Tribology

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Module No. # 06

Lecture No. # 30

Rolling Element Bearings (Contd.)

Welcome to thirtieth lecture on video course on Tribology. Today's topic is rolling element bearings. This is the same topic which we have covered in previous lecture. But, today's lecture we will be trying to explain slightly in detail terms which were expressed or mentioned in previous lecture. In addition to that, we will consider one or two examples to elaborate, to describe how to select a proper gearing for our application.

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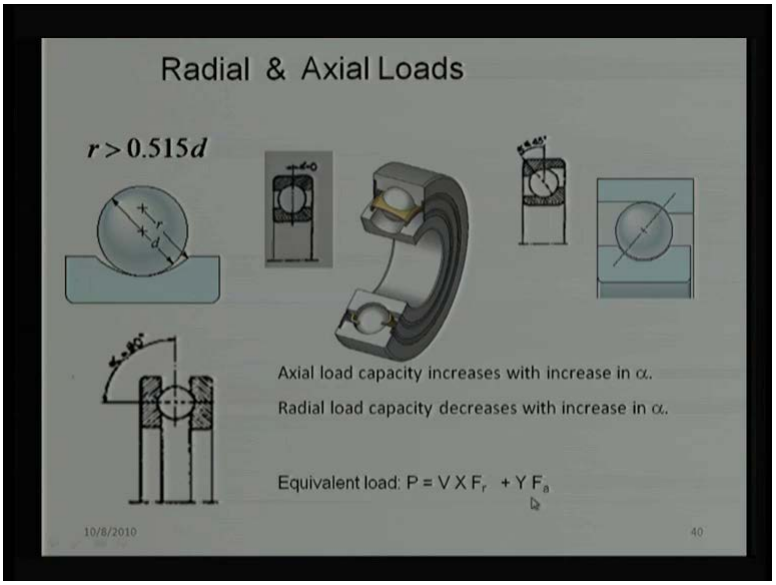

In previous lecture, we discussed about the radial and axial load and bearing selection as per the radial load and axial load. You see that, take an example of the rolling element we can take the example of all bearing. In the inner ring or outer ring we have slightly more curvature compared to the rolling element curvature that will help us in reducing the course of friction. But, it will reduce the point of contacts or we say area of the contacts.

Particularly in axial direction, if they are meant for radial direction. In other word when angle of contact is zero, assuming almost the point contact the line contact this kind of bearing can sustain radial load. When the contact angle is increasing then, in addition to the radial load this bearing is able to sustain excess load.

Able to see this kind of configuration, here bearing center and race center may also come very close to each other. Well, in this case ball center and the race center are slightly displaced and what do you say that in this race lower ring and outer ring centers are displaced. So, contact is happening at the some angle and that is shown over here.

Some angle of the race where that is happening is not a zero degree and this is more than zero degree and in this situation it is particularly 45 degree. So depends on the requirement this can be made as a 20 degree, 30 degree, 40 degree, 45 degree. Larger the angle larger will be the axial load carrying capacity. This is another configuration shown in this case inner ring is same. But, outer ring is slightly inclined what is the meaning of that this kind of bearing can sustain load only in one direction or axial load only in one direction. In this direction bearing will be able to sustain excel load but, in this direction it will not be able to sustain the load.

So, it will be the one direction while this is a both directions which ever direction you apply load. It is there or bearing is able to sustain that load and this is an extreme which is an alpha 0, alpha 45 and alpha 90. When alpha is a 90 degree that means bearing is going to sustain all axial load zero radial loads or almost zero radial load. We can quote we say that axial load capacity increases with increase in alpha, radial load capacity decreases with increase in alpha. Now, this angle of inclination is important when we slide the bearing.

When we choose a bearing for our application and in previous lecture we say that whenever there are there is a combination of axial and radial load; we should find out equivalent load and that equivalent load is given as a p is equal to v is a factor or is a rotation factor if inner ring is rotating the v will be equal to 1. But, if outer ring is rotating the v will be amplified or we say factor will be higher side that is the 1 point 2 factor, acts as a fraction of the radial load which need to be considered for equivalent load. Why as a fraction of axial load which need to be considered for equivalent load?

In yesterday's or in previous lectures particularly, what we felt that why is often more than one also that means what is the load that is been applied? We amplify that load and we count as effective radial load.

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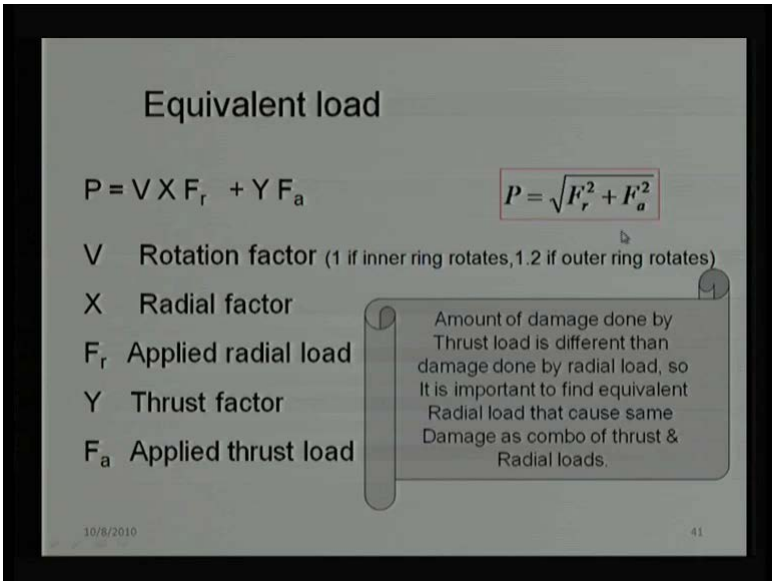

This is what equation was shown in the previous lecture and as well as previous slide we say that v is the one equal to one for inner ring rotation, 1.2 for outer ring rotation.

Now, question comes when the axial load and radial load they are the phase of 90 degree and we know from our simple mathematical analysis, equivalent load should be a vector sum of that f r square plus a f a square under square root of that. It should be given in this form. But, in this formula it has not been done. We say that these factors, this combination will depend on the bearing configuration. Even though apply load are at the 90 degree phase angle.

And amount of the damage which is done by the thrust load is not of the same caliber, it is not of the same scale. It is of different scale. When radial load is applied as well as a axial load is applied it is not simply a vector summation. We see that it is a different and damage done by the radial load. Of course, it depends on the configuration. So, it is important to fine equivalent load.

That causes the same damage. It is done by the experiments it causes the damage same damage as the combination of thrust and radial load. So, we required some sort of

experimental parameters. Theoretically we are not able to evaluate properly or if we do that calculation will not be appropriate, it will not be full proof.

