Acoustics

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Module 7-Sound in Public Places and Noise Management

Lecture 6

Noise in Machines, Basics of Noise Management

So once you have this then what you can do is you compute this parameter called L W it is sources acoustics strength.

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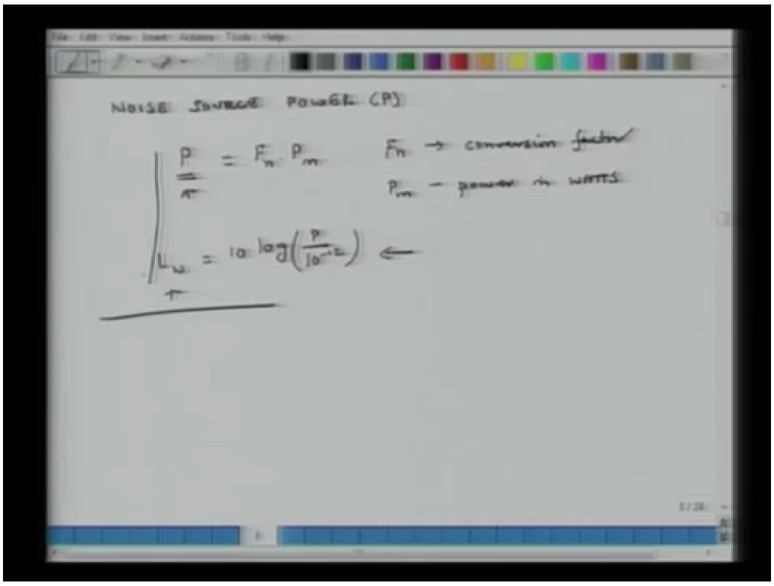

And that is basically 10 log P over her reference power which is 10 to the power of minus 12, reference is 1 Pico watts. Now this again a very course approach in several machines the manufacturer of the machine will himself provide you this value of P or the value of L W, so in that case you do not have to resort to this (())(00:48). So then based on this if you know that ok I have 20 pieces of machinery in this whole setup or 20 different sound emitting components right and each component you can figure out this is LW1, LW2 so on and so forth.

Then what I am measuring is some noise spectrum which has certain amplitude at different frequencies then based on that also you can map how much sound is coming from how much noise is coming from which particular component. So it gives you some course understanding of that ok. So with this deep discussion will talk about noise signatures.

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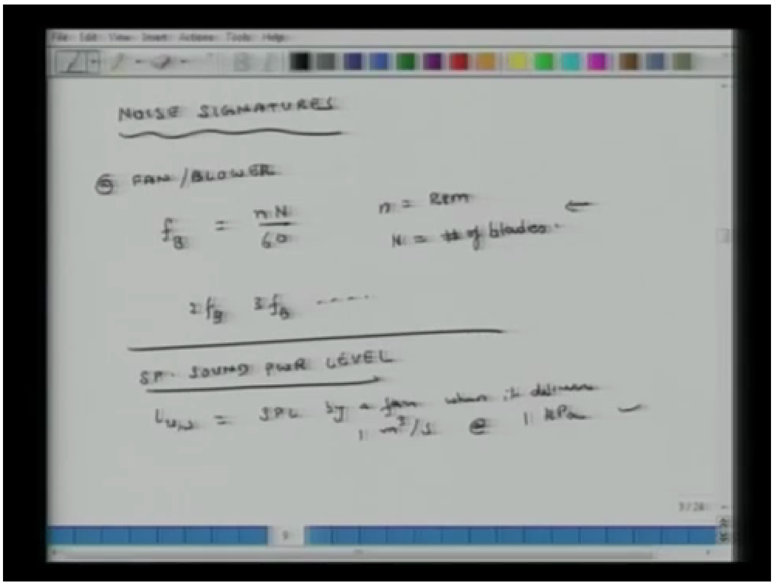

So if I have a fan or a blower so we are not talking about ceiling fan, the fans which pump air then they generate a fundamental frequency F b which equals N times N over 60, so N is the RMP and n I have it other way, n is the RMP and upper case N is number of blades.

And this makes physical sense if I have fan five blades then each time a blade passes through the opening it pushes air into that thing and if it is doing N times and there are five so uhh things then it is 5 n get it. So this will be fundamental tone it will generate then it will have second harmonic, third harmonic so 2 F b, 3 F b and so on and so forth. In case of fan because these generate a lot of noise once we have figured out yeah L W right, then at this point we also introduce another term called specifics sound power level.

Specifics sound power level, and this particular parameter helps me compare noise characteristics of one fan with respect to another fan in a normal normalized way. So essentially it is defined as S P L, P standing for not pressure but power sound power level by a fan ok when it delivers one cubic meter of air for every second at 1 kilo Pascal's. So it is 1 kilo Pascal's above atmospheric air pressure. So if I have two fans totally different fans one is delivering 20 cubic meters at so many Pascal's and this one is delivering some other number of cubic meters at some at other pressure level.

If I bring it down to this specific sound power level I can figure out how much noise is generated (by), I can compare the noise characteristics of two fans ok. So on the second table which you have in hand ok and this is actually a good chart good reference one. What you have on table 14.2 uhh different frequencies actually the frequency bands, so you have a frequency band from 63 plus some hertz and 63 minus hertz and the middle frequency point is 63 hertz ok. So that is the center point.

So 63, so there are eight bands and for different wheel size and different types of fans you have different values of this sound specific sound power level. Now you can use this chart to calculate total amount of noise emitted by a fan and will show that through an example now ok. So before that I will label this as L W S specific sound power level is L W S. So if I know the specific sound power level of a fan and if the fan is running at some at other RPM (()) (05:45) is emitting or producing air at some other value.

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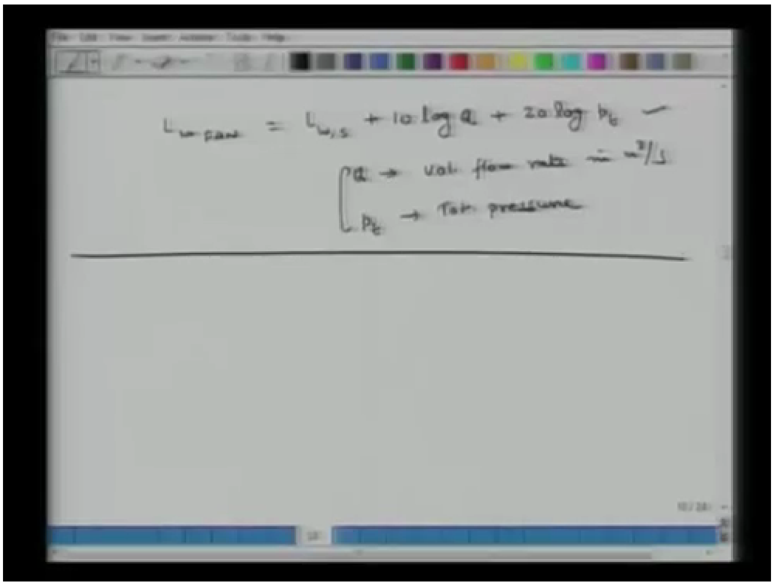

Then LW fan which is the actual noise generated is basically L W S plus 10 logarithm of Q plus 20 logarithm of P T. Q is volume flow rate in meters cube per second and P T is total pressure ok. This relation is good for all frequencies which are shown in this chart except F b, because at F b it will have a peak ok. So for all other frequencies if I lets say at 63 hertz I find what is my (F) L W S first case is 85 right. So if I have a fan which is axial backward curve over 0.75 then it is 63 hertz it generates 85 decibels plus 10 log of Q plus 20 log of P T, understood.

