Manufacturing Processes II

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Lecture No. 28
Abrasive Processes

Welcome to this lecture session-28 on Selection of grinding wheel and its conditioning grinding is basically a chip removal process just like Milling.

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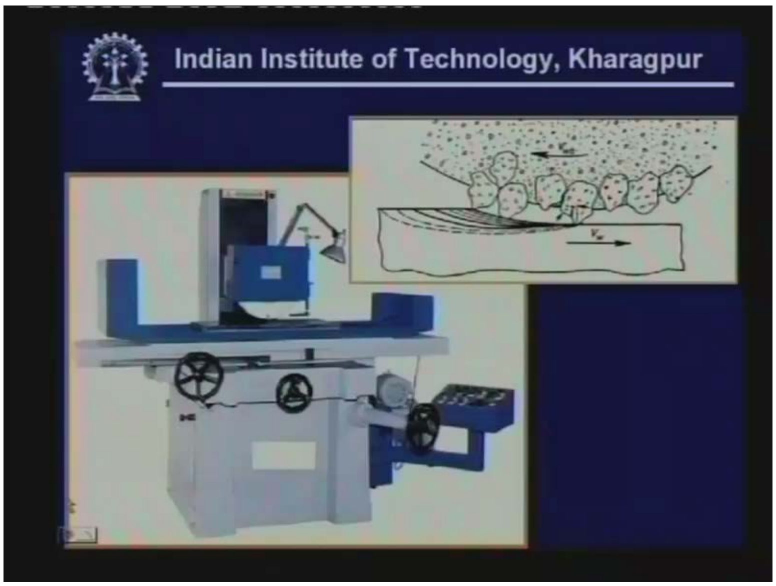

However there is a difference what we can see in this illustration. This grinding process uses a grinding machine and also it employs the grinding wheel where this abrasive grits are the cutting tools. This abrasive grains are working in a similar way, just like the teeth of a milling cutter but there is a difference between these two. In case of a milling cutter we have a well defined geometry but in this case the grits have in determinant geometry. This grits have the characteristics like high hardness, high temperature, stability, retention of the sharpness at that temperature. The grits are held within a material that is called the bonding material or the cementing agent. This cementing agent and the grits they make say composite structure. Now this composite structure is given a particular shape according to the need of grinding.

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Grinding wheels are basically either conventional or superabrasive type. It is according to the materials which are used as the abrasive, according to that we call either a conventional or a super abrasive wheel. In this illustration, we can find varieties of wheels with different geometry. These are the few examples of abrasive grit with conventional abrasive. Here we have some of them with super abrasive the size, shape which can vary widely as we can see here. This is a small diameter wheel which is used for internal grinding and these are the wheels which are used for surface grinding. Now comes the specification of the wheel:

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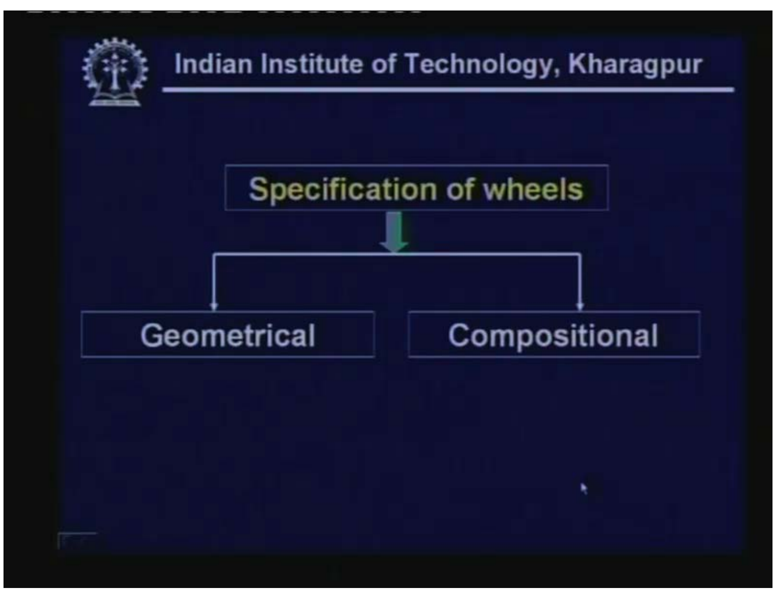

Now there are at least two types of specification. One is the geometrical specification which shows the diameter, the width and the bore of the wheel. The second one is more important that is the compositional specification which takes care of the material of the abrasive, material of the bond, its hardness, grit, spacing velocity and so on. We find here the various shape of the conventional wheel.

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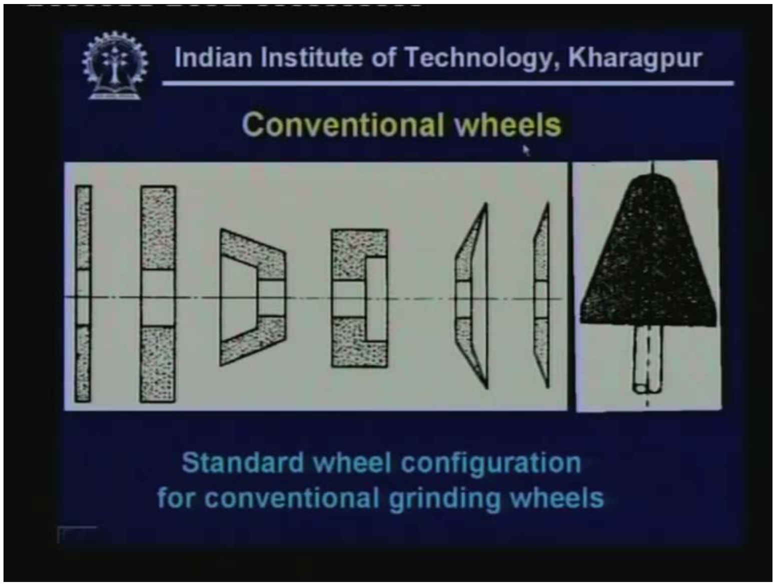

We have a disk type of wheel which is used for surface grinding. These are the some face wheel cup shape wheel, which are used for face grinding. These are the saucer type wheels which are used in those areas where there is a limitation in accommodating the grinding wheel. So there we use a thin wheel. This is another example which is called a mounted wheel. Here we have a steel shaft on which the entire abrasive body is built and this is suitable for internal grinding action.

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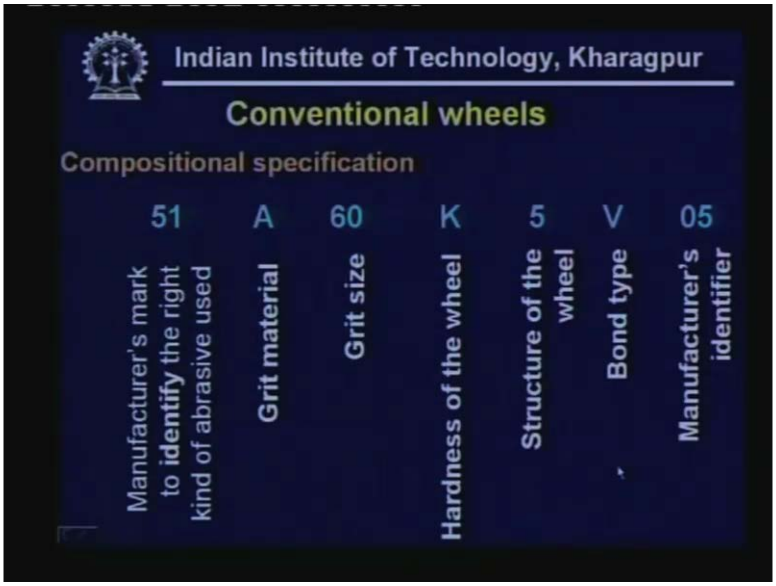

Now it is the compositional specification which is very very important for efficient grinding action. This is about the conventional wheel. Here we need some alpha numeric specification and it is followed in a certain sequence and order and it is accepted world wide and we have to follow the sequence. Now at the very beginning, we have a numeral a number which is actually the manufacturer's code which signifies the type of abrasive used in grinding. The second one that is an alphabet which shows the type of grit material. Here 'A' means Aluminium oxide, then comes the number 60 which shows the size of the grit. If it is 120, immediately we understand it is a finer grit. If it is 30, we understand that is a core size grit or a large size grit then comes the hardness of the wheel.

Actually it is the strength of the bond with which the grit is held in the body and this is provided by the basic formulation and the amount of the grit material which is used in the particular grinding wheel, then we have the structure of the wheel, the structure of the wheel means what is the space available between the grits and that is extremely important considering the freeness of cutting or accommodation of the fluid which serves like a chip pocket or the fluid pocket, then comes the type of bond and this type of bond here. this 'V' stands for the Vitreous bond. We can have different type of bond, then we have another number which is also recognizes a particular type of wheel which has been made under some manufacturing process. So this number which comes at the end and the number which comes at the very beginning this belongs to the manufacturer and the specification in between that actually characterize the basic compositional features.

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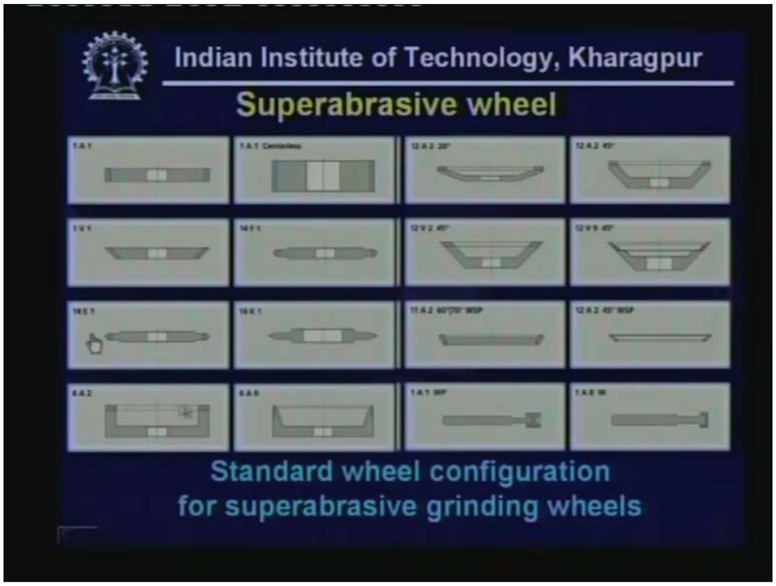

Here we go for go to the super abrasive wheels which shows various shapes starting from a disk type of wheel we have saucer type of wheel. This is the cups wheel which is used for facing face grinding. This is for peripheral grinding. For example, we have some form wheel which are used for making some form grinding, then ultimately we see some internal grinding which are used for grinding a board and there this diameter is rather small. Now this is about the compositional specification of the super abrasive wheel. We know that a wheel is mostly designated by the type of abrasive material what we use. That's why we call either it is an aluminium oxide wheel or a silicon carbide wheel that is in the conventional group when it is comes to the superabrasive wheel we call it either it is a diamond wheel or a cBN or cubic Boron Nitride wheel.

