Introduction to Abrasive Machining and Finishing Processes

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Lecture – 02
Conventional Finishing Process: Grinding

Today, we are going to see the Conventional Finishing Processes. Among that one of the important conventional finishing process or conventional abrasive finishing processes grinding.

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The overview of today's class we are just going to see the conventional abrasive finishing processes and we are going to study the first and foremost and important one that is called the grinding process. So, in the grinding process we are going to see introduction to the grinding, grinding wheel specification, then the grinding wheel problems, what are the problems faced by the grinding wheels as such and solutions if there is problem so, we have to find the solutions. These are all things are available in the textbooks by professor G. K. Lal, professor Ghosh and Malik and this textbooks it is there the solutions also is there.

Then, robotic belt grinding, this is not there in the textbook. So, you have to see for that purpose we have provided you with a good videos, so that you can understand how this particular robotic belt grinding or robotic based soft wheel polishing and all those things.

So, comes to the last section that is called advantages and the applications of the grinding process and other things.

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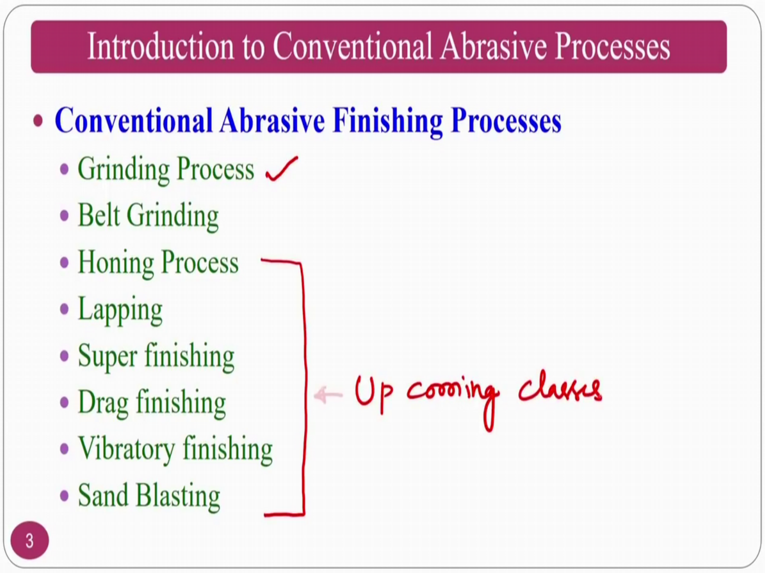

Moving on to the conventional abrasive finishing process which is the main process is grinding process which we are going to see in this particular class, then we also see about a glimpse of the video that is how the belt grinding works. If I tell you may not understand for that particular purpose I am just voluntarily providing you a video. Next in the upcoming classes we will see the other conventional finishing processes such as honing process, lapping process, super finishing process or the drag finishing, vibratory finishing, sand blasting, micro blasting many process are there. So, we will see in the upcoming classes, ok. These are all practically oriented processes or practically conventional finishing process.

In the grinding process just we will see as I said in the overview of this particular class we will study of the about the introduction to grinding, grinding wheel specification, problems, solutions and robotic belt grinding, robotic soft wheel grinding, then advantages and applications of the grinding process we will see in this particular class, ok. So, what is a grinding? Many of you know it is a one of the common process or one of the mostly used in industries process is grinding process. It is one of the mostly used manufacturing process in terms of conventional finishing is concern grindingly comes at first, ok.

So, you might have seen many people in the villagers or cities they come with their portable grinding wheels to sharpen the knives or to sharpen the some of the utilities where you need to cut the vegetables and all those things also comes under the grinding process, but in this particular class what we are going to study is how a grinding wheel for particularly to the surface grinding or cylindrical grinding or for the mechanical people, how this grinding process works we will see.

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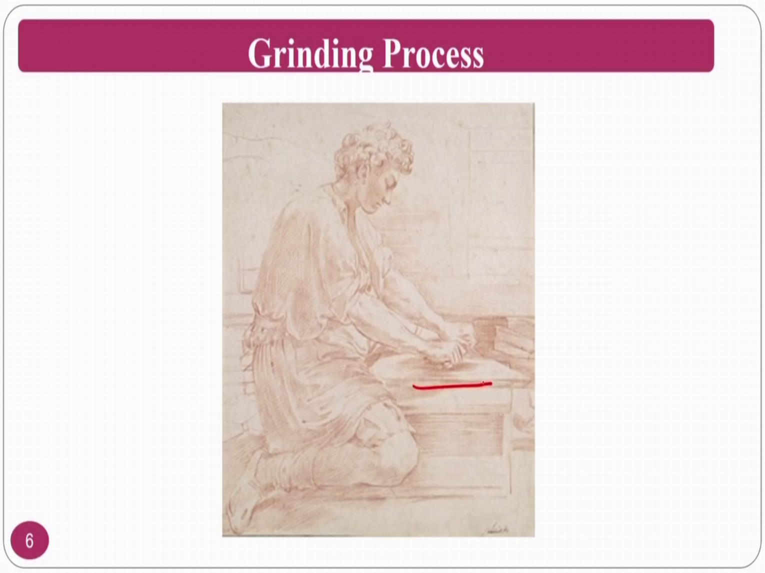

So, this is previously in the olden days the grinding means what is person in this picture is doing is the grinding process. If you see here normally traditional medicines in the villages nowadays you can see the people will do if by keeping on a rock they will take a roller type of rock, they will just put the leaves and what of the seeds or something just they try to grind it that is called conventionality grinding process, ok. Since the work piece material in this particular aspect is the grains or seeds or the leaves compared to the rock. In that circumstances your rock is much harder compared to your leaves that is why you can grind properly and you can make the medicine in the olden days, ok. The same technologies applied in the modern era or in the mid era that is called the grinding process.

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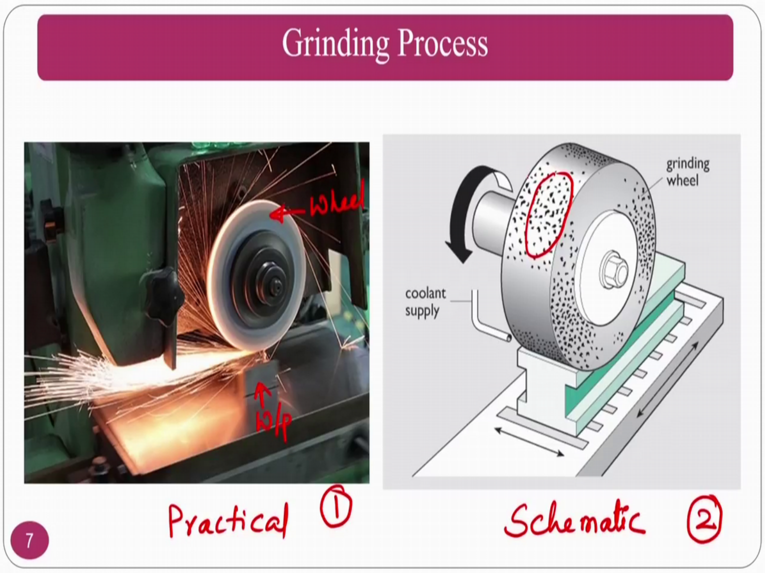

How the grinding process looks like if you see the practically how it looks like. Practically is this is the work piece and this is a wheel this is the wheel which is called as a abrasive wheel also. So, it is a work piece is mounted on a magnetic jack. So, whenever you apply the magnetic field it is firmly hold on to the jack and then the grinding operation goes on. Schematically you can see here this is a schematic this is a practical diagram the one figure 1 is a practical diagram, figure 2 is a schematic diagram and you can see how the abrasive particles are represented on a grinding wheel, ok. Now these grinding wheel grind on the work piece.

So, this is a difference between a practically and schematically. Some of the research papers if you see there is a original experimental set ups are there in some cases you can see the schematics also there. So, this is the difference the practical experimental set up and schematic experimental set up.

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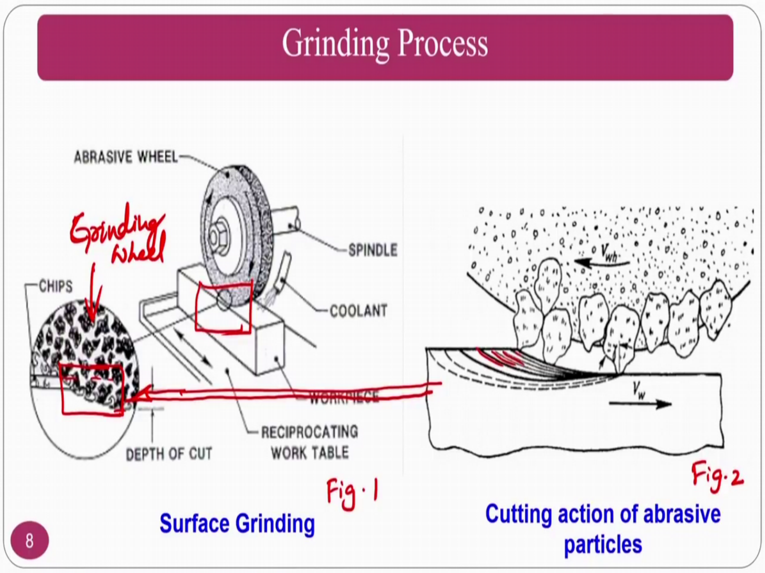

Now, we will move on to the grinding process. So, how the surface grinding works? Normally, in a grinding process to explain for the easiness so, the surface grinding is considered. So, in this case also surface grinding is considered. If you see the interaction in this region so, this is the depth of cut normally whatever is there you can see here this is the depth of cut and this is the grinding wheel whatever the grinding wheel it is a exaggerated version, ok. The same thing you can see here. So, if at all I want to exaggerate what is going on this particular location, ok. So, that we can see clearly in this picture, can you understand what I am showing here. So, this is what is shown here.

So, there are multiple abrasive particles are there on a grinding wheel. Each abrasive particle will remove the material gradually, that is what here shown. So, one chip, second chip, third chip, fourth chip so on. It will take out with respect to the abrasive particle this particular picture this is figure 1 and this is a figure 2. Figure 1 shows overview of the set up in a schematic way then zoomed version what is happening if you still zoom you see the figure 2, ok. So, now, the cutting action of abrasive particles on a work piece you can see in the figure 2 in a gradual manner.

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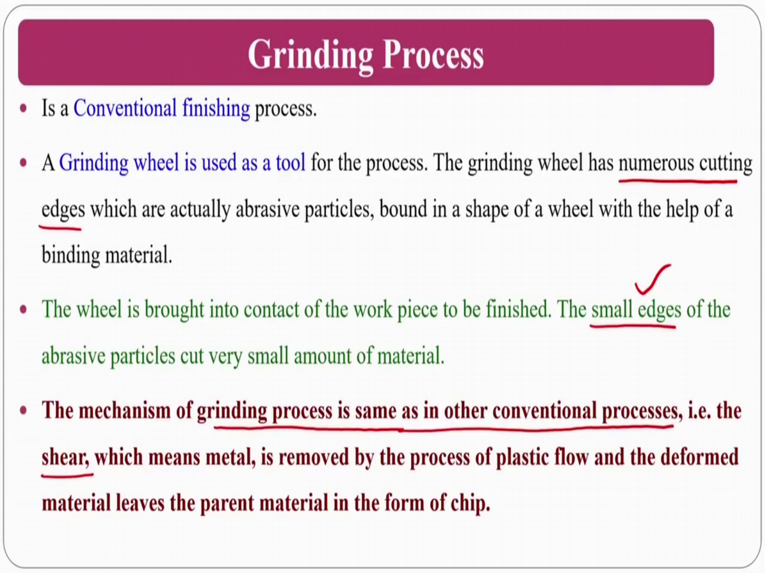

Normally, the grinding process is a conventional abrasive finishing process. Grinding wheel is used as a tool in the process and where the grinding wheel will have numerous cutting edges, ok; that means, that there are it is a multi point cutting tool where the abrasive particles are actually involved in the machining process or the finishing process. The wheel is brought in contact to the work piece to be finished. Normally, the machining will be done in terms of shearing action or a cutting action, so that the small cutting edges of the abrasive particles which are there on a grinding wheel in a bonded form. Yesterday we have seen in the class that it is a bonded abrasives unbonded abrasives.

So, grinding wheel comes under the bonded abrasives; in the previous class we have seen the bonded abrasives and unbonded abrasives. So, the abrasive particles that are firmly binded by the binding material in a grinding wheel comes under the bonded abrasives, ok. So, that means, the small edges which are there on a bonded grinding wheel will remove the material by shearing action or micro cutting action or normally it can also called as a cutting action. The mechanism of the grinding process is same like a conventional machining process that is shearing action or the cutting action. So, there are other mechanisms which are going to see in upcoming slides, ok. So, the shearing action will help to form a chip and this is also called as plastic deformation will takes place and the chip will form.

