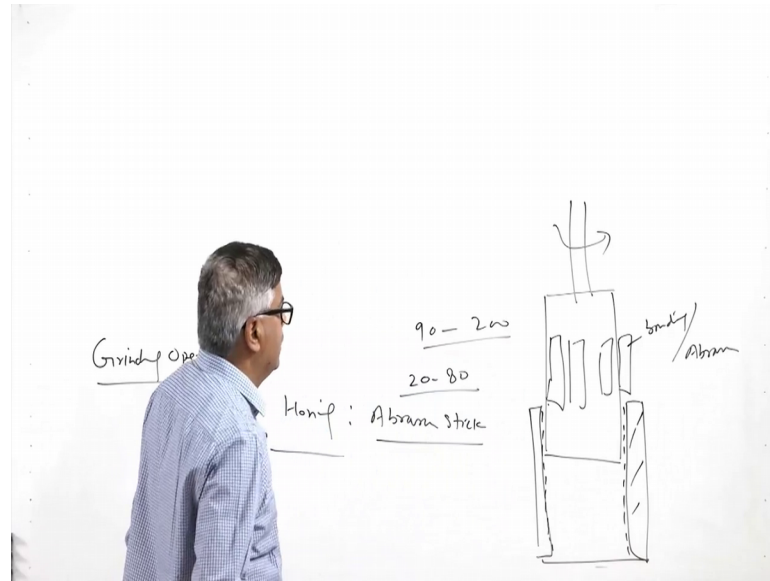
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So, we will talk about the honing. Honing process basically uses the abrasive sticks which are fitted in a honing tool. So, honing tool is nothing just like a cylindrical object where in the sticks are fitted like this all around the periphery of the honing tool like this, and this honing tool is rotated and then this one will be inserted in the object which is to be processed for finishing purpose. So, basically honing is used for finishing of the finishing and correcting of the holes correcting the holes which already exist.

So, basically cylindrical holes correction in terms of the circularity and the cylindricity and their finishing is achieved through the honing process.

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So, these abrasive sticks are just like they are made of the bonding material and the abrasives. So, rotating well work-piece when were rotating tool when interacts with the work-piece internal surface of the work-piece the material is removed from the internal surface.

In order to correct the hole dimensions as well as to give the desired surface finish and normally a high grid sizes are used for the finishing purpose, which can vary from like say like 20 to 80 for the roughing purpose and 90 200 they are used for the finishing purpose means in the it is above the grid sizes which are used of the abrasives for the finishing purpose in case of honing. So, honing is basically the process used for finishing the internal surfaces of the cylindrical hole with the help of the hones or which are which basically comprises the abrasive sticks fitted all around the circumference of the hone.

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Then lapping is another; the process wherein the tool which is generally made of the like a steel or copper or even of the lead. So, there is a tool as per the shape of the surface of the work-piece which is to be lapped like say it is used for the polishing of the lenses or any other flat surface like this.

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So, as per the shape which is to be lapped the tool is made like the shape of the object is like this, then accordingly the tool will be made. This tool can be made of the steel copper or the lead and between these 2 one slurry is placed this slurry comprises either

oil or kerosene plus abrasives fine abrasives like silicon carbide and alumina maybe like say 200 to 600 fine grit size abrasives are used depending upon the kind of the MRR a or the Ra is needed the low grid size like 200 for high Mr and for very low surface roughness the high grit size like 600 is used.

Grits high grit size means fine abrasives low grit size means the coarse abrasives coarse abrasives are used for the high metal removal rate and. So, for high metal removal rate coarse abrasives and for less roughness means better finish high grit sizes are used. So, this slurry is basically placed between the lapping tool and the work-piece then under pressure this lapping is performed. So, the material due to the relative motion between the abrasives and the work-piece material is removed there are 2 mechanisms which have been suggested for the removal of the material in the lapping process one is that when the abrasives when truly soft like lead abrasives get embed in the tool.

So, when the tool is rubbed over the surface on the surface of the work piece, it they remove the material by cutting. So, this is one case another one where in the this is the tool and the slurry is between the tool and work-piece. So, due to the movement of the tool abrasive hit in the surface of the work-piece and they cause erosion.

So, due to the like the impact as well as movement of the abrasives and when they hit the surface of the work-piece, little amount of the material is removed. So, these are the 2 mechanisms which are considered for removal of the material; one when the abrasives get embed with the surface of the soft tools and another is when the abrasives strike the moving abrasives hit the surface of the work piece and cause the removal of the material by abrasive erosion kind of the process while when they get embedded with the surface of the tool basically the cutting.

So, now, here I will summarize this presentation, in this presentation I have talked various types of the operations and the pro grinding processes which are used for grinding the flat surfaces, a cylindrical surfaces, cylindrical holes and for a realizing very high degree of the surface finish using a various especial processes also.

Thank you for your attention.