

Machinery fault diagnosis and signal processing
Prof. A.R.Mohanty
Department of Civil Engineering
Indian Institute of Technology – Kharaghpur

Module No # 06
Lecture No # 28
Ball and Journal Bearings

In this class we are going to discuss about ball and journal bearings as you know by now that everything depends on the bearings. We put our transducer at the bearings okay but the bearing themselves could be having fault. So far we have discussed about faults in the rotating systems bear the shaft misalignment, shaft having unbalance, shafts having cracks them. But eventually all the measurements are done at the bearing locations and we in the earlier cases we have assumed that the bearing were okay.

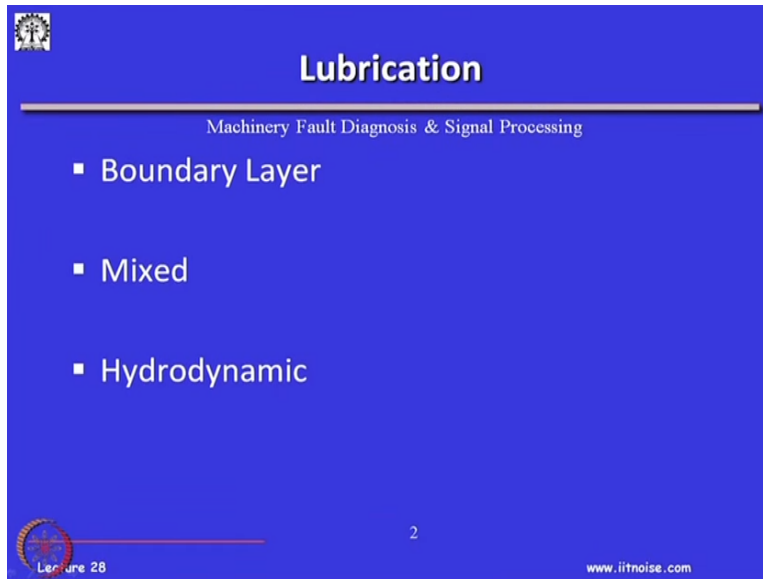
But that is not true bearing themselves have so many rotating elements that themselves could be defective. So we in this class we are going to focus on this two important classes of bearings the ball bearings, the anti-friction bearings and the journal bearings in our class in roto dynamics we have seen the importance of journal bearings because of the fact of journal bearings can take huge amount of static loads on to them.

And they are practically there the shaft is actually supported on a fluid film so there is no contact between the shaft and the journal there is no metal to metal contact and then can take heavy loads. However in the journal bearings there are issue of stability in particularly in flexible systems the stability in journal bearings is of critical concern which is not apparently show in the case of antifriction bearings okay.

But in last gas turbines steam turbines where we have journal bearings stability is very important so all film thickness the clearance between the journal and the shaft all these load on the shaft of the rotating speed. All these control the stability of the system and that is very important which we will not discuss in this class we have discussed I think the class roto-dynamics.

But in this class we are going to focus on what happens or what indication we get when there is defect in the ball bearings and defects in journal bearings okay.

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Lubrication

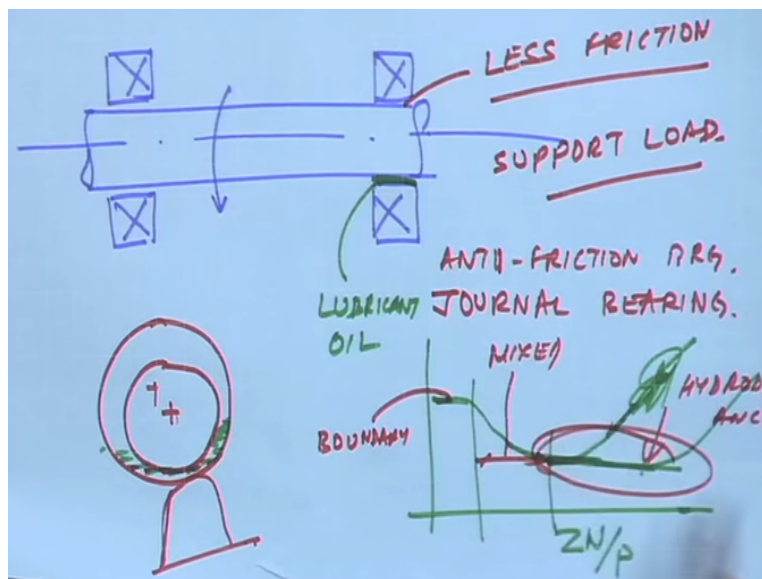
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- Boundary Layer
- Mixed
- Hydrodynamic

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So why do we have bearings we have bearings to reduce friction to moving parts and the bearings support this rotating shafts okay.

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Say if I have a shaft which is rotating shaft is carrying lot of heat so they have to be supported on bearings. And I have to give very less friction to the rotating unit that is my requirement less friction and support the load. So one way to reduce less friction is to have them finely polished surfaces hot surfaces which will not wear off and then they will support load another is certain all fail when we all film here in general bearing we have eccentricity okay.

Because of the converging diverging room there will slit pressure there is fluid here and because of the fluid pressure this shaft is going to get lifted off the journal and then the shaft will support. So we have the case of the journal bearings and of course antifriction bearing but in the journal bearing particularly there is a layer of oil or lubricant or it is actually this oil. So this lubricating oil can give different amounts of friction depending on the Z and by P .

Where Z is the viscosity and P is the pressure of this oil and is the speed RPM and this is the petros law and then you will see that okay am sorry some extent this will go up okay. And this is the case of the boundaries are almost approaching mixed layer and then the hydrodynamic okay. And we are talking about bearing in this hydrodynamic region where the friction is less.

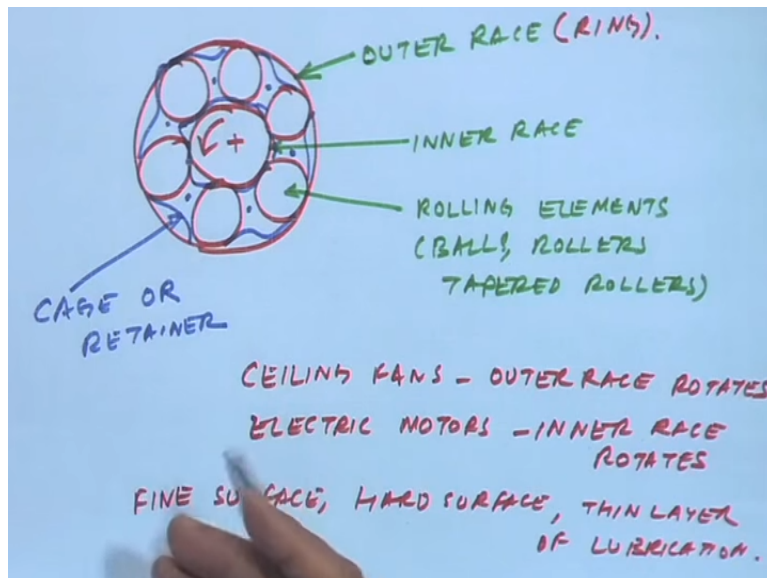
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The slide has a blue background. At the top left is a small circular logo. The title 'Bearings' is centered at the top in a large white font. Below the title is a horizontal line, and underneath it, the text 'Machinery Fault Diagnosis & Signal Processing' is centered in a smaller white font. The main content is a bulleted list in white text. The first bullet is 'Anti-Friction Bearings', followed by two sub-bullets: 'Ball Bearings' and 'Roller Bearings'. The second bullet is 'Hydrodynamic Bearings', followed by two sub-bullets: 'Journal Bearings' and 'Thrust Bearings'. At the bottom left is a circular logo with the text 'Lecture 28' below it. In the center bottom is the number '3'. At the bottom right is the website 'www.iitnoise.com'.