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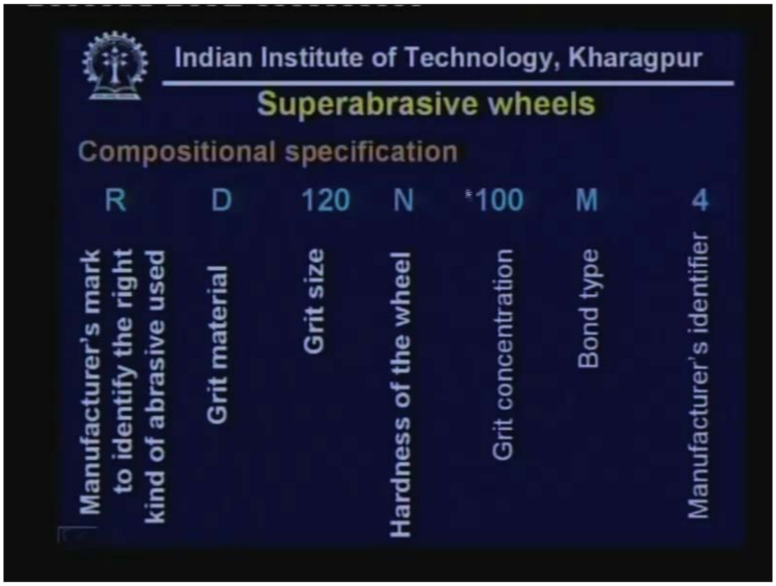

So if we have a closer look here in the specification immediately we find that there is one alphabet which is the manufacturer's identification code but immediately it follows one letter this is 'D' just like the conventional wheel specification here 'D' stands for diamond had it been cBN, we have we could have put 'B' that means 'D' means for diamond and 'B' means cBN then comes the grit size we have already explained. It is here 120 grit size, then we have hardness of the wheel that means this is the holding power or the adhesive force with which the bond is holding the grit then comes concentration of the grinding wheel. In case of conventional wheel we call it the structure of the wheel whether it is a closed structure, dense structure or a porous structure or an open structure but in case of superabrasive wheel we call it concentration.

Now what is meant by concentration? 100 concentration means that means over a unit volume 25 percent of the volume is occupied by the abrasive material and this is in case of diamond wheel that means the diamond wheel will have 100 concentration when it does contain 25 percent of the space by diamond grits, the rest may be bond material or there can be some wide space. Now for cBN this 25 is actually 24 because of there is slide variation in their density. So 100 means 25 percent of the volume is occupied by diamond grit and for cBN this 100 means 24 percent occupied by cBN grit than as usual we comes to the bond material here, M stands for metal we can have other bond material which will be covered in the later section. Finally we have one code number which is also manufacturer's identification code which signifies the type of process which has been followed during the manufacturing of the wheel. So we have at the beginning and at the end two manufacturer's code immediately the manufacturer recognize the total history behind the type of abrasive and the manufacturing technique.

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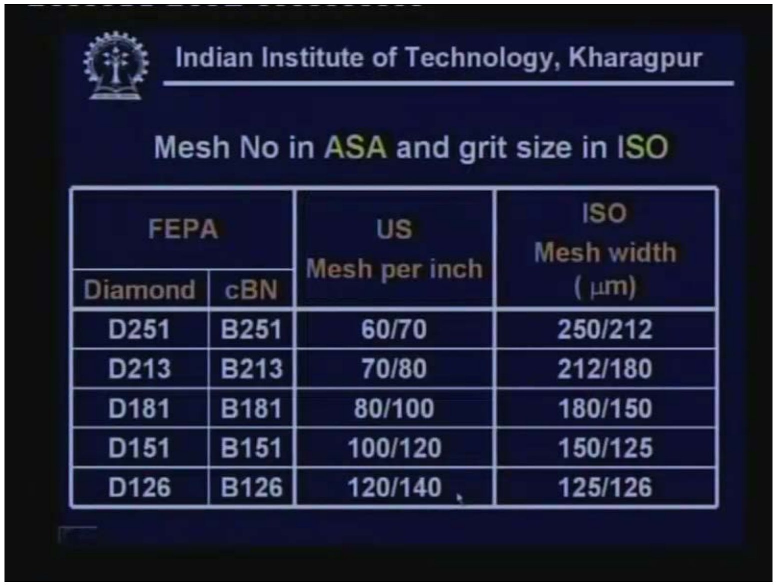

FEPA		US Mesh per inch	ISO Mesh width (μm)
Diamond	cBN		
D251	B251	60/70	250/212
D213	B213	70/80	212/180
D181	B181	80/100	180/150
D151	B151	100/120	150/125
D126	B126	120/140	125/126

Here we find how the grit size should be specified? We have at least three systems. This is European system. This is a federation of manufacturer of abrasive material of Europe that federation of European manufacturer of producers of abrasive. Now they call it either for diamond it comes with a symbol D, for cBN it comes with a symbol B. Now we can see by way of illustration few numbers 251 and we have up to 126. We have correspondingly some US mesh number that means number of perforations per linear inch and then directly as for the ISO norm, we have to express it by the width of the mesh that means if we consider a mesh, the 60 mesh per inch corresponds to 250 micron width of the mesh. So this way either by FEPA or US or ISO we can immediately describe the size of the grain. Now for super abrasive, we have a range instead of having a 60 grit we call it 60 by 70 grit that means the size of the grit is within this range of the mesh that means the grits can pass through 250 mesh but it will be arrested by 112 micron mesh width so that is the range. We can have some wide tolerance or a tight tolerance so far as the size of the grit is concerned. Now come the most important task the selection of the grinding wheel:

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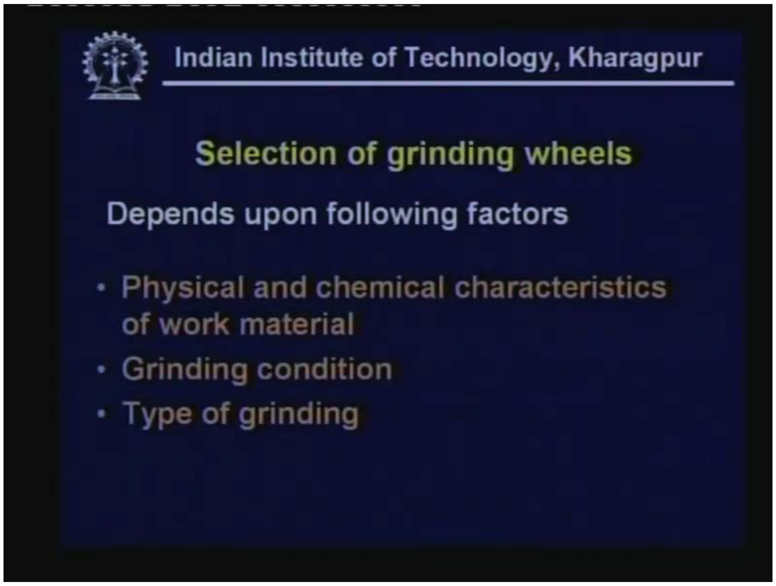

Once we decide upon what should be the size of the wheel or shape of the wheel then comes the real task of getting the correct formulation of the wheel which means the type of the grit, the type of the grit material, among a particular type. Its friability, it is very very important then comes the type of the bond material, its formulation, the structure of the wheel or the grit spacing then the strength of the bond and finally the protrusion of the bond. So these are all considered in this selection of the grinding wheel it is implied that the selection primarily depends upon the type of the work material to be ground because it is a matching pair matching pair means, there must be some physical compatibility and chemical compatibility between the work material and the grit material primarily that is the most important task then of course the grinding condition.

Grinding condition means whether we are allowed to use some grinding fluid, what type of grinding fluid? Whether it is synthetic oil or an alkaline water based fluid or it is just dry grinding. So this is also one major issue which determines the type of the grit material and their composition. Finally, it is the type of grinding whether it is a disk thin disk which is used for dicing or slicing, whether it is used for wide surface grinding, whether it is form finish grinding or ultimately whether it is a small bore grinding. So these are the few things which ultimately determine what should be the type of the grinding wheel. Now comes the types of abrasive:

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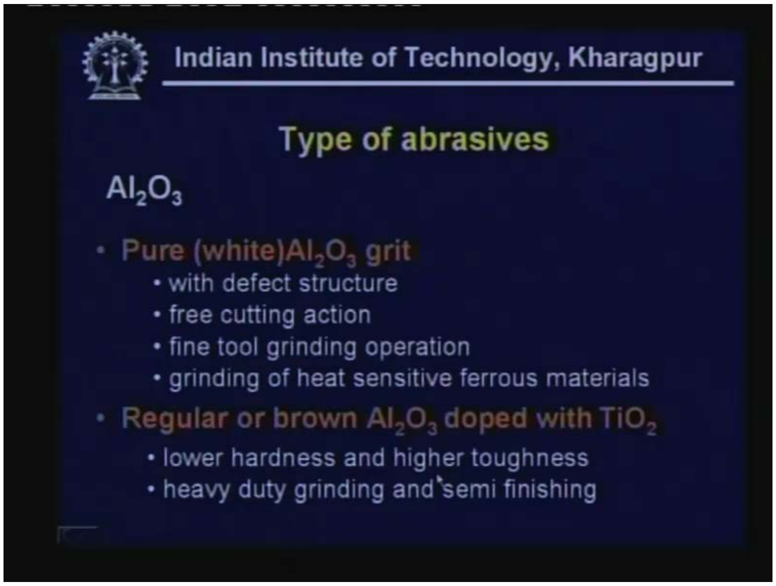

We have aluminium oxide and silicon carbide which falls under the category of conventional abrasive. Now under this aluminium oxide we have at least two varieties. Principle variety one is called the white aluminium oxide and the other one is the brown aluminium oxide. We can see that this white aluminium oxide has a balanced impact resistance and sharpness or form holding capability. These are having some defect structure which is advantageous in that, it can provide the necessary free cutting that means during the course of grinding the grits can experience some wear flat and at that point, it is very very sensitive issue.