But not, so I can use this table to the extent I am not computing

S P L at the blade frequencies. Now to compute the S P L at blade frequency the last column you have is called B F I blade frequency index, (blade freq) so you add that blade frequency index number that is also in decibels. So this is the over approach. So we will do a very quick simple example to make things better look more simple.

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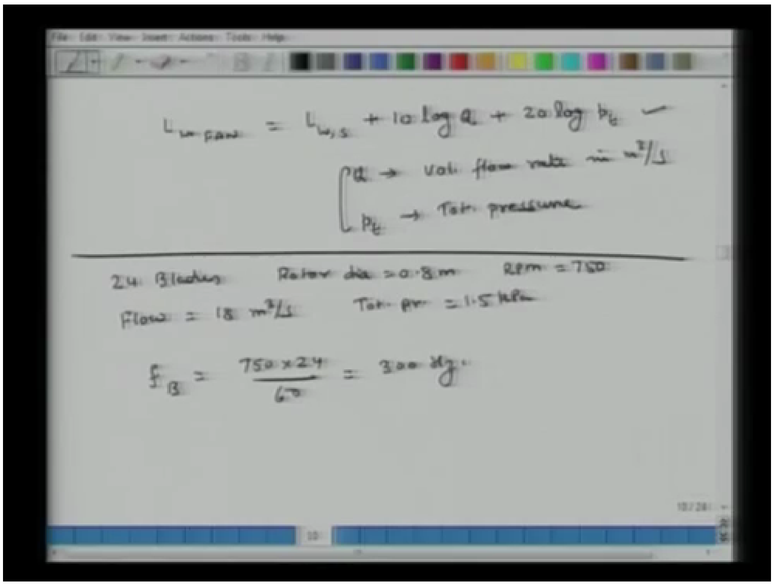

So lets say fan has 24 blades ok rotor (dia) equals 0.8 meters RMP is 750 flow equals 18 meter cube per second and total pressure is 1.5 kpa ok.

So my F b is what? 750 times 24 over 60 that is 300 hertz. What is L W S for this fan? Specific sound power level, this fan is radial curved forward, so in the table if you look forward curved fan what is the L W S, which row should I pick? The last one, right, forward 98 98 88 81 81 that row right, does everyone see that? So what I will just do is very quickly develop matrix.

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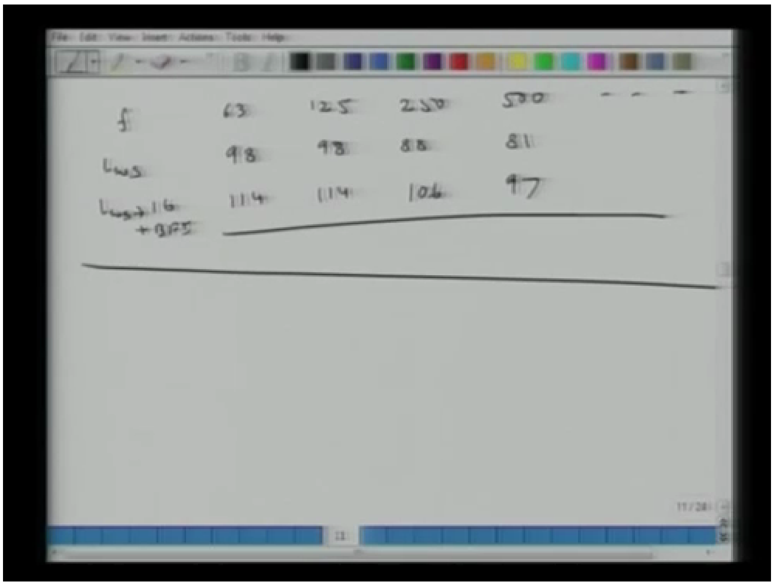

So for different frequencies you have 63 125 250 500 and I will not write all others numbers my L W S for this fan is what, can you give me the numbers.

At 65 hertz or 63 hertz, 98 98 88 81 and so on and so forth right, then my L W S plus 16 oh where did 16 come from?

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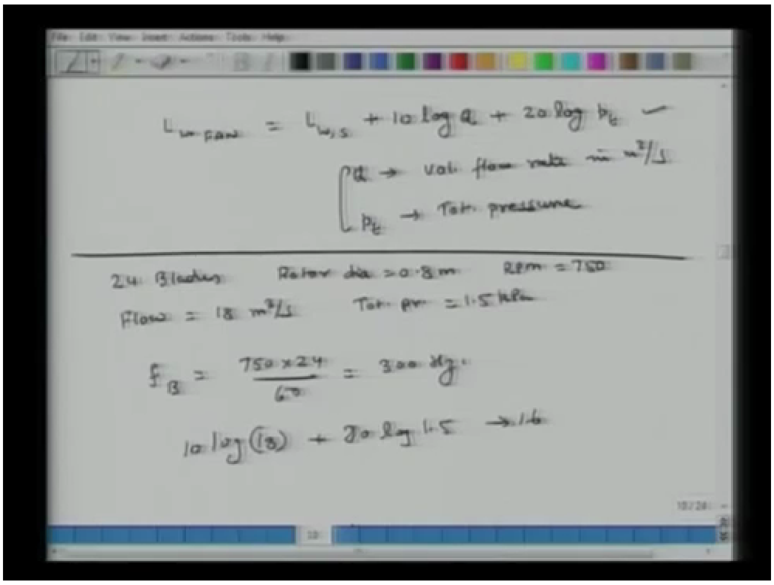

So 10 log of 18 plus 10, is it 20 log? 20, 20 log 1.5 is 16 ok. So if I add 16 to this what I get is 114, 114, 104 and 97 so this is the sound power level if this fan is going to emit for all frequencies except at 300 hertz. So for 300 hertz what is the adder I have to put, yeah that B F

I which is 2 right, so I will change this 250, 200 and what was the number? 97, right plus B F I. So this is how I compute say.

Student: sir can you repeat last point.

So you understood this right L W S plus 16 so this is (hundred and) 104 so at (200) 300 hertz I have to add 2dB's more because of this B F I factor right. So I am just changing this column and I am making it 106. Now you may also we encountered with a question that.