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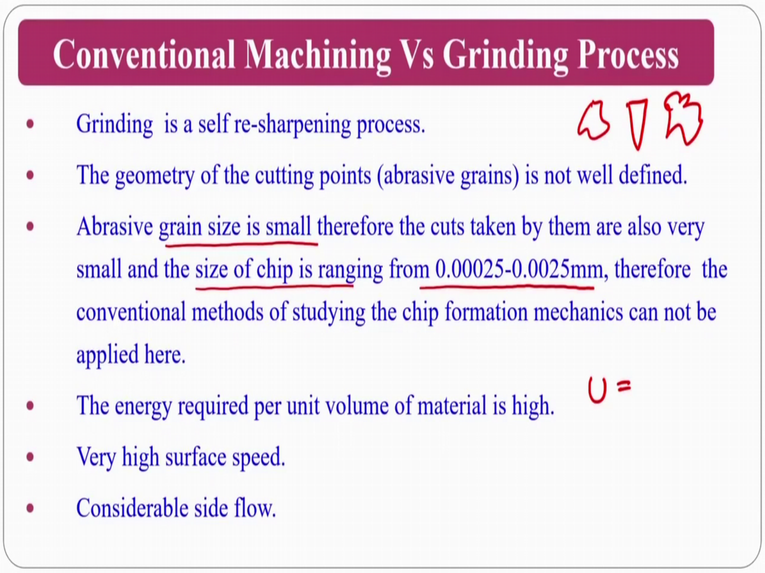

Conventional machining versus grinding, what is a difference? If you see the grinding is re-sharpening process; that means, the abrasive particles in the previous class we have seen the abrasive particles are ceramic particles and these abrasive particles are brittle enough. Assume that I have this particular abrasive particle in a grinding wheel. What is happening? If the it breaks assume that this is breaking like this particular thing is gone the shaded portion is gone; that means, still it is sharp; that means, it is giving a new cutting edge; that means, the abrasive particle is re-sharpening about itself it is that is why it is called self re-sharpening process, ok.

So, geometry of cutting points abrasive grains is not well defined; that means, that the shape and the cutting edges. Some of the abrasive particles may be like this, some of the abrasive particles may be like this, some of the abrasive particles may be like this. So, shape is not perfect at the same time cutting edges also randomly oriented shape is random as well as cutting edge is also random. The abrasive grains or abrasive particles there. Do not confuse between abrasive grains and abrasive particles some of the papers they will explain in terms of abrasive grains some of the papers or textbooks follow abrasive particles, but better if you have your own notation some of the papers they will say like a grains only, ok.

So, there is no difference if you are understanding it is same abrasive grains is equal to abrasive particles both are same some people in a textbooks already some places it is already mentioned abrasive grains abrasive, grains abrasive grains some of the places they may write any how the candidate might have understood. So, they may also write grains. So, you should be ready enough to accept whether it is a abrasive particle, whether it is a abrasive grain, whether it is a grain both all the meaning is same, ok. Abrasive grain size is small therefore, it is taken by themselves and chip also will be very small normally the chip ranges from this 0.00025 to 0.0025 mm, ok.

So, normally I mean to say the chip thickness will be in microns, ok. So, if at all if you go for very high depth of cuts and other things like grit field grinding you will see what is grit field grinding in upcoming slides. In that circumstances your chip size will be much higher because their feeds and depth of cuts will be very high. The energy required per unit volume of material (Refer Time: 13:21) is high in terms of grinding compared to conventional finishing process. Conventional finishing process if I want to remove certain material assume that lathe process if I want to remove normally what I will give I will give depth of cut 1 mm and feed is 0.2 mm or something, but you cannot give same input conditions in the grinding process. You have to give only depth of cut like 5 microns, 6 microns or something.

So, the grinding wheel rotating is a; so input energy is very high, but output is very less if at all I am talking about machining as I said earlier classes that the machining means material removal rate is a main criteria, ok. So, the specific energy means U normally represent the power required or energy required per unit volume material removal. In this case your input is very high, but the material removal is very low; that means, obviously, specific energy requirement will be very high.

So, high surface speed normally in a lathe process you may go for 1000 rpm or something, but anyhow you have to calculate into meters per second or meters per minute. In this case it will be like 3000 rpm or 4000 rpm there are some grindings wheels which go around 10000 rpm also. So, considerable side flow because abrasive particles will have there is a mechanism which is called ploughing I will come into that upcoming slides they because of which side flow will occur, ok.

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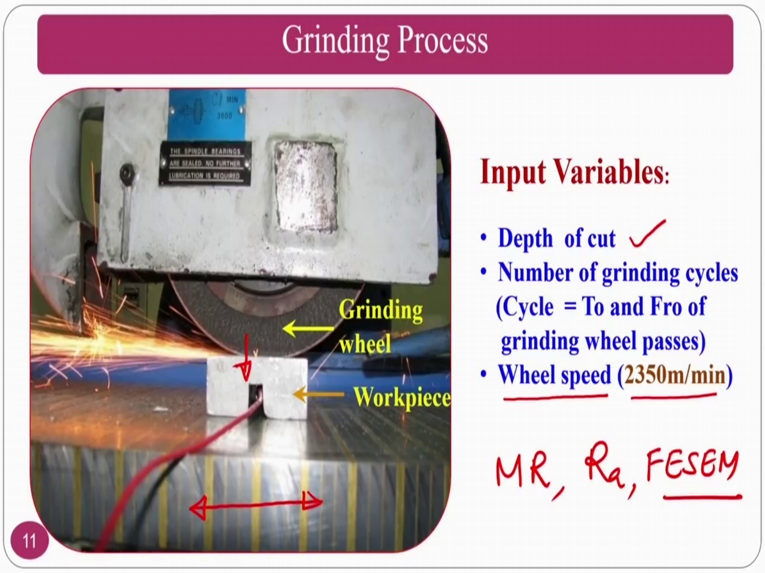

This is how the grinding process looks like, ok. This is the practically taken picture from our laboratory for well explanation for your purpose. So, what are the input conditions normally. So, depth of cut is a one of the input condition so, depth of cut means what I am going to give in this direction is a depth of cut number of cycles. So, number of cycles means it to and fro motion. Normally, this table will move to and fro, ok. So, one movement to and fro is nothing, but one cycle, ok; number of cycles you can give assume that I want to go for as many cycles and I can change depth of cut and other things.

Normally, this wheel speed also can be variable, but in some of the grinding setups. So, wheel speed will be constant in the experimental setup that we have normally the wheel speed is 2350 meters per minute, ok. So, some of the grinding machines the wheel speed is constant and some of the grinding machines wheel speed will be variable, ok. So, if you have a variable you can vary whether you want 1000 or whether you want 1000 rpm, 2000 rpm, 3000 rpm or something when a rpm means Rotations Per Minute whatever the rpm that you want you can use, if it is a variable.

These are the three main input condition that you can give and normally, you can measure the material removal as a one output and surface roughness value is another output and you can also check the surface bonding, surface integrity like surface morphology, surface metallurgy because of the high temperature that is developed any metallurgical changes is there on the surface or something you can cross check using FESEM or SCM applications, ok. You can use FESEM for checking the surface morphology as well as surface metallurgy if there is any elemental composition is there or not, ok.

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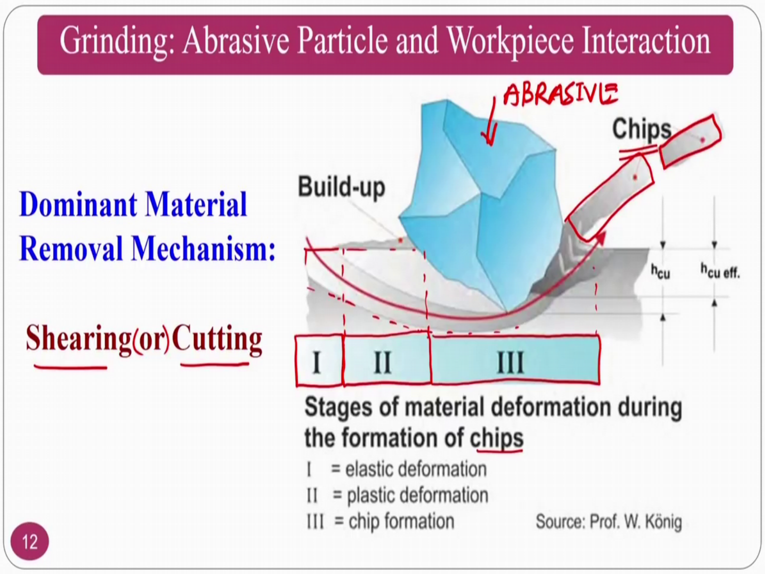

So, dominant material mechanism is in this particular process is shearing or cutting process, ok. Some people they may call it as a micro cutting or something you can see here how a abrasive particle, this is an abrasive particle ok, this is an abrasive particle how it is going to remove the material, ok. So, there are three stages of material deformation during the formation of chips one zone I, this is a zone I refers to the elastic deformation because abrasive particle starts there and the zone II it will end into the plastic deformation because it is try to remove, now the elastic region is gone so, it will enter into the plastic region, then it will form a chip and removes technology material, ok.

So, the same thing is happening here you can see here if you see in this region this is the elastic region and this is the plastic region and chip formation region is this particular thing, ok. So, the chip is gone, these are the chips, ok. So, these are the three regions; one is a elastic, plastic region and chip formation region these are the three regions in the work piece and abrasive particle interaction or regions.

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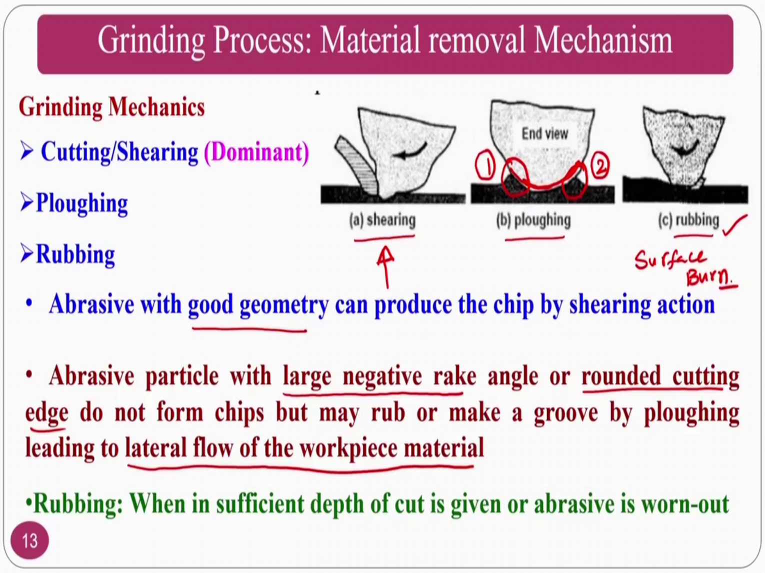

If you see the material removal process in the grinding process, normally it follows three mechanisms. One is the cutting and shearing process which is a dominating one, then followed by the ploughing and rubbing actions. These are the three major mechanisms that are involved, ok. The shearing which is a dominating one; that means, that it is cutting as we have seen in the previous slide it is elastic region, plastic region as well as the chip formation region that comes under the shearing and the ploughing and rubbing regions are two regions or the two mechanisms which normally we do not want as a manufacturing engineer.

So, abrasive grain if it is good geometry and it has a proper bonding with a bonding material and other things normally, it will lead to you a shearing action or cutting action to make a chip. If it is not assume that if the abrasive particle is not like if the abrasive particle is having large negative rake angle or it having a rounded cutting edge; that means, that like this if it is having a rounded cutting edge; that means, that it will have the ploughing action for the better understanding what is ploughing normally farmers whenever you go to the fields they try to do the farm farming like they just try to we using the bulls they will try to use the [FL] in Hindi it is called as [FL].

So, whenever they ride that one what will happen this particular material will remove and throw into the other region that is called ploughing. Normally, plough they will use [FL] is called as plough in English. So, whenever a they do what will happen material will spread into the adjacent region that is what happening here that is called as ploughing. So, this is called lateral flow of the work piece material this 1 and 2 is called as a lateral flow which is because of the ploughing action.

The rubbing action, if normally the operator gives insufficient depth of cut. Assume that I am going to give 1 micron some of the abrasive grains may be perfect; some of the abrasive grains may be less. So, in that circumstances what will happen, there is a mere interaction between work piece and the grinding wheel, in that circumstances rubbing action will takes place. So, the rubbing action whenever the rubbing action takes place there will be a surface burning action surface will burn and may be it become black. So, this leads to the bad surface metallurgical properties; that means, that temperature will goes high and the surface may metallurgically damage, [FL].