- Anti-Friction Bearings
 - Ball Bearings
 - Roller Bearings
- Hydrodynamic Bearings
 - Journal Bearings
 - Thrust Bearings

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So this antifriction bearing could be of many types ball bearings, roller bearings basically an antifriction bearing has an outer race and inner race and this could be the this is the outer race this is the inner race these are the rolling elements which are usually balls, rollers or even sometimes tapered rollers and then there is a cage or a retainer which ensures that no to rolling elements come together in a thin metals.

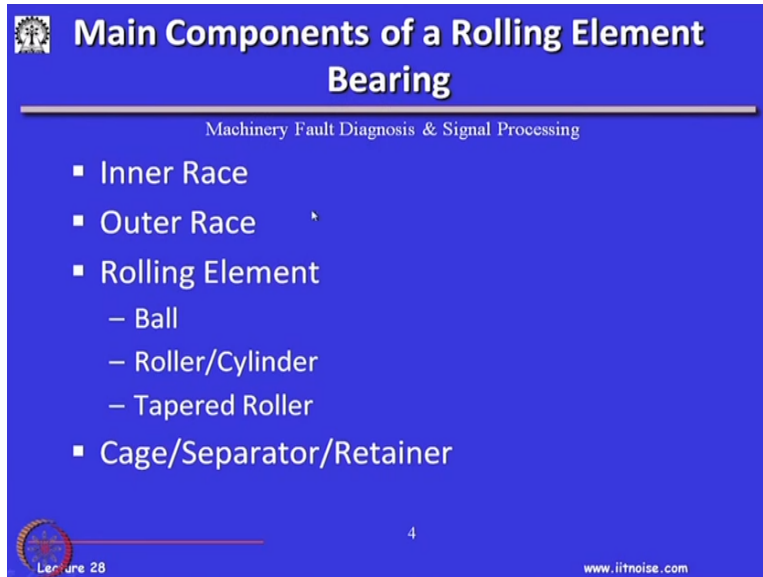
There actually reverted here and this is the cage or retainer at sometimes the inner race rotates with the shafts typical cases or sometime the outer race rotates in the case of ceiling fan bearing the hub is actually stationary hub is attached to the ceiling the shaft coming ceiling fans outer race rotates. In typical other cases all the electrical motors etc is the inner race rotating sometime we call this as race or ring okay.

So the idea behind this bearings antifriction bearings they have to in any bearing they have to less friction. So to give less friction they have to be moving very moving without any obstruction so these elements are manufactured to be very fine surface hard surface and they are lubricated once they come under the fact lubricated at the factory and seal for every thin layer of lubrication and this is the first class first type that the antifriction bearing of the ball bearing of the roller bearing this is what looks like.

And the hydro dynamic bearings basically we have a journals where is pad and then where there are roof for the oil to come in and so on which is to be discuss in the case of rotodynamics I will

not to journal bearings right now. We will focus more on the antifriction bearings and because most so the cases small machines are they only have such antifriction bearings which could be self-aligning also okay.

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Main Components of a Rolling Element Bearing

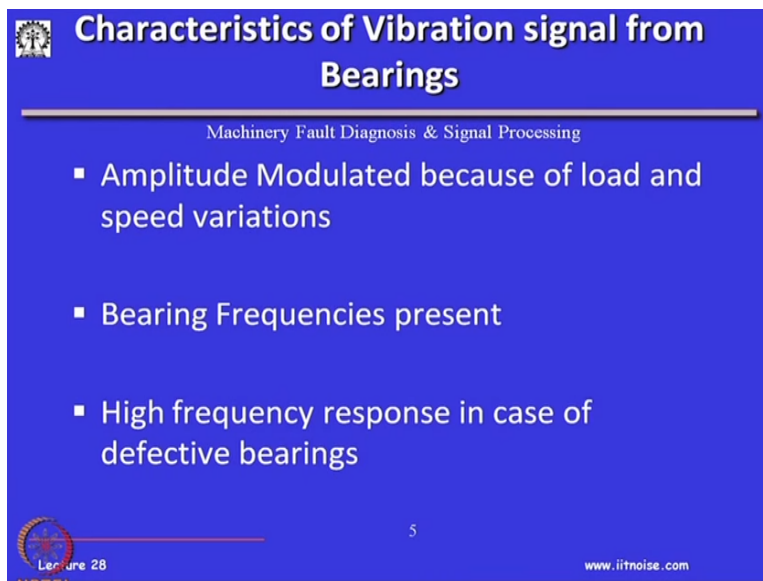
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- Inner Race
- Outer Race
- Rolling Element
 - Ball
 - Roller/Cylinder
 - Tapered Roller
- Cage/Separator/Retainer

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So this is how what are the main components of rolling element which we just saw the inner race, outer race the rolling elements could be ball, roller, cylinder tapered roller, cage, separator, retainer the same thing okay.

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Characteristics of Vibration signal from Bearings

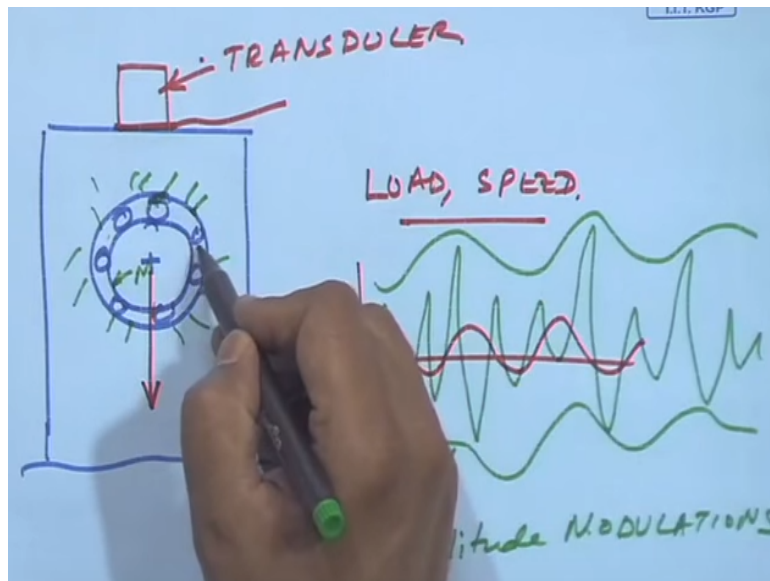
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- Amplitude Modulated because of load and speed variations
- Bearing Frequencies present
- High frequency response in case of defective bearings

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Now why do vibration signals from the bearings occur that is the characteristics of vibration signals from the bearings.

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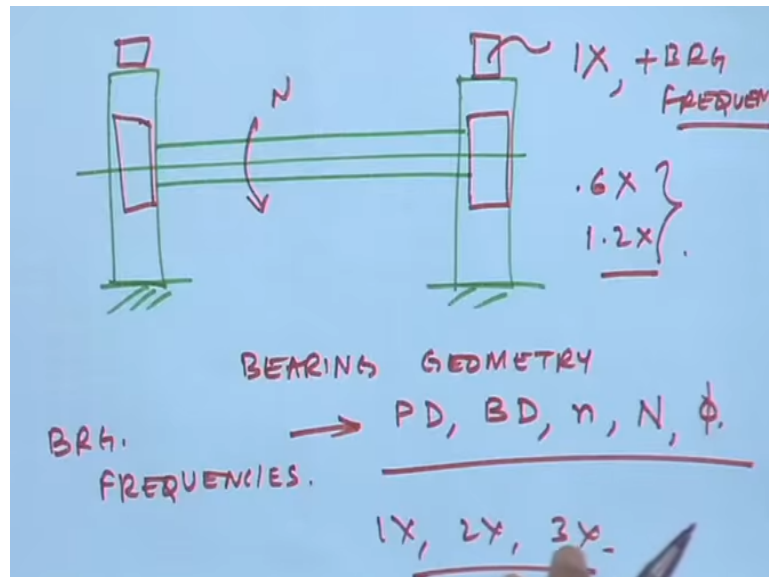
Because once bearings are put in housings I have bearing here some shaft transducer here this is my transducer. So these shafts are carrying loads okay and sometimes these loads are direction speed may be fluctuating so the load coming to the system or the excitation coming to the bearings is varying with load varying with speed. So these are responsible for this vibration signal which is coming out of the bearing to modulate them.