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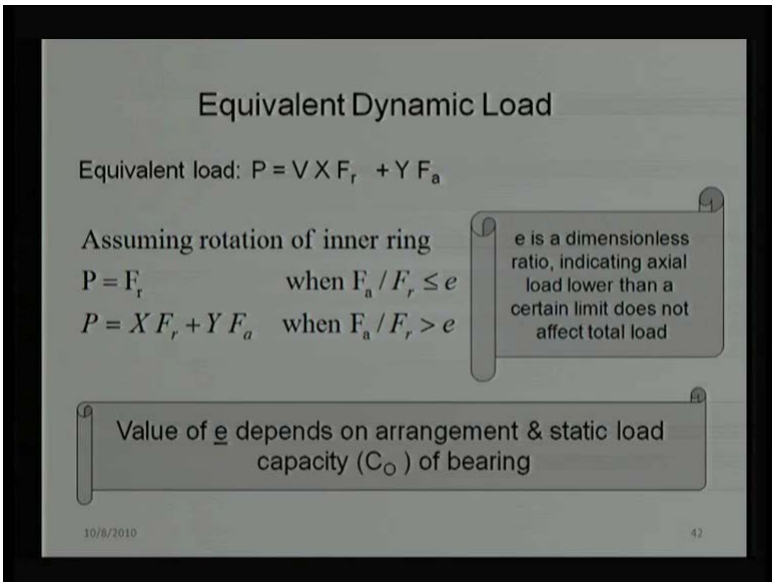

So that is why we use this factor x and y. In addition, in previous lecture we use the one symbol e. We say that if this fraction axial load to radial load fraction is lesser than e, then axial load is not going to affect at all. All equivalent loads will be radial loaded sum.

When this fraction axial to radial load I am assuming that bearings are meant to sustain radial load. But, in addition some axial load is coming on those bearing or imposed on this bearing or may be the because of the some malfunctioning it is been induced. So, in that factor, in that case, if r if it is greater than e we will be using this relation. Of course, in this case when we are implementing this equation assumption is the rotation factor is one that means the rotation of inner ring.

If rotation is been imposed for the, from x form the outer ring or outer ring is rotating, then we will multiply those v factor with this. V will not be equal to one. So, we are bound to multiply. Now, e is been defined in the, this text form. See, e is the dimensional less ratio. We are able to see that we are equalizing that e is a dimensional ratio as the force divide by force indicating axial load lower than a certain limit does not affect total load.

And it is true when we do the experiments we are able to find the (( )) fraction of the axial load is not affecting depends on the geometry. If geometry is perfectly cylindrical geometry and there is the only line contact then surely axial load is going to affect by there is some sort of curvature to retain the rollers, to retain the balls then it can sustain some axial load without affecting overall results.

And when we discuss about the (( )), value of e will depend upon arrangement because of different bearings value of e will be different. For different static load capacity value of the e will be different. So, it is going to be depending on the static load capacity as well as the bearing arrangement.

For deep group ball bearing, for roller bearing, for angular contact bearing, for self aligning bearing; e will be different because their arrangements are different. Not only this is in the same bearing slightly different configuration, different ball diameter, different race diameter; this will also be different. So, we are bound to use catalog table for this purpose.

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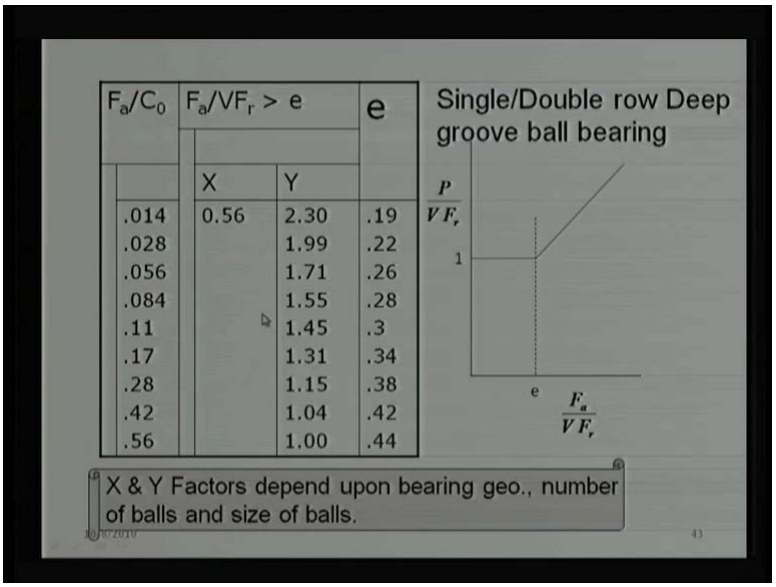

And if I say in diagram physically or when I represent in the figure; we can say, we can represent this in x y dimension e in along the x axis and effective force I would say normalization of the force in along the y axis. There is an equivalent load divide by v into f r. It will be equal to first sum time till e reaches to a certain limit. After that only this ratio is going to be higher side.

Now we can reproduce the same table. We show the same table earlier what we say that if f a that is axial force divided by static load carrying capacity of the bearing is a lesser than 0.014, we will not consider factor at all. However, this factor this ratio is more than 0.014 then, we will see whether what is going to happen.

And in this situation if e is turning out to be more than 19 percent 1.19 then, we should take the disc factor. Otherwise, we should not account these factors and as I say in the previous, I explained x and y factor depend on the bearing geometry number of balls and size of the balls as any of this parameters is changing value of x and y will change. So we are bound to use catalog readings, catalogs tables which are generally given by manufacturers.

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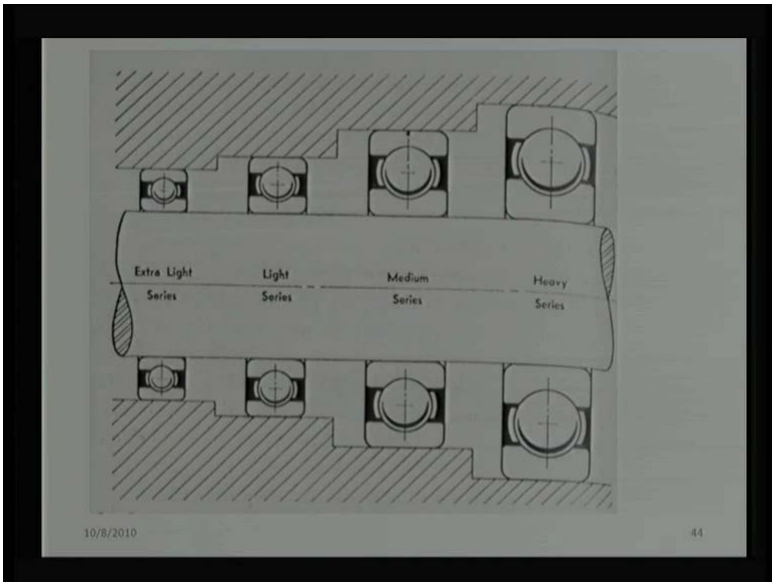

Then we studied about or we discussed about the different series of the rolling element bearing. We say that for the same board diameter we have a number of bearing configuration. While in this case we are able to see the outer diameter of the bearing is lesser. Just for completion we see that this is the shaft represented and there is a long inner shaft that is why it is gained by this similization or this line diagram.

Now bearing is being placed. There is an inner ring which is firmly attached to the shaft, there is a rolling element placed in the cages or in cage and outer ring is in contact with the housing. So, this outer one is a housing. Now, when we are starting from extra light

series to the light series to medium series to heavy series, we are able to see the thickness of the inner ring is also changing.

Inner ring thickness is continuously increasing, dimension of rolling element is also increasing and thickness of outer ring is also increasing. When all these dimensions are increasing; naturally load carrying capacity of this kind of bearing will increase. And we often represent these bearing with the bearing series. Or when we talk about the bearing series there is a one portion will call as the diameter series which represent with the diameter series over here.