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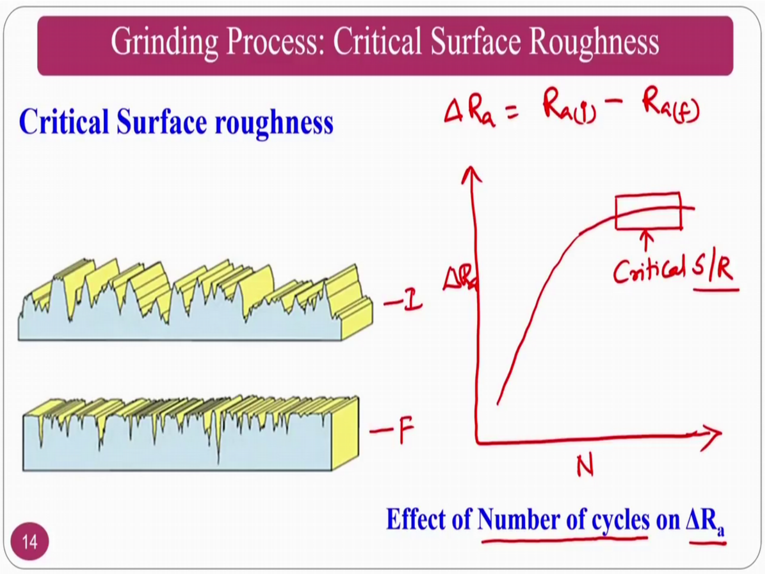

So, critical surface roughness normally what do you mean by critical surface roughness? So, the critical surface roughness is if I have a initial surface, this is my initial surface and this is my final surface normally beyond which if the value is not changing assume that if I want to draw a curve between number of cycles versus delta R a, it is change in R a. What is delta R a? Delta R a is nothing, but initial R a minus final R a, ok. So, this is my delta R a on y axis this is number of cycles, ok. Obviously, as you go on increasing number of cycles your surface roughness value will go down; that means that the difference will go up, ok.

So, I assume a curve like this, ok. So, whenever there is a marginal difference then you need not to stop, beyond which if there is no considerable difference between two number of cycles then you can say this is called critical surface roughness, ok. This refers to surface roughness this S bar S by R refers to surface roughness. So, then you can stop your experimentation because you have achieved the best possible because beyond which even though you are putting input energy; that means, that you are supplying the power to the grinding wheel, but there is no change; that means, that it is waste that mean. So, you have to stop and you have to take out the work piece that is called critical surface roughness.

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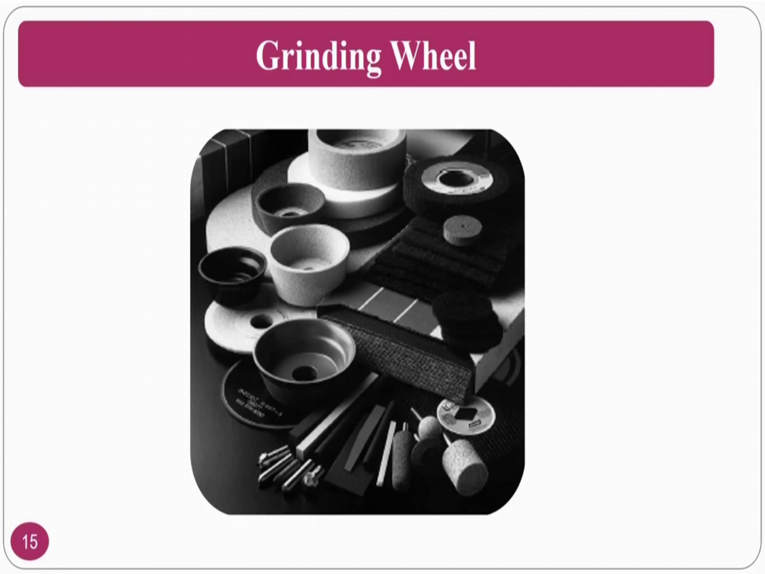

Coming to the grinding wheels there are many varieties of wheels and as an engineer whenever you are going to a company and if you want to order a grinding wheel how do you order? You cannot say I want a ground round grinding wheel; I want a rectangular grinding wheel you cannot say there is some engineering way to explain the grinding wheel's specification.

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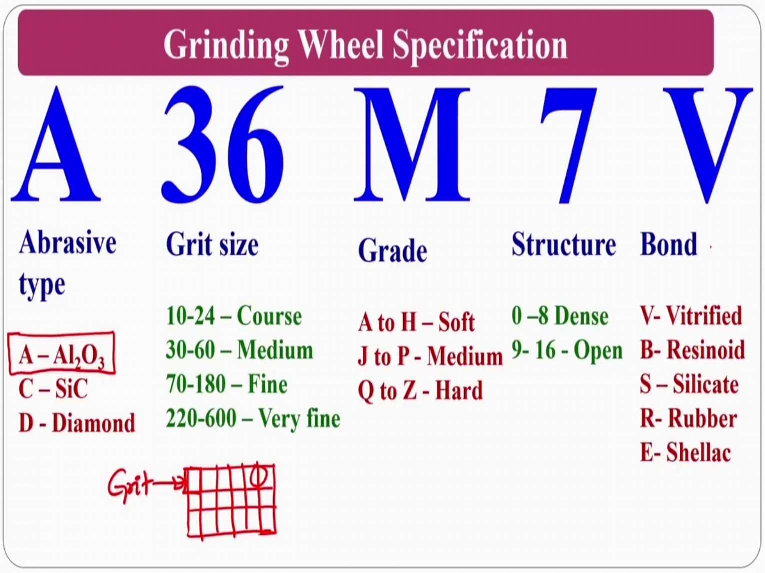

So, how do you specify, for example, let me take an example to explain a grinding wheel specification ok. So, A 36 M 7 V this is what the grinding wheel specification. A represent abrasive type; abrasive type means whether it is a alumina; that means, Al 2 O 3 or silicon carbide or diamond or something, ok. So, normally in this particular contest A represents 2 alumina, ok; that means, that my grinding wheel specification whatever I am asking having abrasive particles type is alumina.

Second one is a grit size. Grit also refers to the abrasive particle, some of the people they say the grit so, the grit size specifies the mesh size, ok. So, if my grit; grit means sieve if my grit per unit area are 10 or 24, 10 to 24; that means, what I have a bigger space. So, bigger particles can pass through it, ok. So, if I am going to still more, if I am going to increase what will happen. So, I cannot pass through bigger particles, medium, fine, super fine, very fine, very thick many type of abrasive particles are there. So, grit size refers to one this particular thing is nothing, but a grit ok.

So, the abrasive particle passing through that particular sieve normally you have seen no our mothers in a villages they will sieve the wheat powder to make the [FL] and other things, ok. So, a particles which are passing through it is specified that is passed the this particular grit. So, the as the grit size increases as the sieve size increases normally the particle size will goes down, that particular also I will explain you in the upcoming slides.

M is referring to the grade. Grade A to H is a soft grade, J to P is a medium grade and hard grade. Grade means how firmly you are holding the abrasive particle specifies the grade, ok. Soft grade means it is hold softly, hard grade means it is, abrasive particles is held by the bonding material very hardly.

7 refers to the structure. Normally, there are two varieties of structures; one is dense structure, another one is open structure dense structure means number of abrasive particles in a particular area will be very high and pores are very less. In a open structure pores are very high and the number of particles in a unit area is very less. V refers to the bonding or the bond material which type of bonding? Vitrified bond, resinoid bonds, silicate bond, rubber bond, shellac bond which type of bonding you want to have in your particular grinding wheel specifies by the bonding, ok.

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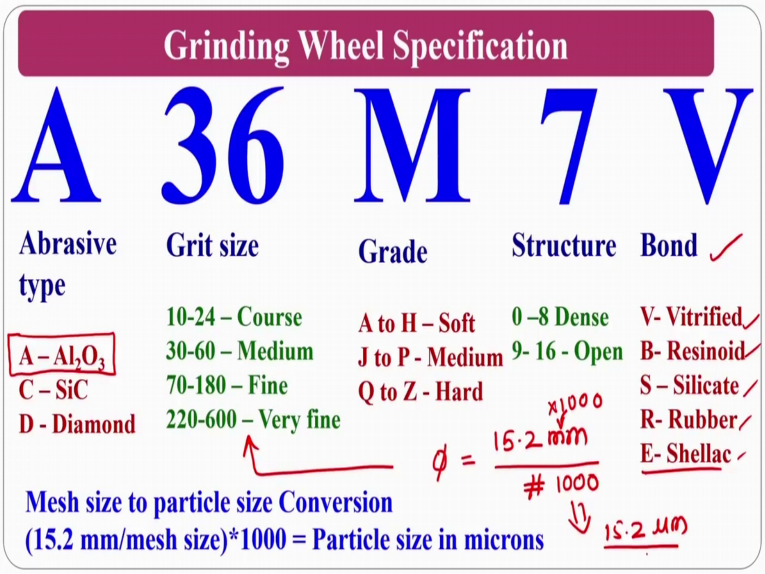

So, the mesh size particle conversion. Normally, if I want to convert particularly grit size as I explained you in the previous class also it will be like particle size normally represent by phi equal to 15.2 mm by hash; hash represent to the mesh size. Assume that my mesh size is 1000 which is comes under super fine, very fine then super fine super ultra fine you can many people say in a many names, ok. Normally it boils out to be 15.2 micrometres because whenever you convert mm into microns you will multiply by 1000. So, it comes to the 15200 microns divided by 1000 normally will boils out to be 15.2 microns, ok.

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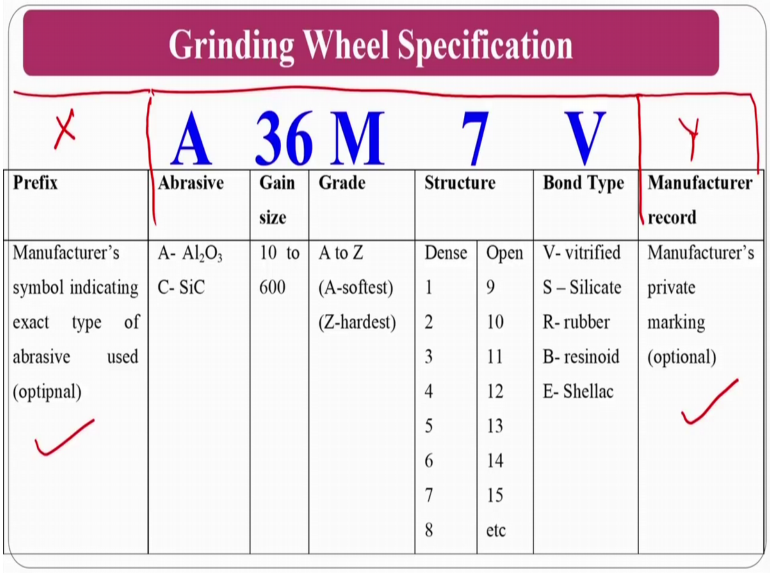

Grinding Wheel Specification

Prefix	Abrasive	Gain size	Grade	Structure		Bond Type	Manufacturer record
X	A	36	M	7		V	Y
Manufacturer's symbol indicating exact type of abrasive used (optipnal)	A- Al_2O_3 C- SiC	10 to 600	A to Z (A-softest) (Z-hardest)	Dense 1 2 3 4 5 6 7 8	Open 9 10 11 12 13 14 15 etc	V- vitrified S – Silicate R- rubber B- resinoid E- Shellac	Manufacturer's private marking (optional)

So, you see here already I have seen this particular portion I have explained you in a grinding wheel specification, but some of the companies will have prefixes which is manufacturers symbol indicating. Assume that x manufacturing company is there. So, they may start their grinding wheel with x, y may start with y and manufacturers also end with some other thing, ok, this may be x, this may be y. This may be y, you they may say for manufacturers private marking, assume that they want to have the batch number, assume that batch number is 8.

So, they may have 8, so that if there is a manufacturing defect in the complete set they can take back the whole set of the grinding wheels to the manufacturing company, ok. For that purpose people will have some optional at the start and at the end. This is nothing to do with the users, but this is solely for the manufacturers understanding.

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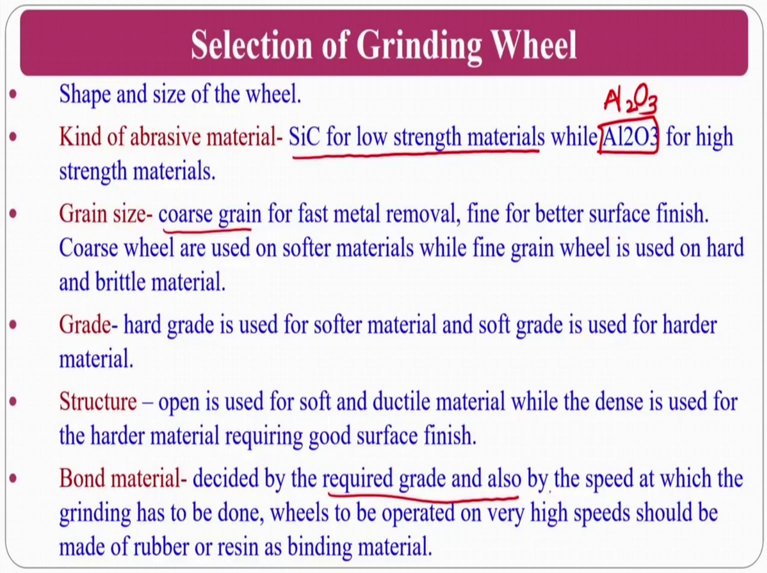

Selection of the grinding wheel: normally shape and size of the grinding wheel. Kind of abrasive materials normally SiC for the low strength materials while Al 2 O 3. Normally Al 2 O 3 will represent like this ok, for high strength materials. Grain size; coarse grain size for the fast material removal; assume that coarse grain size means I have a bigger particle. So, bigger particle means it can remove more material, ok. Fine particle or a super fine particle it will be small particle. So, this will remove very less material. So, depend on your application you have to choose the grain size.