By modulate them I mean certain the amplitude will increase decrease so actually so this sorry these are the amplitude modulation which are occurring which are the load and speed variations okay. On top of it these all these rolling elements have different relative motion one is the balls are for example the balls are spinning about their run axis and also going about the circumference these is if this outer race is fixed okay this inner race is rotating at an RPM.

So I can assume that this is rotating at $N/2$ the train the fundamental train of this rolling elements the moving elements at an speed of an by 2 okay this is fair option okay this is 2 this is an $N/2$ linear okay. You see all these individual components cage the inner race once is outer race non-stationary either inner race is stationary in case of the ceiling final like I told you or the out race stationary in the case of an electric motor.

So these elements are all rotating at different frequency and that is what gives rise to the high frequencies in the even in the good bearing even in a good bearing you will see the frequency is coming up in the vibration spectrum of the vibration which we measure.

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The best part about the bearing vibrations is suppose example I have a shaft which are supported on bearing these are my bearing and I have put my transducer somewhere here transducer will record 1X vibration because of the additional speed but they will also rotate and find out the bearing frequencies plus bearing frequencies but you will see the bearing frequencies you will calculate at any time their actually some fraction either point 6 of X or 1.2 of X and they depend on the bearing geometric.

By bearing geometric I mean the pitch diameter, the ball diameter of the rolling element diameter the number of balls small and the rotational speed the contact angle. So these frequencies are no way to related to 1X, 2X, 3X which we saw in the case of rotating shafts and that is again you will wondering well always I am putting my transducers on the bearing mount what if the bearing frequencies are contaminating or mixing with my actual shaft frequencies of misalignment crack unbalance that will not happen because they are at different frequencies.

The bearing frequencies themselves are at different values compared to the shaft cases and that is actually helping us unlike I told you in this spectrum analysis every peak in the vibration spectrum corresponds to a particular defect in a particular mechanical element it could a bearing

fault. It could be a shaft fault it could be a unbalance it could be a gear box fault they are all different frequencies and that is really they are really saved the work fast okay.

But another thing also happens in the bearing is because there is a defect in a bearing a lot of high frequencies is generally a lot of come to that just in a little while.

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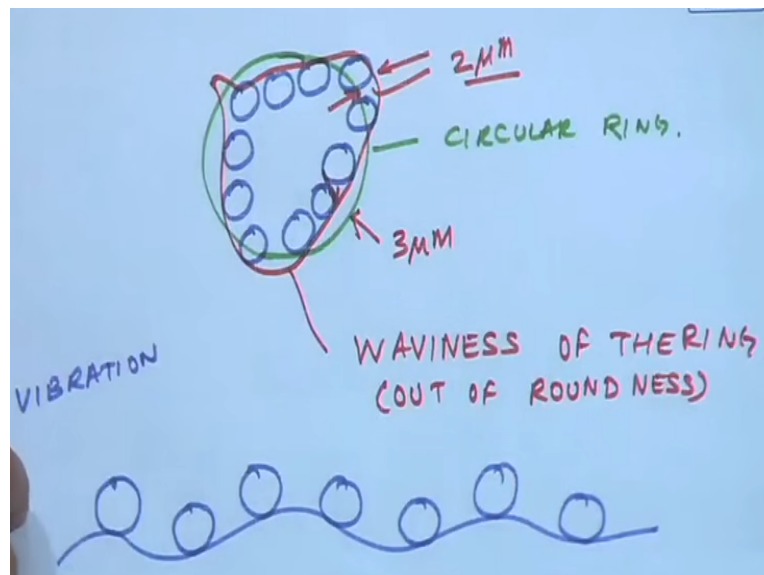
Source of Bearing Vibration

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- Out of roundness of components – Waviness
- Surface roughness of components
- Resonance of components
- Presence of dirt

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But what are the source of bearing vibration okay once we manufacture this bearing when you say this outer race to be a perfect circular ring we manufacture through a grinding process through a polishing process through a buffing process to make a perfect circular ring. But after

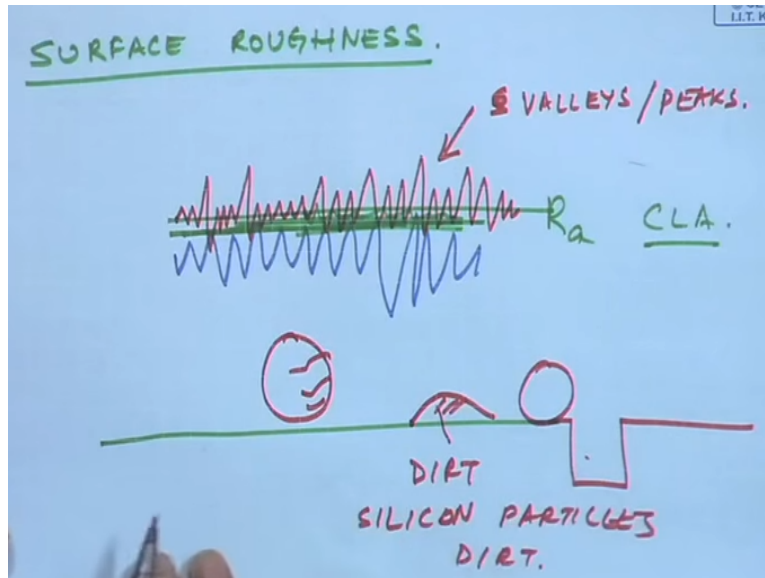
the ring as been manufactured but if you take a dial gauge and measure the ovality of this ring it will not be circular.

It will be surprise to know that it will be somewhere this is a not a shaft peak here but these variation the ring a circle we should have been in green circle actually looks like this and these could be order of two microns very small but these is there in a new bearing also and this is known as the waviness of the ring or what is known as the out of roundness. Through a precision of measurement of the wave of the surface profile we will see that it is not a perfect it is something like this.

So bearing manufacturers when they manufacture bearing the ensure that they had a good amount of finishing operation in the buffing final in the sense so that this happens and on top of it you will see that we have this rolling elements actually riding on these waves okay. So if you put it flat on the surface so we have wavy surface on which this rolling elements are moving this train is moving at an high speed.

So this give rise to the vibration response in vibration we have studied when you go wavy surface what kind of amplitudes we get all of you must have experienced going a motor bike we have experienced those amplitudes coming up same happens in a bearing. So this is why even in a good bearing we have vibrations because of the outer frame of the while manufacture it okay. On top of it if you look at another important component that is the surface roughness of components.

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This surface it was any of the surface are suppose to be manufacture all this surfaces where supposed to be manufactured as nice flat surface which in RA of the center line average or the surface roughness very low. But if you look under the microscope there will be lot of values and pits and this is because of the values and peaks.

And they are not smooth they have an surface roughness so imagine a rough surface moving over another rough surface this rough surface could be that of the ball or a rolling element or a roller riding on a inner or outer which also as surface roughness and which is wavy. And this is what is actually there in a bearing in microscopic level so all this wavy surfaces they are having emotion and that is why this vibration come even if you have a good bearing.

Now to reduce this manufacturers what they do is they ensure that they have good amount of manufacturing of operating in terms of polishing operations on top of it that the factors of the bearings are manufactured they put a layer of lubricant right once the bearings can manufacture it. So this lubricant will go into pits and values and try to make it smooth surface so if you hold a new bearing and if you just play around with a bearing you will not feel any roughness to your hand because of this lubrications.