This grit should breakdown itself that there by releasing the grit and the face grit from beneath should appear and which will continue the necessary grinding. Now what we gain by that? By that we can control the level of grinding force and also the grinding temperature and this is very very important when we go for fine and precision tool grinding operation or grinding of heat sensitive ferrous material. Here neither we allow the force to rise nor the temperature to rise. So once there is some wear flat develop on the wheel, the grit should release itself. We just now we have mention a regular brown. This has a lower hardness but it is having better toughness compared to the white variety and obviously this should be the choice for heavy duty grinding. So these are the two types of aluminium oxide grit. Further classification is also possible again in this aluminium oxide family.

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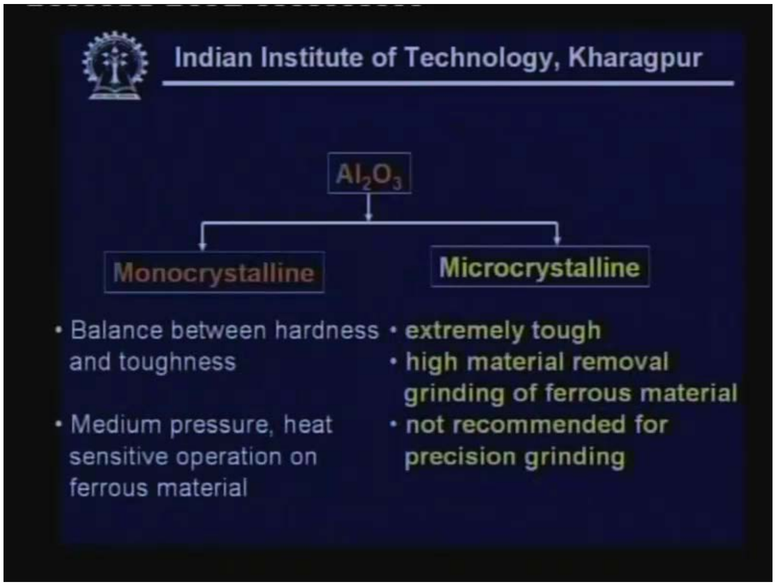

We have either mono crystalline or microcrystalline. Mono crystalline it is a balance between hardness and toughness. So this is also for since we have a balance so we do not have very high hardness neither toughness is high. So it can be used for medium pressure grinding or those areas where it is very sensitive to heat. We have some crack or flaw in the grinding during this process, rubbing process. So that is not allowed and there this should be the material of choice. We have microcrystalline really, this is an extremely tough grit material and this will be obvious choice for heavy duty, heavy depth grinding.

Now this microcrystalline grist they do not have a well-defined cleavage, but when there is some increase of force, a tiny particles just given it comes out gets separated retaining the sharpness of the grit and this has some auto sharpening character which is also one important property or characteristics of the grinding wheel. However one point to be remembered that this is not recommended for precision grinding. For precision grinding we must go for this white variety crystal. Now we have silicon carbide which is another member of this conventional group.

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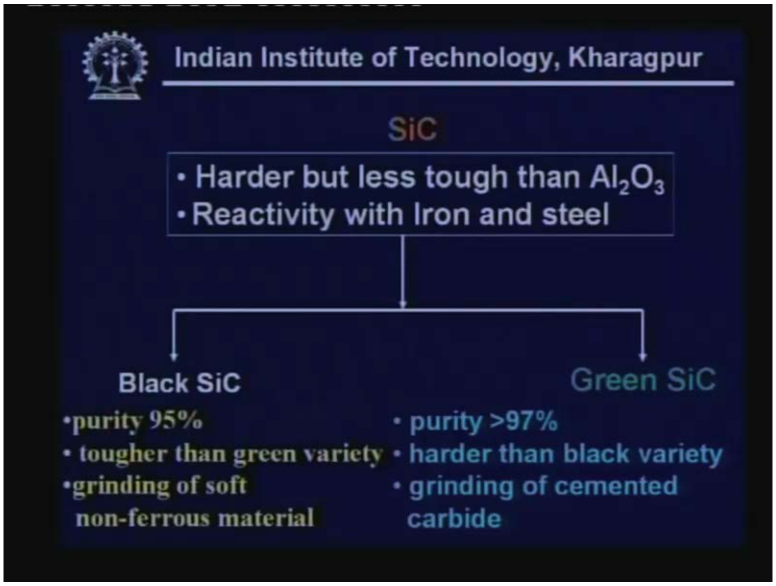

Silicon carbide; one is interesting thing we can look in to it is harder than aluminium oxide, but it is not used for grinding steel. It can be safely used for carbon. Although it is harder, but never recommend it for grinding steel. Another point to be also considered as we have said the chemical stability of the crystal it is just not the hardness or the retention of the hardness it is also the chemical stability or the chemical inertness that matters much. Now if I consider silicon carbide as the abrasive material, we know the steel it is a long chipping material, it can have an intimate contact and that causes reaction between silicon and iron. So silicon will be transported towards the chip material and this silicon carbide will simply have termination of its life.

So this silicon carbide is not used for machining of steel although for cast iron we can safely use the reason is as follows. This cast iron is already saturated with carbon. So there would not be any migration in that respect and also cast iron produces fragmented chip. We do not have any intimate contact that is also another reason in the silicon carbide family. We have two varieties; one is the black silicon carbide having around 95 percent purity and we have the green variety purity. It should be better than 97 the appearance is like that. So this is a tougher variety compared to the green variety and this is used for soft and nonferrous materials. Non-ferrous material not for ferrous application, but this green variety, which is which can retain its sharpness and that is the material of choice for grinding tungsten carbide particularly the tools. The cemented carbide tools if it needs some sharpening or resharpening then we can use this silicon carbide the only grit which can be used amongst all the materials available in the conventional group. Now we go to the super abrasive grit.

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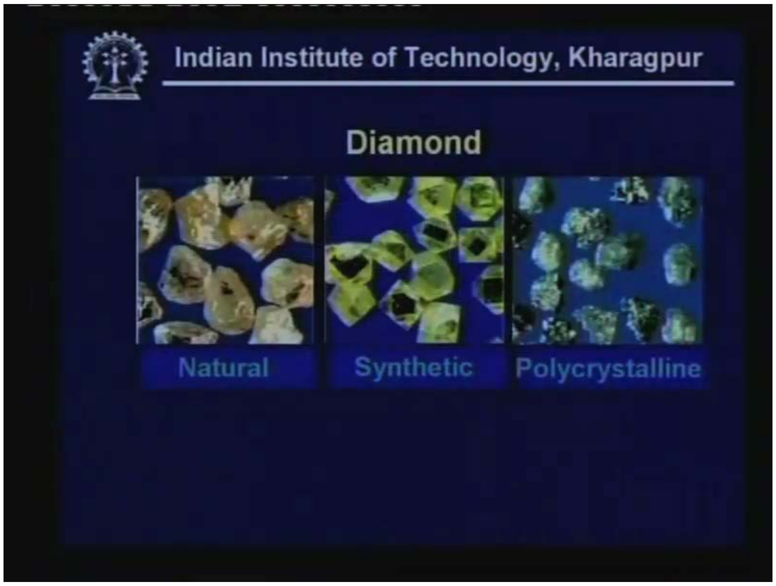

The first one is diamond. Diamond is one of the super abrasive grit. We can find the natural diamond it is a mind product, natural product which is crushed and then screened according to that need you have different size of the diamond and it can be used. Now this is actually the non gem quality of the mine diamond. So the gem quality is one variety which is used it can be also used in tool application like your diamond turning and diamond machining. But, this is the non gem variety which can be used for all this abrasive tool preparation. So this is natural variety, but later on synthetic variety also came in to being and in the synthetic variety, we have at least two types of crystals.

One is absolutely strong tough synthetic crystal. This one you can recognize the well developed crystals and here you can see in the natural, the irregular shape and here we have multifaceted morphology. It is a fractured surface, it is a crashed product but this is a synthetically produced product and which has well developed crystal habits. It is rather strong, tough, but we have another variety which is polycrystalline. Here some friability is introduced by controlling the process parameters like pressure, temperature thereby we can have the polycrystalline type. The difference between this two is that this particular thing can be used for very tough grinding where high grinding pressure is expected but this has a better friability that means once there be any wear flat develops on this, there will be micro fragmentation of that part living sharp points. So this is the particular use of this poly crystalline type where large force is not allowed and free cutting has to be there.

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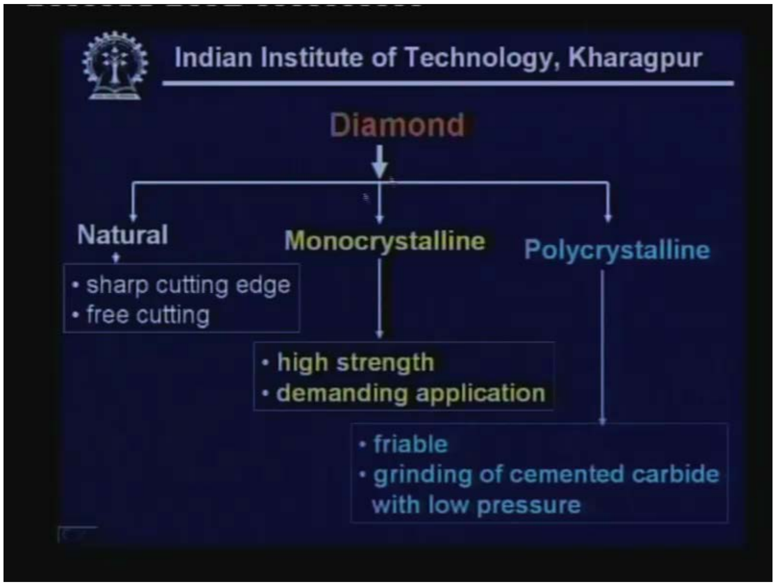

So what we have just discussed it is a summary sharp cutting edge it gives free cutting action. Mono crystalline, high strength, its demanding application means high depth, heavy feed grinding. That’s why what we called demanding application. Polycrystalline its character is friable control friability. It is particularly the choice material of choice for grinding of cemented carbide with low pressure. Otherwise there could be some thermally induced defect in cemented carbide. So there we should not use this monocrystalline but a polycrystalline even there be anywhere flat immediately its breakdown living sharpness. That is very important here protecting the job is rather important rather than protecting the grit. So far we have discussed about the uncoated grit but now we have some grain coating.