Grade; depend on your requirement if at all you want to go for to do hard work piece material you have to go for soft grade, soft material you have to go for hard grade. Why, we will see it upcoming slide. The structure; whenever you want to remove a soft material you have to go for open structure whenever you want to remove the hard material you have to go for the hard dense structure, ok.

So, why and all those things we will see in the next one. Bond material normally decided by the required grade and also by the speed, speed and grade which grade whether you want a hard grade, whether you want a soft grade or what is the rpm that you want to operate and all those things we will decide which type of bonding material or which type of bond in a grinding wheel you want, ok.

So, the abrasive type as well as abrasive particle size is straight forward, there is no much requirement. Abrasive type whether it is a silicon carbide, alumina or something you can understand; abrasive particle whether it is a big one normally you can go for material removal application that is a machining application, if it is very fine you can go for the finishing applications. So, the important ones here is grade, ok. People should understand or the engineering colleges people B. Tech especially the B. Tech students will have some doubt about the grade and structure which are critical for a grinding wheel, ok.

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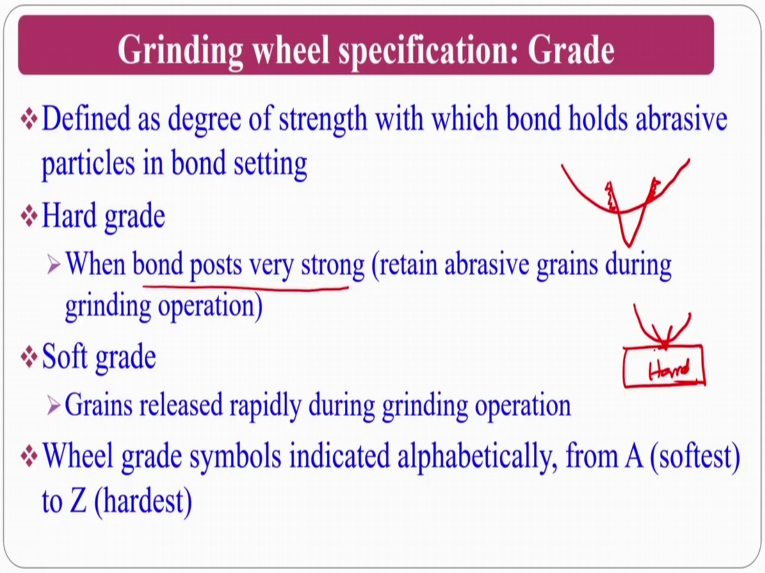

What do you mean by grade? Defined the degree of strength which bond holds the abrasive particle in a bond, ok assume that I have a grinding wheel and this is my abrasive particle. How firmly it is bonded decide by the grade. Whether if abrasive particle is there assume that I have an abrasive particle if it is tightly held the bonding material where how do I make assume that vitrified bond. Vitrified bond if at all I want to make I will make a clay first, then I mix some of the additives, normally company to company it will vary then you add the abrasive particles, you mix it, you compact it as per the shape then you just fire it, then you will get a grinding wheel, ok.

So, you choose now how firmly the abrasive particle is held is specified by the grade. If my abrasive particle is held by the bonding material very tightly very hard that is called hard grade, if it is loosely binded then it is called soft grade, ok. So, hard grade when the bond post very strong; that means, the bonding between bonding of the abrasive particle in the grinding wheel is very strong, ok. The soft grade grains releases rapidly during the operation, ok.

Wheel grade symbol indicate the alphabetically; normally you have seen in the grinding wheel specification, why I require a soft wheel for a hard material and hard wheel for a soft material, ok. Assume that I have a soft material for example; one of the soft materials is aluminium. Normally grinding people would not do aluminium for example, if I have a soft wheel what will happen this material is soft and my grinding wheel is also softer; soft means my bonding is very soft in that circumstances. If as soon as it touches what will happen it may remove some material and, but it will goes off. So, the dislodging of abrasive particle goes off.

Assume that if I have a hard wheel, what will happen? It can continuously work because the bonding is firm where material is soft. In the reverse case, if I have a hard material assume that tools steel or harden steel is there I have a grinding wheel hard grinding wheel, ok. So, my work piece is very hard, this is hard and my wheel also is very hard, in that circumstances what will happen? This abrasive particle will goes off; that means, that this particle will breaks and it will become null, it will become dull, ok. That is why if we have a soft wheel what will happen if it can remove the material if the abrasive particle can remove the material it will remove otherwise it will dislodge and gives the opportunity to the next abrasive particle, that is the beauty, ok.

If you use hard versus hard, hard work piece versus hard grade then the all the active cutting edges will become dull, then it is called glazing. We will see what is mean by glazing and other things in the upcoming slides.

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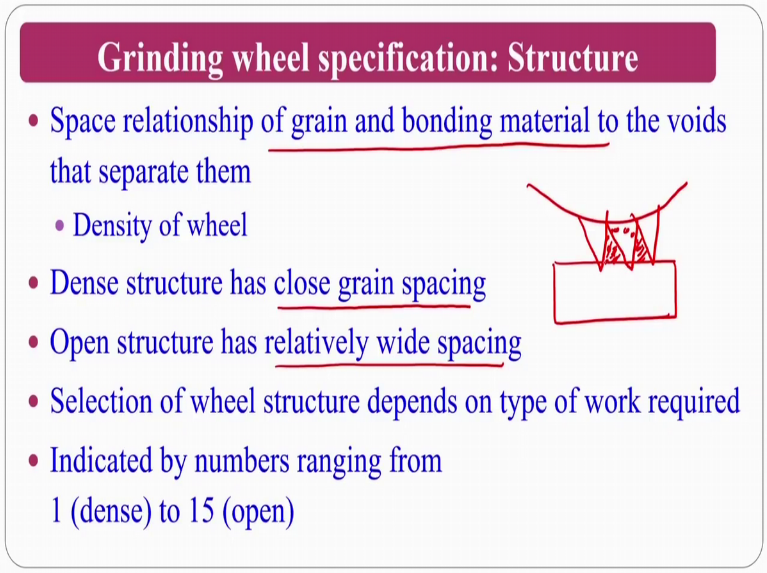

Coming to the structure: the relationship between of the grain and bonding material in the void separation them. Normally it specified the density of the wheel, ok. Dense structure; that means that close grain spacing, open structure relatively wide spacing, ok. The selection of structure depend on type of work piece required indicates the number this is number is just for your understanding. Assume that I have a soft material aluminium. If I am going to have open structure; that means, that this is my aluminium material and I have two abrasive particles open structure like this, what will happen? This material is soft so, the chips will come and clog here. So, it has a sufficient space.

Assume that I have a dense structure, what will happen? There is no sufficient space. So, as soon as it starts within no time the wheel loading takes place, all this material will clog here in the gaps and the abrasive particles will become dull. This is called wheel loading this is also a problem we will address in the whenever the grinding wheel problems will come. That is why whenever I want to remove a material of soft grade then go for open structure, whenever I want to remove a hard then you go for a dense structure.

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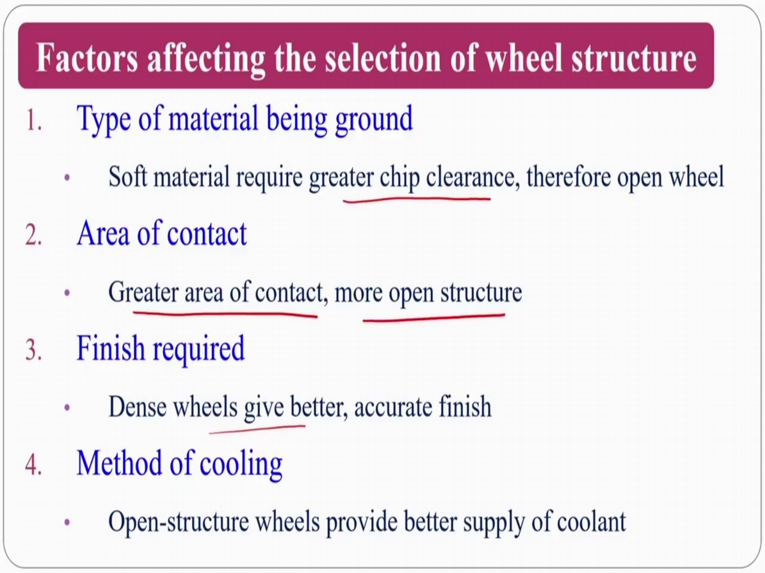

Selection of grinding wheel: in this one type of material being ground soft material require greater chip clearance, it is called open structure and area of contact greater area of contact more open structure. And, finish required, dense wheels gives the better surface finish and method of cooling normally if at all I want to provide a coolant, so, open structure is better one.

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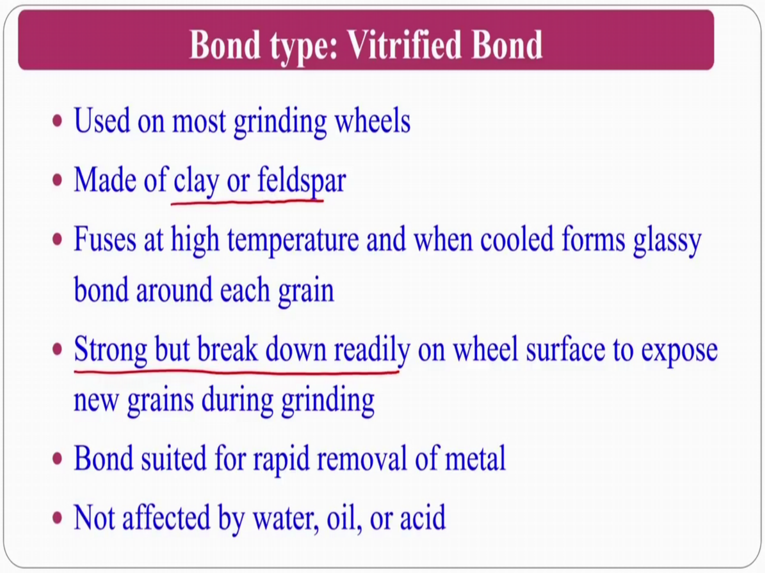

Bonding: the common bonding that you can see is a vitrified bond. Normally it is used or for the clay or feldspar and this temperature as I already explained you just make clay then add the additives, then add the abrasive particles, then fire it. Then it is strong, but break down readily when the speeds are exposed. Since clay is a low strength material it has ability to fail if you are going to use for extreme conditions, ok. Bond suited for rapid removal of the material not affected by the oil water or something the only problem with this one is the strength may not be very high. So, you should not go for high depth of cuts or very high speeds and other things.

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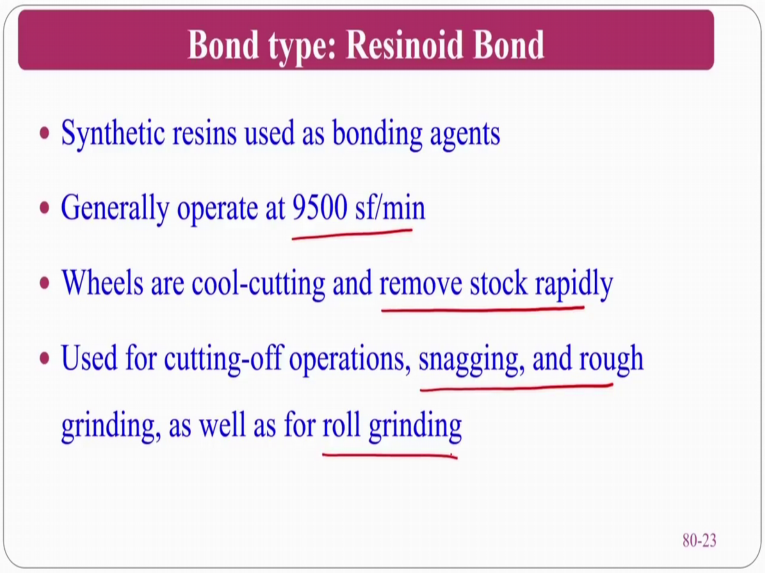

Resinoid bonding: basically synthetic resins are used normally and these are operating at very high speeds and those you can remove the material at very fastly. So, swift action if at all I want you can go for normally operations like snagging or rough grinding as well as roll grinding you can use this particular thing.