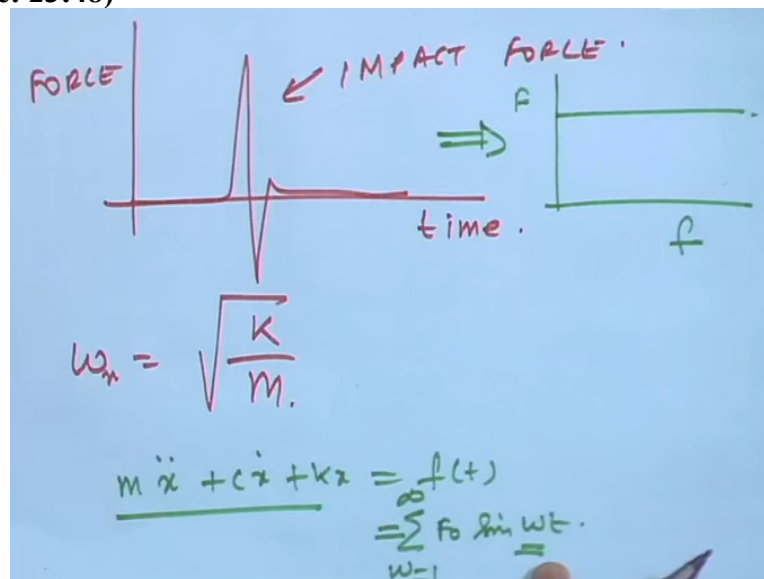
To remove the lubrications if you take this new bearing and wash it with kerosene and remove the lubricant you can all do that and feel it you will feel very huge amount of roughness in your

feel because of vibration have increased we have removed the lubricant by washing with kerosene okay.

So that is the reason why new bearings also have vibrations it is not true that new bearings not have vibrations. New bearing have vibrations because of these two reasons waviness and surface roughness on top of it becomes more complicated in the sense. Let us going to this case of the presence of dirt now imagine on a surface smooth you suddenly come across a bump or a path hole.

So these and then you have a rolling element so these bumps or path holes the bumps could be presence of a dirt on the surface of the inner race and outer race. Very hard silicon particles sand particles a very hard they will not disappear they are going to scratch scrap the surfaceness they are going to crawl there are certain scratch mark like path holes so imagine when you go on a bicycle of a path hole you will get a impulse.

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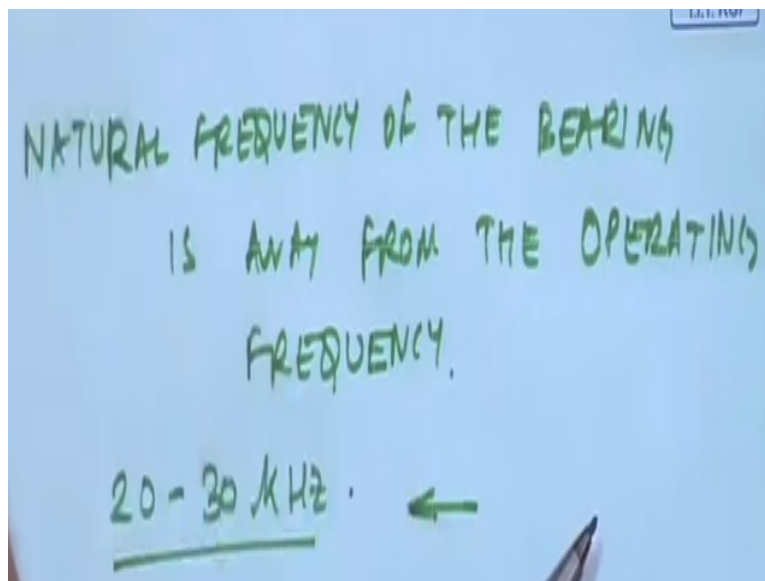
So these rolling elements are subjected to a force of this nature and impulse force in the time domain. If you look at the force they are subjected to a pulse like this or this is an impact so the rolling element which are rotating at the inner or outer race or subjected to such impact forces because they came in contact with a hard dirt particle which is like a bump on a road or there are some pits on the inner race because of some corrosion something as happened a pitting mark.

Some scratch marks so these impact basically this forces impact the bearings elastic structure bearing as mass bearing as elasticity so bearing also have natural frequency of its own. Bearing as a natural frequency K / M it as a mass it as a stiffness so it has natural frequency. Now if you look at the frequency response of an impact force is basically a random force in the frequency domain an impact is look like this force.

Impulse short time force would have lot of frequency lot of forces in the frequency domain or white marks now imagine is the bearings equation if I write some force this force happens to $F \sin \omega T$ where it is $\omega = 1$ infinite for that matter because this goes all the way up. So that means these bearing is getting excited at all frequencies agree. Why did they excited to all the frequencies because of this impact force are impulse force.

So the right hand side is equation as got all the frequencies importance now it may happen so these are the forcing frequency it may also happen that the forcing frequency is equal to the natural frequency of the rolling element bearing as been designed.

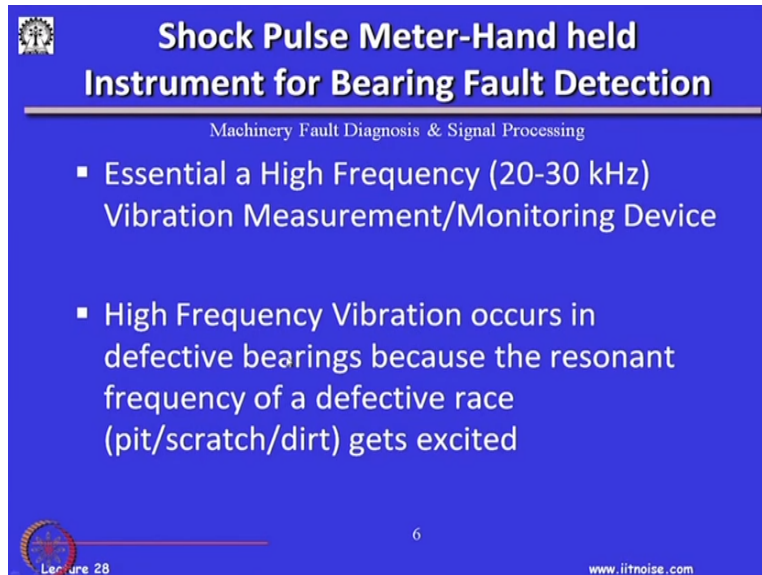
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So and we always design a bearing to ensure that its natural frequency of a bearing of the bearing is away from the operating frequency by the operating frequency means I mean the shaft rotating speed at few harmonic so it should not interfere in operating frequency. Usually a bearing of natural frequency are in the order of 20 to 30 kilohertz because we never operate at this frequencies so the bearing would never undergo rather this conditions.

But the problem is because I have excited it here by an impulse force which as all the frequencies the natural frequencies get excited so I will have a large response at its high frequencies okay. So resonance of components occur that means in bearing have excited at natural frequencies so if I see a high frequencies vibration in the order of 20 to 30 kilohertz in ultrasonic range if I see high increase in vibration level I can say for surely a bearing as under gone effort okay.

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Shock Pulse Meter-Hand held Instrument for Bearing Fault Detection

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- Essential a High Frequency (20-30 kHz) Vibration Measurement/Monitoring Device
- High Frequency Vibration occurs in defective bearings because the resonant frequency of a defective race (pit/scratch/dirt) gets excited

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And that is what actually people use in an instrument called as a shock pulse meter say shock pulse meter is actually nothing but a hand held instrument for bearing fault detection it is nothing but an high frequency bearing equation measurement. So basically essentially a high frequency 20 to 30 kilohertz vibration measurement or monitoring device and because high frequency occurs in defective bearing because the resonance frequency of a defect is race because of a pit, scratch, dirt gets excited.