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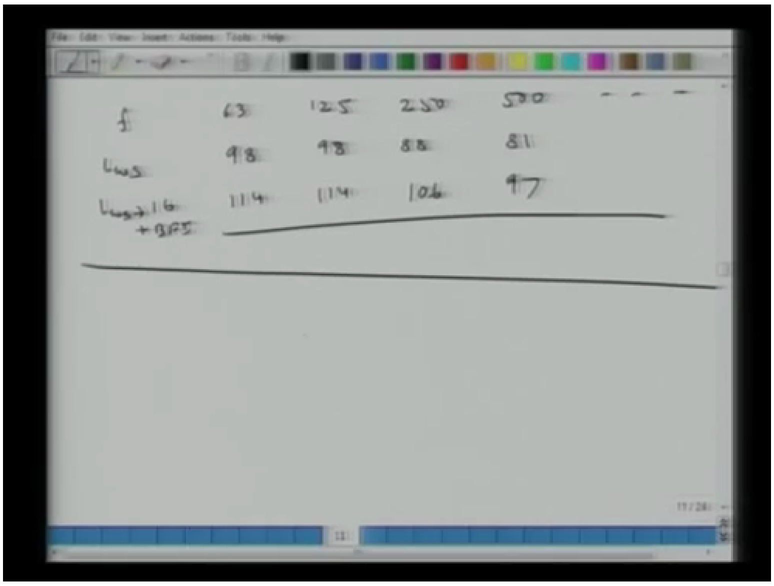

So you have a fan it has an inlet and it has an outlet. So you maybe wondering how much is contributed by inlet and how much is being contributed by outlet. So you just split it half and half. So by inlet contribution is when I do half of it what is it? What does this number become?

This is in decibels and power, so how much do I should I make it 57 or what do I do? 3 dB, because power is 10 log something so half of this noise is coming from inlet of the fan and half of this noise is coming from outlet of the fan this is an assumption. So half of the noise translates to 111, 111, 103, 94 and the other half is coming from, why do I need to know this? Because now if I have to do some A N C active noise cancelation I can actually place a small transducer in the inlet and it will correct the signals that is why I am saying.So this is the signature for a fan.

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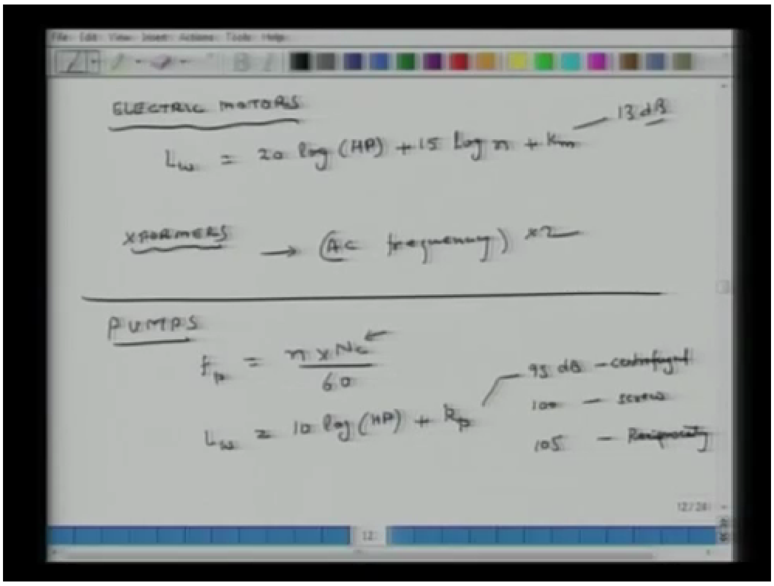

Electric motors so this is just to give you a flavor that depending on which type of machine do your components you have, you have to figure out what are the noise signatures of different components. So for this L W is 20 log of power but when express power and horse power because most of the motors are rated in horse powers plus 15 log N where N is the RMP plus K M, typically this K M is provided by the manufacturer or it is quite often used as 13 decibels.

Transformers, does transformers have any moving parts? But still it generates sound. If you go by some of these big transformers on the roads you hear noise, where is it coming from? Sometime it can be appreciable the S P L

Student: vibration needs plates.

But where is that vibration coming from? Even if you put it in vacuum it will not vacuum in still air it will still emit sound. The electromagnetic forces are pulsating based on whatever is your AC frequency and they induce vibrations in the metallic structures. So if it is a 50 hertz current supply as in India then it is typically twice of that number 100 hertz signal or 120 hertz in country like USA. So lot of times some of these signatures you can attribute it to transformer sometimes you have a PCB which has an inductor on it nothing is moving and you hear that noise most likely it is coming from some inductor.

This relates to AC frequency into 2, ok, pumps so the fundamental frequency of a pump is N is the RMP and a lot of these pumps water pumps or fluid pumps they have pressures chambers so whatever number of pressure chambers cycles they have in each revolution so n times NC over 60 and for this guy L W is 10 log again a lot of this pumps are rated in horse powers so you don't have to do a lot of conversion plus Kp and Kp is again provided by manufacturer or if you don't have anything then it is 95 dB for centrifugal pumps, 100, 105 so this is for screw pumps and this is for reciprocating pumps.

So the point here is not to make you experts in pump but if you see or experts in electric motors but if you see what types of noise emitting sources are there you should be able to figure out after some exploration which type of a signal or peak is attributed to what specific sources that is all I am trying to explain ok.

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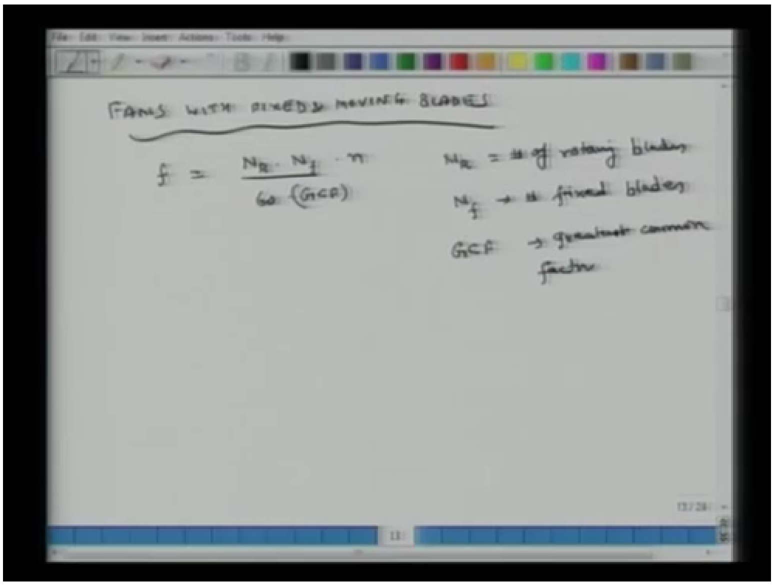

Then you have some fans which have obviously they will have rotating blades but in front of the rotating blades there are stator blades fixed blades right, stator blades.

So fans with fixed and moving blades and you have these even small electronic fans or even in compressor fans so if you have this kind of a thing then your fundamental frequency is N R times N F times N over 60 times G C F, N R is number of rotating blades, N F is number of fixed blades and G C F is greatest common factor, so we have to (())(18:02) factor. Greatest common factor of N R do you understand (why) where this is coming from? So again you can calculate the fundamental frequency of the noise generated by a fan with fixed and moving blades using this approach.

And then you find its harmonics and higher second and third and fourth harmonics and so on and so forth.

