Noise Management & Its Control
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Lecture – 47
Measuring Sound Power Level – Fan Noise – Part II

Hello, welcome to noise control and its management today is the fifth day of the on-going week and what we have started discussion over last couple of days is how to compute L w for different machine components and just yesterday, we started discussing how to compute, L w for fan and in that context what I had mentioned is that such computations require a very organised and step by step way of approaching, the problem and specifically in context of fan what I mentioned is that the first step is to identify, what type of fan, we have the second step is to figure out how does noise, which is generated inside the fan gets out. So, we have to find the pathways through which noise comes out. The third thing is then we have to figure out that what is the proportion of noise which can come out from these different pathways.

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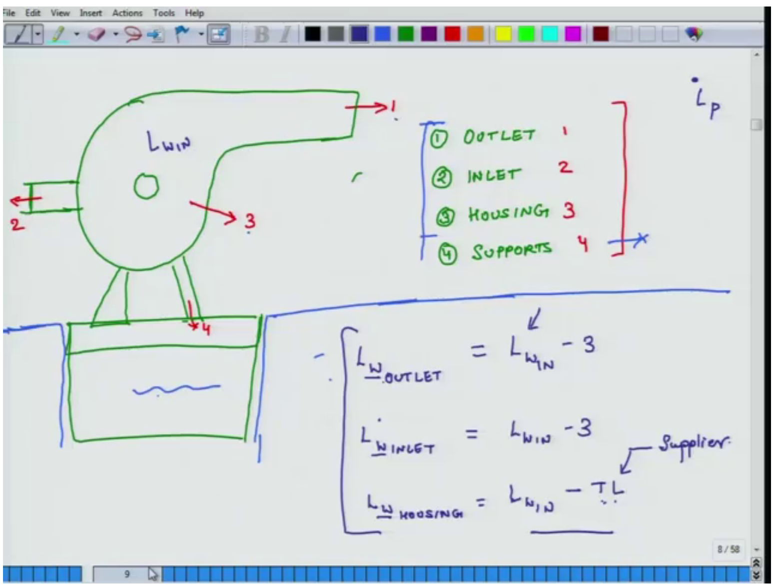

So, once again I will draw the picture of a fan or actually blower. So, that is it is sitting on a foundation. It also has an input inlet, this is the outlet. So, the four pathways we had discussed were outlet second is inlet, third is it can come out through housing. So, this is. So, this is 1, this is 2, one this is two path the third path is through the housing. So, that is housing and the fourth possible path is through the supports or foundation these are four possible paths and then you have to estimate, how much sound possibly can come out from these four paths. So, the fourth path is through here.

Now, based on experience of lot people, who have dealt with this noise and also available literature and also if you are a good engineer, you can always design a support, in such a way that first that the vibrations, which go into the foundation. They do not extend larger into the room, how do you do that? Basically, the fan could be mounted on a foundation like this. So, the remaining room could have a separate foundation. So, it is physically not connected to. So, this is the foundation of the whole room and this is the separate foundation for the fan. So, physically this foundation and this foundation are not connected and because of that whatever vibrations are here, they do not propagate into the room. So, these four pathway, we can just avoid it and kill it. So, no sound comes out from here. So, the amount of sound, which is leaking from this four path we can say it is negligible, we can ignore it then what about these two paths, first, second and third.

Now, imagine that the outlet is open and the inlet is open and of course, the body is also vibrating and what you would expect is that roughly half of the sound will come out, because the amount of sound, which leaks through the body, it will not be that large compared to amount of sound, which comes through the outlet. So, roughly half of the sound will come from path, one half of the sound from path two and there will be some sound, which will come out through the housing vibrations and a lot of people have done studies and experiments and this is indeed, what they have found out that L w for outlet.

So, suppose, it is generating sound inside and the sound power level inside is L w in. So, L w which comes out through outlet is roughly L w in and I said half. So, half means how much dB less 3 dB less. So, minus 3 the same argument holds for inlet also. So, L w inlet- is L w in minus 3 dB and then the question is how much sound comes through the housing and the answer is it depends how strong, how stiff the housing is. Suppose, the housing is very flimsy and it can vibrate very easily, then it will be a large source of vibration.