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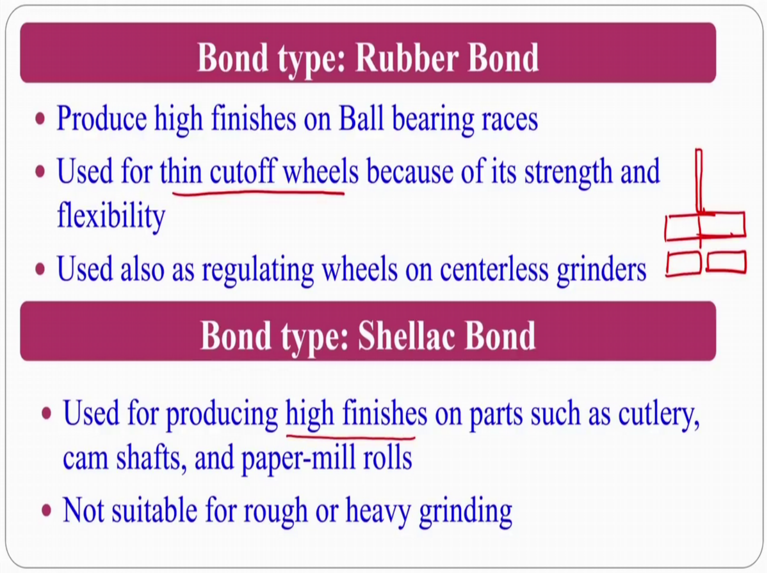

Bond type: rubber bond, rubber bond produces high finishes. Normally if at all I want the finish see as I said the coarse deals with abrasive machining and finishing. So, if at all I want machining you can go for the previous ones if at all you want to go for the finishing normally you can go for rubber type of bonding. Used for thin cut off wheels assume that I want to do the partition of this particular sample so, I can go for a thin slit cutter. So, that it will cut into two pieces so, I will get two pieces of this one. So, this is a beauty about this and this also can be used for the regulating wheels in the centerless grinding process.

Shellac bonding normally used for producing high finishes as a rubber bond. It is also uses for the finishing and not suitable for rough and heavy grinding it is just to go for the soft material for small applications you can go for rubber bonding as well as shellac bonding.

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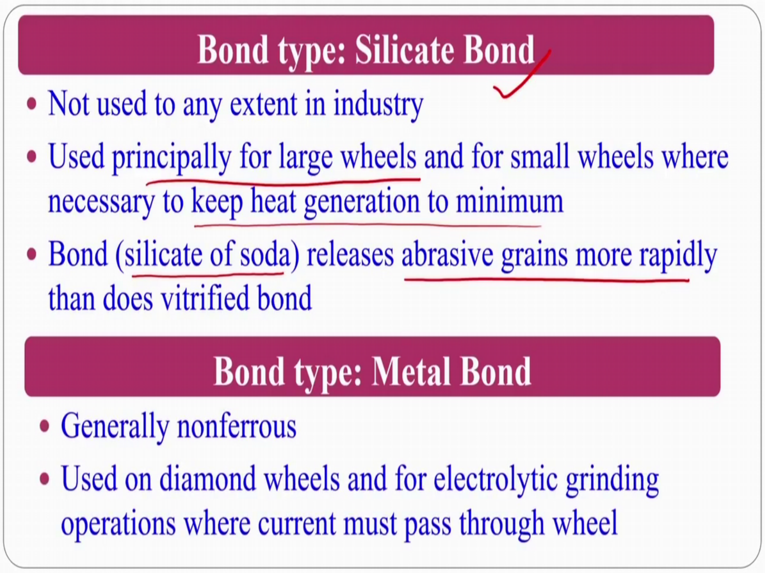

Silicate bonding not used for any extent in industry; this is very less useful in the industry. However, there are some specialised applications where you can use this one. This principally for the large wheels and for small wheels where the necessary to keep heat generation to a minimum. Normally if at all the heat generation during the machining is minimum then you can go for the silicate bond, ok. Bond silicate normally it is made up of silicate of soda which releases the abrasive grains more rapidly, ok; that means that this is a one of the soft wheels.

Metal bonding: normally metal bonding you can use for any type of things. People might be understanding about electric discharge grinding, electric discharge diamond grinding and other things there, you need your grinding wheel to be conductive in that circumstances normally you can use the metal bonding. So, you can have the spark to make the work piece soft then abrasive particle will enhance. So, these particular thing what I am going to what I am teaching you that electric discharge grinding, electric discharge diamond grinding I will take up this in a elaborative way in the upcoming classes, ok. So, just for your understanding what I mean to say in EDM you know that both work piece as well as the tool should be conductive. So, here if at all I want to make a conductive then I have to go for metal bonding.

What are the problems that are faced in the grinding wheel? If you see the problems as I explained you in the grade as well as structure whenever your grade is soft grade and you have to go for hard work pieces, if you are going for a hard grade hard work pieces then the problem will come when the open structure if you are going for soft material it is ok, if you are going for dense structure soft material then wheel loading will occur this also problem so, this problems.

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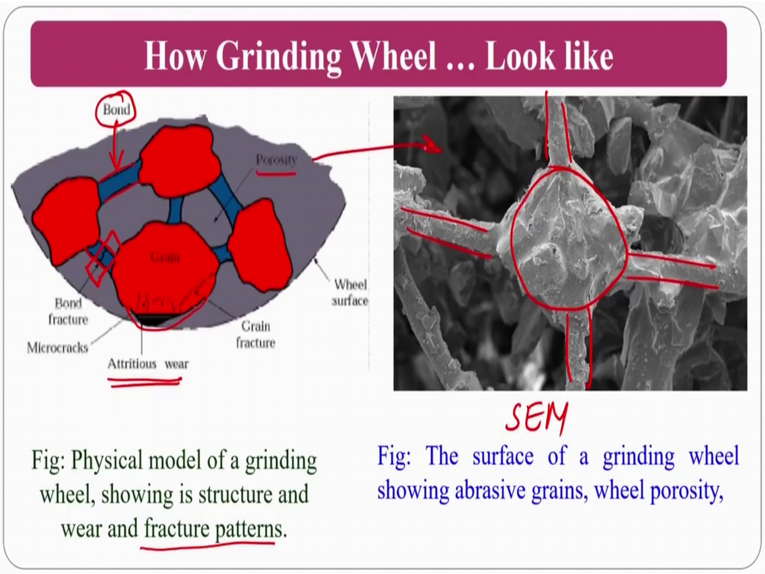

What are the problems all the problems look like, normally if you see if you see here physical model of the grinding wheel showing the structure and fractures pattern. Normally this is the bonding you can see this is a bonding and these are the abrasive grains. So, the bond this is the bonding and the same thing you have bonding whenever there is a wear on a abrasive particle. So, this is called attritious wear and not only abrasive particle only affect there will be a affect of bond fracture also, ok. So, these are the problems normally gains.

You can see the porosity here the most important thing normally the text which do not show is how the porosity will be generated in a grinding wheel. You can see a SEM image basically scanning electron microscopy image. These are the abrasive particles where are the end a group of abrasive particles are here and this is the bonding, multiple bonding is there and this is called porosity is this one is the porosity, this is a porosity is most important for a open structure materials, ok. So, that the soft material whenever you are removing the material removal it is very high so, it will go and sit in the porous region.

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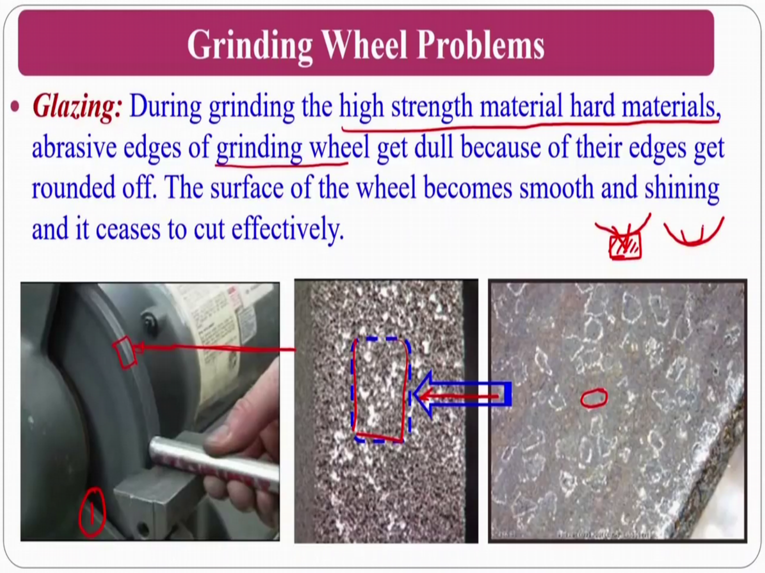

[FL] Grinding wheel problems first one is the glazing. What do you mean glazing? The glazing means for a practically what do you mean by glazing that thing is glazing; that means, it is shining.

So, during the high strength material hard material a whenever you use the grinding wheel hard grade what will happen, the abrasives cannot remove the material, but abrasives also will fracture and it will become dull. As you can see here the abrasives are fractured in the figure one, you can see in this particular region of the grinding wheel the abrasive particles are completely damaged. So, if you still zoom out from this region see how abrasive particles are there.

There is no active region of abrasive particle I mean to say assume that this is my abrasive wheel schematically this activeness is not there; that means, that this particular portion is missing every abrasive particle assume that this is like this my abrasive particle is like this, ok. So, it gone inside the bonding material so, it became a inactive in that circumstances the surface is very smooth and it is glazing that is why it is called glazing.

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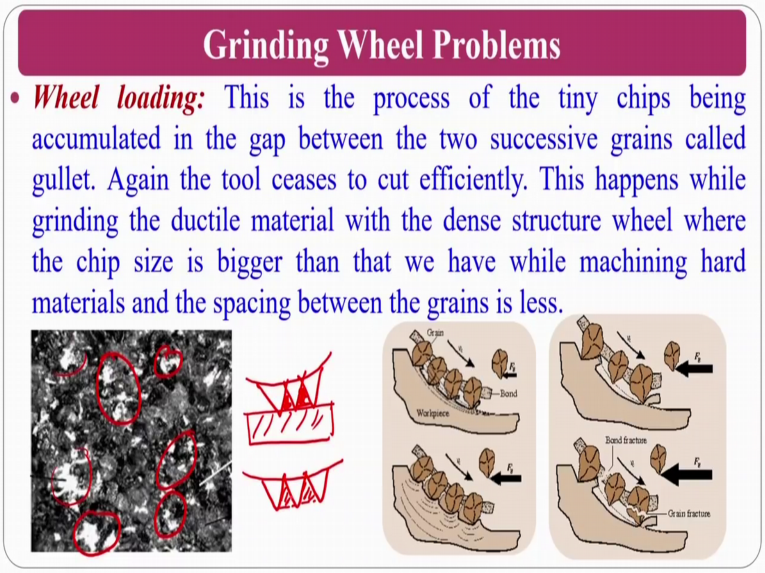

Another problem is wheel loading. What do we mean by loading? Whenever you see the truck, truck is loaded; that means, that truck is loaded with a goods. So, here what is our goods? Our goods is tiny chips, if the dense structure. Assume that I have a dense structure is there and I am using for a soft work piece material. This is a soft work piece material what will happen there is material removal rate will be very high in that circumstances where the material go material go and sit here and it will become all things will be loaded, ok. As you can see here chip material is loaded inside, ok, this white one is chips are loaded, so that my abrasive particles will become inactive. As I am explaining these are the abrasive particles assume that my material is loaded here this, what will happen? This active abrasive grains will become dull this is called loading, ok.

Now, how do we solve this particular problems. Not only this problem there is another problem that is called that we will have the solution. Whenever you have a hard work piece material with soft grade and all those things there will be a fracture of grinding wheel, there will be a sudden burst of the grinding wheel, these are the another problems, ok. So, we will see how a sector of a grinding wheel goes off, how to rectify and other things.