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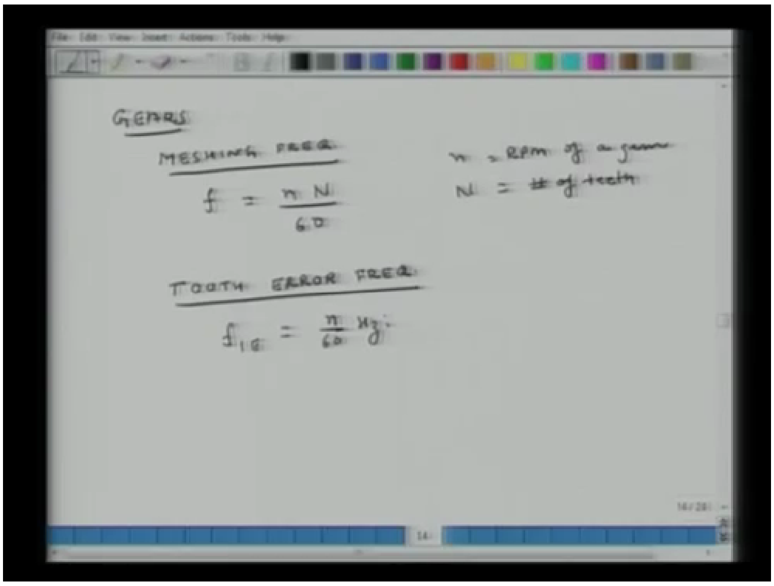

Another example most of the moving systems have gears right, and they can also generate noise on their own. So ideally a gear profile in involute you assume that teeth are rigid perfectly rigid and in theory they should not generate any noise but in realty their manufacturing errors their gaps where if there is a gap the gear will come and hit one teeth will come and hit the other teeth so it will generate an impulse force also these teeth bend in reality so all this generates noise imperfections in geometry.

So these gears generate two different broad categories of noise, one is one as a frequency which we call meshing frequency. So your meshing frequency is n is the number of teeth on a particular gear times N upper case N is number of teeth and lower case is RPM divided by 60. So if you have two gears which are meeting they have one single meshing frequency the smaller gear will have same meshing frequency as the larger gear, and then the other one is tooth error, tooth error frequency.

Student: sir what are n and N here?

So n is your RMP of a gear and N upper case is number of teeth on the gear whose RMP is n, ok. So tooth error is that suppose you have two meeting gears and one particular tooth is broken or damaged then in every revolution it will come and generates its own signature. So we call that F 1 E and is essentially n over 60 hertz right, what happens if their two teeth which are broken and they are next to each other, will it be 2 N? (Or) in that case the other broken tooth has to be opposite 180 degrees phase.

Here you will have two impacts in one revolution so it will not be just 2 N it will be a combination of different signals right, so what we will do is next five six minutes will do a example on gear then we will close and then doctor Kalyan Maydev is here for evaluations so that will close the thing. So will do one very quick example.

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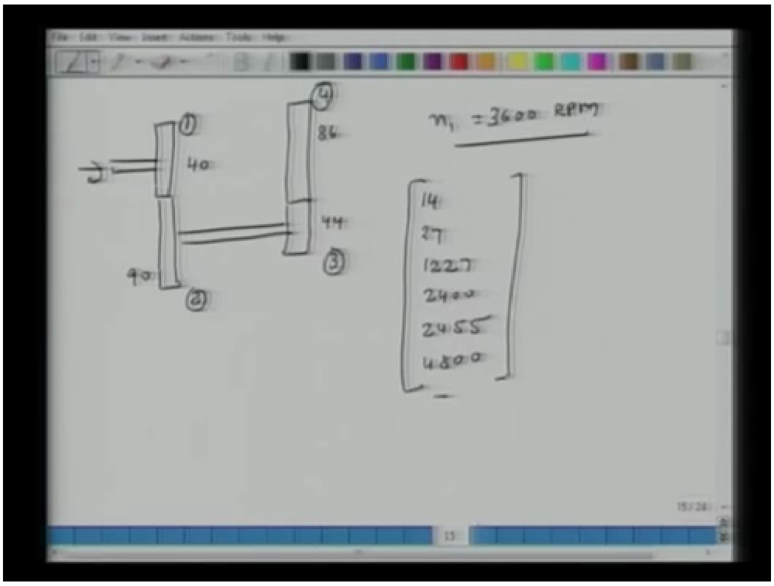

So I have a gear train (actually) this is a good simple example but pretty educational.

So I have four gears 1, 2, 3, 4 and the number of teeth on this guy are 40, 90, 44 and 86 and my n1 is 3600 RPM now when this gear train runs it is generating some noise. So I measure the noise signal I plot it on a graph sheet and I find that there are peaks at different frequencies so my peaks are at 14 hertz, 27 hertz, 1227 hertz, 2400 hertz, 2455 hertz, 4800 hertz so the question for the engineer in this case you is that, given this gear train can I develops some sort of a hypothesis that how is this sound getting emitted, what are the sources of this sound?

Assuming this gear train as the only source of the noise in the rom. So some possible explanations so what we do is we start computing different frequencies.

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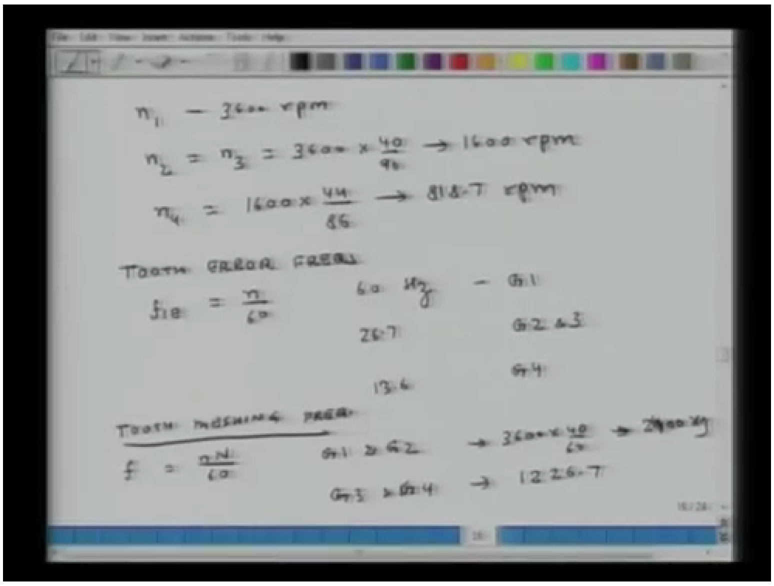

So n1 is 3600 RPM right, n2 equals n3 is 3600 times 40 over 90 that gives me 1600 RPM , n4 is 1600 times 44 over 86 that gives me 818.7 RPM ok. So now I have figured out RPM's of different gears so now I find different fundamental frequency so tooth error frequencies F 1 E is what n over 60 right, so for gear 1 it is 60 hertz for gear 1, for gear 2 and 3 it is 26.7 hertz and for gear 3 it is 13.6 hertz no gear 4 ok, so remember this.

