Design of Machine Elements – I

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Lecture No - 35

Design of Shafts

good day we continue our lecture on design of shafts and this is lecture number thirty-five [noise]

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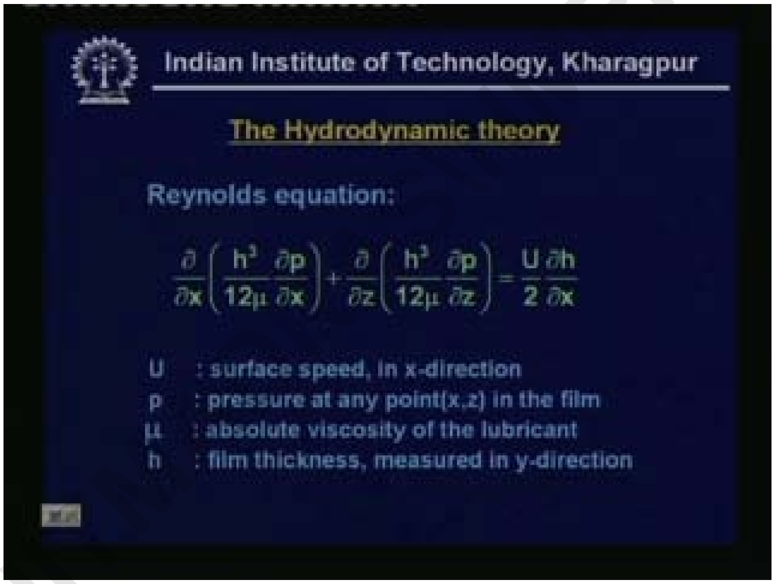

in the last class we have been discussing about the hydrodynamic theory of lubrication

so what in short we have written hydrodynamic theory and ah just a recapitulation that this particular hydrodynamic theory ah the historical background is that that from the experimental investigations of Petrov and Tower ah and looking at their interesting results ah what happened that Reynolds ah suggested a general equation for the hydrodynamic theory

and this equation is given here as you can see this equation is nothing but purely a flow equation under the pressure radiant and that is for the left hand side and the corresponding right hand side is a some sort of device or some sort of pressure generation mechanisms that we will talk about in this {exper} (00:02:13 min) in this particular analysis i mean equation what has been assumed is that the lubricant is incompressible and ah you know the wedge shaped what we have been talking about earlier has been assumed to be a somewhat ah a straight profile okay

this is this a this is the wedge if you consider and this is the converging passage through which the lubricant is flowing

now here essentially the variation of pressure is in the if we if we consider i think it's the first thing is that we give the coordinate axis this is a X Y and this comes out to be Z

so bearing is very long in this Z direction and ah in this case the pressure variation is only in the X and Z direction and the essential remains same in this particular Y direction

and once again as already i have told that the lubricant has been assumed in this equation to be an incompressible one

and ah with this assumptions the very well known Reynolds equation stands like this which is basically as i told you is a flow equation

now let us have a look of this particular right hand term in details okay

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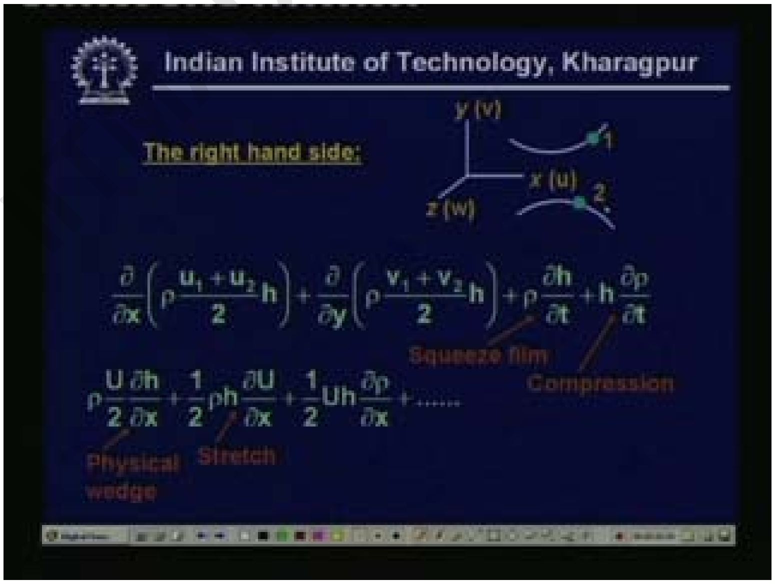

so what we look at the right hand term if we see then what is happening that if there is two moving surfaces say this is one and this is two and for which at point one and point two your velocities are u one u two u one v one and W one respectively which is in this direction

and in the point two also we are having the velocities as v one ee ah ee uh uh u two v two and w two respectively

so in this case uh general form of the equation is as given over here this is the term {fo} (00:04:41 min) in with respect to the delta x this is with respect to the y and these are other two terms that is coming into picture[noise]

now if we consider this expression and take a partial derivative only for this particular parts say just we are taking up this part and gave the part partial derivative of this one then we will be getting an expression of this sort of and this (( )) ((00:05:10 min)) all other terms are present over here [noise]

now in this case ah we are replacing this u one plus u two okay as a capital U now [noise] you see this particular term is called as it is being given a physical wedge

what is that

that particular wedge action that means how the wedge this h is the {clu er} (00:05:38 min) h is the film thickness and that is how it is changing with respect to x[noise] and that has got a name which is called a physical wedge

so this is one of the pressure generation mechanism

this is also called a stretch this particular term is called stretch where the {flo} (00:05:56 min) how the flow {veloce} (00:05:58 min) i mean the velocity is changing with respect to x

and this is ah another [noise] term in this expression which gives you how the variation of lubricant density is taking in the directions of x

well as i told you that it is an generalized equation ah where all these variations of ah density variations etcetera are also taken care of

now this is also another very important term that with respect to time how the film thickness is changing and that is actually called a term called squeeze film

and the last one how the compression is taking place with respect to time and that is simply it is termed as a compression now in the present case ah of the Reynolds equation you do no find all these terms in the right hand side

as a matter of fact just have a look we will be only considering this particular term which is called the physical wedge well ah [noise]

so we consider this term physical wedge okay this is the term we are considering in the present case of journal bearing where as the other terms are also applicable in some other applications

well so we understand that this an idea which gives us the physical concept of how the pressure generation mechanism works for a flow problems when ah for a basically for a flow through an converging ah converging passage uh and ah that gives us the total idea of Reynolds equation um

and that is what we once again [noise] we we once look at to this one [noise] okay so this is the equation now we come down to this basic equation [noise]

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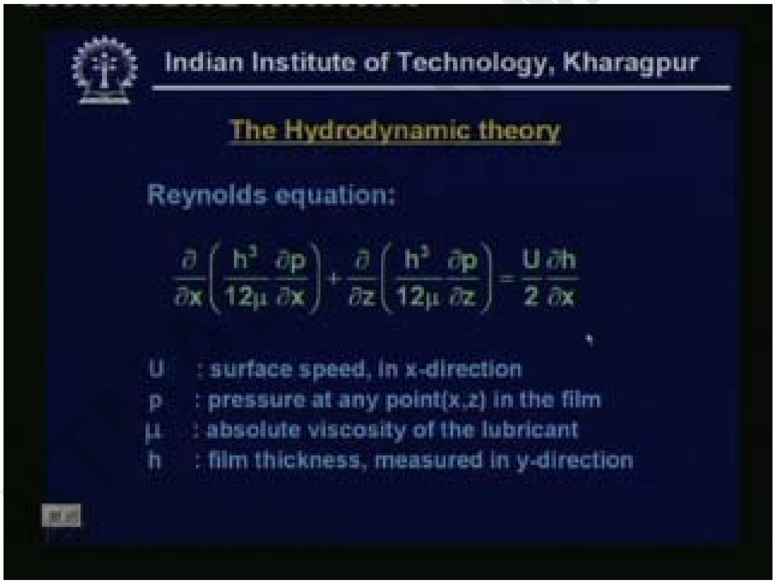

so as i was telling you this is one of the very ah the ah basis for design of a journal bearing [noise] now we come down to the idea of journal bearing design

the steps in journal uh ah the steps in the journal bearing designs are like that