Say that diameter series are in 8 number, 9 number, 0 number, 1,2,3,4 number. This indicates that as this number is, we are moving from left to right, bearing dimensions are going to change. Bore diameter will remain same, thickness of inner ring diameter of rolling elements and thickness of outer ring will change, will increase continuously.

The load carrying capacity will be on higher side. By default, if nothing is been mentioned we will assume this is a zero. Or bearing dimension has been placed with a zero diameter series. That is a nominal that is a default value. Sometimes, we want extra slide that is on the lower side. Nine number has a lesser load carrying capacity compared to zero.

Eight number has a lesser load carrying capacity compared to nine and of course, their dimension, outer dimension, invalid dimension there will be lesser. Also like in this situation we can say the phone number series will be showing the maximum dimension, maximum load carrying load capacity when we compare I mean on this diameter of series, load carrying capacities.

We can find more detail about all this (( )) bearing dimensions, curvature and its concentration factor or this website. This is this shows that it is SKF company website. SKF is a manufacturer of rolling element bearing. They have been developing this bearing since long so, they have lot of experience and that is why they are able to give the details of dimension on their website.

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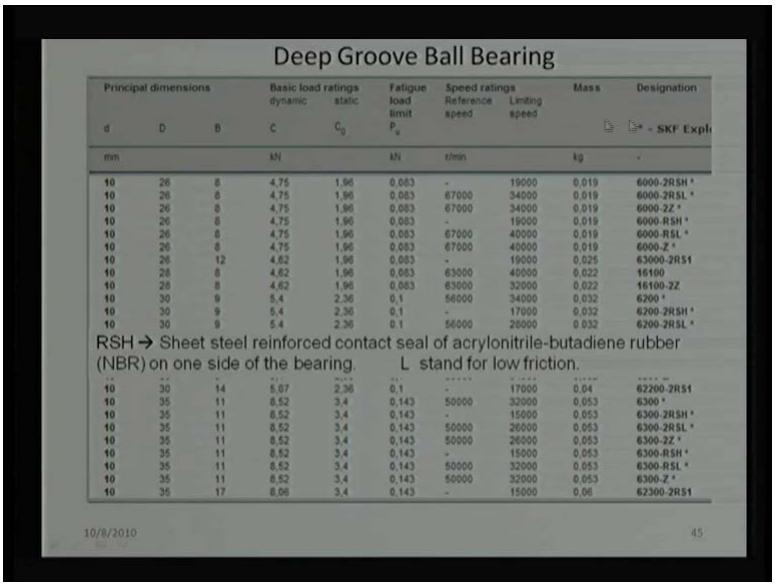

Now, we will just see the one catalog. So, in short we say that bore diameter is given over here. The bore diameter is 10 mm, 10 mm, 10 mm, 10 mm. All, everywhere complete catalog says that ten mm list or we say the snap shot which is the shown in the slide shows the bore diameter is same. Coming to the outer diameter; outer diameter is initially 26 then 28, 30, 35. Now, naturally, this series is increasing.

Dimensions are going on higher side as a diameter is increasing to some extent. Bearing length is also increasing, bearing width is also increasing. This is an exceptional case, 12 mm. Otherwise it is 8 mm initially, then 9 mm then 11 mm. This indicates also the bearings, also of the manufacturer as a special form.

It happens may be in a rolling element bearings or which we are going to use in some big manufacturing company. Talk about the Electric Motors or when they require some specialized length and specialized diameter then, these bearing companies they manufacture in bulk for those companies. As well as they release in the open market. Like in this case, this is an open market, it has come with some special purpose say twelve mm. Suddenly as appearing it is one a special bearing used for some machine, some company in a bulk order. And then they had already this kind of dice this kind of manufacturing processes that is why they have opened for everybody.

Similarly, over here there is a 14 mm of extra length is also developed for some company. And after that we are able to see there is a continuity in 11 mm length. Now,

when we talk about static and dynamic load carrying capacity; we are able to see most of the time dynamic load carrying capacity is much larger than static load carrying capacity. In addition, most of the time rolling element bearing the fatigue limit is almost negligible.

So, whenever we have fatigue consideration, we should opt for the rolling element bearing unless it is essential a fraction of radial load is coming in the axial load. Because rolling element, the roller bearing are not generally very good option for axial load, slight axial load they can tolerate but, not more than not more than certain limit.

In addition now, there is, there are some sorts of dimension given or some sort or rpm is given here. We are able to see the 10 mm bearing, 10 mm bore bearing, 26 mm. Outer diameter can sustain up to 60000 60000 r p m of the rotation rotational speed. Now, that is a very high value particularly when we are talking about the, this high value and this is some sort of symbolization, some sort of the nomenclature given by the SKF Company to these bearings.

What we are able to see 6 0 0 0 and this may be with series is zero dimension is zero and this zero zero is a number which we in previous lecture. We indicated zero zero means ten mm. Similarly, where as we move ahead, we are able to see all 0 in this case because of the 10 mm. If we go for the twelve mm it will appear as the zero here, if we go for 15 mm bore diameter then, it will turn out to be 20. If 17 mm then, this number will turn out to be 0 3.

That that means that this number is indicating what is the bore diameter of bearing. In addition there are some sort of suffix 2 r s h 2 r s l 2 z these all are the suffix. That means, bearing has been added with this additional parameters or additional surfaces or additional geometries in that. This is important to understand for us particularly in this case when we are using about r s h. That s means that it is a sheet metal or sheet steel which is a reinforced to make it as a seal or a shield.

R stands for the general seal and that is why we say when we use the z that is the shielding. While in this case r stands for the seal. Now, we say that this is there is a contact seal and made of n b r that is nitrile butadiene rubber. This bearing is being placed at the both the sides when we talking about the word. This 2 is a 2 r s h means both the sides r s h is given or both the sides this kind of seals are been given. When you

are using the word r l and h; l it means it is going to give develop a high coefficient friction, l is assigned for low coefficient friction.

We are able to see that when we talking about the operating speed over here, when we can see there is a coefficient friction on the higher side then, we clearly indicate that high side coefficient friction. Operating speed is just 19000 compared to when it is mentioned l operating speed is 34000, 15000 more. Almost double this speed because of the coefficient friction. Now, it is important whenever we see this kind of nomenclature, we should predict or we should estimate what will be the behavior of this kind of bearings.