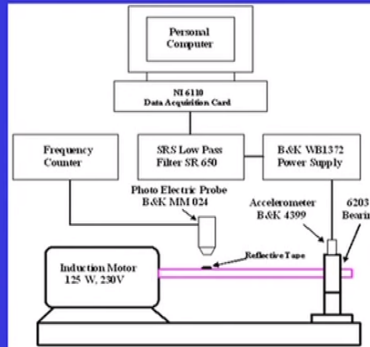
And you know the physics why it is got excited because I excite at right hand side of a equation by a forcing vibration which happens to have the natural frequency of the system. Obviously the resonance happen and then high frequency vibrations. So bearing vibrations a bad bearing vibration would have the frequencies of this inner race outer race cage retainer etc plus a sure case to say that the bearing as scaled is when you see a high frequency vibration in the 20 to 30 kilohertz range okay.

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A Simple Experimental Set-up : Bearing Test Rig

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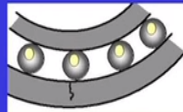
So to under this we did a small experiment in the lab basically what we have here this is a motor having a 6203 bearing okay and all we have to do is put an accelerometer and put a filter I have an data acquisition card and we take all the data to the computer and then we have a photo-electric probe to measure the rotational speed because as you see every all the bearing frequency is dependent on the rotational speed of the this shaft and this frequency can also be calculated.

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Rolling Element Bearing Defect Frequencies

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$$\text{Outer Race Defect Frequency} = n/2 \times \text{RPM}/60 \times (1 - \text{BD}/\text{PD} \cos \beta)$$

$$\text{Inner Race Defect Frequency} = n/2 \times \text{RPM}/60 \times (1 + \text{BD}/\text{PD} \cos \beta)$$

$$\text{Ball Defect Frequency} = \text{PD}/\text{BD} \times \text{RPM}/60 \times [1 - (\text{BD}/\text{PD} \cos \beta)^2]$$

n = Number of balls

RPM = Relative rotational speed between the Inner and Outer Race

BD = Ball Diameter

PD = Pitch Diameter

β = Contact angle

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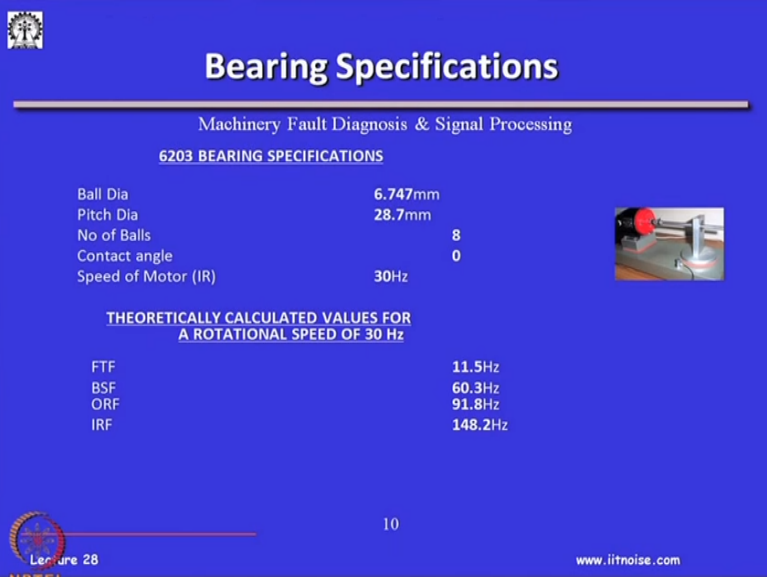
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And in fact the rolling element bearing defects frequencies we can call them as defect frequencies we can call them as bearing frequencies also and they are given by this equation the outer race defect frequency is given by $N / 2$ times $\text{RPM} / 60$ into $1 - \text{ball diameter} / \text{pitch diameter} \cos$ sign of the contact angle beta okay. And 1 is - 1 is + and then the ball defect

frequencies where small N is the number of balls RPM is the relative rotational speed between the inner and outer race BD is the ball diameter PD is the pitch diameter and β is the contact angle.

So this can be calculated from a the bearing manufacture where all the bearing manufacturer give this data some of them give only the ball diameter not the pitch diameter some time they do not give the in the catalogue in the number of ball but you can always find them in the internet or measure them top of the manufacturer.

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Bearing Specifications	
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6203 BEARING SPECIFICATIONS	
Ball Dia	6.747mm
Pitch Dia	28.7mm
No of Balls	8
Contact angle	0
Speed of Motor (IR)	30Hz



THEORETICALLY CALCULATED VALUES FOR A ROTATIONAL SPEED OF 30 Hz	
FTF	11.5Hz
BSF	60.3Hz
ORF	91.8Hz
IRF	148.2Hz



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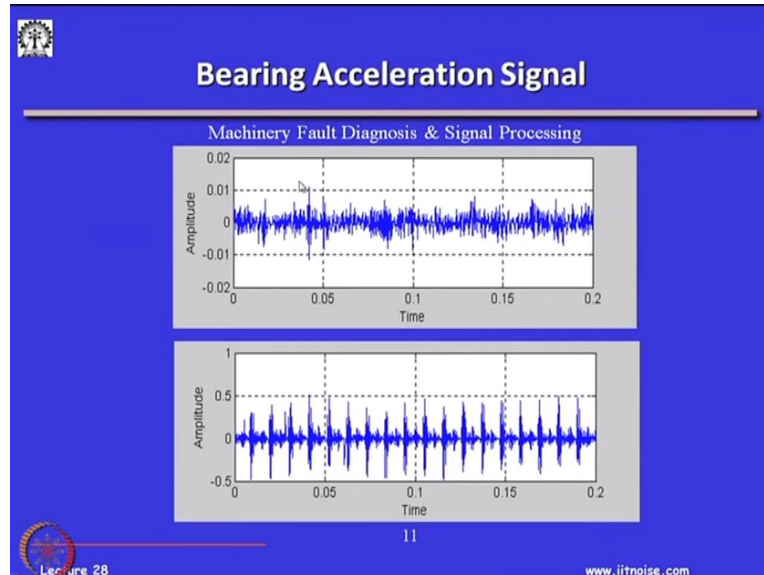
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So here what you have done this experiment is we took a 6203 bearing okay which had a ball diameter of 6.747 millimeters pitch diameter of 28.7 millimeter then number of balls in the rolling element bearing is 8 contact angle as 0 $\sin \beta$ is 1 speed of motor is running at 1800 RPM is 30 hertz. Okay this motor was running at 1800 RPM we have a bearing here and then this bearing actually we had a series of 6203 bearings.

Manufactured by a company who wherein we could artificially create defect in the race by putting an electric scratch mark put on electric itching pen we could create scratch marks in the rolling elements we could create scratch marks in the outer race. So then we one by one we introduce we manufacture bearings defected bearing and put them in (()) (32:08) and then we measure the vibrations.

So a theoretically calculated values for a rotational speed of 30 hertz the fundamental electric frequencies is 11.4 hertz ball spin frequency is 60.3 outer race frequency is 91.8 inner race is 148.2 you will see here nowhere the bearing frequencies of multiple of 30 hertz they are some decimal fractions of the inner race outer race other rotational speeds so that is a good indicator.

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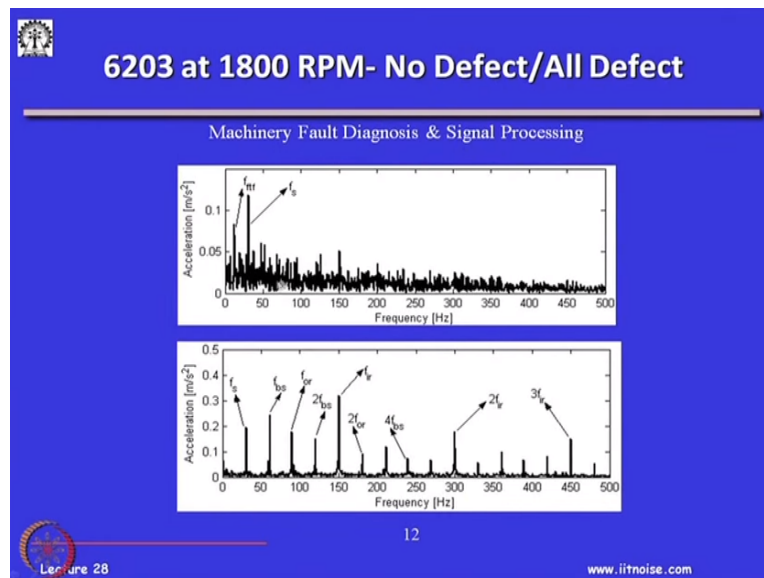
Now this one here just to give you a feel of the bearing vibrations how they look like when there is no defect and there is lot of defect. So when there is no defect the amplitude level the vibration of very low if you compare to the second one which is case of a defective bearing and if you look at the time is there almost periodic okay and then the very small peaks but the magnitude is very low .01.