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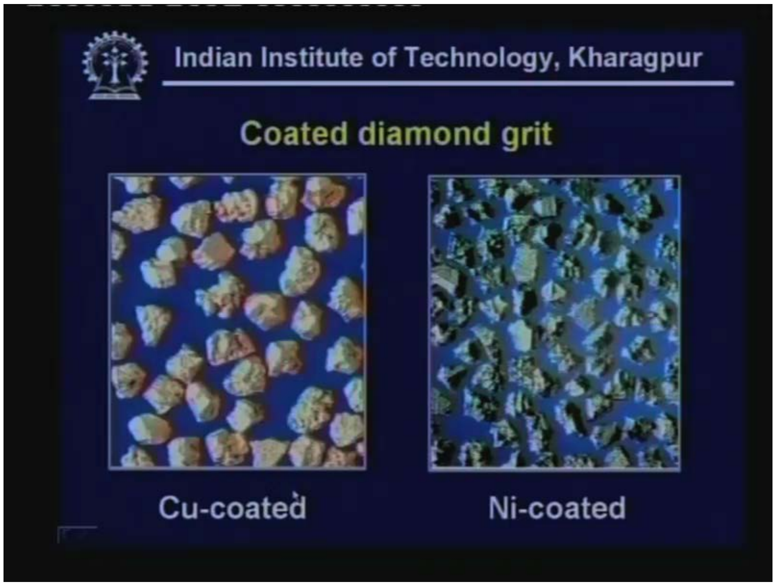

This grain coating the whole idea is to enhance the performance of the grit under respective or specific application. Now for grinding of cemented carbide normally, dry grinding is recommended. It is just not to have differential cooling in the cemented carbide. It is safe to have dry grinding rather than to use unreliable cooling, non uniform cooling. But, in that case also protection of the grit is also very important. One thing we can say here that, this type of crystals are used with a resin bond which will cover in the later section and there due to generation of the heat that heat should be conducted away and this copper coating is actually serving the heat conducting medium.

So this is actually copper coated polycrystalline grit which are used with resin bond and these are exclusively set specified for dry grinding of cemented carbide cutting tools. We can also have wet grinding just like dry grinding, we can also have wet grinding. In case of wet grinding, we also can use resin bond but there to hold this crystals in this resin bond instead of copper, a heavy metal coating of nickel. For example; nickel that is given on this surface; Perhaps we can have a closer look, it gives a rough texture. The whole purpose of this rough texture is to get a rough surface where mechanical anchorage with the resin bond will be further improved. The whole idea is not to allow premature grit dislodgement during grinding. So this is used just to have better retentivity of the grit throughout its service life. That is why we have heavy nickel coating it’s about 65 percent of the weight of the grit that is an approximate indication. We have also coating of materials like chromium, titanium, tungsten and molybdenum.

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Now if you look in to those materials you can immediately see these materials are strategic material for use as a coating on diamond. The number one point which can be looked in to these are all carbide forming elements. So this carbide forming elements are used not just as a coating but a coating with a well good adherence with the diamond grit. Now where this coating should be used? This is not used with polycrystalline friable grits this coating is used with strong, tough, well developed single crystal diamond which can support high magnitude of grinding force. Now the grit can withstand the force. But it has to be also held in the wheel. So there also we need a tougher bond and this tougher bond needs a metal bond.

Now this metal bond ordinarily cannot have a good adhesion on the uncoated diamond. So for that if we have the uncoated diamond or a bare diamond used with an ordinary metal bond there will not be any chemical bonding there will be just mechanical bonding and during this heavy duty grinding, there are dangers and risk that there will be premature pull out or the grits dislodgement that terminates the wheel in a very premature manner premature manner. Now what is necessary in this case? We have to have a coating of material which are basically carbide former like chromium, titanium, tungsten and molybdenum and what we have shown here by way of illustration, it is a chromium coated grit. This is the surface of the grit where we have a chromium coating and this chromium coating can have a very good compatibility with a metal binder which is just not possible with a conventional uncoated grit. So we have all this metal coated grit, this coating materials are like carbide forming elements. These are all the transitional elements of group 4 B, 5 B and 6 B. Now we come to another group of material which is known as cubic Boron Nitride cBN.

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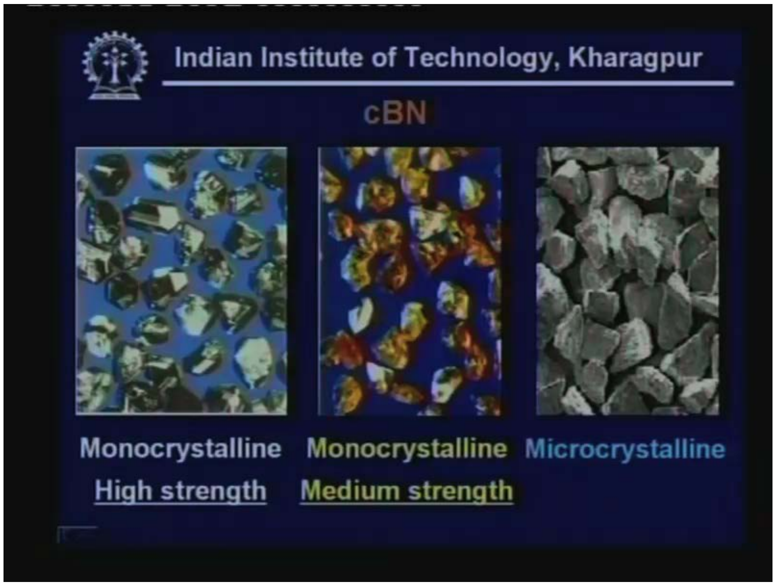

In hardness wise, it is just below diamond just below diamond but still it has such a potential that it can be well used for grinding of steel and super alloys. Unfortunately diamond though hardest, it cannot be used for grinding ferrous group of materials because there will be immediate migration of carbon to the steel to the long chipping material but in that respect cBN is much more chemically stable, thermally stable at that temperature and this is the material of choice for grinding of steel like say high carbon steel, high speed steel, die steel, tool steel and the superalloys like Inconel, mnemonic, and so on. Now in the cBN family we can immediately recognize three types of grits. These are manmade material, artificially produced.

This is a grit having the black appearance. These are mono crystalline high strength grit. This is having amber color. This is also mono crystalline, but having medium strength that means artificially some friability, of course in a very controlled way that has been introduced. Friability; by controlling the process parameters namely pressure and temperature also cBN means cubic structure Boron and Nitrogen. There is at scope to have little variation in the percentage of boron or nitrogen, little deviating from the stoichiometric and then also we can have some control on the physical properties. So one can be rich in nitrogen, another can be rich in boron, that comes during the basic manufacturing of the crystal. But these are well within the mono crystalline family.

On this side, we have microcrystalline grit that is the latest development in this process. What is this microcrystalline grit? These are the tiny crystals which are bounded together with sufficient adhesion. Now during the course of grinding, one particular tiny crystals actually participates in grinding and it can wear out and there may be some wear flat developed. Now this wear flat will increase the force and then that micro crystallite will simply fall off then the one crystallite just behind that will participate in the grinding action. So it is a continuous process, but what is the gain? The gain is that this crystal can maintain and autosharpening character throughout its service life. So it is a microcrystalline grit having that auto sharpening character.

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So in cBN just what we have discussed, we have summarized, mono crystalline medium strength, friability, better friability, low grinding force and this are used with resin bond. High strength and high grinding force. These are with vitrified electroplated or brazed bond. We have microcrystalline remarkable for there toughness it has auto sharpening character and now we have this high efficiency, dip grinding or abrasive milling that is the new innovation in the area of grinding and there this is the best material for such application. Like coated diamond, we too have coated cBN grit.

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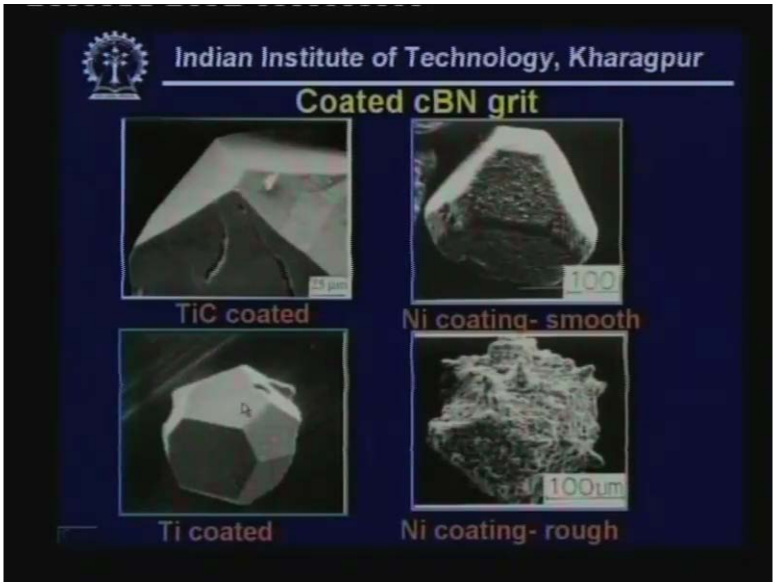

Here we can see nickel coating which can be rough textured or smooth we have titanium coated we have also Ti C coated. There have various types of coating process, but this is one grit, the smooth grit, the uncoated grit after having this rough texture coating take this appearance. Immediately, we understand this rough texture with the spikes at the edge that is good for mechanical encourage. So immediately we understand this grit can be used with a mechanical bond that means a resin bond. Similarly we have titanium coating just the way we have chromium coated or titanium coated diamond. This is titanium coated or we can have TiC coated which are useful for enhancing the adhesion with a metal bond.

Normally the metal bond cannot provide good adhesion with a bare surface of cBN which is chemically very very stable. The metal cannot have very good adhesion. For augmentation of this adhesion, we put either a metal or this hard metal TiC or Ti. This is this go well with a metal binder metal bond. But vitreous bond, that is also one successful bonding system with cBN. Now if we look into the vitreous bond, it's basically a glass like material having some alkaline constituents. Now during this high temperature firing where this bond is going to actually hold the crystal, we promote some chemical reaction to have the bond but during this this alkaline materials had a tendency to attack the cBN.