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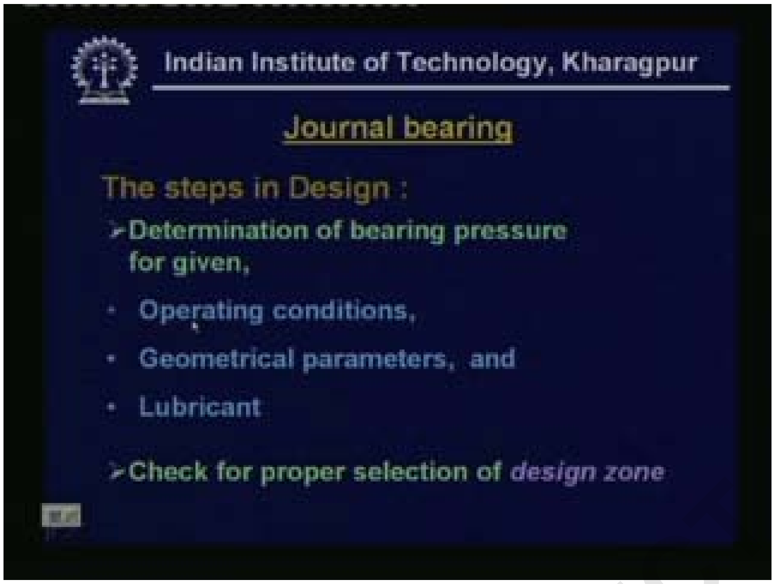

what you have to find out basically is that is the bearing pressure

if you know the bearing pressure you know the what is the load capacity that means how much load it this particular bearing can carry

so for finding out that one has to find out what one has to look for the operating conditions okay [noise] temperature speed etcetera then the geometrical parameters and the lubricant

these are the basic three things what we will be finding out in the ah journal bearing designs

and once we can finalize this particular parameters then we get a [noise] bearing pressure okay

so once you find out this bearing pressure then we know what will be the load carrying capacity

now ah after all these designs parameters been selected one very important situation comes that

you have to check for the proper design zone okay this word what has been used over here

ah a a really a requires some little bit of explanation and let us come down to the idea that what we mean

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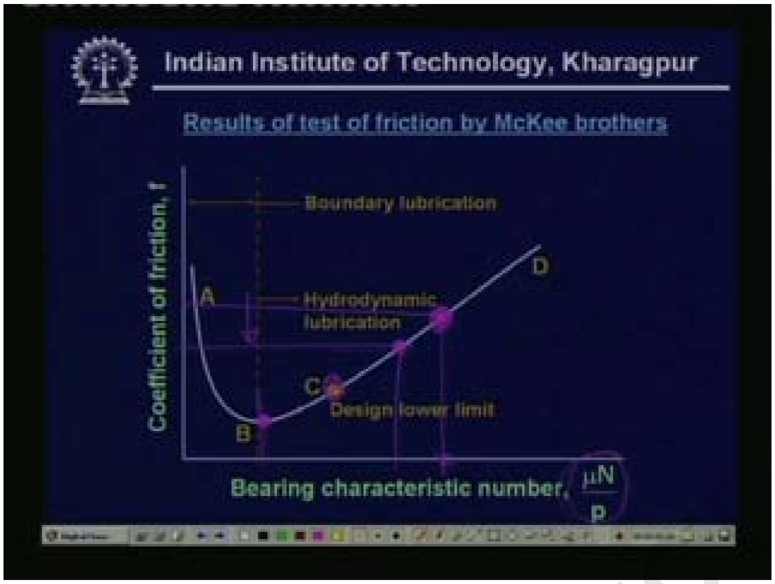

by this design zone now this is the one of the plot you can see of the coefficient of friction verses bearing characteristics number

so what is this bearing characteristics number

this is a non-dimensional parameter which comes out to be in the form viscosity speed of the bearing and the pressure okay

so this pressure is as a matter of fact the projected pressure is what is that one i think

i have explained you this is the thing now if this a bearing and it is acted upon by some load capital P if we consider then this is the diameter of the bearing so that p is the total P divided by projected area that means this is the d into l that okay

so this is the projected area that gives you the pressure of the ah bearing [noise]

so considering this {ss} (00:11:12 min) particular fact we come down to this what we understand by this ah this particular plot

this plot has been taken from the test results uh of McKee brothers

ah and this shows a very important characteristics of journal bearing um design

see ah in this particular case there is an demarcation line upto this one

so up to here you know with the increasing bearing characteristics number the curve goes on increasing whereas uh the friction goes on increasing sorry and a here with the reduction of bearing characteristics number the friction goes on increasing

so here this is the limit

and beyond this limit we call this is an boundary lubrication or sometimes it is also termed as imperfect lubrication also ah

imperfect lubrication means a in this boundary lubrication there ah wont be a very

definite ah film ah lubricant film uh present there will be a metal to metal contact and ah some sort of an oiliness sort of thing might be also present over there

so this is what is what we called as boundary lubrication

and the this particular portion from B to D what we called as hydrodynamic lubrication[noise]

now once we ah uh look into the design zone means is that the calculated bearing characteristics number should be somewhere in this design somewhere in this zone of C to ah eh sorry eh C to D

now well we can talk about B to D also but why not just i'm just telling it [noise]

what happens that say in any any point over operating point you consider over here then what is happening that in this particular case you are having an given viscosities speed and a pressure

so these two parameters are not changing suppose by continuous ah movement what is happening

the due to some friction suppose what will happen sudden amount of temperature generation is there so suppose ah if the temperature rise is taking place

then what will happen that immediately the viscosity of the lubricant will be falling down okay

so as it is falling down immediately what will happen the bearing characteristics number instead of a this location say it is coming out of with a this location so this particular one goes down operating point goes down over here

so resulting in what lowering of the frictions

so the moment there is a lowering of friction then automatically temperature decreases and ah again bearing ah comes down to this particular value again it can go up but anyway it has got a self controlling phenomena somewhat a self controlled phenomena is there [noise]

so that's the reason what happens that people consider these zone to be the design limit

however ah one thing is there although we can we can see that normally from here to here we could have chosen our design zone but design lower limit is somewhat kept at C which is roughly around five times from this particular value okay

or in other words we can just say that it should be sufficiently away from this particular zone so there is no possibility by any means that this particular design point goes on this one[noise] so on the contrary what you can see is that at the reverse will happen

if there is by chance there is an reduction in you know ah bearing characteristics number the friction goes on increasing means more an in more an in increasing of the temperature takes place and that is what we consider the bearing becomes unstable in operation

so the now i think you hope you understand that what we mean by the design zone well [noise] so ah as we see that this was the test results of McKee that we have described about the design zone so these design zone is clear to you

now we come down to the

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two methods very popularly ah um uh used for uh bearing design first method developed by