But in this case we have bearings which where there were lot of defects and you will see this impact nature okay. This is because of the rattles of the dirt's so it is ringing okay so if you just look at the time domain signal of good vibration from a bearing and a bad vibrations when you can right away say looking at it these is a bad bearing okay. So you will see time domain analysis itself is very helpful to identify bearing faults.

And if you do the feature calculation from these signals like its mean RMS you will see obviously the RMS value of this is much higher than this but there are factors like this KURTOSIS of the bearing signal. If I measure the KURTOSIS you will see the KURTOSIS

value of the bad bearings are predictable pretty much high more than about 4 or 5 and then you can say for sure that this is a bad bearing.

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And this is how this spectrum looks like the earlier example was for the case of the time domain okay. And then these are both time is the same now as been converted to the frequency domain and from 0 to 500 you will see for a good bearing the amplitudes are low and you see the fundamental frequency and the shaft frequencies is going up nothing else but once we have a defective bearing first of all the amplitude are high and almost in this case there was a in organized defect the ball defect out race defect.

All this frequencies are showing up okay this are sure cases and in this bearing we are not even monitoring the high frequency vibrations are told you about 20 to 30 kilohertz okay. The reason I told you to monitor the high frequency vibration from 20 to 30 kilohertz is for the fact that bearing are actually put in systems there could be frequencies of faults from other defect like thin shaft misalignment unbalance etc.

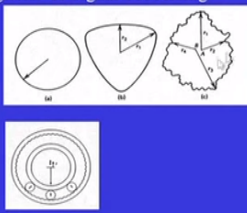
So they will smear the spectrum okay it is very difficult for you to distinguish many frequencies other defect frequencies okay. Unless we have a very fine resolution or very high for it okay. So a sure test is that high frequency monitoring to a short measurement.

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Sources of Vibration in a Bearing

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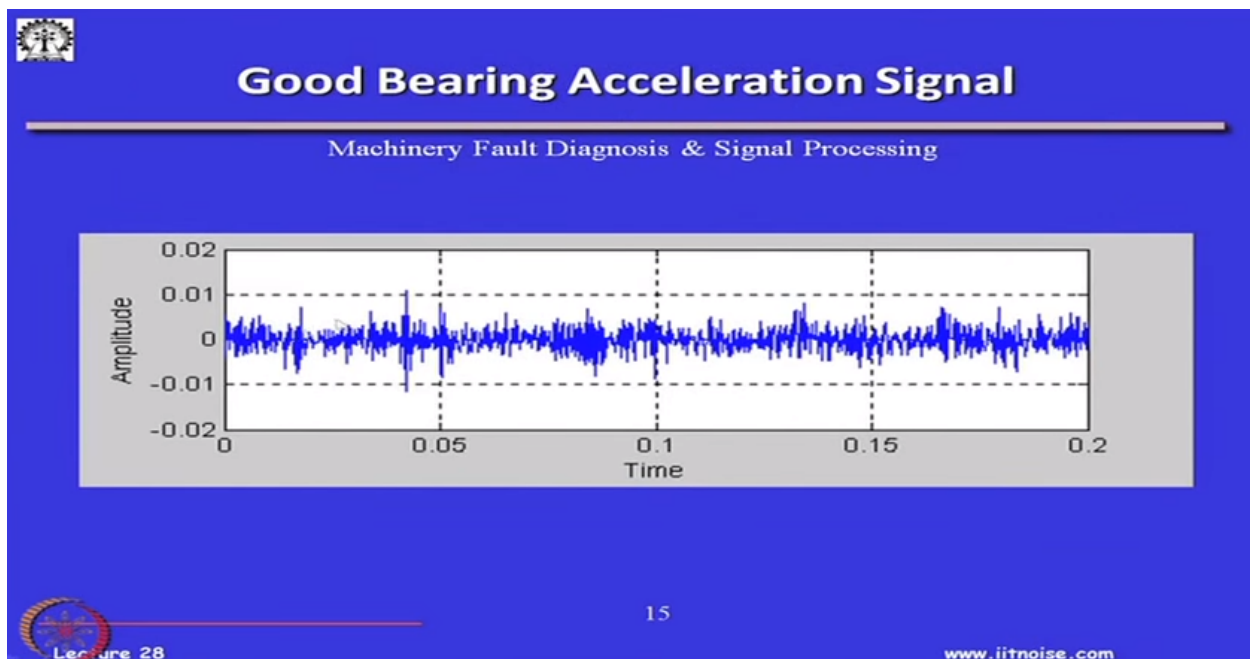
- Waviness of the rings
- Surface roughness
- Crack, Scratch
- Presence of dirt



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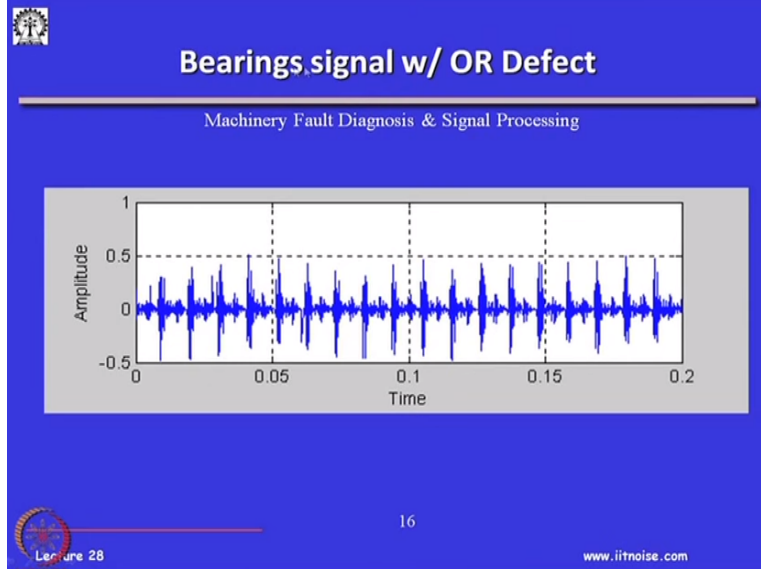
Okay and this is how this waviness on out of round is looks like.

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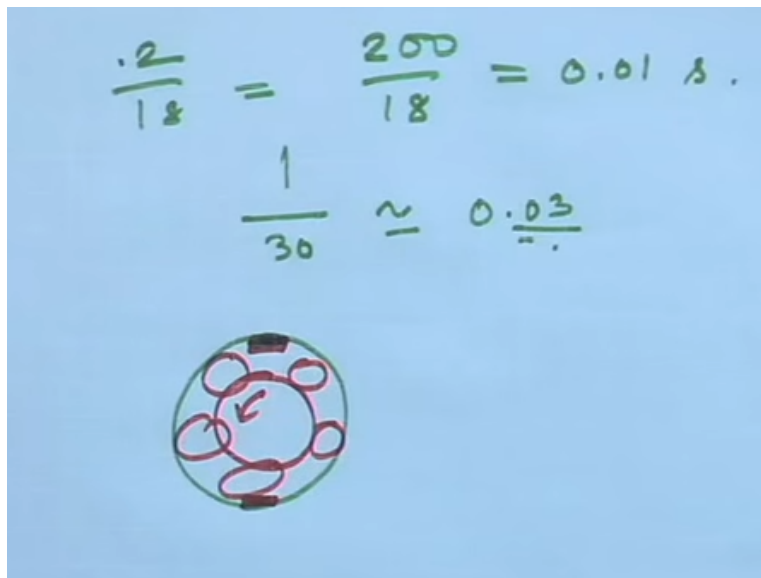


So this is the good bearing acceleration signal okay.