Similarly the fundamental tooth meshing frequency so that is F equals n times upper case N over 60 so we find this for all four gears. So gear 1 and gear 2 they are meshed with each other they have same frequency that is 3600 times 40 over 60 that gives me 2400 hertz right, and gear 3 and 4 that is if I do the calculations right it is (12 12) 1226.7. Does so these numbers tell you some story? So tell me, which one?

Student: tooth has frequency of 2 by 4.

Which one?

Student: tooth error frequency of gear 2, 3 and 4 are giving the first second 14 and 27

2, 3 and 4 tooth error is for 2 and 3 it is 26.7 and 4 is 13.6 ok, so you are saying and then what about others?

Student: this 2400 and 1227 is directly you are getting, next mode is (())(26:31)

Ok, so that is one hypothesis and then how would (you) what you do is you back and then inspect those gears and see whether that your hypothesis is indeed correct or not and then you see whether another slightly different interpretation could be that 14 and 27 hertz is coming just from one gear because you would think that is another way to think about it and that is coming from gear number four. That is (another) because yeah 26.7 is also fairly close to 27 so I understand where you are coming from.

(But) A lot of times you would not have two teeth's broken teeth you not want to two gears you have a broken teeth tooth each. So that is another hypothesis so the point is that you have all these different types of approaches to figure out signatures of different moving components. So similarly there are rules and formulae for ball bearings, chains, sprockets, belts, pulleys all sorts of moving components. So you figure out what are the fundamental noise signatures from different components look at your fundamental overall noise spectrum and then try to intelligently start mapping what is coming from where.

Also some of them may not be attributable to any of these moving components so in that case you may also want to see that am I exciting some structural member. Let's say you have a wide flat sheet (meta) metallic sheet and it gets excited at 55 hertz and that is showing up. So in (that) so first develop overall map of what type of frequencies are being generated by different moving components figure out. Can you map some of those to your noise spectrum second then start turning off each of these and see.

If you turn off one particular unit what happens there, does not change anything then it is not coming from there. So it is a very iterative process and here the understanding of the physical system is probably much more important than the understanding of noise itself. So with this we come to a close. So continuing on from what we had started in the last lecture in today in the (last) final lecture what we will cover is a little bit about active noise cancelation approach and the limitations of that approach and then a very broad overview of how noise is controlled in different types of environments.

So active noise cancelation and a very broad overview of noise control in different environments, cars, machines shops, and all sorts of places where we encounter noise.

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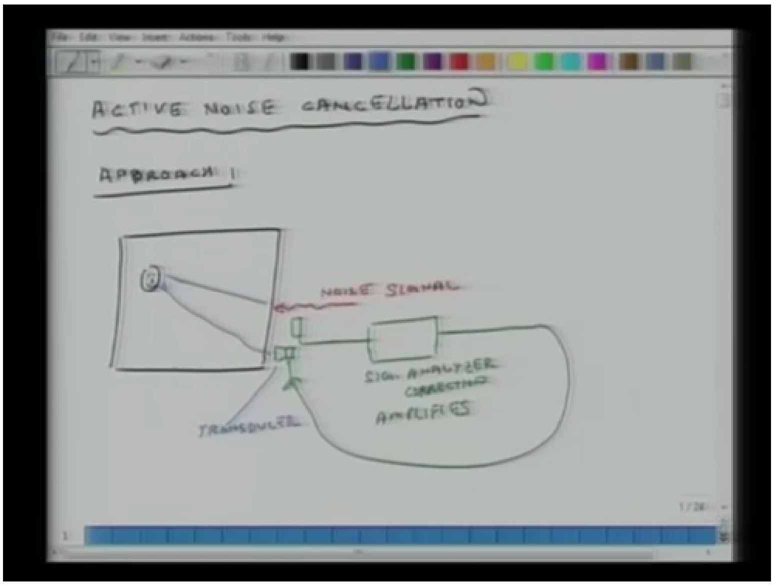

So we start with active noise cancelation and the principle for the active noise cancelation is fairly straight forward it and it is it may appear the simplistic if I say that if you have a source which is generating noise then if I generate (())(30:05) entire noise signal then it gets canceled and there is no noise.

But this is very simplistic way of approaching this (because) there are lots of if's and but's and constraints when we try to cancel noise so that is what we will try to uncover in next 15-20 minutes. So one approach noise could be canceled is will show here, so let's call this approach 1 and in this approach lets say I have a room there is a listener here and lets say noise is coming from a concentrated source so I am getting a noise signal and it is not coming from all sides it is coming from a local area ok.

So to cancel this noise what I do is I place a microphone near this noise source send the signals to a box which could be a combination of a signal analyzer and signal processor well I mean ok. So signal analyzer and corrector so it also (gen) generates correction signals and then it also amplifies to the appropriate level for every frequency and then that signal is then fed back to a transducer so it comes back to a transducer so that is my transducer.

So I have this noise signal coming and it is getting compensated by the corrective signal coming from uhh the transducer and these signals reach the human ear and arguably and will see limitations on this approach. The human ear does not perceive any noise. So now we will explore this a little more deeper at a conceptual level and try to expose some of the fundamental limitations of this type of an approach.

So the first limitation of this approach limitation 1 it relates to the time delay, so in this the limitation is caused by time delay. What do I mean by time delay? By the time noise reaches this point and it is sensed by a microphone then the microphone has its own inertia so it takes some time to sense that noise, then that noise is sent to this black box signal analyzer plus corrector plus amplifier and the electronic takes some time to develop corrective signals and that corrective signal then comes back and it is fed to a transducer.

So there is a delta T in this whole process also the location of the transducer is not identical to the location of the noise source so because of that separation physical separation of distance also there is a phase lag. So the corrector signal reaches the human ear maybe delta T seconds later than the original signal. So that has implications in terms of what does that mean in terms of how much noise really gets canceled.

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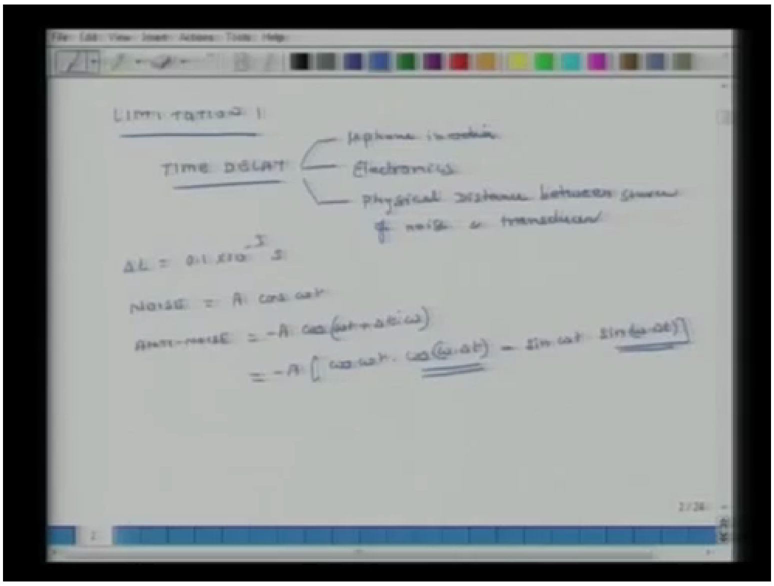

So the time delay could be due to as we said microphone inertia it could be also due to electronics it could also be due to physical distance between this concentrated noise source we are not talking about a diffuse noise source we are talking you that it is coming from a very local points kind of a source. Between source of noise and transducer which is emitting the corrective signals.