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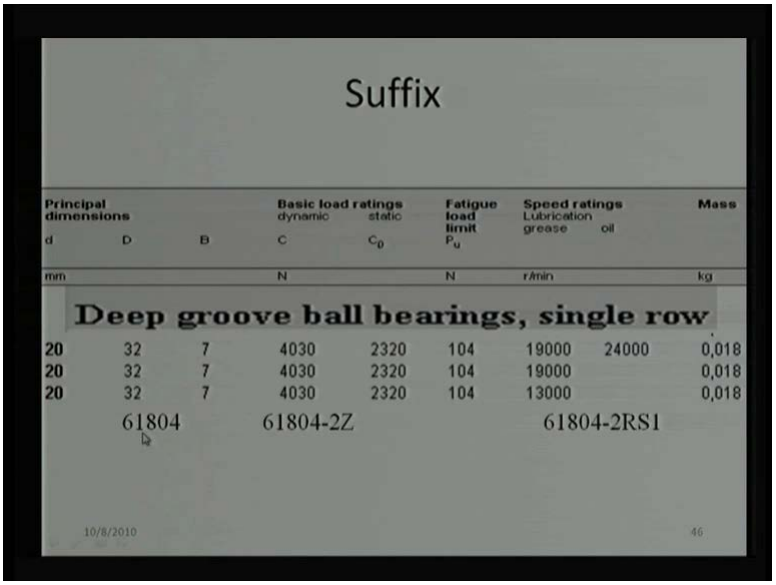

This is what we say the suffix and generally bearings are given a suffix and that is and if nothing is mentioned then that means this bearing is without any seal, without any shield. When it is given a 2 z that means bearing is a shielded on the both the sides. When it is given 1 2 r s that means bearing is a shield both the sides. Now, some definition of seal and shield is important to understand bearing or without any of this. What is going to happen and how it will be useful or how it will be harmful for us? Now, this is a sketch shown on I picked it from catalog. So, this is the bore diameter that is 20 which is shown here this is the outer diameter.

That's shown as is indicated over here. This is 7 mm, this is the length of the bearing and this is dynamic load carrying capacity as I mentioned earlier that dynamic load carrying capacity is often more then a static load carrying capacity of this bearing. Then n ball

bearings are known for the low fatigue limits that is a very low limit. We are comparing, there is a 4000 just 100 0 104. Now, this is operating speed.

This is the first bearing specification for the first row. This is a specification for row number two. This is a specification for row number three. Also, this is a nomenclature for row number three. Now, when we say that when there is a baring is shielded both the sides operating speed is not changing. That operating speed remains same in the situation and this is for the oil lubricated case. In this column it is indicated the grease lubricated while this is indicated oil lubricated.

That means, when we are using the shielded or when we are using the seals; oil cannot be used as a lubricant. They are bound. We are bound to use the grease there will be otherwise a leakage and bearing will be starved and there is no point to continue that kind of bearing.

So whenever there is a 2 z or 2 r s or z or r s, we cannot use liquid lubricants because that will not be you know, we will not be able to retain within a bearing. And whenever there is a liquid lubricant compared to grease lubricant, we are able to receive a high operating peak. Of course, the weight is not going to change that is may be because the sheet metal configuration is light configuration and similarly, seal weight is also not very high and it cannot be compared with the bearing.

That's why they have almost the same weight for the all three bearings even the specifications are different, the suffix are different. And this is shows a 0 4 0 4 into 5 will be 20 and it is clearly indicating and this is indicating whether diameter series that is narrowed down or dimensions are lower side.

This is indication and this is picturization of this. This is the sketch of this. This is bearing without any seal. This is bearing with some sort of shield. You can see there is a contact over here. But, this is just touching over here. That means there is no form kind of negotiation will not be very different. While here firm firmly engagement of rubber material, the outer ring as well as the inner ring.

That may be (( )) there is a more grade grip, there is a fine grade grip and coarse of friction will be on higher side in this situations.

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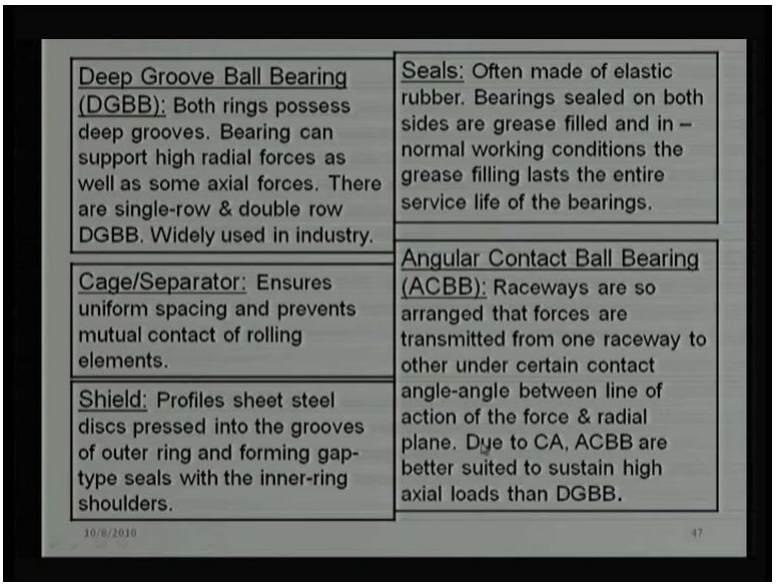

Some definitions: Because we have discussed a deep blue ball bearing, we talked about the seal, we talked about the shield, we talked about the angular contact bearing. So some formal definition has been given on this slide.

This is the deep groove ball bearing which is often known as the DGBB. Both the rings possess the deep grooves. That is why they are known as the deep grooves ball bearing. This deep group means they have a radius more than ball radius. That is why ball is able to retain or they are able to retain the ball within rings. And that can sustain some actual force. And that is why we say the bearings can support high radial force as well as some may be fraction of radial load. There are single loads as well as if you want to go ahead with bearing selection; there are single row deep groove ball bearings as well as the double row deep groove ball bearings.

Double row groove deep group ball bearing naturally will have higher load carrying capacity because we have more number of owing elements which are subjected to load and there will be good load sharing among these rolling elements. That is why the double row will show high load carrying capacity in a static case as well as dynamic case or dynamic load carrying capacity will be higher compared to single row.

Not necessary it will be double it will be slight lesser than double but, there is a possibility. Of course, depends on the dimension, depends on the length which is provided with that. Then we have discussed about the cage and separator we say that the

cage is necessary or to ensure the spacing or uniform spacing or not even the, if we go ahead with non uniform spacing all the balls are coming in one instance and other balls are coming after certain phase lag, it is like naturally the load carrying capacity will be decreased or whatever the minimum load carrying capacity.

We need to account that. Well when we are able to prevent that kind of incident and we are able to retain their equal spacing or uniform spacing then that kind of bearing will can show a better performance. Of course, there is another option that do not use any ring but, whatever the space available it should be filled completely with the rolling element.

That is why we know as full complimented bearings. Their space again is uniform only what is the problem there will be mutual contact between the rolling element bearings and coefficient of friction will be on a higher side on the situations. So, that is why the cage is required for uniform spacing as well as to prevent mutual contact within the rolling element which are going to rub against each other and generate friction and that will generate heat and bearing may deteriorate the performance. The performance will deteriorate with the time.

Then, we talked about the shield. We say the shield is a profile sheet metal. It is a disc sort of thing and placed into the grooves of outer ring. There is a groove, there will be a groove in outer ring. That is why the contact happens when they are placed in that they are firmly engaged without a ring but there in the inner ring there will be some sort of touch there will be some sort of finite gap. So, that coefficient of friction is much more lower in those situations. Obviously if inner ring is rotating sheet it is not going to rotate along with that. So whenever we are buying this kind of bearings and we start seeing that and the shield is also rotating with the bearing inner ring then, we are bound to place that bearing immediately.

So, the coefficient of friction heat generated will be increased or we say that bearings are mounted. But, with some sort of misalignment, some sort of inclination, so we are supposed to change the bearing. Coming to the seal, we say is often made from a elasto material or elastic material which generally the elastomer or we say that any material which is showing the visco elastic nature which can be formed to the shape which is desired then this kind of seal works.