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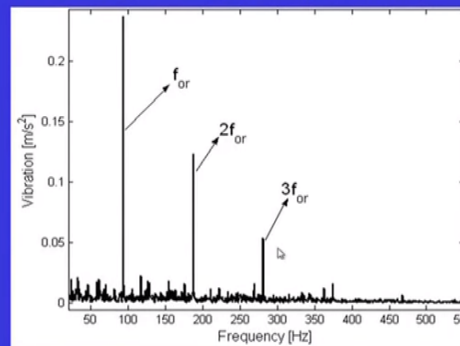
This is the bearing signal with outer race defect okay you can measure okay you see 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 0.2 / 18 or that would be approximately how much about 0.3 is it on the time period is 0.2 seconds per 200 / 18 0.01 second okay. This is 1 / 30 is actually .3 is not it .03 okay you can actually looking at this you can say whether the more what is these special spacing of the defects.

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6203 at 1800 RPM – OR Defect

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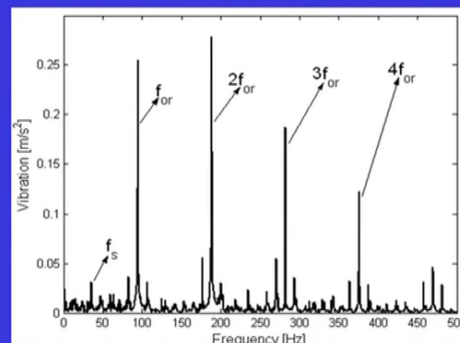
Whether two defects are there or one defects are there in fact am not sure the multiples come up is not only the single frequency by also there are multiples.

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6203 at 1800 RPM , Two OR Defect, 180 deg apart

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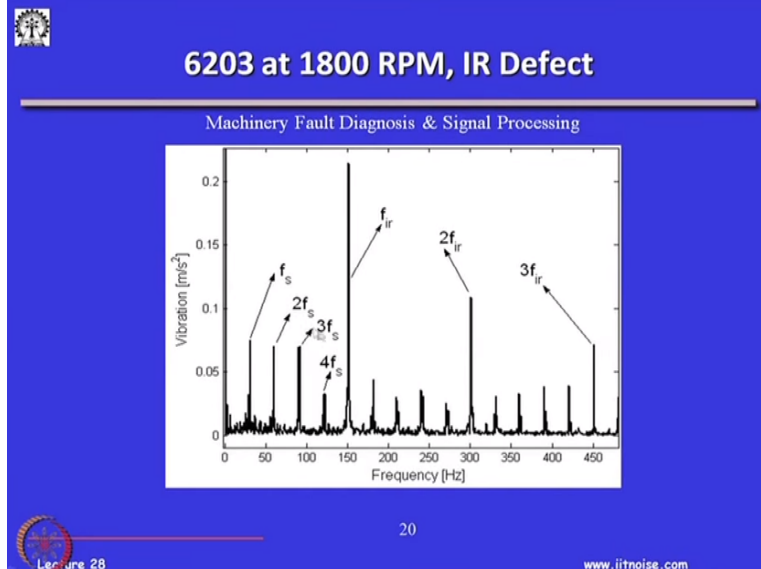


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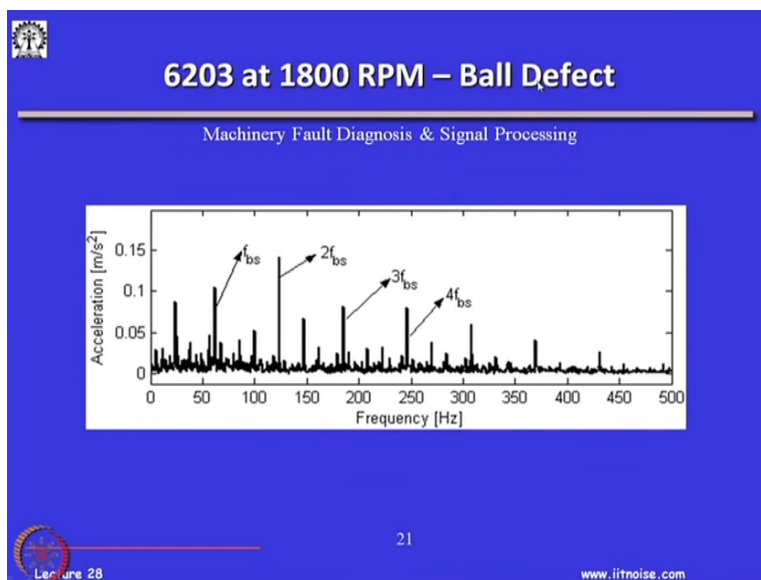
Yes two outer is less defects 180 degree apart in this case what we did as we created one defect here and then the defect here okay.

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And this is for the less defect some time you will see the shaft frequency is showing up because inner race is shaft.

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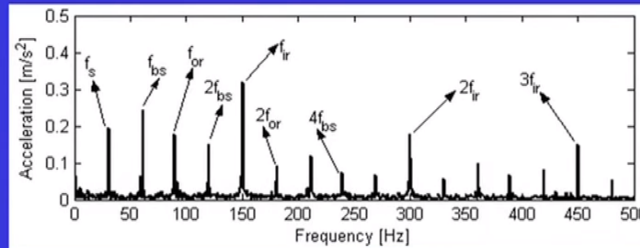
And here when we have a ball defects and the defect in the ball frequency will show up.

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6203 at 1800 RPM, IR, OR & Ball Defect

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And how are the frequencies is calculated this is inner race outer race all three were there okay. What I am going to show you is this equations so these equations are there in the books this equation you can know only thing is that you have to know the ball diameter, pitch diameter and contact and find out this and then you can find out okay.

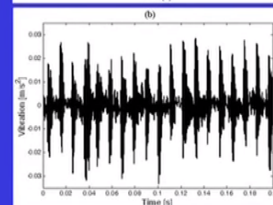
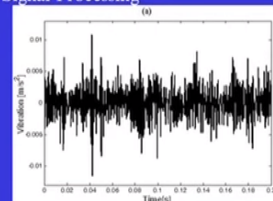
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Ball Bearing Vibration Signals

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- Defect free case
- One defect in outer race



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So a this is usually what you will see when you measure the vibrations out of a bearings in case of the defect free and in case of defect okay.

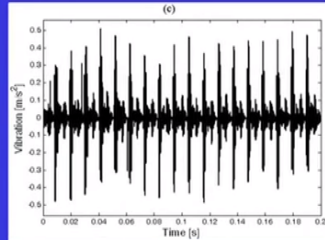
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Ball Bearing Vibration Signal (Cont' d)

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- Two defects in outer race



Kurtosis value of the signal gives a clue about the bearing condition.