M D Hersey and the second method by A A Raimondi and J Boyd but this particular uh method what we call as a first method is relatively old ah more um people do by the second method anyway we will discuss over here the two methods

as has been told here the first method [noise]

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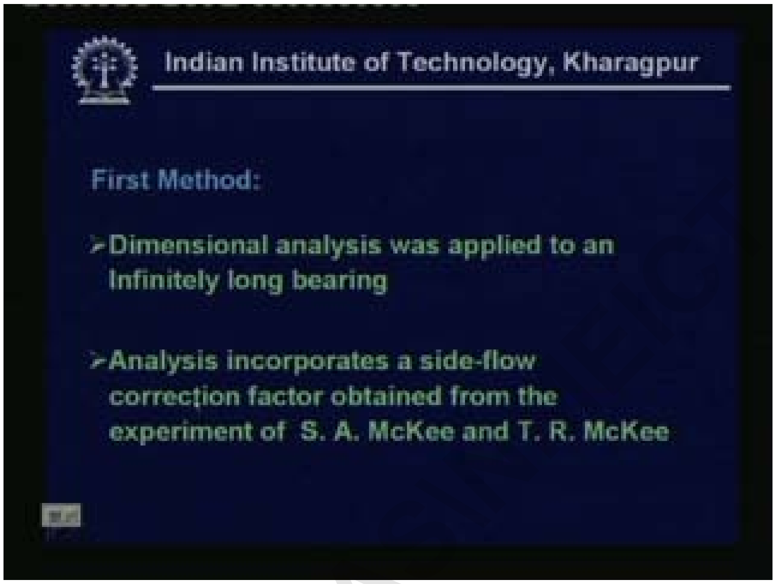

ah what is this one this particular method you say what is has done that he applied dimensional analysis to an infinitely long bearing and this

particular analysis as it is given over here incorporates a slight a side flow correction [noise] because you understand may be long but due to the pressure the a the oil might be leaking out from the sides and that is what is called a side flow correction factor obtained from the experiment of McKee and McKee

this is what we are mentioning earlier as McKee brothers

S A McKee and T R McKee they are responsible for all those experiment of friction what you have just seen

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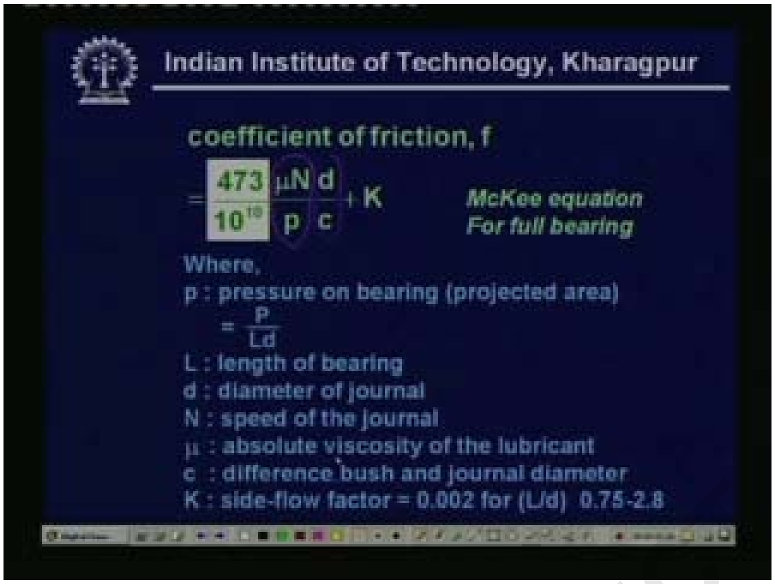

now here ah coefficient of friction F is defined now in terms of this parameters this we have seen the bearing characteristics number then d by c is the diameter of the journal

and {a ans ans} (00:17:31 min) K is a and this is the difference um ah difference bush and journal difference i think it is difference in something like that [noise] difference in bush and journal diameter and K is some factor

so what you understand that pressure on the bearing projected area P by Ld that i have already explained length of bearing diameter of journal speed of the journal absolute velocity

so all these terms are known to you ah only this K is a side flow factor

what is point zero zero two for L by d ratios ranging from point seven five to two point eight now here ah ah this uh particular expression of friction ah eh can be used for um ah determining the coefficient of friction as i just told you

and this is called as a McKee equation for full bearing

so you know the full bearing means uh not that entire three sixty this entire the uh sorry so entire three sixty zone has been taken into account okay

so if it is half bearing something like that or some somewhere the entire bearing may not be onto the bush system it can be somewhere like this also okay so this is other {da} (00:18:53 min) things what is called an half bearing etcetera now ah you can see a factor four seventy-three divided by ten to the power ten is being present over here and that is ah basically an constant but this uh that uh this constant actually is dependent on what

this constant is dependent on the units

so this constant here mentioned in uh Pierce units though if you use the other units like SI units this requires a change so that's the reason be careful that this is given in an shaded ah shaded zone okay that means this constant ah has to be verified depending upon the units of your choosing

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so [noise] ah now what happens that the steps for the first method known design parameters are bearing load journal diameter journal speed okay

this is a this is a you have to provide from your ah you know from your operating conditions

then how you design the bearings so you have to know the L by d ratio ah a bearing pressure C by d also that bearing load has to be calculated and corresponding bearing pressure also is required to carry this load

and the dimensions also C by d ratio proper lubricant and an operating temperature

now in this case uh i have just have mentioned one important thing that all this L by d ratio bearing pressure C by d ratio proper lubricant operating temperature these are all available in standard ah you know design hand books where various ratios of L by d and corresponding pressure what should be the clearance ah uh ratio C by d ah the lubricant properties it's ah temperature of evaporation etcetera uh the best operating temperature all these things are nicely tabulated

now in this particular one as i'm giving an overview of bearings there is no scope as a matter of fact to include all these charts[noise]

so the idea is that you refer to a design handbook and select a design parameters means these are the design parameters combinations for which you will find basically what you will be finding out that mu N by P that I'm just describing in the next slide[noise]

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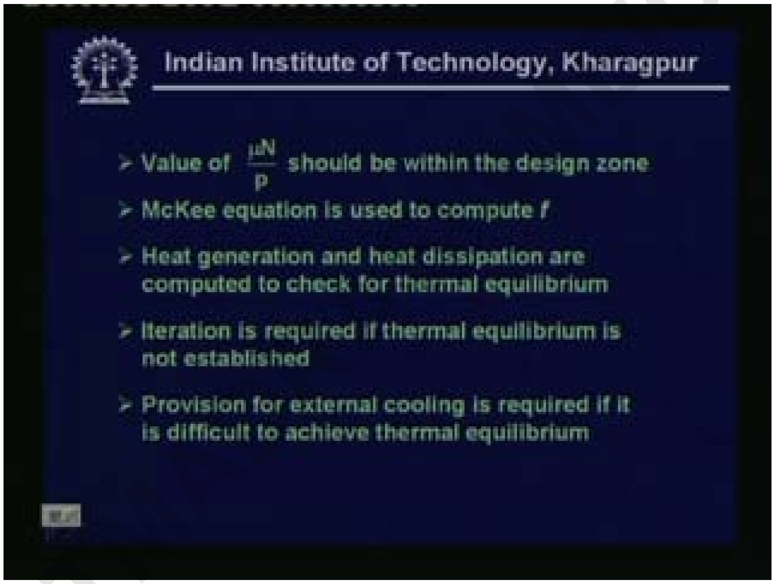