Now to have this to have this prevention or minimization of this effect, what we have to do? We have to put a barrier around the cBN, which should have a barrier which should stop this chemical reaction that means it is try to etch chemical etching of the surface by these alkaline constituents and that should not be allowed. So what we have seen? In one case this TiC promotes the chemical adhesion with a metal bond and for vitreous bond this is like a barrier which does not allow the possible attack of this vitreous bond towards this cBN and at the same time this TiC or Ti promotes a chemical bridging with this vitreous bond as such there is no problem.

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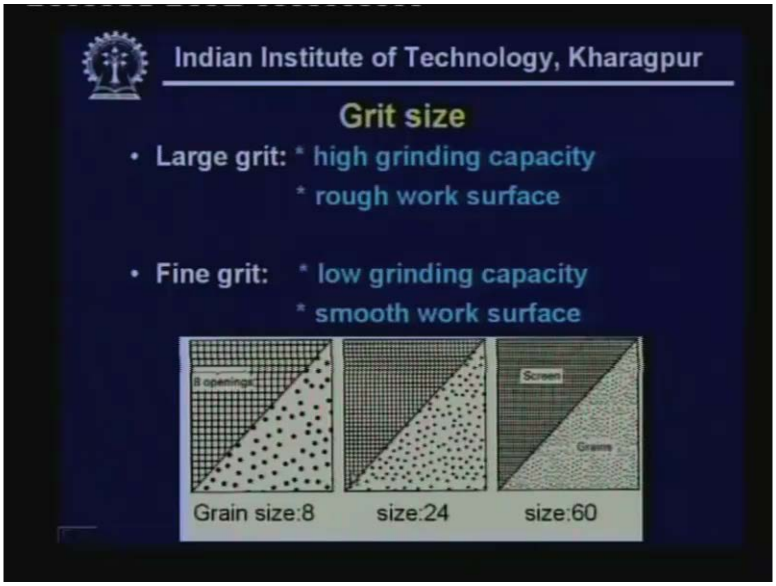

So we have so far discussed about types of grits which can be used for various grinding application and here we can see that it is actually the type of the work material which determines the choice of the grit material. Just by way of illustration, we can say if it is mild steel grinding even cBN should not be recommended. The reason is that even iron can react with boron. So there will be immediate sticking. So if it is so needed the grinding of low carbon steel then the best material will be aluminium oxide although from hardness point of view, aluminium has the lowest hardness. If I consider diamond cBN, Silicon Carbide and aluminium oxide, aluminium oxide has the lowest hardness but this is the best material against mild steel.

Why? The simple reason that chemical stability is the best against aluminium against mild steel with aluminium oxide. So this way we can have proper understanding, how to select the grit depending upon not only the physical strength, physical characteristics of the work material but also the chemical characteristics, metallurgical affinity and the prevalent grinding condition. So now we go to the grit size. We now understand large grit means high grinding capacity and it is obviously used for rough work and fine grit means low grinding capacity and smooth work piece. Why it is so? High grinding capacity means we have certain grit protruded above the bond. This is necessary to have that chip formation and when it is a small grit, then to cover at least say 50 percent, we have small protrusion of the grit. Then this grit cannot be used for larger chip thickness or higher depth of cut.

So that is the reason to if we like to increase the material removal rate than the chip thickness or the grit depth of cut has to be increased and this grit depth of cut is directly related to the grit protrusion. So if we have large size grit, even after adequate coverage we get enough protrusion of the grit but the small grit if we allow this protrusion to have deeper cut, there is a chance of prefecture grit pull out. So here we can see how this scheme on the screen controls the grid. This is eight number of opening spal linear inch and we can see over the unit area, we have less number of cutting points. Here we have more number of cutting points. Here we have still higher number of cutting points. So naturally for the same area given the unit area we have more number of cutting points we get we promote more number of overlap cuts and that’s why we get a smoother work surface. Here we discuss about the grade of the wheel.

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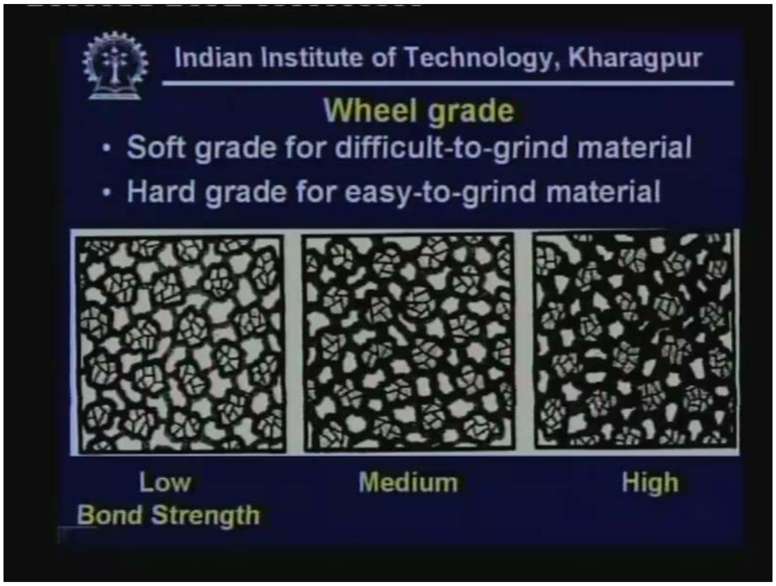

We know a soft grade should be used for difficult to grind material and harder grade for an easy to grind material. Now here the grade or hardness, it is understood actually the force which is required to break the bond between the grit and the cemented material. It is actually the strength of that bond. Now, if we look in to this illustration we can see that with the same grit and perhaps with the same grain density, we can have different hardness of the bond. Here, we use small amount of bond around the grit and you can see this bond it is surrounding this grit. They are making a bridge here and that is called the bond bridge.

Now the thickness or the size of this bond bridge that actually determines the strength of the bond; We have here low bond strength. This is medium and if we go to this figure where we say this is high bond strength. Immediately we can recognize we have larger amount of bond material surrounding the grit compared to what we find here. So obviously this particular structure or the grade that gives you higher bond strength or holding capacity of the grit. Now when the material is difficult to grind we expect rapid grit wear. Now to have efficient grinding, we have no other choice but to release this grit.

So for quick release of the grit, the holding capacity should not be very high. In that case the worn grit would not be released but it will continue rubbing over the workpiece and that will spoil the job or the work piece. Now not to just to avoid that situation, we have no option but to release the grit. So bond should be weaker. We should take such kind of bond, but when it is an easy material, low strength material, we can have prolong use of the grit because the grit will not wear out at faster rate. So in that case, it is rather useful to hold the grit for a longer period of time. So, in that case we can use rather a strong bond for holding it over a longer period of time because of the simple reason that the grit is not experiencing any wear because the basic material does not cause any rapid wear on the grit. So we can safely take a stronger bond which can hold the grit with a stronger force. Now we go to the structure of the wheel.

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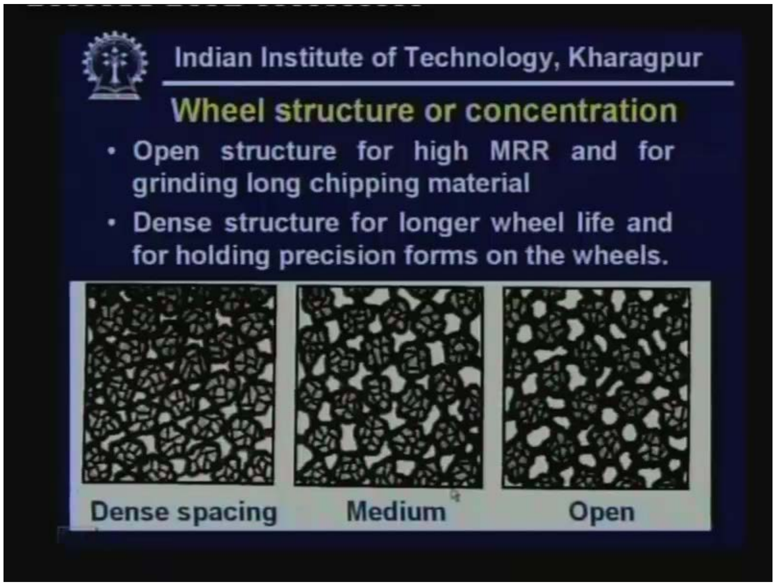

Here we can see dense structure, open structure and this one in between. The structure means what is the space available? Free space I mean the free space or the pores, whites that means by the openness. If we look in to grinding, it is almost like a milling operation. Chips are produced and this chip should be evacuated with an ease. The chip should not have a tendency to clog or get accommodated that is the beginning of the problem in grinding wheel may be efficient grit may be efficient but the chip clogging can terminate the life of the wheel. So there this pores has a major role to play. So open structure means with the same grit material, same amount of bond material, either I can have more number of grits or less number of grits.

So either I can have more space or less space and accordingly the void will change the amount of void material. But, definitely we understand when we have more number of grits load per grit is reduced. Here we have load per grit will be higher. So accordingly the strength of the grit should be also properly chosen. Here we have less force per grit naturally wear on the grit will be also less. So form holding or the precision form holding will be better in this grit because load per grit is substantially reduced, but when it is high material removal rate, then it is not the question of form holding. It is the only the question, how to prevent wheel loading? How to clear up the space? How this chip can be thrown out efficiently? So there we need such kind of structure. Now we go to the bond.