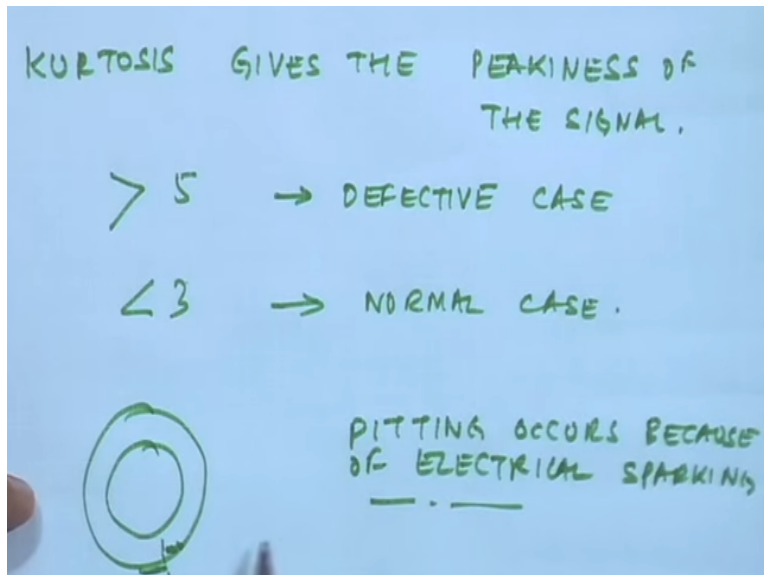
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And this KURTOSIS value gives you can indication as to why this fault whether as occurred in the bearing okay. You blindly pass it through a signal processor where in you just calculate the kurtosis of the tanned signal.

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And usually kurtosis gives the peakiness of the signal okay and usually kurtosis value is greater than more than 5 in case of a defective and less than 3 is normal okay. because if this bearing faults go unnoticed for example a crack in a bearing outer range if it goes unnoticed we are going to have problems the bearing will fail okay. And many time I will tell you other case study in a many times when in a particularly in a electrical motor when there is a electrical conductance

And this flux gives rise to small ground voltages okay and this at the bearings because the all film that is the sparking very significance parking occurs. So this grounding does not done properly this sparking is going to occur and this sparking is giving rise to pits so if a bearing goes dry not lubricated not properly careful pitting marks will occur pitting occurs because of electrical sparking so this is going to give rise to the initiation of the defects okay.

Ununiformed wearing again gives rise to ununiformed clearances and then forces are going to vary support forces are going to vary. Again this is going to rise to fatigue loading so it is actually a domains effect one leads to another okay. So we have to careful whether you know who came first.

[illegible]

So I will give you as closer I will talk about a small case in a particularly in a paper mill wherein we have to be careful about the supporting the bearing which are there in the number of roles which are there in a bearing. So this is the flow chart of a paper mill basically you will have the this area where the pulse etc., come okay the paper part etc pump and then they are faded next with the casting so that clean, bleached impurities are removed.

And this pulp paper pulp is actually fed through a wire press wherein the wire is going in and then basically their pressed here the first stage are the water is squeeze out from the pulp okay. And this pulp is made through pass roller wherein we do lot of drain so initially once you dry this wet pulp okay immediately then slowly this paper is going to get formed and paper will be pass through about the dryer big drying drums.

And each of them supported on roller on bearings and bearings are and they are stinted dry there are steam went to the drums. And eventually and they are you know hot pressed after the dryer is called Cal ending operation and finally they are put it into roll and then the rolls go to the mark. So if you see in the typical paper mill there are about 200 to 300 roles just roles rotating at typical speed about 1000 meters per minute.

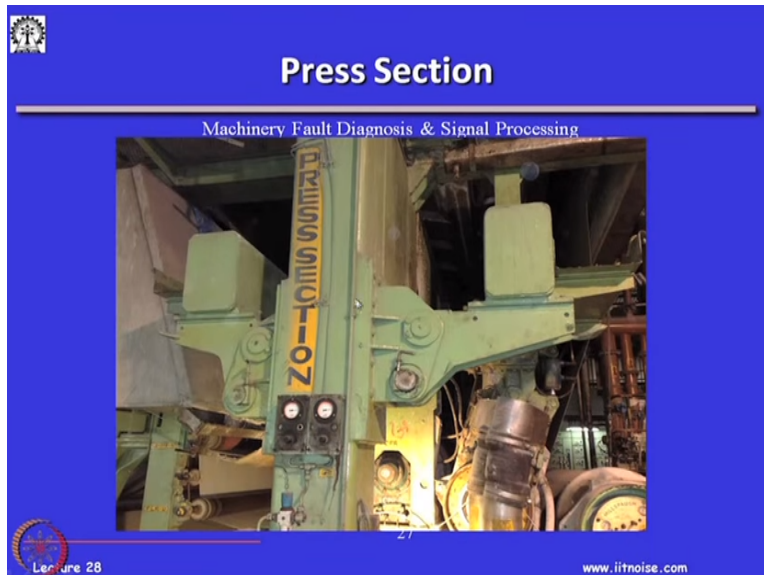
That speed a 1000 meters per minute this paper come about 1000 meters per minute and then roll typical production about 80 tons per day in a 80 tons of paper per day particular the new spread okay. And this bearing one bearing fails because this is the operation in serious everything as to be shutdown.

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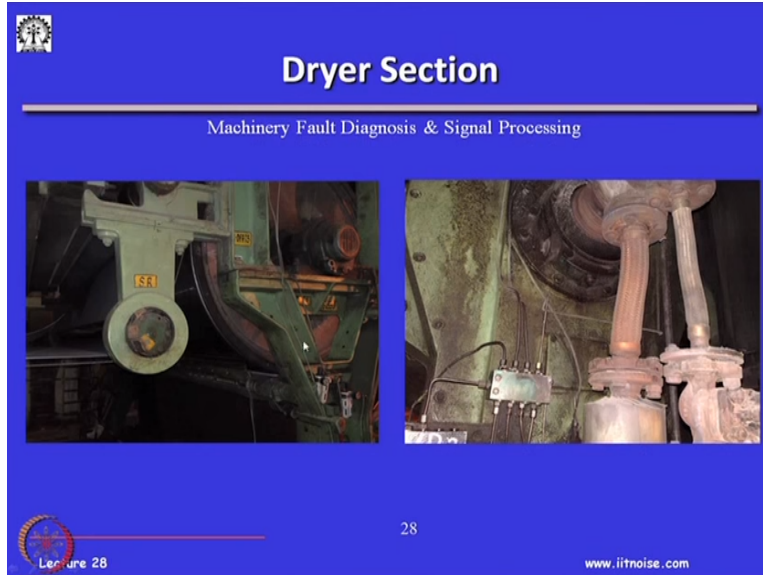
So this bearings have to be monitored around the clock this is one view of the press section near the washer wherein the pulp has been fed this is the wire on which they take of roll this is a very big role you can see is standing there is about 1 meter to 2 meter in diameter okay and then going through this rolls.

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And then this is the pressing section there are few presses here and other side you will see this is the rolls coming in here and this particular plant.

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And here then you will lot of drums a big drums and in one drum one side of the drum where actually steam going in heating the drum. So drums are very hot okay because the water as to be dried after you pressed and removed the water from the paper pulp it has to be dried over series of rolls okay.

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And then these are the bearings another view every roll there is a bearing here and you will see in such a plant the bearings are monitored by vibration you see this white lines here. This is a bearing transducer here another bearing transducer here another bearing transducer here. So round the clock vibration monitoring of this rolling bearings and then there are diagnostic

algorithm wherein a people can know which vibration signal is coming from which bearing what is its kurtosis value what is the spectrum value okay.

And if you because this are very critical operations because imagine if one roll breaks and falls it is going to damage few other rolls it is going to damage few other bearings and to put everything together you can imagine the problem one as to face okay. So everywhere depending on the criticality of the equipment of the process plant monitoring of rolling element bearing is essential okay.

And particularly in paper mills etc., this monitoring of bearing is done sometimes continuously online through these and now a days this state of the art is write at the bearings they are having transmitters wireless transmitters. So that in an complicated plant we need not have all the cabling coming to the junction rather you have over the wireless and with the proper routers have signals you know which are coming in and then sitting somewhere remotely in the control room we can know which bearing signal is where.

And people are now you know in fact monitoring them over the internet okay sitting in Kharagpur you can be monitoring plant in Malaysia okay it is possible it is no longer you can be having your paper mill in Spain and you will monitoring bearing at Kharagpur okay and then we can be giving them a diagnostic measures so they have to take okay thank you