now the value of mu N P should be within the design zone no explanation required it is already ah uh ah uh we have seen McKee equation is used to compute the value of friction coefficient of friction f

so once you know the f the this particular handbook or the handbook will show you the expressions required to find out heat generation

and also heat dissipation okay depending on the varying dimensions lubricants etcetera

so this is required for thermal equilibrium means whatever the heat generated should be properly dissipated otherwise the continuous heat generation will take place[noise] iteration is required if thermal equilibrium is not established that is very important the thermal equilibrium has to be established

next the provision for external cooling is required if it is difficult to achieve thermal equilibrium

in certain cases ah no matter whatever iterations you perform ah it will be very difficult ah to obtain the thermal equilibrium

so in those cases an external cooling device is a always recommended

so this is the brief idea of the bearing design by the first method

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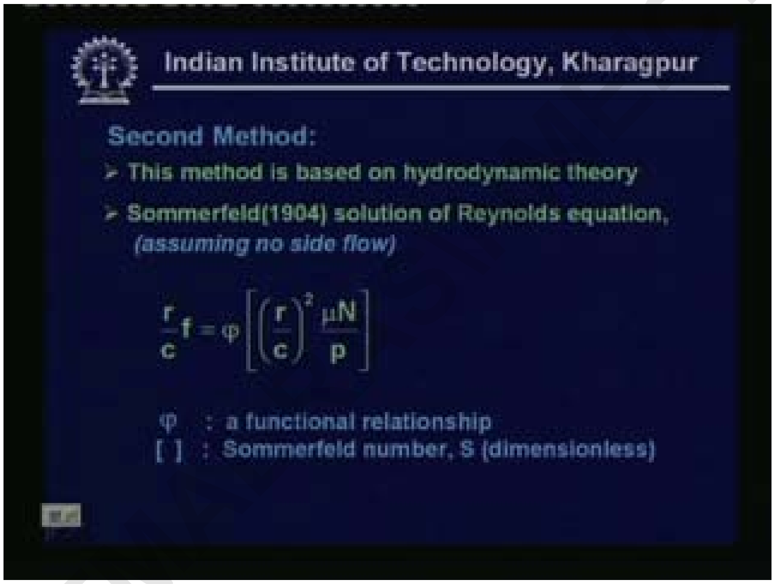

now ah if we look for the second method this method is again based on hydrodynamic

theory of lubrication and ah this method gives ah one idea is that the Sommerfeld in nineteen hundred four gave a solution of Reynolds equation assuming no side flow

so that particular ah solution if we look at ah if we look to then we find out ah something like this that this is the total expression of the solution where if this particular one of functional relationships what Sommerfeld has obtained for different bearing uh different types of bearings now here you can see this particular ah equation

the solution is a very potential one because you can see it includes bearing dimensions it includes ah it it includes the friction it includes the viscosity it includes that speed of rotation pressure but only thing it do not contain is the bearing arc that means what is happening this particular how much is the bearing arc so that is not taken into account

so that’s the reason this functional relationship can be obtained for different assuming different type of bearings means three sixty degree bearing ah um sixty degree bearing that means full bearing half bearing one-fourth bearing like that [noise] okay so this idea is utilized by the Raimondi and Boyd in their some solutions [noise] so what is that

so this one again this bracketed term is called the Sommerfeld number S which is an dimensional number

here you can see this is a bearing characteristics number what we have already discussed earlier this is ah this is inbuilt in the Sommerfeld number [noise]

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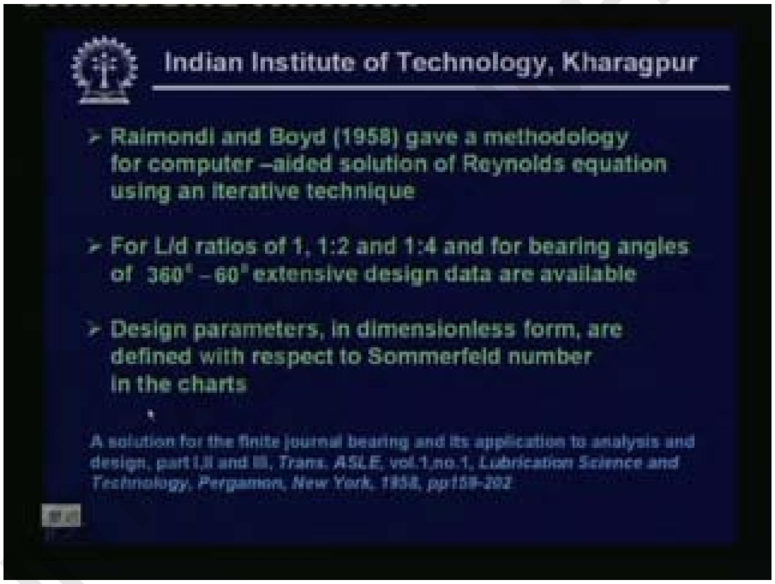

now if we come down the basic idea of the Raimondi and Boyd uh explanations i mean the methodology for this bearing design that what is that one that Raimondi and Boyd in nineteen fifty-eight uh just gave one methodology which is basically an computer-aided solution of Reynolds number

uh some iterative technique has uh been used and of course this particular solution is dependent on types of bearings means for different kinds of journal bearings the solution is {ex} (00:25:54 min) solution exists

what are those things we can see

for L by d ratios of one ah L by d ratios of this thing um one one point two one point four and for bearing angles three sixty degree to sixty degree okay

so that is the full bearings coming down to the sixty degree uh bearing okay

so for all this data all this uh sorry not data parameters one L by d ratio and bearing ah angles means beta angles what is normally being called [noise] extensive design data are available okay

these [noise] design parameters in dimensional form are defined with respect to Sommerfeld number in the charts means we will be finding out various charts he has prepared ah

this Raimondi and Boyd have prepared different charts depending upon various design parameters and once you consult ah the chart then we get the idea of the design

now here all these charts are for you know are for three hundred sixty to sixty degree bearings because as i told you the bearing arc was one which did not uh which was not considered in the Sommerfeld solution

so for different bearings uh arc lengths it has been uh solution has been solution has been obtained [noise]

now you can have this reference ah for this particular work a solution for the finite journal bearing and its application to analysis and design part one two and three uh

and this was in turn ((projections)) (00:27:41 min) of ASLE so on and so forth

so ah what are these particular design parameters what we are interested for

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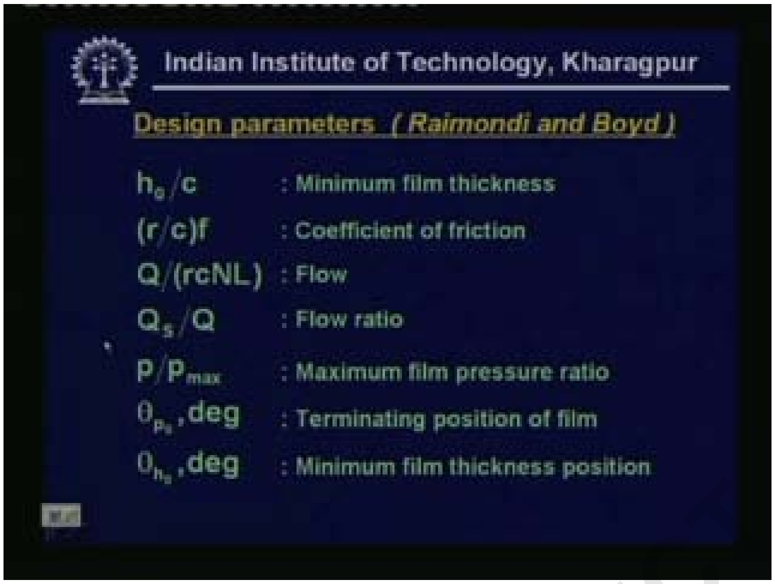

so these design parameters are as shown here

so these design parameters as per Raimondi and Boyd h zero by c is the minimum film thickness r by c by f that is called a coefficient of friction

all you can see are all non dimensional Q by rcNL this is an flow parameter it means you need to know what is the amount of lubricant flow that will that has to be passed that should pass through the bearing passage