Student: Sir are the transducer canceling them? How is a transducer canceling the noise?

So in theory if I have a sine wave coming out as a noise then if transducers (sends) generates an (inver) negative sine wave whose amplitude which has a phase difference of Pie.

Student: But it again depends on where the person is, because they will be since physical separation is air and the direction is also there then the distance travel by the wave from the transducer.

Yes so that is what we are quantifying in this discussion so it this cancelation will not be 100% and that is what we am trying to sensitize you all that there is a limitation they will be some cancelation for some frequency wavelengths but it will be not a broadband 100% cancelation. So lets say because of this time delay lets assume a fairly small number of value of time delay so lets say this time delay is delta T equals 10^{th} of a millisecond ok.

So that is 10^{th} to the power of minus 4 seconds and lets assume that noise is a pure tone and it is A cosine omega T and lets say that my entire noise signal if I do everything all the mathematics and the electronics correctly that signal is A cosine what will it be? Omega T plus delta T right, times omega

Student : Plus Pie by 2.

Oh minus ok minus, so if I expand this what I get is A cosine omega T times cosine omega dot delta T plus sin omega T times sin omega times delta T. So at a mathematical level minus I put outside oh yeah there has to be minus yeah so at a mathematical level forget about the implementation even at very mathematical and the level of principle. The cancelation will be identical and hundred percent when this number is exactly zero or it will be satisfactory when this number is fairly small and also this number is fairly small like both of these numbers have to be small.

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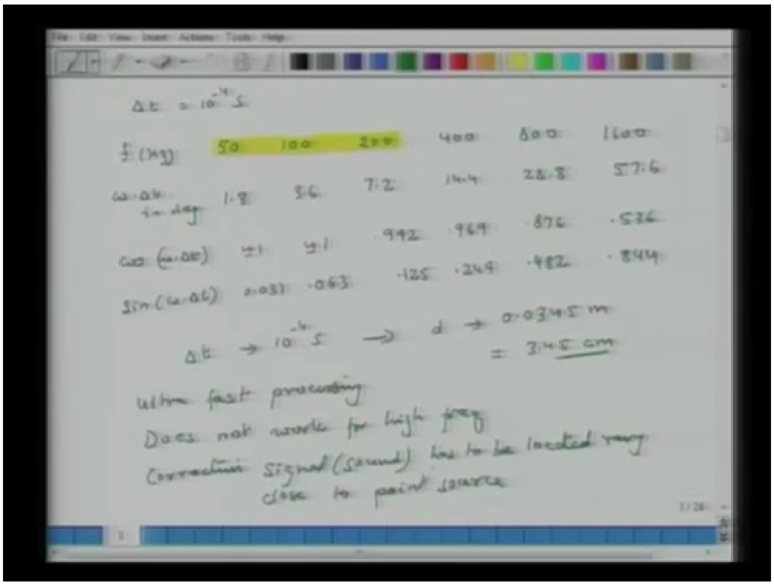

So let’s look at some actual numbers so we assume that delta T equals 10 to the power of minus 4 seconds and we evaluate for different frequencies what are the cosine omega delta T and sine omega delta T terms. So I am putting frequency in hertz 50, 100, 200, 400, 800 uhh lets also put 1600 so omega dot delta T and this is commutative radiance but if I transform to degrees in degrees my value is 1.8, 3.6, 7.2, 14.4, 28.8 and 57.6 degrees.

So as frequency goes up very rapidly my theta is increasing and when you look at cosine values so this is approximately equal to one this is again approximately equal to 1.992, 0.969, 0.876, and this is 0.536 and the sine value is 0.031, 0.63, 0.125, 0.249, 0.482, 0.844 what you see is that maybe just looking at some broad numbers maybe this approach will work upto 100 or maybe 200 (degrees) 200 hertz.

Above that things become the sin value starts between fairly appreciable, starts between fairly appreciable. Also to give you a perspective delta T (in) if all the delay is a caused just by the physical separation and the electronic delay is zero which is not true then delta T at 10 to the power of minus 4 seconds it corresponds to distance of what, 0.0345 meters that is 3.45 centimeters. So things have to be very close to the noise source and we are also assumed that the noise source is more or less a point source.

So there is a fundamental limitation in this approach. So it does not work for high frequencies the good thing about it that if it works when the person moves from one place to other place he will still have the same amount of attenuation noise cancelation, because it does not depend on the location of the person but the canceling unit has to be fairly closed to the source and the overall time delay has to be fairly small.

Student: But one thing can be done if that from the formula if omega delta T is to n Pie sir then even if their time delay the it will be exactly exact noise cancelation.

So what you are thinking is that all the noise is purely sinusoidal.

Student: No sir that is, for this case I am saying.

Yeah-yeah for this case but in reality noise is noise so it is essentially a very transient signal so if you have induced a delta T of 2 Pie then it will be totally off in real noise conditions right, so that is (())(42:28). So again so first limitation we said is that so will just write some limitation so it requires ultra-fast processing does not work for high frequencies and the correction signal or sound actually not the electronic signal the actual sound has to be located very close to point source.

So this approach may work where lets say you have a generator which is running at a constant speed at fairly low frequency 40 hertz, 50 hertz, 60 hertz, 80 hertz so and then the person is fairly far away from that so then if you place a transducer and correct it you may have a very good uhh performance but of the source generates a broadband noise then high frequencies will not get attenuated and also if the source is distributed for instance if you are moving in a train all the walls of the train or if you are in a plane noise does not come from just one source. So this approach has limitations in that sense.

So then the other extreme approach so here you have in this approach the transducer is very close to the source the other approach is you put the transducer very close to the ear that is other approach so will talk about that also.

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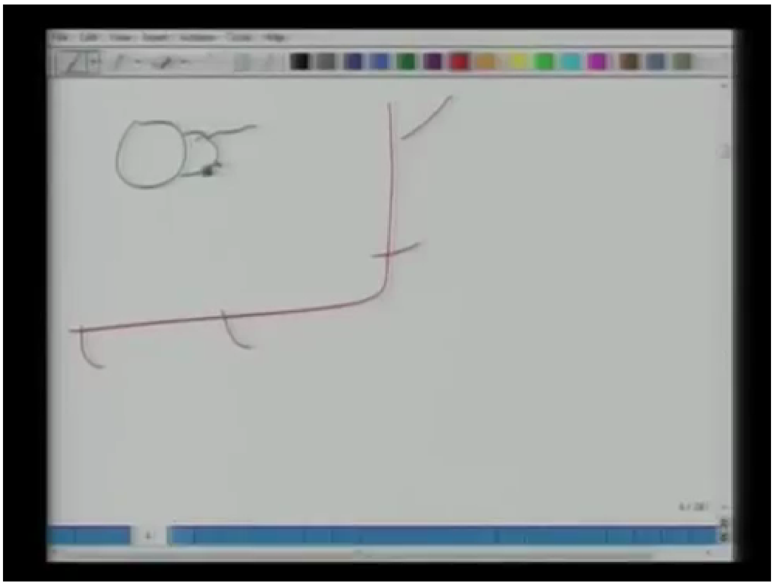

So you have the person and the noise is coming like this lets say this is his chamber through which noise is going in and hitting his you place a transducer here and also if a microphone could be place here then it does not matter whether the noise from which point the point is coming from.