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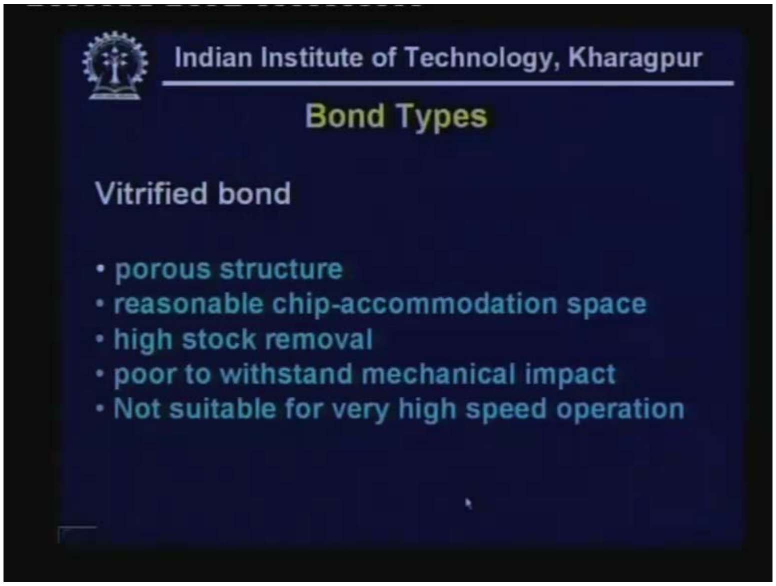

We have at least three types of bond material. We start with vitreous bond, the basic characteristics of this bond; It offers a porous structure during the manufacturing I mean during the firing, there is a free lad material which is put inside the mold and during the firing at that firing temperature that gets evaporated living some white space. So this filler material creates the white. So that gives reasonable chip accommodation space since we have chip accommodation space, it can be used for stock removal grinding.

However there are two short comings. It cannot have very high impact resistance, resistance to impact number one and also not good for high speed operation. If we have say solid wheel made with vitreous bond, in that case because of this high speed operation, there could be some centrifugal stress and with the centrifugal stress what we find? There can be some breakage of the bond and with this breakage of the bond the wheel with this breakage of the bond we have the problem with the wheel.

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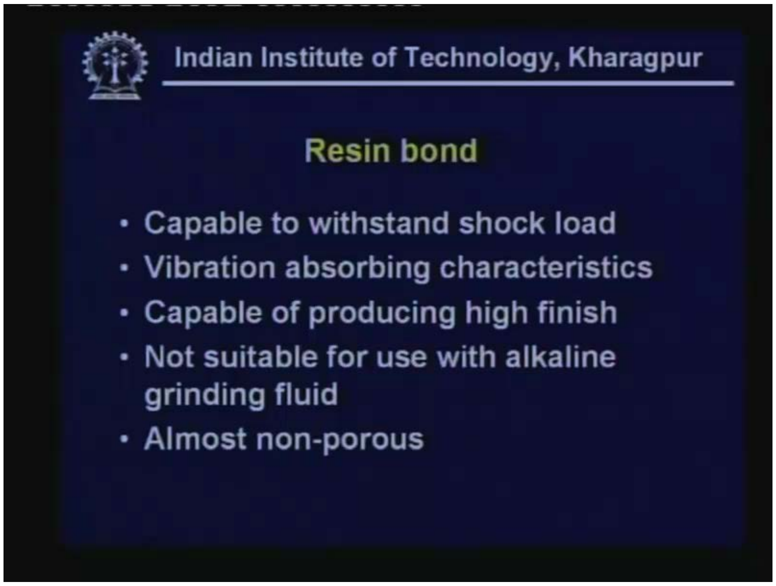

Now we have resin bond which is capable to withstand shock load vibration capacities and it is also used where we have some kind of vibration in the machine and this is also good for high grinding finish, but it is not suitable for alkaline grinding fluid.

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This is actually a metal bond which is extremely tough suitable for high form accuracy and large stock removal. It is almost nonporous.

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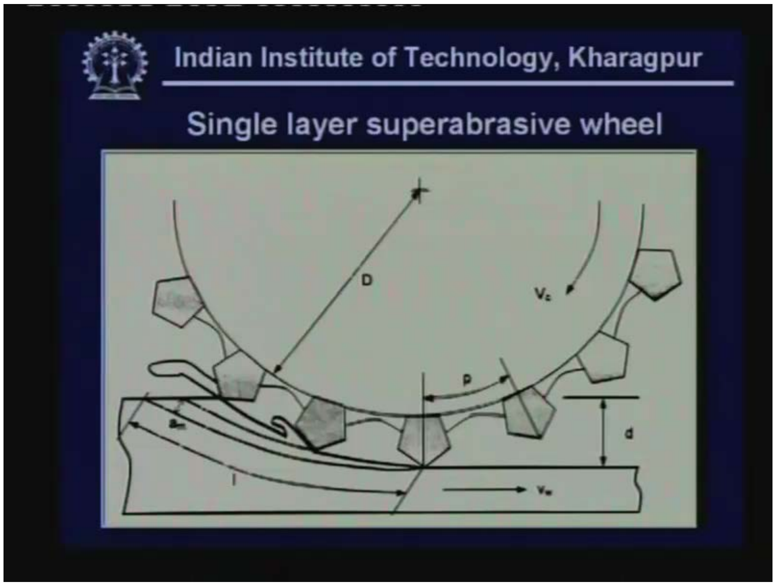

So this shows us actually the type of wheel which is a single layer type of wheel. This is a special type of bond which is illustrated in the following slide.

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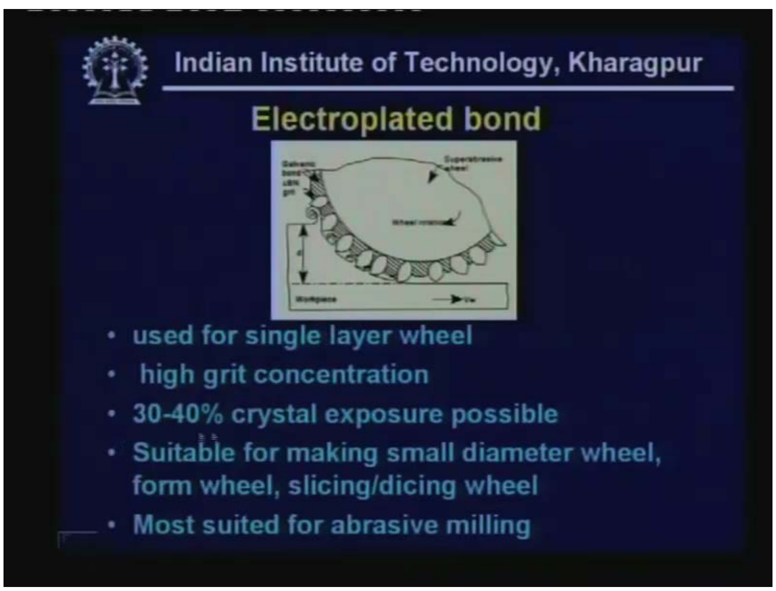

This is an electroplated bond which is used for high crystal exposure. It gives high concentration. Here single layer that is bonded suitably in a galvanic metal layer and this is used for high material removal rate for abrasive milling and so.

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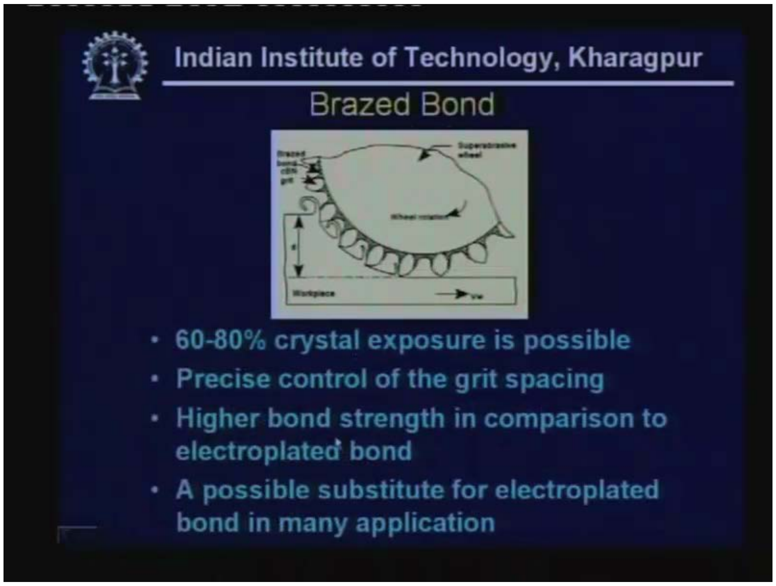

Now this is braze bond. This is an innovative approach made where we can still increase the crystal exposure and with this crystal exposure, the high material removal rate can be possible and this is going to be a substitute for electroplated bond. Now we go to the wheel conditioning section.

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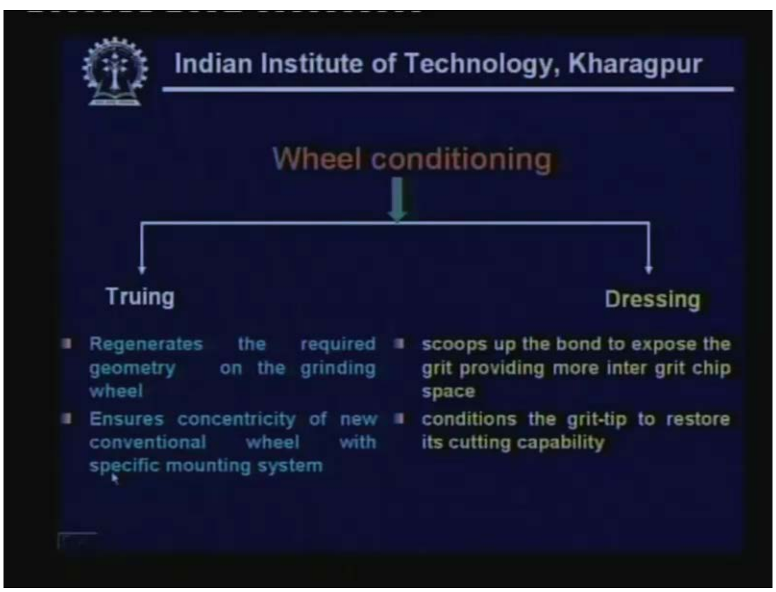

Here we have either truing or dressing. Truing means getting the macro form on the wheel and in those cases where making the spinning axis properly aligned with the geometrical axis of the grinding wheel that also comes under the purview of truing and what is dressing? Dressing means opening of the wheel, that means making the space for chip accommodation and if we need to have some micro modification on the grit tip geometry that is also done by dressing.