Q by s by Q is flow ratio P by P max is maximum film pressure ratio

theta p zero in degrees terminating position of film theta h zero in degree minimum film thickness position

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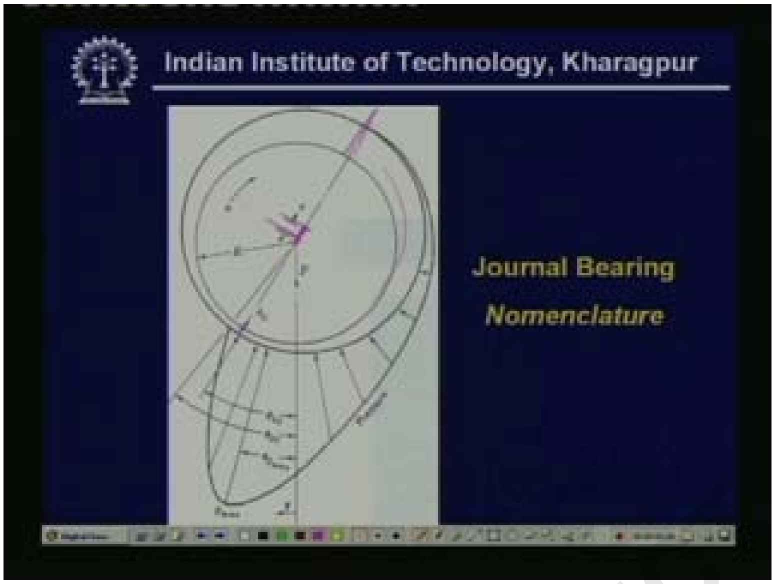

now as a matter of fact all this design parameters are based on to this particular figure

you can see this is a journal bearing this is the eccentricity and you now by now you understand that when a journal bearing is operating it cannot ah uh it cannot operate in a concentric manner it has to be an eccentric otherwise no wedge will be formed thereby no load bearing capacity will be developed okay

so this is the ah minimum film thickness a zero it's location this is the P max we measure from theta by the way just ah just have a note that this particular pressure is only for the positive part of the {jou} (00:29:31 min) bearing all right

where you are having this converging {june}((00:29:36min)) the negative part has not been shown in the picture because that is not of our use not

so this is the theta h zero the position of minimum film thickness is degree theta p zero is a terminating term of this particular position of the um pressure terminating pressure and ah this theta P maximum is the maximum position where the maximum position is generated [noise]

so you can see the there is an one to one correspondence between this particular one and ah this is this theta p zero i told terminating position of film okay that is the terminating position of the film theta p zero

so that you can see there is a one to one correspondence between this particular figure and the parameters so utilizing those parameters one can have all those design ideas all right

so this gives you the some ideas of the ((burning)) ((00:30:39 min)) design of the journal bearing

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next let us concentrate our idea onto the rolling contact bearing and this are of the two kinds one is called the ball bearing another is called the roller bearing [noise]

so uh out of this two kinds of bearings both are in use and it has uh where it will be used are being very well defined in the design hand books and we will have a brief uh review of this particular types of bearings that are normally being used[noise]

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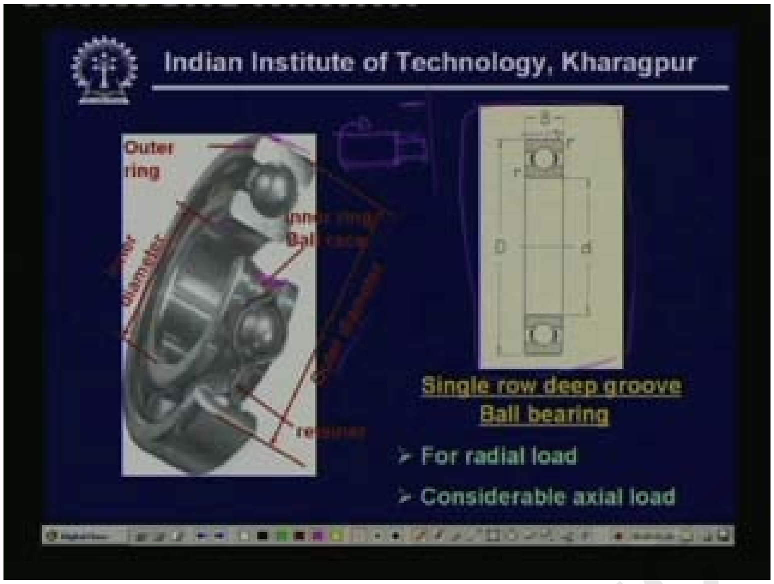

so let us see ah typical figure of a bearing

this is called single row deep groove ball bearing

so you can see the this is the bearing this is called although everything has not been specified over here

this outer ring and this is the outer this is the outside diameter as has been shown over here outside diameter {exter} (00:31:56 min) extreme ends this is the inside diameter

and these these are the balls we can see the steel balls are there and this is called a retainer which keeps the steel balls in position this is called retainer and this are the some this groove type of situations are the inner ring of the ball wrist

similarly we will be having an outer wrist of the ball wrist um ah this ball wrist

so normally what happens in the bearing the design is being made that outer ring this outer ring having an outside diameter this is actually placed inside a ah bearing ah what you call the bearing holder or the bearing block

and this is the inner diameter onto which the rotating shaft uh is assembled okay

so for that means for this one you are required to make some sort of seat on the shaft

so these are the seat okay so this is here the bearing will come and fit over here so that the when the shaft rotates the inner wrist rotates and outer wrist is always within the bearing housing

so this is in the bearing housing and this is having the rotation now this one is just an figure which shows that how uh we represent a bearing in the drawing

so this is the representation of the bearing in the drawing uh this is the ball this is the outer diameter this is the inner diameter this is the width of the bearing and that is the this is the width of the bearing where it has in this particular ah actual figure

and this name again i am just telling it ah sing single row deep groove ball bearing this are the deep groove ball bearing this is mostly meant for radial loads but it can take up considerable amount of axial load too [noise]

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so ah we go down to other bearing this is called the single row angular contact ball bearing these are mostly used for uh ah radial load

and for also for heavy axial load because you can see that is uh here in this case now this particular configuration allows you for an sorry allows you for an axial load transmission

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next we go for double row angular contact ball bearing the same kind of thing having two rows of balls where you can see this retainers are very nicely placed and the one thing is that axial displacement of the shaft can be kept very small even for axial loads of varying magnitude means if there is an reciprocating load in the shaft as we have seen in the design ah still the displacement of the bearing housing and the uh and the shaft can be kept small utilizing this double row angular contact ball bearings