Then, this case particularly if the bearings are sealed both the sides. Not necessarily bearings need to be sealed both the sides. Sometime we use a bearing sealing only one side we know very well that other side there is some liquid lubricant and we want to use that for the lubrication purpose. I have designed number of bearings based on that only and only the one side bearing seal and other side even there is a bearing seal we generally remove to reduce the cost of friction to half.

We say that if bearings are sealed for the both the sides then, the bearing grease can be retained completely within the bearing. And this kind of fully sealed bearings can be used for number of application. Or typical application is elect motors. We generally use a sealed bearings in motors and whenever there is a failure then we simply displace those bearings.

We do not relubricate these kind of bearings. How we did or even in after certain hundred hours. Then last one which we defined is the angular contact ball bearing deep blue ball bearing is extensively used. Second largest bearing is used is a angular contact ball bearing. In this case we say that force is transmitted in such a manner that some sort of actual force can be transmitted. That is why we say the race phase or generally we use the word rings are so arranged that the forces are transmitted from one ring, one race way to other on a certain contact angle and whether it is contact force will be transmitted.

And due to the contacting angle, c a is for the contact angle. The angular contact ball bearings are better suited to sustain high excel force. High excel force is nothing but, the relative term. When we talking about the high excel force, are in this particularly slide high excel means compared to the deep blue ball bearing. It is not an absolute sense we cannot say this a c b v is sustaining high higher axial force compared to thrust bearing. That will be absolutely wrong in this situation because thrust bearing are meant to sustain axial force.

While in this case we are comparing this angular contact ball bearings with the deep blue ball bearing and that is why they are these kind of bearings are able to sustain more excel force.

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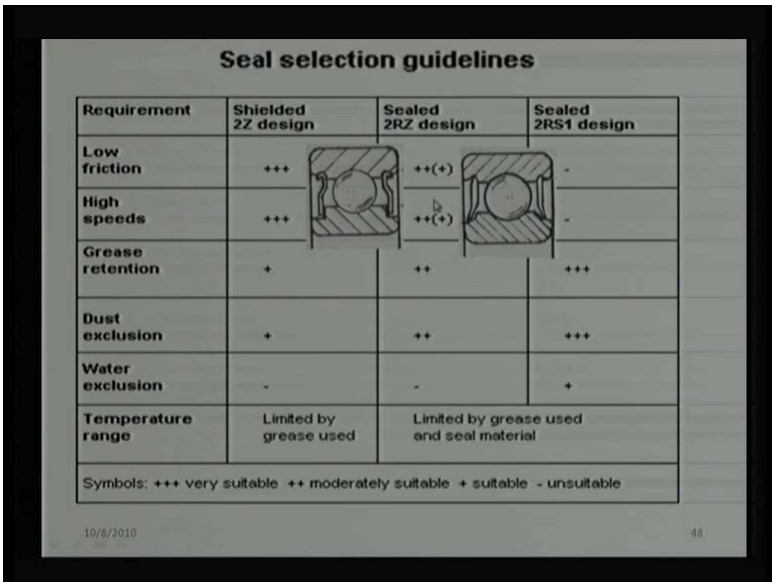

Sometimes, we come over the bearing selection or whether should we choose seal of no seal or shield and we go ahead with this kind of comparison. So, comparison can be made based on the low friction, can be made based on the high speed of operation whether we want to retain the bear grease with a bearing or we have operating the machine in the dusty environment and we want to retain the bearing clean or we say that dust should not in grace in a bearing rings and between the rolling elements.

Sometime, there is a water environment, moisture environment then we want to retain the bearings clean without any water and grease in those situations. Sometimes, bearings are sealed or shield guided based on the operating temperature. Wood is operating temperature. Naturally operating temperature is one hundred and eighty degree centigrade, I will not be using the seal material or elasto material because we know elastomer will melt and start flow and there is not fine to use this kind of seals for that application.

When we talk about the comparison, it is shielded or both the sides the two sides end, they show reasonably low friction. That is why the three stars or three plus have been assigned to this configuration and so, it is a highly or very suitable for this can be comparing to these three. I mean these three is very suitable configuration.

When you take about the two or z there is a one side bearing is sealed with the elastomer other side bearing is shielded so that, there is a some sort of sheet metal and this

shielding is often required from dust prevention point of view. Now, we say that seal is one side seal and one side shield; it is more like an hybridization. We are able to see two places pluses. In that next case the design is very good, it can get also three starts or three pluses in this situation. Similarly, if we talk about the higher speed, whenever there is a higher speed we naturally will consider the low cost of friction. Again shielded bearing will be preferable compared to 2 r z compared to 2 r s. compared to Coming to the grease seat (( )) or to retain the grease within a bearing what we say, shielded bearing has a low retainability compared to seal or sealed from both the sides bearings or one side sealed or one side shielded.

So, we are able to see minimum suitability from to retain the grease is with 2 z and maximum suitability is with 2 r s1. That is the sealing both the sides. Next expulsion which is the dust should not enter should not embrace within a bearing. Again the maximum suitability is been given to the seal wearing because dust is like it is going to provide more isolation from outer or external environment.

So from grease retainibilty point of view that means, grease will remain within the compartment, dust should remain away from the compartment. These two bearings will be preferable coming to the water exclusion. Generally, none of the bearing is very, very good in to keep away from the water. That is why we often we use lubricant additives to remove the water or we say that to capture the water molecules. So, that they should not corrode or water should not corrode bearing surfaces.

Of course, the comparison comes, we will always prefer 2 r s1 because it is in contact and water will get a into lot of difficulty or some difficulty water can engrace in that. Coming to the temperature side we say that these 2 z bearing generally seal the sheet metal can sustain high temperature. Naturally in these situations only the limiting parameters it is a lubricant if it is grease lubricated, that is limiting parameter for the temperature.

Coming to the 2 r z and 2 r s1 initially the grease is the one unit but, in addition to that seal material is also considerable thing. If I use a grease; one at thirty degree another at forty degree centigrade sustainability but, I use a rubber material that cannot sustain more than seventy degree centigrade, naturally the seal material is going to find the performance and we need to check the temperature, we need to reduce the temperature in

those situations. So, depends on the friction requirement, depends on the high speed application, depends on the grease retainibiltiy and depends on whether we are operating the machine in grease environment or water environment. This should choose a proper bearing accordingly.

And these two diagrams show that this is the shielded side and this is the sealed side and in between will be one side shield and other side one side will be shield and other side will be sealed. This is just to illustrate what is the meaning of shield, what is the meaning of sealed. We are able to see there is a metallic surface and going inside groove of outer ring while there is no form connection over here.