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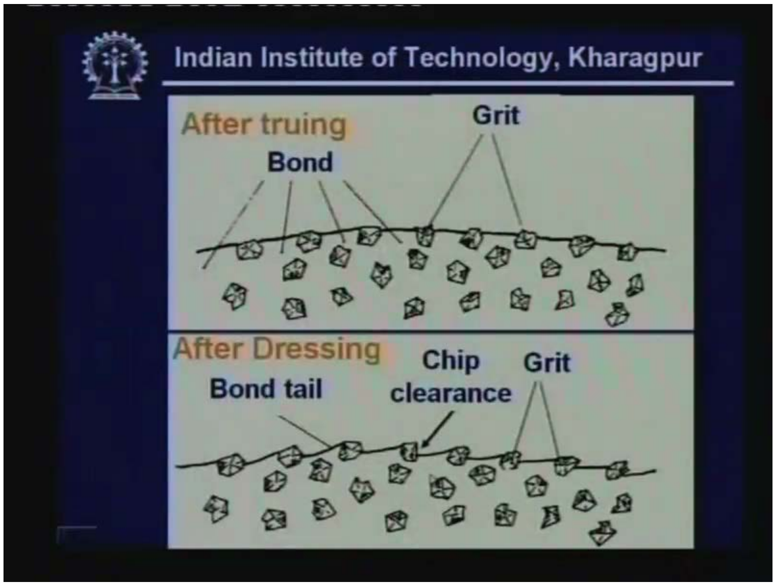

Here we can see a truing after truing operation, what we can see the bond material and the grit material that they are leveled. So this grit cannot have any cutting capacity. Now in the dressing, we have to scoop out this material to clear the space for chip clearance. Now with this chip clearance, we have enough space for grinding action. So this is actually dressing.

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So here we have four types of truing tools, steel cutter, and vitreous abrasive stick steel crushing roll or diamond truing tool which happens to be the most efficient.

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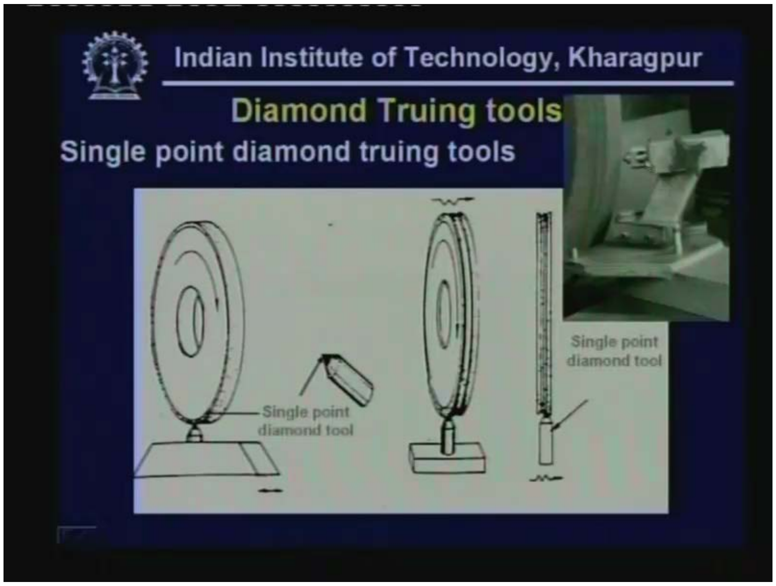

So here we can see this is a diamond point which is basically just like a turning operation. This tool is doing the turning operation of the way the turning is done in a lathe to have the necessary truing over. It can be flat space, truing or it can be a form truing using a single point diamond tool.

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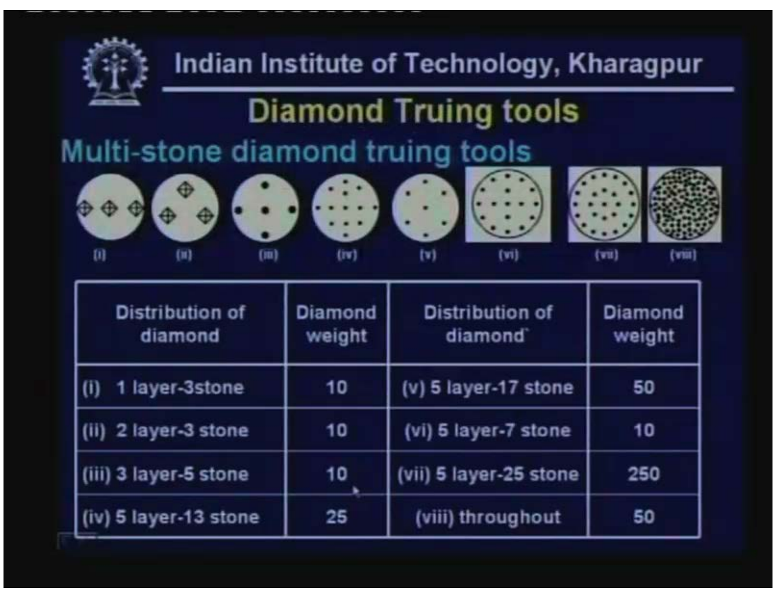

Distribution of diamond	Diamond weight	Distribution of diamond	Diamond weight
(i) 1 layer-3stone	10	(v) 5 layer-17 stone	50
(ii) 2 layer-3 stone	10	(vi) 5 layer-7 stone	10
(iii) 3 layer-5 stone	10	(vii) 5 layer-25 stone	250
(iv) 5 layer-13 stone	25	(viii) throughout	50

We have different types of truing tool either with a multi point this diamond or we have an impregnated diamond which is illustrated in this figure.

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These are the different types of diamond crystals which are used for this truing tool. This is natural crystals and we have also synthetic crystals, which goes straight in the preparation of the truing wheel.

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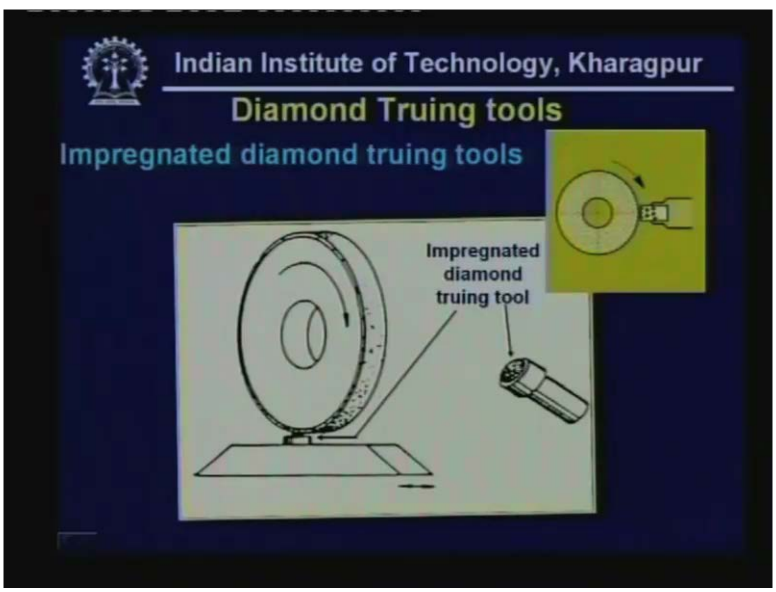

This is an impregnated wheel impregnated tool which is used for this truing action which is illustrated here.

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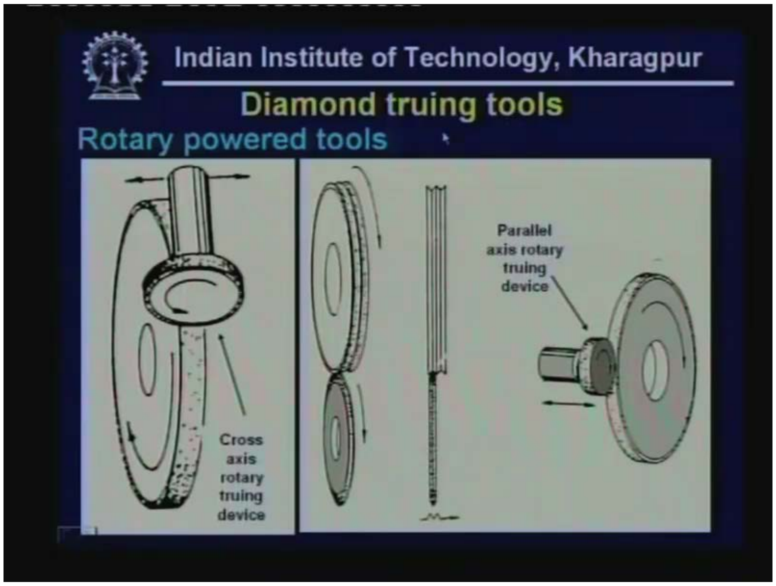

Now so for we have used a translatory tool, but here we have a rotary turning truing tool and this rotary truing tool can have cross axis or parallel axis instead it is just like a rotary tool which is doing the necessary truing action.

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These are the actual truing wheel which can be used in practice to do necessary truing on the abrasive actual grinding wheel.

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Now we have specific application; truing wheel is truing the form on the grinding wheel and grinding wheel is doing the necessary grinding on the actual job. It is tap grinding and it the knuckle steering mechanism on the steering on the knuckle grinding.

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This is a step grinding, the use of the truing wheel is illustrated here how it is being used. This is the groove of the ball bearing inner race grinding and the use is illustrated here.

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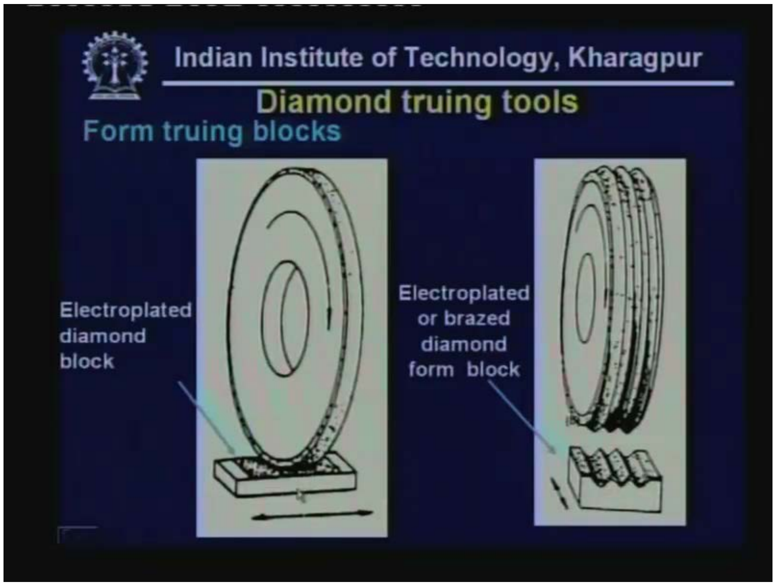

These are the two electroplated diamond blocks. This can be also used as a truing wheel and in this case these blocks can be reciprocated to have necessary truing, it is a flat truing or a form truing instead of using either a rotary tool or a single point diamond nib. So this can be done either by electroplating or by brazing.