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the next one we can have ah single thrust bearing this is purely for unidirectional axial load so when there is an pure load axial load you can you can utilize this sort of thrust bearing you can see that it goes to the bearing axis then these are the balls uh suppose this is in the this is suppose uh this is actually what is happening that this particular one if it is in the housing and load is falling onto it

so these are tip positions over which this particular bearing can rotate

so these are used for single thrust ball bearing for unidirectional axial load only

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now you come down to this this is the taper roller bearing

this is also another kind of bearing ah this is roller bearing having a taper type you can see this configuration of this one as shown over here and shown over here the the things what is being represented over here[noise]

and this is also as usual the ah drawing representation of this particular bearing

and you know ah this typical feature of the taper roller bearing is a four simultaneous heavy radial load and heavy axial load

so these are one kind of bearing uh which are used for the purpose just mentioned ah anyway ah i think that the very beginning we started with the ball bearings now this is the kind of idea which are having the roller bearings so the that is a roller this is a length in this way but anyway in this particular case it is in the tapered manner

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then you are having the spherical roller bearing and ah this this particular bearing has got a self aligning property this is for the heavy radial load as it is been mentioned considerable axial load in either direction can be also applied onto the bearings [noise]

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the next one is a cylindrical roller bearing

so ah either earlier you have seen the rollers were tapered in nature and these rollers are basically cylindrical in nature

so these are used for heavy radial load for high speed use and within certain limit relative axial displacement of shaft and bearing house is also permitted in this particular type of roller bearings

[noise] so ah you can see the roller bearings are normally used for heavier load because uh ball bearing has a point contact and in the radial in the roller bearings we are having a line contact so thereby the contact area means contact location is increased and thereby it has a capacity of more load [noise]

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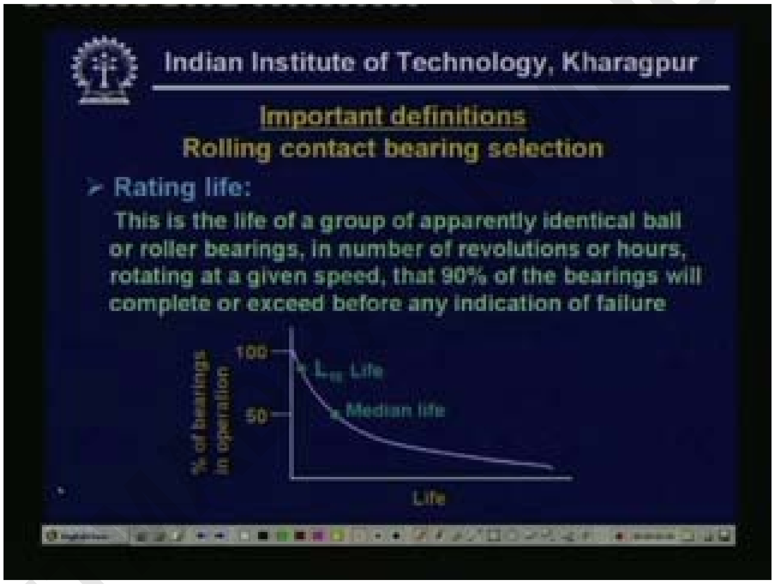

now some of the important definitions of rolling contact bearing selection okay

it is the certain important definitions what we understand however the word rolling contact bearing selection ah also rolling and ah ah um uh this particular idea of the rating life other things also comes into picture

well before uh starting of this one now ah what i would just like to just say that just now we have seen the types of bearings what were those the ball bearing and {lore rolel} (00:39:31 min) bearings and this roller bearings are having higher load capacity compared to what we are having in the um uh ball bearing [noise] and ah various kinds of bearings i have already been showed to you

now one of the important part of the bearing is coming out to be and rating life what is

what is rating life the definition says like this is the life of a group of apparently identical ball or roller bearings in number of revolutions or hours rotating at a given speed that ninety percent of the bearings will complete or exceed before any indication of failure

now let us look in to the ah ah idea ah what is that

suppose we consider hundred bearings okay all hundred bearings are put onto a shaft there's a shaft and it is rotating at a given speed all right

and it is acted upon by some load also [noise]

now when uh you see that when this bearings are rotating then all the bearings will be performing its operation

now after some time we see hundred bearings are all together there after some time you see one bearing failed okay then we see the second bearing failed then we see third bearing failed and so on and so forth

then what will happen uh the when the tenth bearing fails we stop the experiment we see what is the number of revolutions that means that is the number of revolutions the bearing life will be something like what we call as an L ten life that could be number of hours or in number of revolutions

so once again to read it this is the life of a group of apparently identical ball or roller bearings in number of revolutions or hours [noise] rotating at a given speed that ninety percent of the bearings will complete or exceed before any indication of failure

so here ninety percent of bearings were perfectly all right after going for the this thing one

so that is what we call as L ten life okay so this is your L ten life

so obviously this will be very small

so if we see fifty percent of the bearing then this is median life it will be much more larger

so normally people can go for L ten life in general um or other median life etcetera are also are quite common in selection of the bearings

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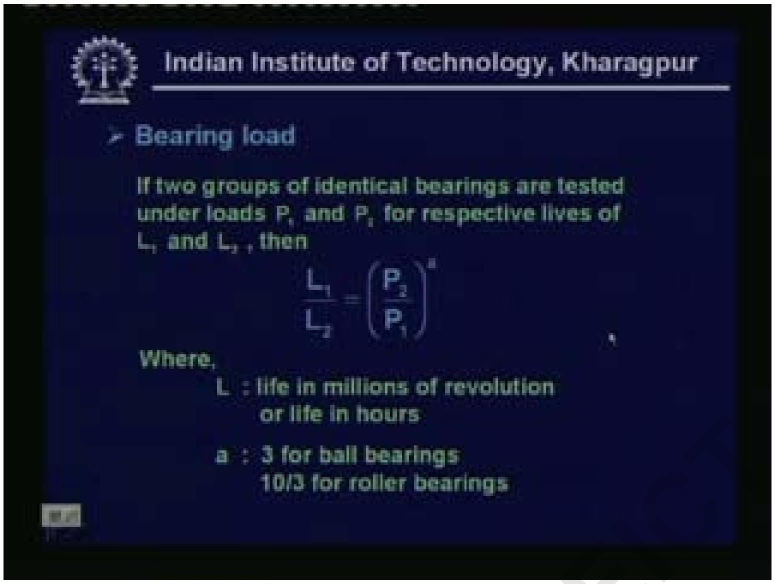

then uh we go for another definition what is called bearing load

now it has been seen that if two groups of identical bearings are tested under loads P one and P one for respective lives of L one and L two then a relationship stands like uh inverse relationship stand like that within power to the power a

L one by L two is equals to P two by P one to the power a where L is the life of bearing in millions of revolution or in hours either of these two and a is a constant which is three for ball bearings and ten by three for the rolling bearings