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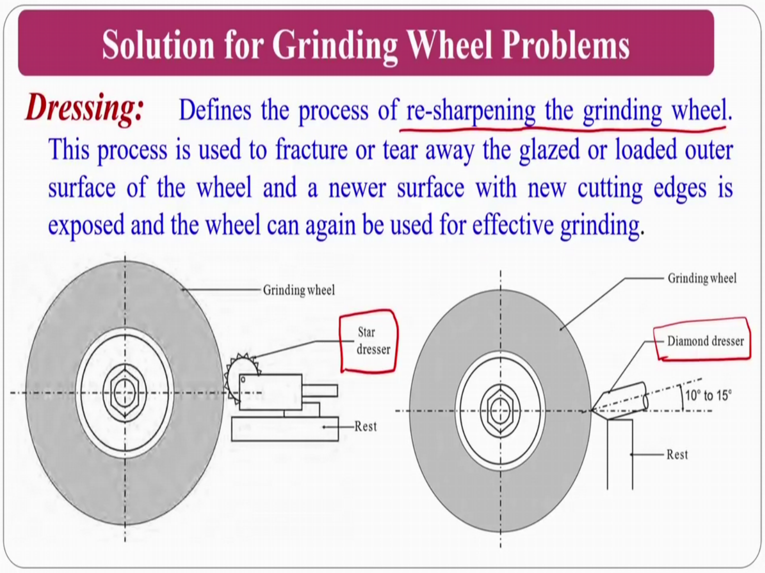

Solutions: if you see the dressing normally dressing means dressing defines a process of re-sharpening of the grinding wheel; that means, that if it is gone bad now you are doing the re-sharpening, ok. If it is loses the sharpness; that means, that as you have seen the glazing condition everything, assume that my like this these are the things and these are all became blunt, what will happen? So, there is no nothing is there like this, like this, like this. So, it is completely gone activeness of the grinding wheel is completely eliminated.

So, to bring that one normally you will have a dresser; that dresser will help in order to remove the surface layers and the diameter slightly reduces. The abrasive wheel or the grinding wheel diameters slightly reduces, but a new set of abrasive particles will come into picture, ok. This can be done by the two varieties of dresses one is a star type of dress, another one is a diamond dresses. These are the two dressers normally people will use to remove the inactive layer of the grinding wheel to bring out the new layer of abrasive particles into the existence, so that we can use the grinding wheel again for the grinding process.

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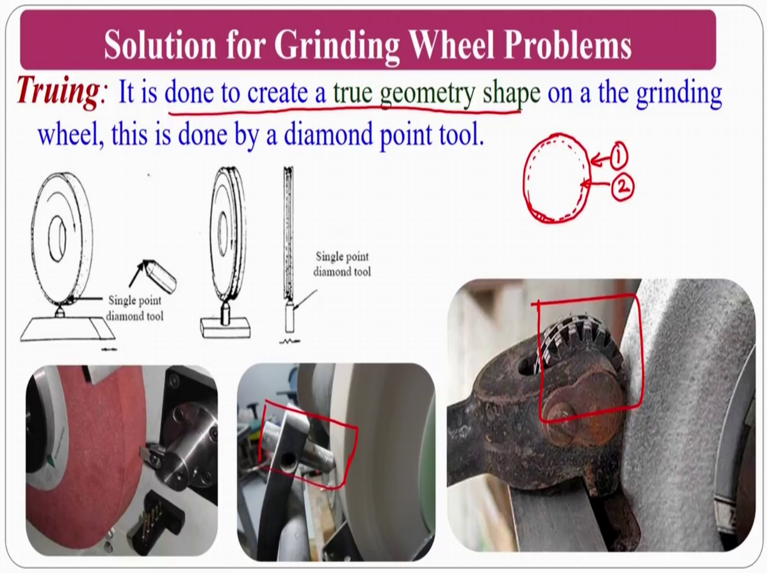

So, truing, normally to create the true geometrical shape; that means, that whenever particular shape is gone in that circumstances you can use this particular truing operation. As I said my grinding wheel should be perfectly circle; assume that a sector is damaged because of inclusion in a work piece or because of hardness change that is occurring in the work piece because of which if this particular sector is gone, then what will happen? You have to bring to a true shape otherwise what will happen if this sector whenever it reaches to the work piece what will happen sudden load will occur.

So, it will damage the work piece, which we do not want. For that purpose normally truing will be done, so that the true shape of a circular shape will be bought into the picture in this circumstances also people will go for the dressers, and they can go for the diamond dressers or this type of dressers.

They go for the dressers, so that they remove a sector parallel to that wear everything they will remove on a periphery of that grinding wheel and it makes a perfect circle, ok. This is the one out one and the dotted one is modified one. So, that it gains a true shape that is called truing operation, ok.

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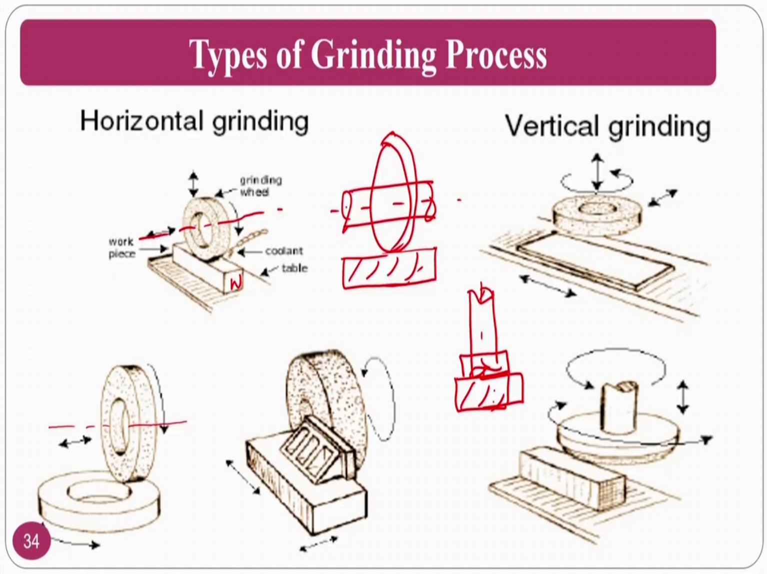

The types of grinding processes, there are varieties of grinding processes in the world. Many people uses many among that we will go and see what are the normal types. One is horizontal grinding you know many people might have studied horizontal milling, vertical milling other things and all those things. Horizontal grinding whenever your arbor normally people know if your work piece and arbor direction is parallel in that circumstances assume that this is my work piece and my arbor direction is like this, because on a arbour the grinding wheel is mounted, ok. So, this is my arbor and this is work piece. If both are parallel what will happen this is called horizontal, ok. So, vertical it is similar if my arbor is vertical to the work piece then it is called vertical grinding process.

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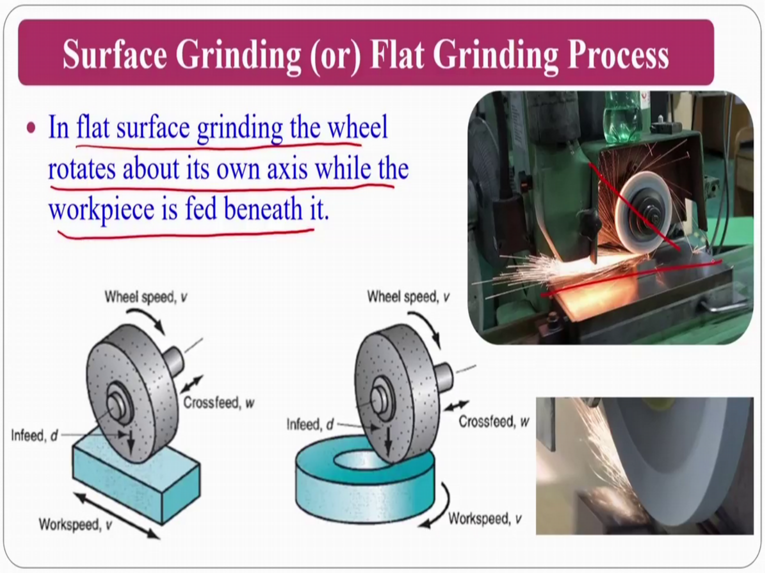

So, surface grinding normally it or the flat grinding you can go for wherever it is a parallel to the work piece surface. Flat surface grinding that the wheels rotate about its own axis while the work piece is fed beneath it this is called the flat grinding as you can see the work piece is beneath it for and this is my axis and this is my work piece axis, both are parallel to each other. This is called surface grinding.

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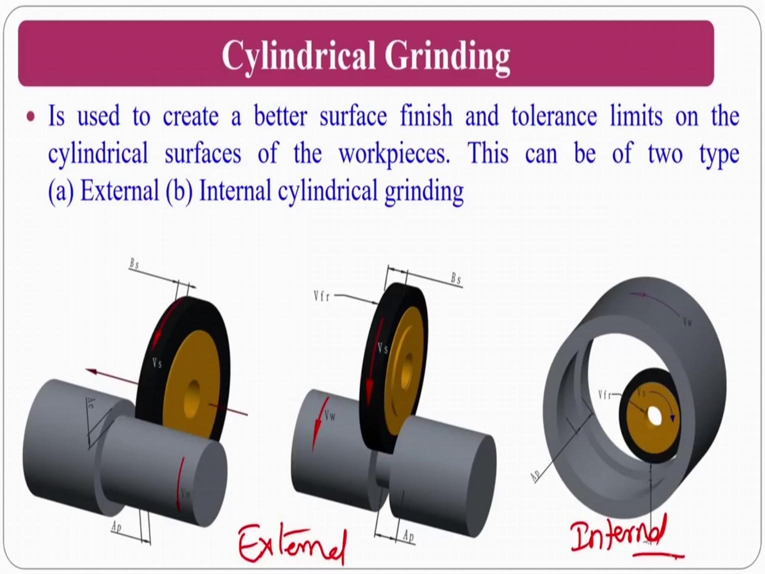

Cylindrical grinding whenever I am going to use the work piece here what normally the work piece is held in a rotatable jack and it can be rotated, so that the grinding wheel also will be rotating. So, you can generate the cylindrical surfaces. You can generate two ways; one is internal grinding, as well as external cylindrical grinding. You can generate external cylindrical shapes you can also generate internal cylindrical shapes, ok. This is called external, this is called internal, but in a internal your grinding wheel will be very small and you can use inside a pipe or something, ok.

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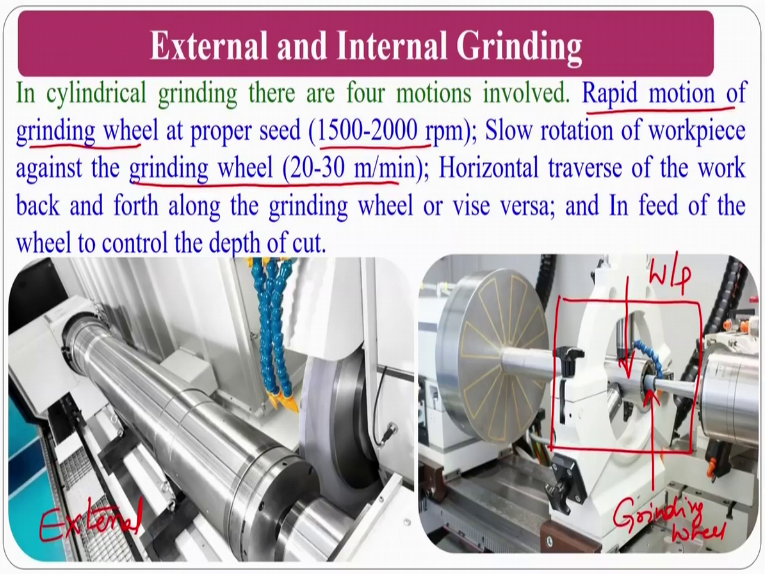

In a practically, how do you visualize? That previous slide shows the schematic ones, now I am going to show you practically how it look like. You can see the external one external one cylindrical grinding where four motions are involved which is rapid motion of the grinding wheel at proper speed normally the speed will be like 1500 to 2000 rpm; slow rotation of the work piece against the grinding wheel, normally the work piece will be rotated at very low rpm and horizontal transverse back and forth of the grinding wheel these are the other motions, ok.

In a if you see here in a internal grinding this is a grinding wheel and this is the work piece material, ok. So, the work piece material is internally grinded. This particular picture shows you how external and internal cylindrical grinding works, ok. Many of the universities or many of the institutions may have may have this one and some of the institutions may do not have this one, for that purpose I am showing you, so that you can see how internal and external cylindrical grinding process works.

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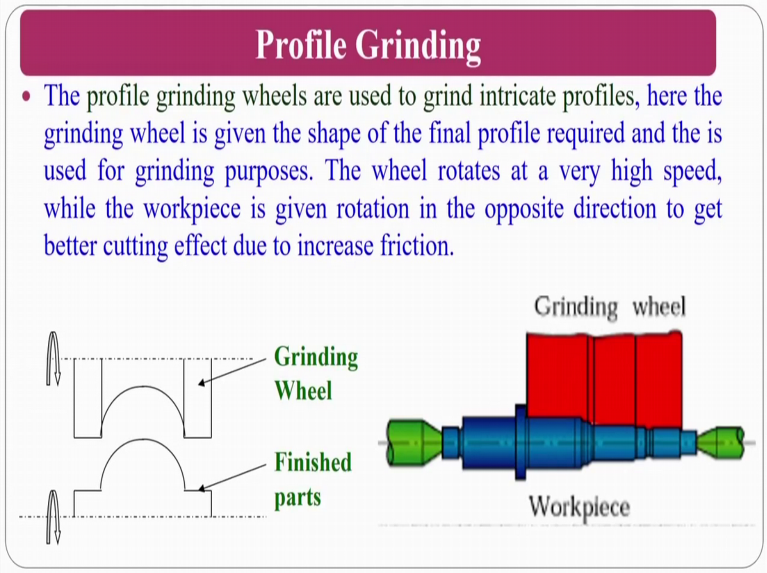

Profile grinding: if at I want to generate a profile in that circumstances you can generate or you can make a grinding wheel converse to it and you can generate. Profile grinding wheels are normally used for grinding intricate profiles assume that I want to do a work piece of this one or finished part of this one. So, the grinding wheel will be a converse shape.