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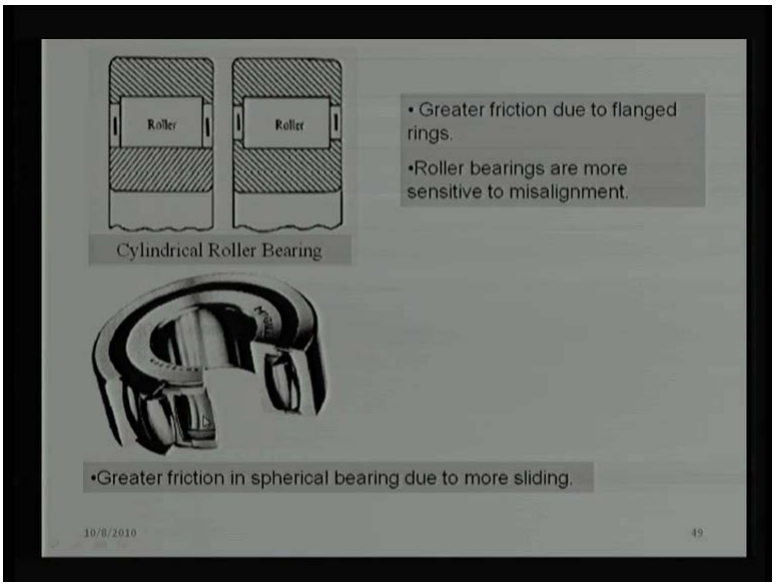

This is just a touch. We discussed about the roller element rings and we say that the roller element bearing can be can sustain some axial force but, not major axial force and that is again shown over here. This roller bearing inner ring is not guiding the rollers as such, it is does not have a grove old outer ring has a groove in this situation. In this situation inner ring has a groove, outer ring has a groove naturally; the load carrying capacity in axial direction will be in higher side particularly for this configuration.

However, there are some drawbacks also what we say that in this case both the surfaces are happen coming in a contact, there is a more contact force or more contact area. Naturally in coarse of friction will be a higher side this configuration will show high coarse of friction compared to the configuration shown over here.

And second thing is that this bearing, both the bearing is nothing like this bearing or this bearing now all roller element bearings generally are more sensitive to misalignment. If there is a misalignment we need to think about the some sort of spherical shape. That is why we say that in case of the misalignment we use this spherical roller bearing.

You know the spherical there is a curvature given the surface, is this surface is been in curvature. So, that there is a there is a, if there is a misalignment roller will adjust its own and will not create a high stress. Stress is that contact point it will keep contact more or less same stress level.

However, in this case we know there is some sort of misalignment possible while happened because of the some sort of variation in the curvature. There is a possibility of the sliding of these rollers. It will not be always it will not be always this kind of bearing or very good option compared to this but, because of this is spherical nature. Of course, the cost of the manufacturing itself is only very high but, other side the greater friction force is developed in this kind of configuration because of the sliding, relative sliding is more compared to the strict roller cases.

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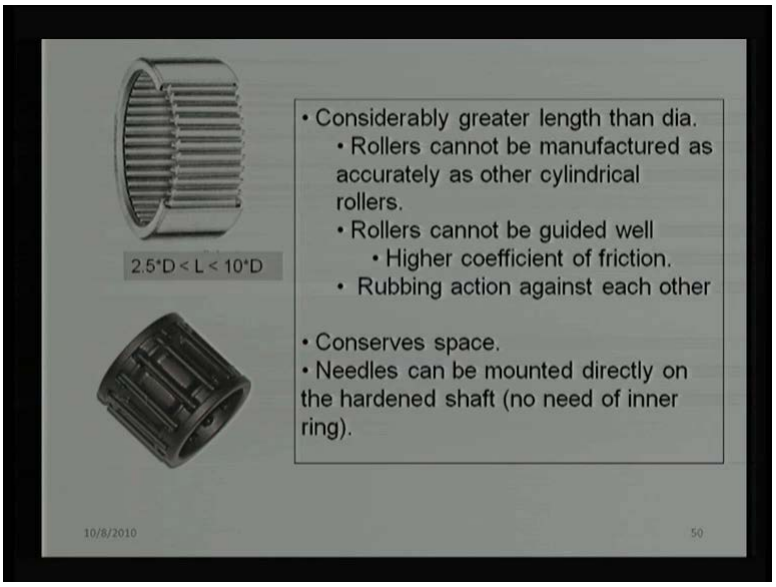

Then, we discussed about the needle bearing. We discussed about the two examples of which were the first full complimented or the every space available has been occupied by the rollers and other case there is a cage which is a separating these needle rollers. What we discussed about something like dimension we say generally needle roller bearing has

some specification we say the length of this roller need to be more than 2.5 times of the diameter.

Diameter of roller is 40 percent. While maximum value in this case from misalignment point of view, we can keep infinite long rollers but, from misalign capability point of view generally, this length is lesser than ten times of the diameter. So, this is for the needle roller bearing whenever we want to design or slide we should understand that what the length of the rollers is. If we are going for the much larger length it will be really good to support larger length of the shaft. But, it is also possibility that the sensitivity towards the misalignment will be much larger in this configuration.

So, if we try to summarize about the needle low level bearing we say that diameter the length of the diameter, length of the roller is generally very large. Then length of the roller will be larger the bearing length is also larger in this case.

Again, as these rollers are manufactured for the smaller size then, there is a possibility of some sort of tolerances, for some sort of non uniformity. That is why we say that rollers cannot be manufactured as accurately as other cylindrical rollers. That means as the length to diameter ratio is decreasing, we have more control on the diameter side, dimension or periphery of that rollers. Again we say that generally if the cages are not provided properly then it is not fully complimented in that situation the roller cannot be guided very well.

And they will show high coefficient of friction because there will be a some rubbing of one roller against another roller. However, the major advantage of needle roller bearing is the conservation of this space. As the diameter is much more lower and if we have a space restriction from dimension point of view then, this needle bearing is the best option.

To reduce the space and they occupy almost the same space sliding bearings. But, they show much larger load carrying capacity compared to sliding bearing. And many times we use only outer ring with a cage. That means this is a cage and outer ring will come and this kind of bearings can be simply mounted on the shaft. The shaft surface is relatively harder. We do not have to separately mount in the ring.

Keep in the mind that when we buy a needle low level bearing outer ring, inner ring and cage with the rollers will be separate. We need to assemble it properly if we are not able to get the dimensions available, we can use a shaft as it is we can buy a roller separately also. We can make a own cage and buy a outer ring and assemble this needle low level bearing. So lot of customization is possible. Obviously the designer role has a designer role increases and we think about the needle roller bearings.

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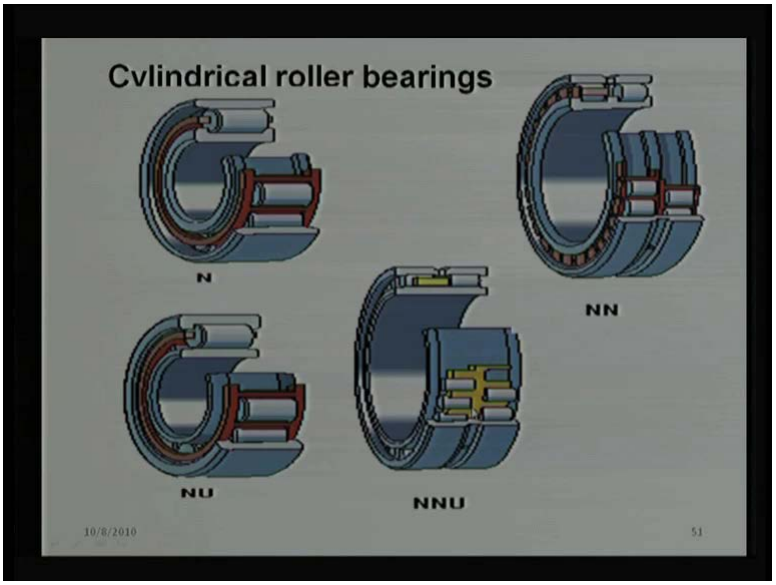

Then we talk about the cylindrical roller bearing in some sort of specification. We say that giving series generally come in some sort of specification like a six number comes with a deep groove ball bearing. Now, in this case we are showing one of the cylindrical low level bearing we can say the single row single roller bearing and the specification is what particularly to represent the series is only n.