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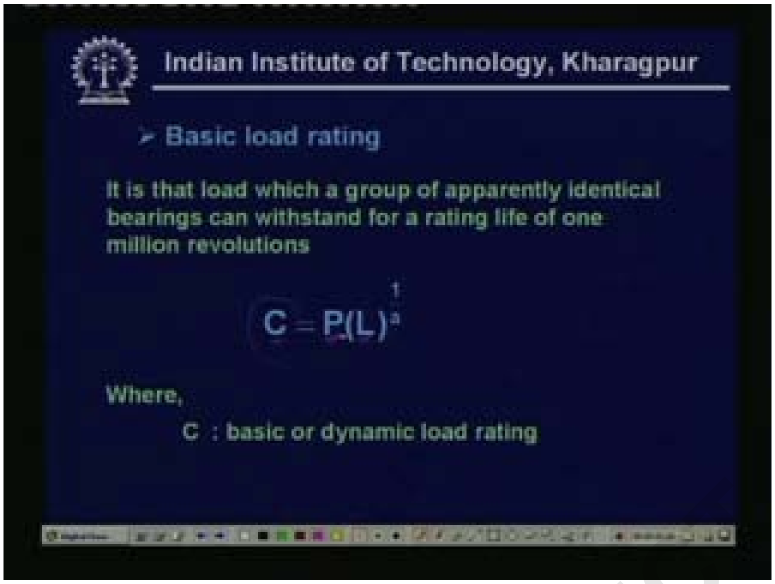

so ah we consider one interesting situation that this is the basic load rating

now this basic load rating is that load which a group of apparently identical bearings can withstand a rating life of one million revolutions

so you can see that if we consider in our earlier expression that either L one or L two becomes uh what you called one million then what happens we consider the corresponding load as C and this is called the basic or dynamic load and corresponding P is this one and corresponding life is this one

now what physically it interprets means what you are telling that bearing will have a life of only one million revolutions

so if it is only one million revolutions ah for which what is the basic load rating

okay so thereby what happens the dynamic load rating if ah the load at which the bearing fails only in one revolutions should be very high

so normally in practice if your load you are having a load P then we will find that load P for whatever the life of the bearing you uh choose this value of C will be very very high

so this particular factor uh or the basic loading rating uh really do not fall onto a bearing this is a ((conservative side)) (00:44:43 min)

that means you are designing a bearings so basic idea of the designing of the bearing you will see just right now that ah for a given load and given life what you have prescribed uh you know for your application should yield some value of this C and this value of C should be lower than what has been given by the manufacturers in their catalogue

and normally as i once again to repeat that this basic loading rating or the dynamic load onto the bearing as being prescribed by the manufacturer is sufficiently high uh compared to the normal load so the {fai} (00:45:24 min) chances of failure will be relatively less [noise]

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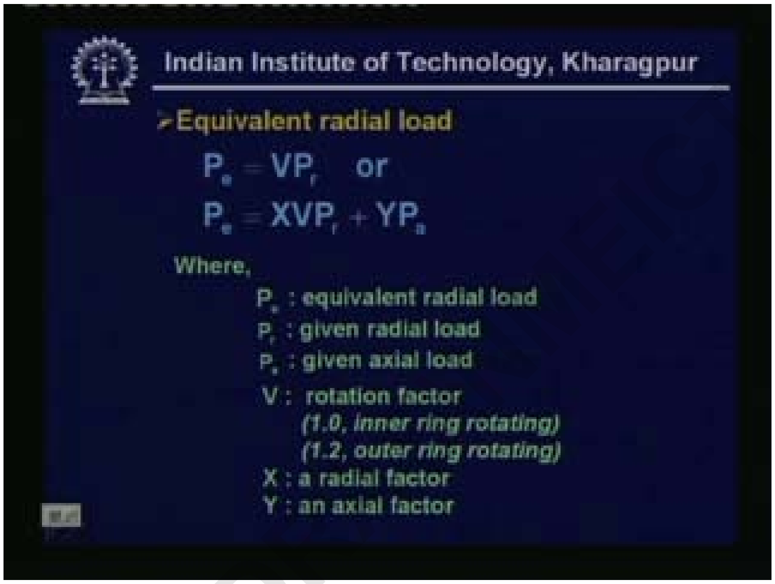

now ah if we consider the other ideas that is is the equivalent radial load now here is ah formula which gives an equivalent radial load what it means a bearing can be simultaneously under operation of you know um um radial load as well as an axial load

so what should be the equivalent load is the thing of which is which uh which is being mainly described through this particular equation [noise]

now the what is this equation suggests

this equation suggests that ah P e this P e equivalent load will be nothing but V P r or P e equal to X into V p r this is the radial load and P a is the axial load

now V is the rotation factor normally the bearing rotates in which way the inner wrist or the inner ring rotates and outer ring is {st} (00:46:39 min) stationary in the housing

in that case V has got a factor of unity

if it is other way round then V has a factor of one point two now again you can see X a radial factor as mentioned over here X is an radial factor and Y an axial factor

so in this two cases what is happening that you have to find out the values of this X and Y and these are normally found from a chart here i am not again

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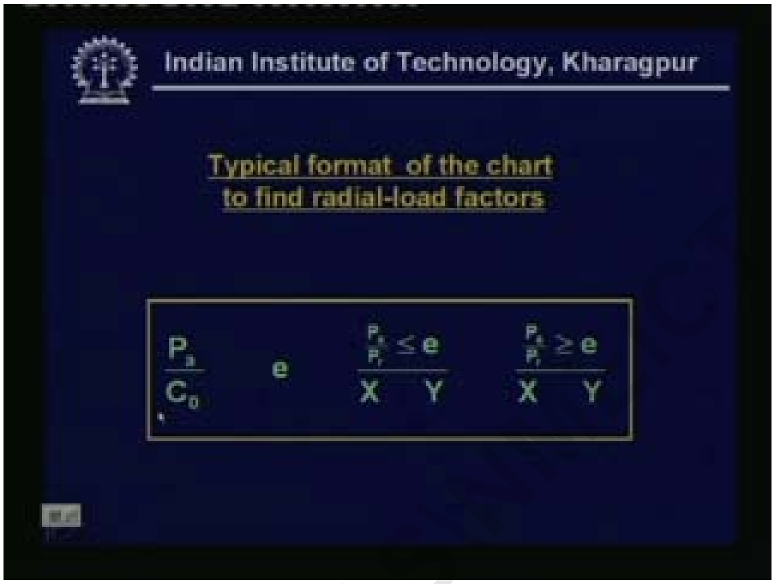

giving you the values ah just i am showing you a typical format of the chart okay

now this is typical format of the chart to find radial load factors

we'll find this sort of chart is there and the values are listed over here

first of all you can see in that you require the P a axial load that is known to you no problem C zero is what

actually what happens as C zero is a factor which one has to find out from the bearing catalogue how uh once you find out the basic load rating corresponding to the basic load rating you will find another factor called C zero is being prescribed over there

now looking at that particular factor what you can consider the value of C zero so this will give you ah P a by P zero corresponding to that you will be ah getting an value of e some arbitrary constant e

if this e is greater than this particular factor of axial load by radial load you choose the X and Y value from these two columns

other way otherwise you choose the value of X and Y if this e is less than this value of P a by r so this type of charts are available at the in the design book or the manufacturers' catalogue from where one can find out the radial and axial factors