The grinding wheel will be given a shape final profile is required according to the final profile is required, ok. So, you just give a converse profile, so that you can generate the required profile on the work piece.

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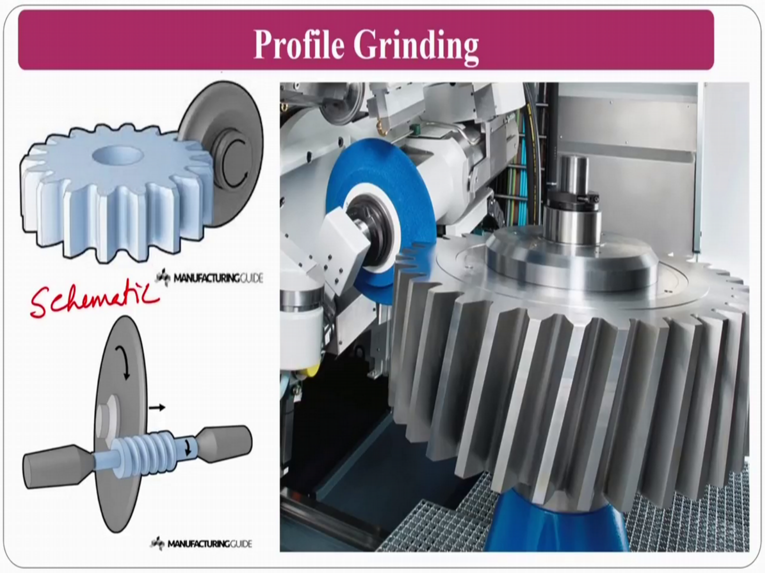

So, profile grinding also uses for making some the gears. As you can see the schematic this is the schematic diagrams and originally or practically if at all I want to see how the grinding process profiles are generated. Normally helical gates or spar gates all this type of gates also can be fabricated by the profile grinding. Only thing is that we require converse shape grinding wheels.

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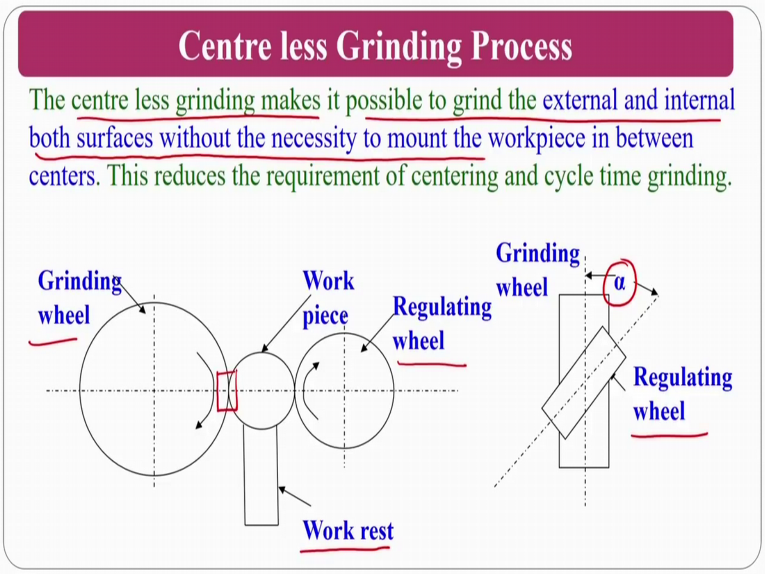

Centre less grinding process, this is one of the important process where there is no centre between. If at all I want to go for the cylindrical grinding as you have seen in the previous slides you have to held the rod in between the centre. Assume that this is my cylinder and I have to hold like this between the centre otherwise it will not stay. Assume that if it is not a uniform shape, here it is a cylindrical shape that is that is no problem in, it if at all I have a elliptical shape or something assume that I want to do the camp in that circumstances you cannot put under the centre. So, it cannot be between the centre so, in that circumstances it is called centre less grinding. In that circumstances the grinding process that we will use is a centre less grinding wheel process.

In a centre less grinding wheel makes it possible to grind the external and internal both surfaces without necessary to mount between the centres, ok. So, this is a work rest where you will mount the work piece and the grinding wheel is there on a one side, another one is regulating wheel will be there on other side. Regulating wheel do not do any machining operation, only the grinding wheel do the machining operation. Regulating wheel controls the feed continuously it will give the feed to that one, so that the contact will be there between the work piece as well as the grinding wheel. So, that the surface get machined or finished, ok.

The regulating wheel and the grinding wheel normally they will have certain angle that is normally represented by the alpha. So, alpha can be varied depend on the requirement or you can keep constant also.

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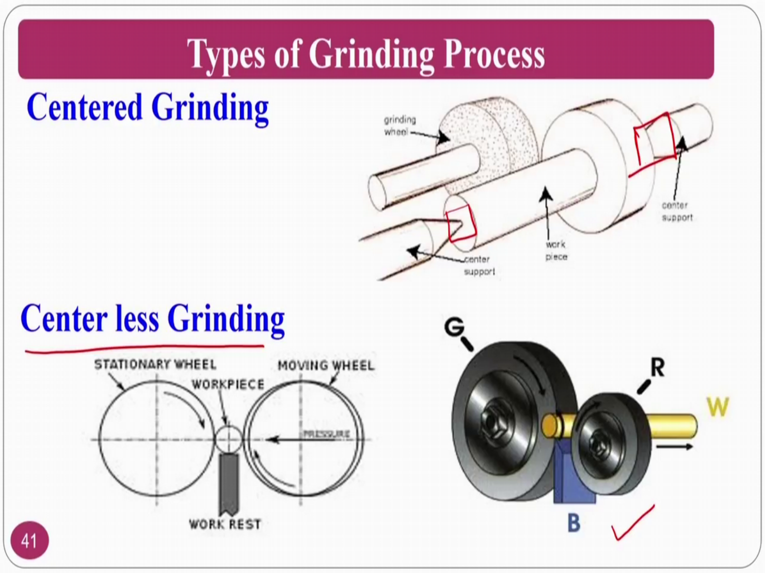

So, practically how it looks likes centred grinding wheel as I said centred and centre less. Centred means you have between centres two centres are there normally you see the lathe the work piece is held between dead stock and live stock. Here, there is no requirement, centre less grinding wheel normally they have a stationary wheel, the moving wheel, stationary wheel will be like a regulating wheel and work rest will be there and you can remove the or you can you can, so that you can remove the material on a irregular surfaces, ok.

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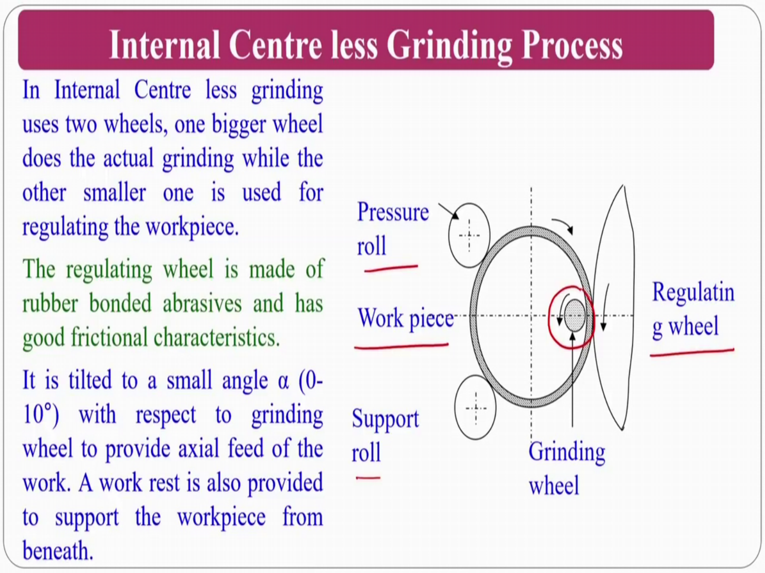

Internals centre less grinding process, normally if you see internal centre less grinding wheel process two wheels are one is a pressurized roll another one is a supporting roll, work piece will be very big and the grinding wheel will be inside so that the regulating wheel will put some pressure on it, so that it will do the machining operation as we have seen external here also internal. Only difference here is one of the supporting as well as pressurized rolls will be there, so that it will have it can remove the material uniformly

Creep feed grinding normally in a centre grind centre less grinding process regulating wheels as we have seen they are made up of rubber bonding abrasives and has a good friction characteristics, ok. So, that it can regulate the feed. So, it can be tilted the small angle alpha, normally the value will be between 0 to 10 degrees with respect to the grinding wheel to provide axial feed a work rest also will be provided to support the work piece normally. Work rest always be supported in a external one for that purpose here there is no work rest, for that purpose work rest is replaced in a internal centre less grinding wheel by pressure rolls as well as support rolls. These rolls will act as a work rest in a external centre less grinding process, ok. That is about the centre less grinding process external as well as internal.

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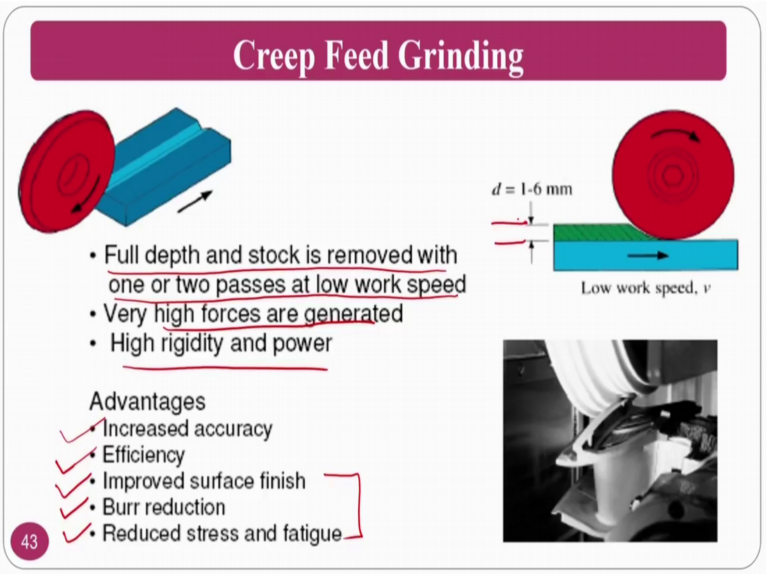

The creep feed grinding: as I said the creep feed grinding means there is a high depth of cut normally in a creep feed grinding you will have to remove the stock of material very fastly; that means, that high amount of material will be removed in a one go; that means, removed with one or two passes at the low work speed very high forces are generated and high region power. Normally it requires the grinding wheel should have very high bonding and it should retain its original structure it would remain without any fracture even though the operators giving very high depth of cuts, people are going to give depth of cuts whenever the material removal requirement is very high, ok.

The advantages of this process: increased accuracy, efficiency will increase because material removal is very high, improved surface finish. Normally in some cases the surface finish will be improved and burr reduction compared to other processes and reduced stress and fatigue some of the things may not be true for all the cases some of the things will be true and the basic advantage of creep feed grinding is the stock removal will be very high, ok.

So, you can see here depth of cut is given 1.6 mm. So, that means, normally in lathe also you do not give that much. So, if at all you would give there is a danger of blast of the grinding wheel, for that purpose you should have a specially designed and fabricated grinding wheels that is a beauty about the creep feed grinding.

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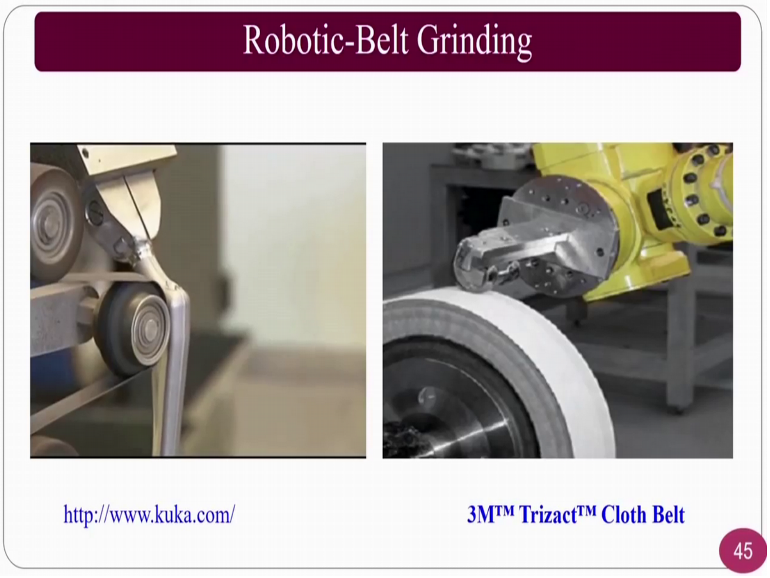

Robotic and belt grinding process. If you see the robotic and this is a costly process wherever if at all I want to go for finishing of complex surfaces, for example, here I am having a belt continuously moving belt is there.