The noise is being sensed fairly closed to the ear and the corrective sound is also being generated fairly close to the ear so because of this, this kind of an approach can handle sources of noise which are distributed in nature but even in this case (the) you do not get away from the fundamental paradigm that delta T still has to be fairly very-very small because of all the reasons which we talked about it has to be very close to uhh I mean because at very high frequencies or at high frequencies the requirement of delta T becomes extremely important.

So this approach also does not work well enough at high frequencies but most of the attenuation at higher frequencies happens fairly well with passive approaches like you have a damping material on the headsets so that those materials damp out high frequency. But this approach also work fairly well for low frequency content. Biggest issue with this is that you have to wear this device as you move so which is not a very appealing approach.

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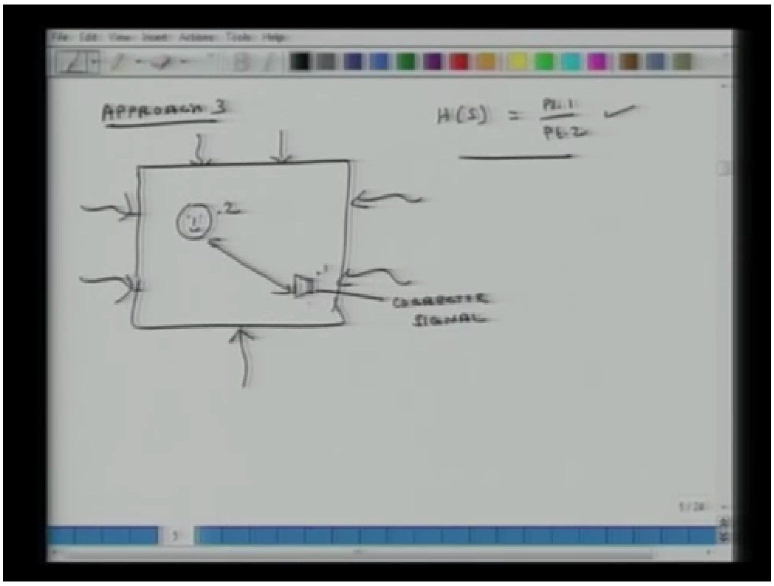

A third approach is something like this so approach 3 is such that there is a room here the individual here sitting here and lets say your noise is coming from all directions like, so again the noise is distributed if this person is sitting at a fixed location the I can place a transducer here and this transducer generates the corrector signal and how does it generate corrector signal? To understand that first you measure the transfer function H S between 0.1 and 0.2, so between 0.1 and 0.2 we measure the transfer function.

What that physically means is that the transfer function means is that if I generate a particular sound profile at 0.1, what will be its frequency spectrum at 0.2? Right, that is what transfer function is all about. So based on that understanding and also if I so once I have this H S which is a fairly (stan) easy thing to do. You generate a broadband uhh noise source here you measure it here and then you take the ratios at every frequency you have your phase and magnitude plots for this transfer function.

Once you have that then if you know what noise is coming at location 1, then you can compute what noise is being heard at location 2 right and from the same principles you can also figure out what kind of (noise) what kind of corrective sound has to be generated at location 1 which will compensate that noise at location 2. So using such a thought process you can develop a system which helps attenuate distributed sources of noise. How do you measure H S? That is fairly straight forward lets say you

Student: before applying the process we first calibrate it?

Yes so have to initially you have to place a microphone at this location and calibrate it right, you have place a (microphone calculate). In this approach also the requirements of delta T do not go away that is a fundamental so this approach also does not work for high frequency that is one, second if this guy moves to a different location if the person is moves to a different location then you need to have a new transfer function so the validity of this approach is to the extent that the person is fixed in the room.

A good example could be that if you want to attenuate sound noise levels in a car which is moving and lets say noise is coming from the engine then because the person is fixed in a seat more or less then you can use this kind of an approach to cancel that noise. Another limitation of this is that because this distance is large, because this distance is large and there maybe sound sources which are fairly close to the human ear by the time this corrector signal reaches even for low frequency content there are some noise uhh there is some noise content even at low frequencies which reaches the human ear significantly before the corrector signal comes then he has already heard it (that person).

So that is another limitation, then it adds up to the noise yeah at a very basic level it is very people say oh you just generate (())(51:15) noise in it will get cancelled but it is very complex technical problem and there are physical limitations in what can be done and what cannot be done governed by laws of physics. So with that overview of some basic strategies how noise is cancelled will move to noise control.

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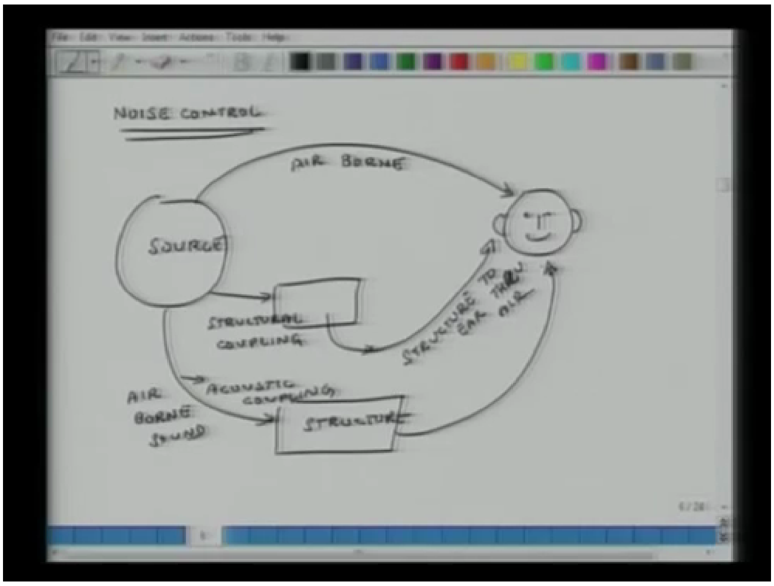

So my aim is to minimize the noise human being is hearing right, and to do that I have to understand how noise is getting generated, how it is getting propagated from the source to the listener and how it is being interpreted. So once I have understanding of all these three things then I can figure out how to control and regulate noise. So at a very conceptual level you have a source and I have a listener, some of the noise reaches this individual directly, so the source just emits noise and atmosphere in it radiates and reaches the human person.

In other cases the source is also vibrating and these vibrations get transfer to other structural members of the system for instance you have an engine which generates vibrations because of that the transmission and a car vibrates and that generates its own noise. So structural coupling, structural coupling and two structures are coupled one is not generating a lot of noise in decibel levels but it is generating sufficient amount of vibrations to excite resonances in some other physically coupled structure.