When we talk about the two rules, this time has to be n n. That is very simple to think. Now in this situation particularly we are able to see outer ring is not supporting axially. Outer ring does not have any shoulder. Similarly, in this case grooves are made on the inner race that means n n n will have only inner ring. Naturally, if you want to go for third row we have to add one more n in this.

Just slight change in this configuration is n u. e u can be termed as the upper obviously that particularly the flunges or the shoulders are the upper ring. It is not at the lower ring or is not at the inner ring. It is outer ring outer ring can be say this is the upper ring or

outer one. So, this shoulders are generally aware guided the lifts are given at the outer ring. Naturally, if you want to the go for the double row what you need to do add one more n in this it will be n n u and in both the cases you can see in this case the ring does not have any groove and in this case inner ring has a groove shoulders or legs.

While in this case outer ring has lips. You are able to see that outer ring have the lips and we are able to retain the rollers in the shape or in a particularly in that position, location.

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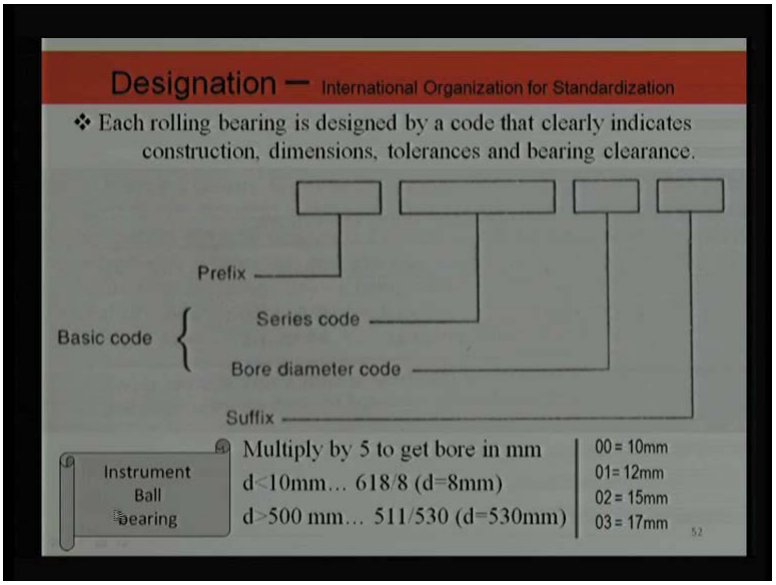

So if this kind of configuration, naturally we have to go ahead of the assumption of the specification and what do we say that is the ISO standards. International Organization for Standardization have given some sort of series or bearing series with suffix and prefix. That is why we say each rolling element bearing is designed by the code.

Or presented by the code are clearly indicated what is the construction, what are the dimensions, what are the tolerances, what are the bearing clearances. Bearing clearance. When we are talking about the rolling element bearing have some self outcome with a number of clearances. We call as a C 0 clearance, c1 clearance, c2 clearance, c3 clearance, C4 clearances. As clearance increases, the numbers also increase in this situation.

Gearing of course, it is a very bad choice if we go ahead with the high clearance and the bearing is subjected to some vibration. Naturally, the impact loading will be higher and

bearing will fail immediately or maybe say within in before step real timer, there will be premature failure of that bearing. Naturally, we need to choose a proper bearing clearance in this situations and that can be represented as the one of the suffix.

Now, we discuss about this series. We said there will be some sort of prefix there will be in series that is the code and they will be amateur code and will be called as the bore code particularly and comes to finally, suffix and this particularly diameter code is generally given by some number right. If it is given as 00 that number done is 10 mm, 01 02 030 they are non conventional. Obviously they have been utilized but, cannot be represented with some sort of formulation. But, 04 onward we can predict a bearing damage or multiplying either by 5.

If I say multiply by 5 to get the peering row diameter. In this case, if bearing lesser than for the configuration, if any time bearing dimension is lesser than 10 mm then it has to be represented with the slide. So, 6 1 8 is a bearing series slide slash eight is a d diameter of the bearing or both diameter of the bearing. There is a one case and another one is the bearing dimension is more than 500 mm. In that situation also, we have to give a slash. In this case a 511 is a bearing series and the 530 is the row diameter of the bearing and of course, lesser size when there is particularly when the d is lesser than ten mm those kinds of the bearings are often used in instruments. They use all mass produce and are available in the market.

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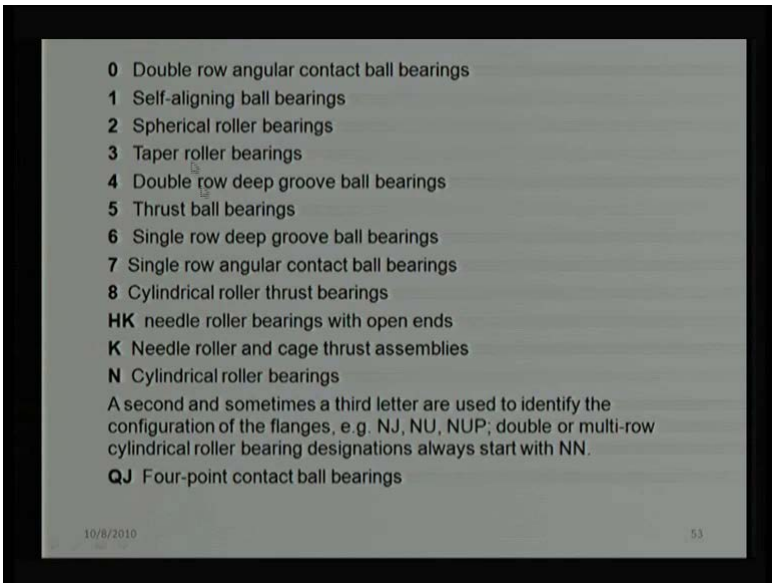

Now, this is giving some sort of the bearing series slightly difficult to remember but, when we have table we have a catalog we can simply pick up the bearing as the number. And we know very well in tabular form when that data has been entered we try to conserve the space lesser the space occupied will be better the representation. Or that will be better from reading point of view. That is why I say when the bearing number is zero that means that there is a double row angular contact ball bearing.

Gearing number is one, it will be self aligning ball bearing and bearing number two has colors. It is color roller bearing. Bearing number three I am not just talking about the serial numbers these numbers are the bearing series, bearing numbers, bearing series numbers. It is not a serial number 12345. Nothing like that when we say that one its self aligning ball bearing and it will be for all the catalog. It is been decided by ISO.

Similarly, we talk about the six number we say, it is a single row deep groove ball bearing. Of course, if we increase the number of rows; number is decreasing from 6 to 4. Even the number of number of rows in this situation are two. So double row deep groove ball bearing, the single row there is a one number, double row there will be another number for that.