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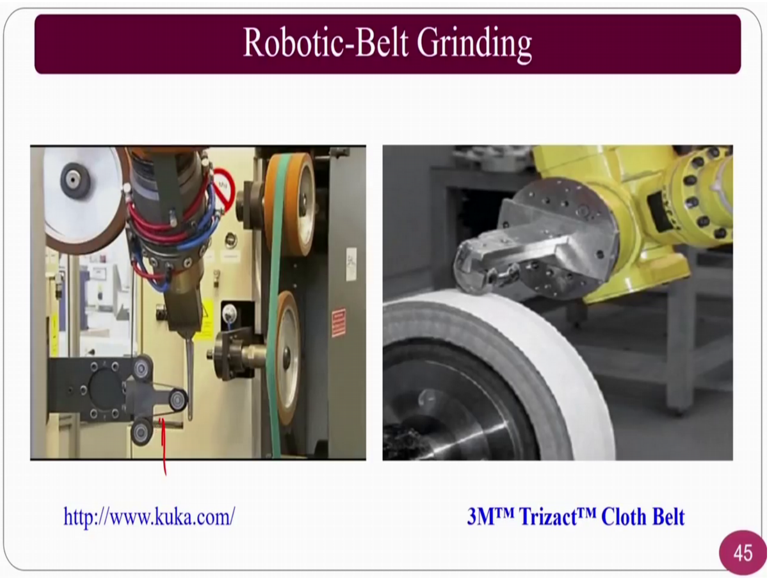

Continuously moving belt is there here and (Refer Time: 62:22) plant is normally machined against. So, the robot having it is own motions and it presses or it will give the depth of cut as per the requirement against the grinding surface that is called the grind belt which is continuously moving you can do and soft wheel also can be used to machine this time using the robot. Robot have its own motion to do to apply pressure against the surface as well as to give different motions to the work piece different motions to the work piece.

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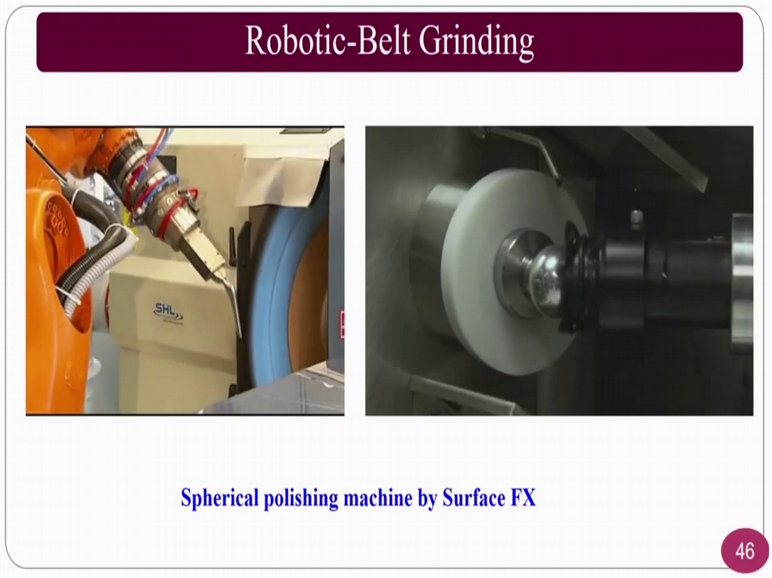

If you see whenever the implant is pressed against the grinding wheel what will happen? This wheels are made up of rubber bonding or this are elastically deformed, ok. If you can clearly see now the deformation of the grinding wheel is taking place that is called rubber bonding wheels or the soft plot best wheels they are going to use, ok.

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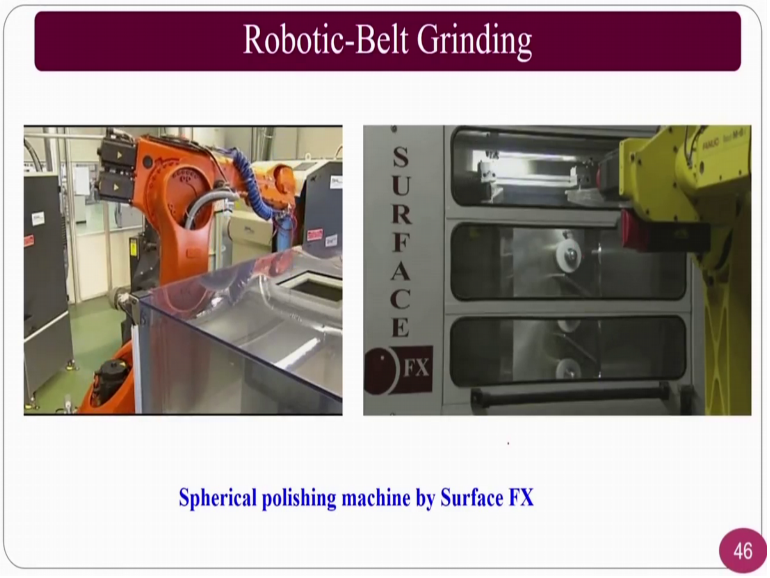

This is hip implant. Normally whatever you are seeing in the figure 2, it is called as tabular head is machined or finished. Normally figure 2 shows the acetabular head finishing using the robotic grinding.

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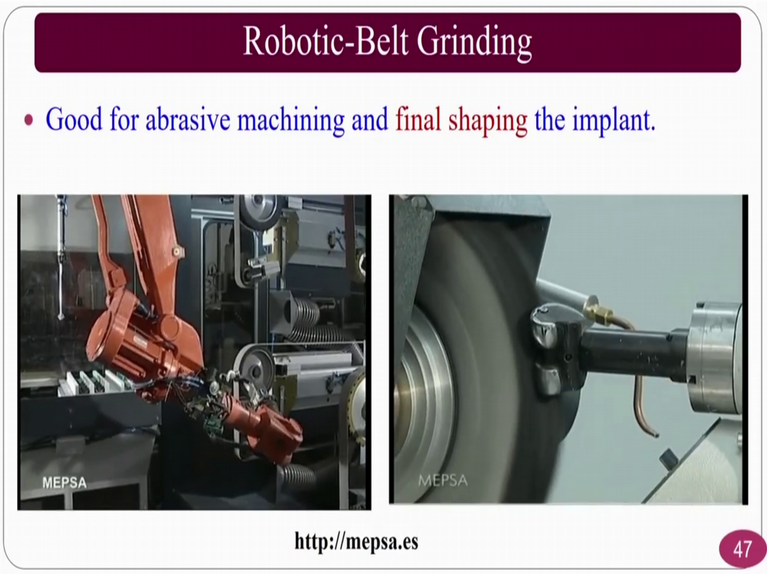

Here in this case you can see the robotic belt grinding where the belt is continuously moving and the knee implant is coming in and it is robot is giving its own motion. So, that it press against the grinding wheel which is a belt here and it will remove the material. At the same time soft wheels also can be used to polish, ok.

So, what normally the people do is this abrasive belts are normally is the solid ones. So, you give the shape to this one, then they will move on to the soft cloth based wheels to go for the buffing which is nothing, but finishing operation, ok.

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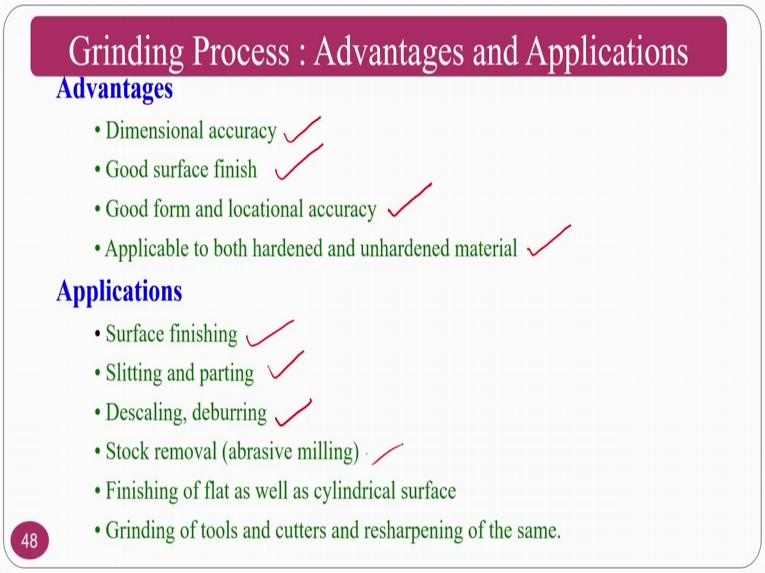

Advantages and applications; so, the dimensional accuracy will be very, good surface finish will be very good, good form geometry and local accuracy will be there and both hardened unhardened materials can be used, ok.

So, the applications: the most important application of the grinding is surface finishing and then you can go for thin grinding wheels for slitting and parting and descaling and deburring also you can go and stock removal. Normally, if you want to go for material removal you should go for big abrasive particles, I mean to say coarse type of abrasive particles. Finishing of the flat surfaces as well as cylindrical surfaces you can do and grinding of tools and cutters.

Normally, there is called a specialised tour tool and cutter grinders are there which you will see if time permits, ok. Those are all also used for making assume that I have a HSS tool I want to sharpen it then you have to go for tool and cutter grinders. Normally, work shop will have tool and cutter grinders. So, many of the work shop because you have to use this tools for the lathe application and other things, ok.

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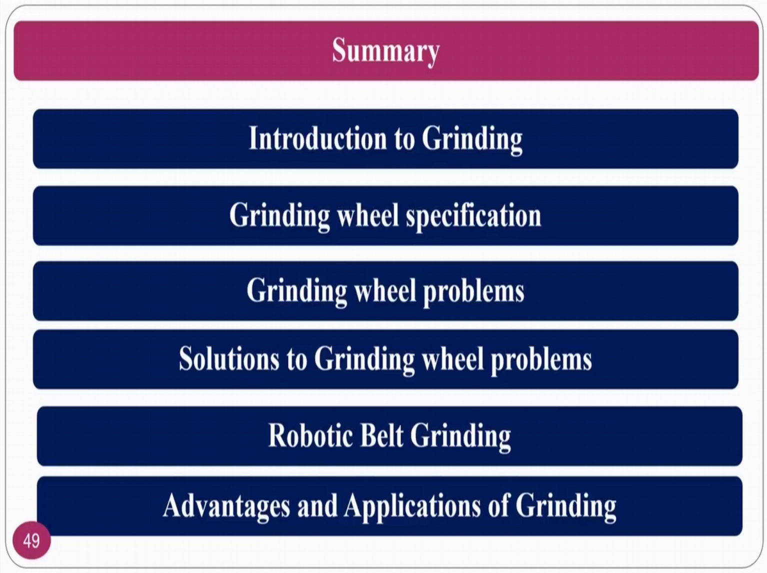

Coming to the summary of this class, we have introduction to the grinding, then the grinding wheel specification; we have seen what is type of abrasive, size of the abrasive particles and types of mesh grade of the abrasive particle then we have seen the structure, then what type of bonding we have seen. Wheel problems, wheel grinding wheel loading, truing these are the problems, wheel glazing is another problem that we have seen and the solutions you can do the truing operation to get the true shape, we can remove the you can do the dressing operations, so that you can remove the top layer of the glazed surface or you can also remove the loaded material by the dressing operation.

Then, the robotic belt grinding or soft wheel grinding we have seen and the videos might have helped you in a great way to understand how the latest technology of the grinding is emerging, these are the latest technologies people are using for manufacturing of the complex surfaces, manufacturing of the bio implants like knee implant, hip implant and other metallic implants in the industries.

And, advantages and applications these can be used for finishing applications and it can also use for the machining applications. So, the abrasive particle is constant, but how you are using, whether you are using for the machining applications by using a bigger coarser compressive particles or super fine abrasive particles for polishing, whether you are using in a grinding wheel, whether you are using in a soft wheel, whether you are using in a belt or all depend on you. It is up to the manufacturing engineer to decide depend on his requirement, which type of wheel they have to go, which type of process they have to go, which type of abrasives they have to go and what type of bonding what type of structure and all those things are there.

So, this might have helped you in a great way. So, thank you for this particular class. Hope, this particular class might enlighten the conventional things as well as slightly advanced things, so that the people can understand in a great way.

Thank you.