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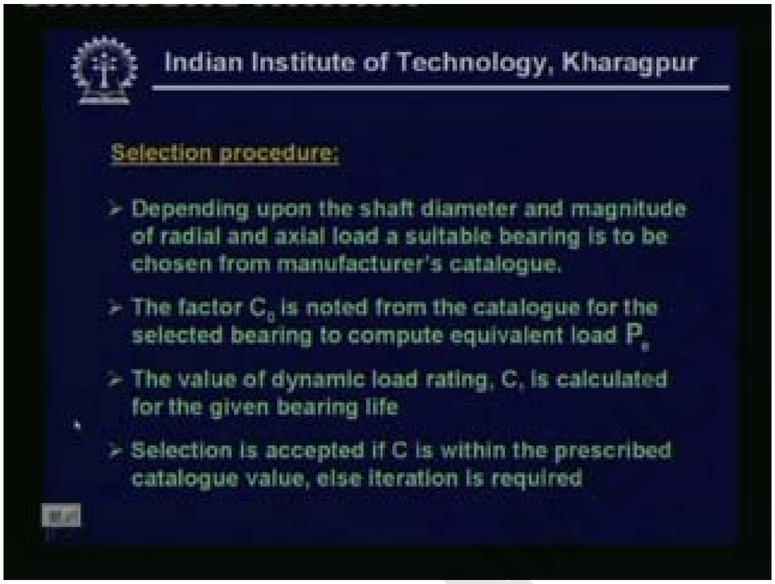

so what is this ah idea then let us come down to the selection procedure [noise]

now what is this one depending upon the shaft diameter and magnitude of radial and axial load a suitable bearing is to be chosen from manufacturers' catalogue uh uh

i think you ah this way you do not have any problem of this statement first of all of course you have to find out the shaft diameter

how the shaft diameter is uh found out depending upon your um ah depending upon your machine element design what you have discussed so far

so shaft diameter cannot be altered that has to be there for carrying a certain amount of load

now you know what is the amount of radial load and axial load that is acting onto the bearing [noise]

so from that knowing the shaft diameter [noise] ah you can find out from manufacturers' catalogue that what should be the diameter of bearings

now you know ah in this case i would like to suggest you one thing that you know the radial component and the axial components so automatically you can find out that what type of bearings you are going to use uh ah either it will be ball bearing or a roller bearing or something like that but here one thing eh ah eh is to be mentioned that the expression for equivalent load ah what has been described here is for ah normally for the ah for the bearings having more of the radial load little changes comes in equivalent load calculations for the tapered bearing but the ideas are more or less the same

so what is happening that you choose a typical bearing say single group uh single group ball bearing single row sorry single row deep groove ball bearing you have chosen

and then ah in that in that particular catalogue you find out that what is the what should be the bore size of the bearing so that it {sh} (00:51:03 min) it fits onto the shaft diameter

well then you have selected that bearing then ah for that particular bore diameter you will be getting all the dimensions of bearing and also two factors

one is the uh C zero factor that is and another one is the C factor

now once you get the C zero factor then immediately you go back to that expression from the from the chart to find out X Y and then in the subsequently you can compute the load P e

so once you find out this equivalent load then you can compute the value of dynamic load rating for the given bearing life because you know C equals to P into L to the power one by a

so from these expression you can find out what is the value of C

check the value of C ah with the manufacturers' catalogue selection is accepted if C is within the prescribed catalogue value else iteration is required [noise]

so ah in this one ah i think now you have understood that how you can ah have the simple way of design procedure ah i uh think uh it is not the correct word i have written here selection procedure because normally we are not going to design a ball or roller bearing we are going to select it from the catalogue

so what in in actual it appears for the ah rolling contact bearing there are various types of bearings depending upon the radial load and axial load or its combination light heavy whatever may be you can choose either a rolling contact bearing rolling contact uh uh roller bearing or you can choose a ball bearing

now once ah from this ah definitions we find out the basic load rating is something defined by P into L to the power one by a {expre} (00:53:08 min) expression where P is actually to be determined as an equivalent radial load for which we require two factors X and Y where from you get the X and Y

so stop at this moment

you find out the type of bearing depending upon your load conditions and then you find out the manufacturers' catalogue the type of bearing you have selected and the size of the bearing you selected

once you have chosen the size of the bearing from the manufacturers' catalogue you will be finding out the value of C zero and C

C zero will be utilized to find out the equivalent load

use that equivalent load equivalent load means equivalent radial load and the life of bearing it is your choice your design i mean your um idea so that life of the bearing in ah revolution number of millions of revolutions you put it in the expressions find out the dynamic load capacity check with the manufacturers' catalogue it should be satisfied

if not then go for an higher size and ah why not lower size of course you can go for lower size the basic idea is that uh can you go for ah lower size in that way you require to change uh shaft diameter if you go for a higher size you required to go for a shaft change in the shaft diameter well those are certain things you have to take care ah in the design of the shaft and manufacture of the shaft [noise]

so this is the idea so all this combinations will lead to the final design of the shaft okay

so not only strength criteria not only stiffness criteria selection of bearing materials all those things are to be chalked out before it is put to the final uh manufacturing form or in the assembled form

so this ends our lecturer on design of shafts

thank you

Preview of Next Lecture

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Design of Cylinders and Pressure Vessels-1

Lecture No. #36

dear student let us begin the lectures on machine design part one this is lecture number thirty-six and the topic is design of cylinder and pressure vessels

now this is the first part of the lectures on the same topic[noise]

now cylinders and pressure vessels they are one of the very important components of modern day machines

there are number of equipments used in machines which ah are made in the shape of cylinders and they contain ah uh a liquid or gas ah if with high pressure

so it's very important to design them properly because as i said the content pressurized liquid sometimes they may be chemicals which are toxic in nature

so a failure of such component leads to disaster that may be the loss of life property and many other things

so the design of cylinders and pressure vessels is very important here now we are going to begin the discussions

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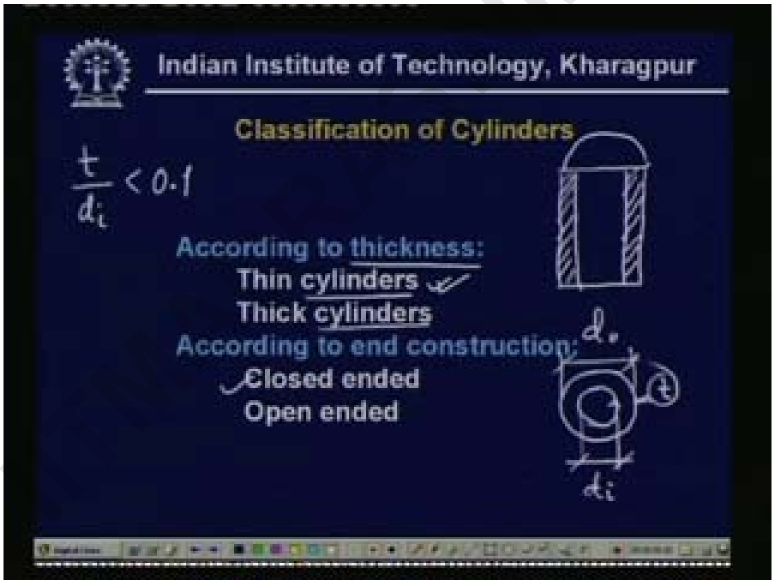

now first classification of cylinders now cylinders [noise] you know cylinders they they are very well known that is this is the cross section of a cylinder [noise] if you look at here so this is this is the internal diameter d i

this is the external diameter d o and this distance is the thickness t definitely t will be equal to d o minus d i divided by two now cylinders are classified according to various criteria one is according to the thickness now if this t that is the thickness of the cylinder is much much small compared [noise] to that of d i that is t is very much small uh um compared to d i then we call this to be thin cylinders now how much small then {mod} (00:57:43 min)

the practice is t by d i must be less than zero point one

so [noise] the thickness of the cylinder if it is lesser than ten percent of the internal diameter then we call this to be ah thin cylinder then if this is not satisfied that is t is sufficiently thick then we call it a thick cylinders

now in this class we are going to discuss the thin cylinders

remember in the thin cylinders the thickness is very very small

so according to n constructions now there is another way of classifying the {se} (00:58:23 min) same same ah cylinder one is the closed ended sometimes we have the cylinders which are closed ended

so