The way we have found for the roller bearing one n is roller bearing and the number of two rows then it will be n n. Similarly, we talk about numbers other numbers like eight number, it is a cylindrical roller thrust bearing. It is not radial, it is a thrust bearing. For roller radial load carrying capacity, these bearings and numbers, not numbers, alphabets as such is been given for that. There is a n cylindrical roller bearing. If you keep on adding, gives some other specification then bearing configuration will change.

We have discovered the n u that is per lip shoulders will be the outer ring in these situations. Similarly, if there is a multi row the two rows it can represent that cylindrical roller bearing with n n. And this one is a special one, will be called as some time we required a high load carrying capacity in axial direction. That can be done with a four point contact, four point ball bearing. There are four point at the contact. That is why the bearing name is being given and extensively used for the positional accuracy and this number, this is represented with two letters q and j. If the bearing catalog we say q j then that will indicate it is a four point four point contact ball bearing.

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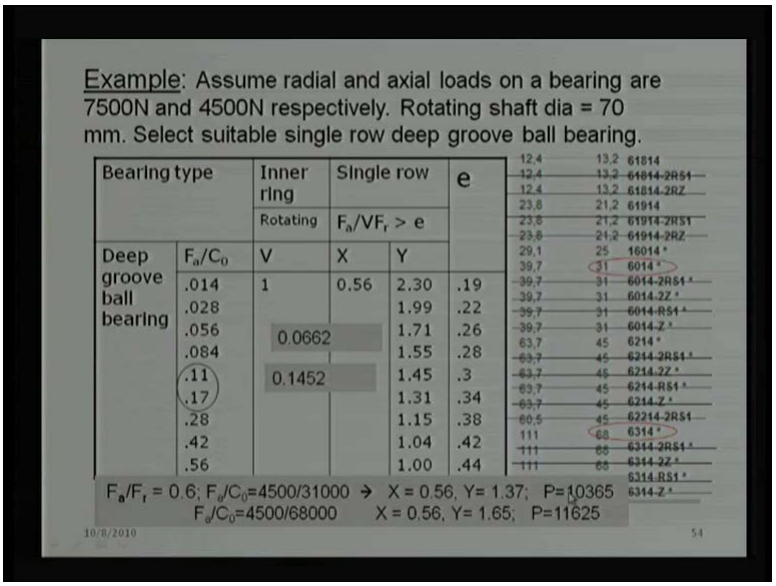

Now let us take one example to understand what we have done in our, have learnt in our lecture. You assume there is a radial as well as axial load on a bearing and magnitude of the radial load is 7.5 kilo newton, magnitude of axial load is 4.5 kilo newton, bearing is rotating sharp diameters at 70 mm and what we need to do? We need to select our suitable deep groove ball bearing. So, here option is not open. Now you need to choose so only the ball bearing in here. We do not have any option but, bearing dimension is also mentioned but, that is only restricted dimension only is board diameter or other dimensions are not been specified.

That means we have a open choice we use a one bearing series, deep groove ball bearing that will be six series and diameter is one four series. Bore diameter series is been 14 that is the 70 divide by 5. When I divide 70 by 5, I will be getting a fine 14 number and that bearing bore diameter series is 14. So, we can choose bearing from catalog. How? See this is bearing with fourteen number and deep groove ball bearing, six is for the deep groove ball bearing and fourteen is for the bore diameter. So, both are there. Then, this is with 2 r s seal arrangement. This is with the shield arrangement, this is slightly in higher side diameter is increasing form 8 to 9. There is slightly higher diameter.

If there is a higher diameter naturally load carrying capacity will be involved. Here the load carrying capacity, dynamic load carrying capacity 12.4. Here dynamic load capacity is 23.8. As we move ahead all every where there is a 14 and then we are able to see

bearing with series is increasing initially it is 0 then 2, then 3, then 4. Not 4 only up to 3. So, bearing series is increasing.

If i read the question back I see oh there is no, nothing has been mentioned whether you want to seal this bearing. Is there any dirt environment? There is nothing mentioned to us so why to do any assumption? So, cancel out. Those bearing will be slightly costlier so we do not require 2 r s1. It will be going to give us lot of coefficient friction or has coefficient friction. 2r z is not required. One side is sealed. Where do we go ahead with this kind of bearing?

Similarly for others, like 2z also not be requiring. Nothing has been mentioned whether we need to prevent the dust, we need to prevent the, we need to retain the lubricant. We will see that those things later. when We see first to reduce our efforts by considering all the bearings which are not desired, not not desirable is a bad word in this situation. We say that it may be not essentially needed.

If it comes finally, as one of the best configurations we will choose it. But, these are the bearings that are not essentially needed as such. So we have some options available on the first number, fourth number, seventh number, then comes eight number. Similarly, other numbers and this number. So, limited choices. That is better for us. Now, we can just for the experiment, just to explain the concept we can choose the two bearing and compare. However, there is no harm that we should not choose this bearing or there is no harm in the way I am not choosing this bearing.

This is just to illustrate with some example I am writing over this bearing that is ellipse in this and similarly, this bearing. What is been given? In this case static load carrying capacity of this bearing is a thirty one kilo Newton. In this case, a 6 3 1 4 bearing which is the, high diameter, high dimension side. Static load carrying capacity of this load bearing is sixty eight kilo Newton.

So I know the, what is the static load carrying capacity that means the C 0. I know how much axial load has been applied that is, the 4500 kilo Newton, 4500 Newton or 4.5 kilo Newton. I can find out the pressure. See I have a C 0 that is the simple of 4500 divided by 31000. In other second bearing that is f a by C 0. That is a 4500 divided by 68 thousand. So, in first case what I am getting? First case, I am getting a ratio as of 10.1452. I am not able to find any dimension like this.

I have in table .11 and .17 and this number comes somewhere in between. Naturally, I have to do some sort of interpolation to come up the figures. So that, I can select, I can select what will be the value of x and what will the value of y. Interestingly, I do not have to do interpolation for x. It is a constant value so for this number, this number, this number everywhere the x value is same.

I will choose as x as it is. But, for y we need y interpolation. Similarly, this factor, this ratio turns out to be 0.0662. Again I do not have that dimension available. They say that .056.084. Naturally I have to do some sort of interpolation to find out what will be the value of y. Again, x value remains same. So, we do that. X is same .56.56 while in this case first case y is turning out to be .37 and other case it is turning out to be y is equal to 1.65.

What I will get in this case? P say, that is equivalent load when we use x factor and y factor and use this kind of equation, what we find? The equivalent load in this situation is 10365 Newton. While in second case equivalent load is 11625 Newton. 25 newton Interesting! One observation; I am choosing a higher series or bearing and effective load is increasing towards the dead higher side. Is it appropriate?

From load point of view. I say no. This bearing should be selected, this bearing should be rejected because unnecessarily this second bearing is increasing the load carrying or we say the applied load on the bearing. Why should we choose this kind of bearing which is costlier, larger in dimension and in addition to that is applying more load? However, we require some more clarification we require some more parameter.

So that will be, this parameter will be discussed in our next lecture. We will be continuing with the same example. We will give additional parameter. How to choose a right, a proper, a suitable bearing for our application? Thank you.