So this guy goes into resonance and this emits sound and that sound reaches the human ear, right. So structure to ear through air so that is the other path (and) the third path is that I have airborne sound which excites some other structural member so here the coupling is what acoustic coupling, this is acoustic coupling and then from here some particular modes and resonance is get excited, so again sound reaches the person.

Student: sir what is structural coupling?

Structural coupling is that pieces are physically connected, so you have an engine lets say its first resonance happens at maybe (5) 1000 hertz but it generates some low level of frequency content at 200 hertz and it is coupled to a big sheet metal structure whose resonance is at 200 hertz or maybe 50 hertz so it gets excited that is structural coupling. So to control noise you not only require a good understanding of principles of acoustics but more than that you have to understand what, the nitty-gritty and details of the physical system which you are trying to monitor, that is more important than just understanding physics of sound.

Because what you will not understand by just understanding the physical principles is, what are the different signatures of different types of noise and frequencies which are getting emitted by different components. So once that understanding is there then in a very broad sense some controls strategies you can develop.

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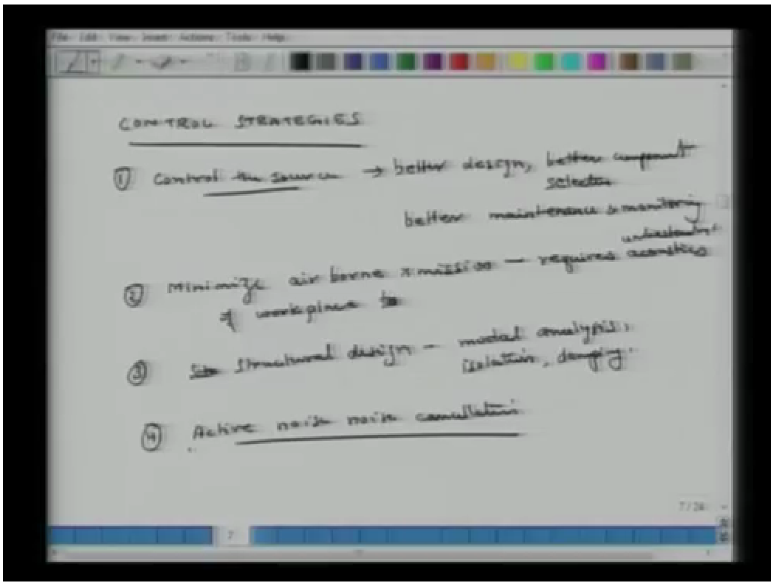

So first one is that we control the source, and control I am not talking in the sense of control theory just so you can do this by better design if the product is being developed that to design, so you are at a design stage

So better design, better selection of components and better maintenance this is extremely important, maintenance and monitoring ok, so this is how you control the source. The second thing is this airborne element right, this one so that to address that you do minimize airborne transmission and here we have to understand the acoustics of the works place requires acoustics of workplace requires better, requires understanding of understanding of acoustic of the workplace, so whether I have resonance modes and the room reverb times and all the discussion which we talked about earlier.

What can you do about this one, so this is structural coupling, how do you addressed this?

Student: Sir (())(58:20) come under the controlling lessons.

No controlling source is basically (())(58:25) engine which is vibrating a lot if I can balance it for better and so it generates less vibrations or lets say it is still generating at 80 dB 50 hertz vibrations signal and that gets coupled to a sheet metal lets say roof of the car so ten the roof of the car starts getting excited because its resonance it is, is at 50 hertz.

Student: Change the resonance frequency damping.

So yeah so on the structural coupling side you have to do basically structural design, mode analysis, isolation it does not have to be necessarily physical isolation but isolation in the sense that sound doesn't end vibrations do not propagate easily.

Isolation damping and so on and so forth right and the final one is active noise cancelation. So people start with active noise cancelation but this is in general the most costly and probably the least effective approach in general but if you already have a problem hand then it is definitely looking at active noise cancelation approach but if things are being designed they are in getting you know people are planning then all these considerations could be kept in mind while the whole system is getting developed.

So at for each of these and actually most importantly for this source we have to understand what kind of signatures different types of sources generate for instance if I have a shaft which is rotating at 60 hertz and it has a little bit of eccentricity so instead of rotating just on access it will do this it will wobble a little bit. So we have to understand what will be the frequency of sound it will generate, so obviously it will generate 60 hertz because it is rotating at 60 hertz and it is wobbling.

So for different moving components it is good to have a broad based understanding, what kind of signals different types of components generate because then when you look at the overall noise spectrum which the ear is listening or the microphone is capturing then you say oh I see a 100 hertz peak and this whole machinery is having this particular component which could generate a 100 hertz signal. So then I co-relate that peak to that particular component and then I explore it further and try to figure it out.

So what we will do today in the remaining lecture is just expose you to few different types of machines and see what kind of noise signatures they emit ok. So we will start on that the other thing is that so that understanding the noise signatures of different components moving components is one thing the other thing is getting some very cores not accurate to second place or even first place very cro-corse understanding of what is the total sound power level this different types of components are generating. So that is another understanding we have to have, ok. So we will start talking about noise source power level.

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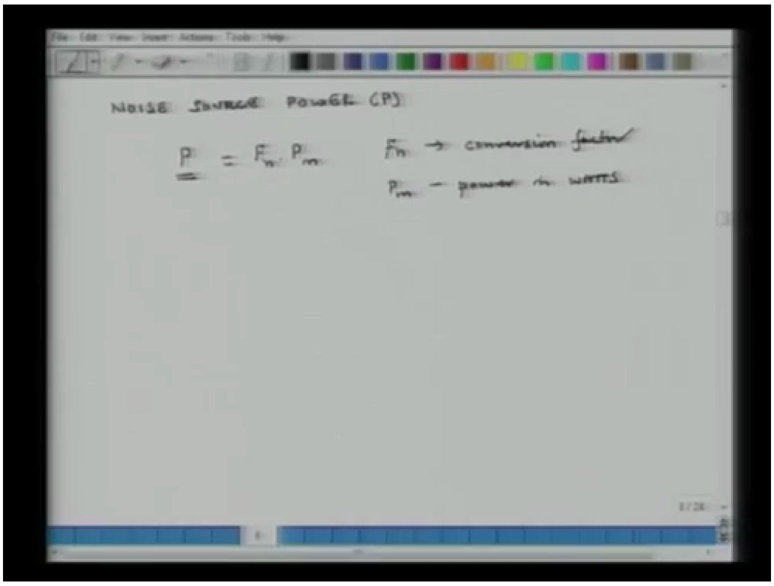

You can call it P and this is in watts. So this is (the), this particular relation P equals F N dot P M this is an empirical relation. So I am not going to offer any proof or anything like that, where F N is a factor conversion factor and P M is the actual power of that particular machine in watts. So in the handout which you have if you look at table 14.1, what you have is different conversion factors for broad types of some machinery.

For instance, compressors you have 1 to 100 horse power and if it is low power compressor then it is 3 times to the power of minus 7 and so on and so forth. So there are standard some of these data there you can extract that data and get some broad corse understanding of what is the noise source power level emitted by a particular type of machinery you can figure out from that.

Student: sir what is this low (())(64:17) and high power?

So this is dependent on the power, how much power they are transmitting which is basically (())(64:27.6) times omega.