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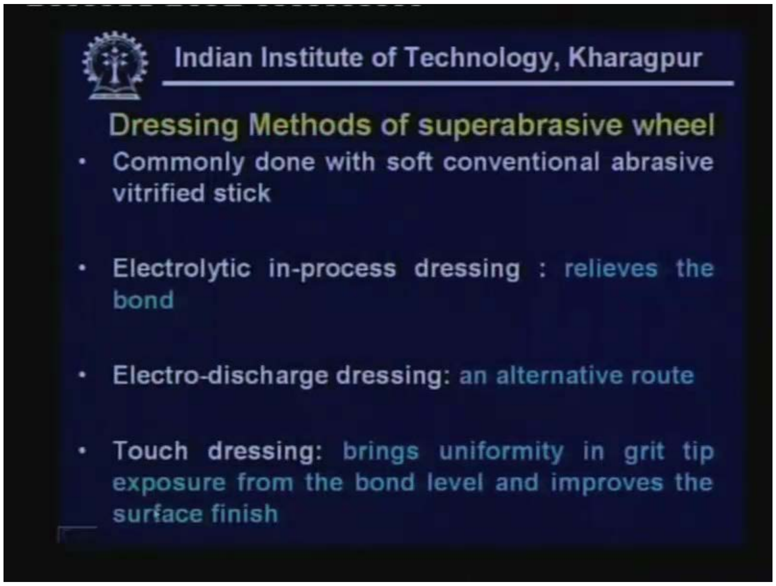

So this dressing method of superabrasive wheel which goes along with either use of a vitrified stick or we can have just electrochemical dressing where by the bond material can be electrochemically etched to have release of the protrusion of the grit material and

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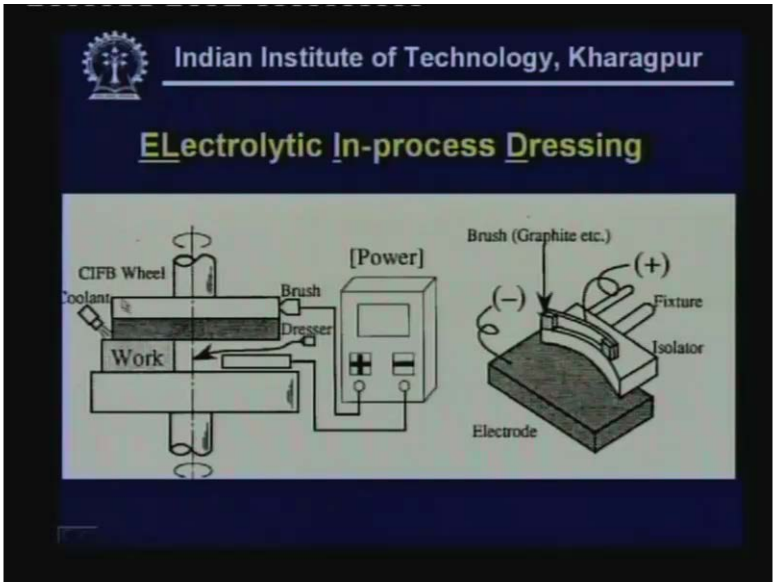

here we have this illustration. We can see that, this is the grinding wheel on which by this electrochemical action, this is being used as the anode and we had we have a cathode. So by electrochemical dissolution, the metal bond from the grit around the grit can be etched away and we can have better crystal protrusion or opening up of the wheel.

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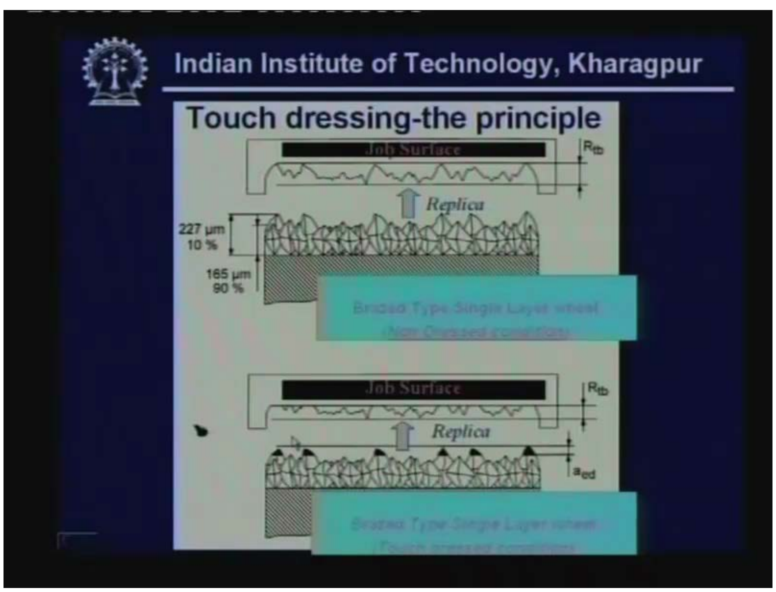

Now we come with the touch dressing. Now here this dressing means not opening of the crystal. Here this is done on the tip of the crystal, why? Because we can have irregularity in the size of the crystal and with this irregularity, the surface finish may not be acceptable to the grinding finish. Now if we have a dressing tool which can only touch in micron level only the overlying grits. We can have better uniformity on this grinding wheel and this grinding wheel can safely produce a finish, which is can be regarded as a grinding finish.

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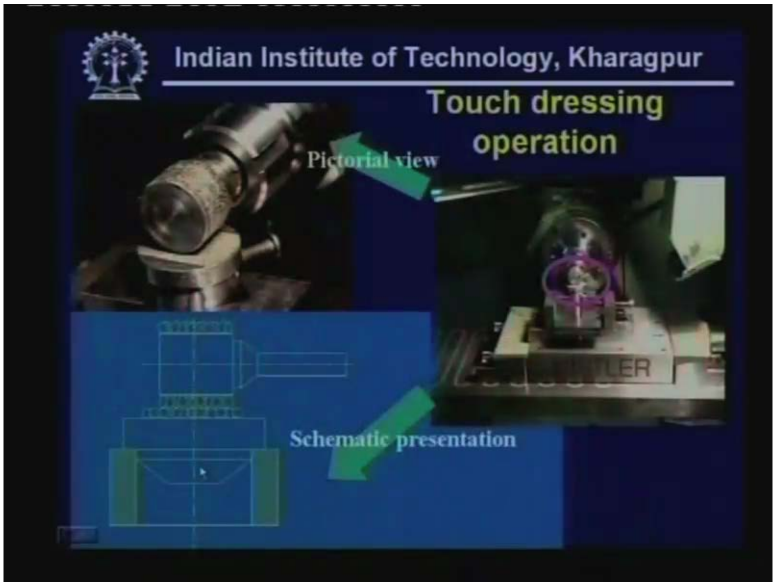

So, this is actually the touch dressing is conducted. This is the wheel, this is a dressing block. With this we can have better uniformity on this particular grinding wheel.

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Now we go to the exercise section: Why aluminium oxide wheel is preferred to silicon carbide in grinding steel?

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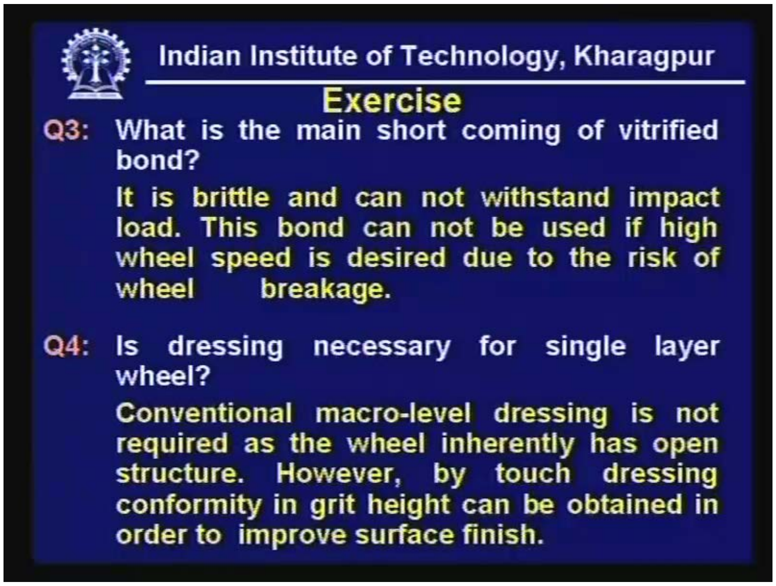

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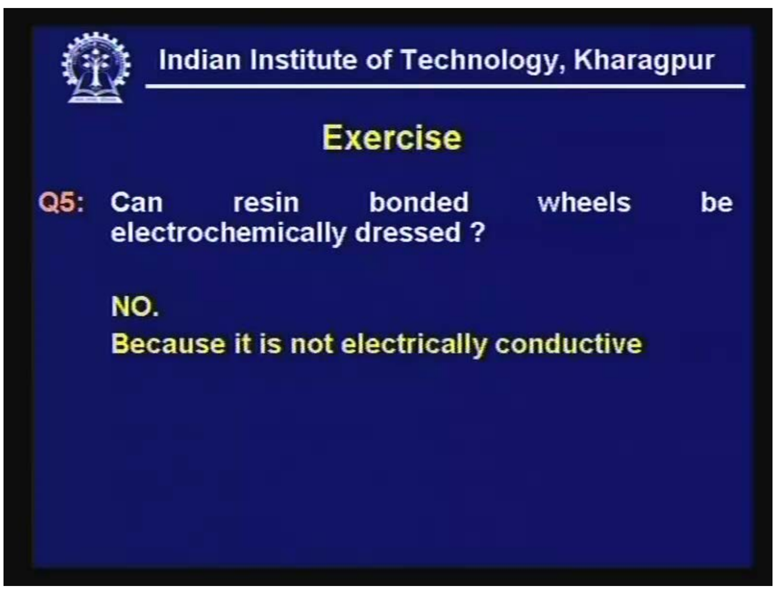

Thank you very much for your kind attention.