So, it depends on the stiffness of the housing. So, L w housing is equal to L w in minus a number known as transmission loss. So, the housing, when I fabricate or the supplier, whenever the supplier, who sells the fan he will actually specify what kind of decibel loss will be there, because of the housing. So, this number is going to be provided by the supplier or the vendor and again all these are frequency specific including data on transmission loss. So, here I can. So, what am I interested in; I am interested in L w outlet, L w inlet, L w housing, because these are the numbers which I can put in my equation to compute L p, because I am interested in finding out L p here, that L p will essentially depend on what is l L w 1, L w 3, L w 2 right. So, I have to compute these. So, what these relations tell me is L w outlet is L w in minus 3 same relation for L w inlet and same and L w housing is L w in minus transmission loss. So, now, what is L w in? that is our question.

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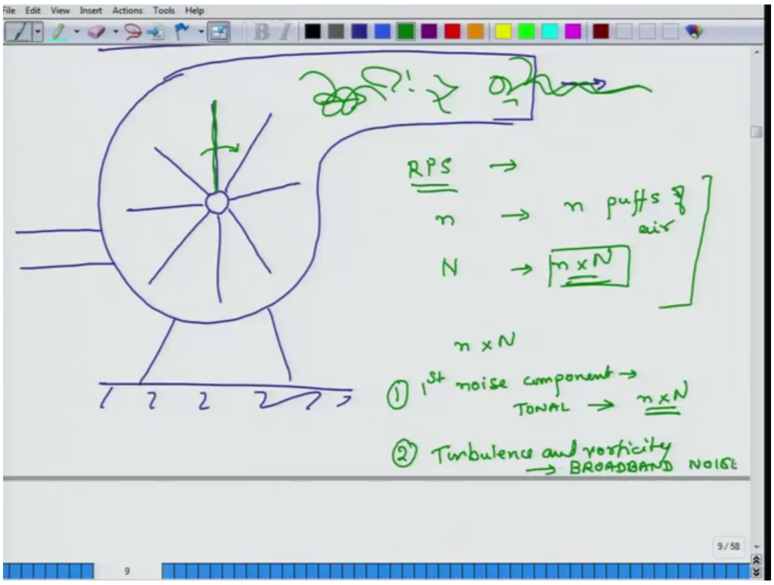

To understand that, we have to now go to the next level of detail and we have to figure what kinds of noises would a fan produce, it will depends on its geometry construction and all that stuff. So, internally what kind of noise it will produce. So, how do we find out, L w in for fan, this is what we are interested in finding out.

Now, think about it. So, you have a fan or actually it is a blower and it has lot of blades. So, you have to look at the construction and based on the construction you have to figure out, what is what will happen and of course, this air coming in and air is going out from here as the blade, blades rotate what do they do when say let us say this blade, this green blade, it comes to the outlet side, what does it do or forget this one, consider this blade as fan is rotating, what does it do as it comes in front of the outlet? It pushes air outside. So, this blade will push air outside and then it will keep on rotating and one, it is one whole revolution is complete; it will again push it outside. So, each blade will push the air outside based on how, what is it is RPM or RPS revolutions per second. So, if there is. So, if this fan is rotating at some. So, many revolutions per second, each blade will generate. So, let us say, this number is n, then each blade will generate n puffs of air, each blade will push air n times, every second and if there are lots of blade, then total number of puffs, which will go out will be what it will be n times N. So, this is how air is coming out.

Now, it now as air is coming out it is coming out in small puffs and the number of puffs each second is small n times, capital N, and because of this the sound also comes out in puffs. So, one type of noise which will come out from this will be having a frequency of this thing n times N. So, first noise component, it will be tonal in nature and what will be the frequency of that sound, it will be n times N, n is the R P S and capital N is number of blades n is the R P S. So, this is based on some physical understanding of the problem based on the physical understanding of the problem. So, first noise which will come out of this thing will be tonal, it will be like, it will be directly related to this frequency. The second thing is as noise air comes out, you know it will not just go straight it will also have some turbulence, and it will not just come in a straight way, because of turbulence and vorticity and all that factors.

So, because of all that complicated motion of air, a large amount of noise. So, some are noise will be having a particular frequency, but some noise will have all sorts of frequency, because when air, there is lot of turbulence, there is no fixed pattern around it. So, then there will, because of turbulence and vorticity. We will also have broadband noise.

So, what does broadband noise mean, that it will have a large range of frequency, may be it will start from 100 hertz, 101 102 and it may go up to several 1000 hertz. So, all sorts of frequency will there, be there, but on top of that this particular frequency, may be stronger, that particular frequency may be stronger. So, again, we are still not doing computation, but it is important to understand the physics of the problem, before we start solving the problem mathematically. So, this is what is happening. Now, based on this understanding a lot people have done experiments and they have come up with an estimate of L w in, remember L w out, we have already discussed.

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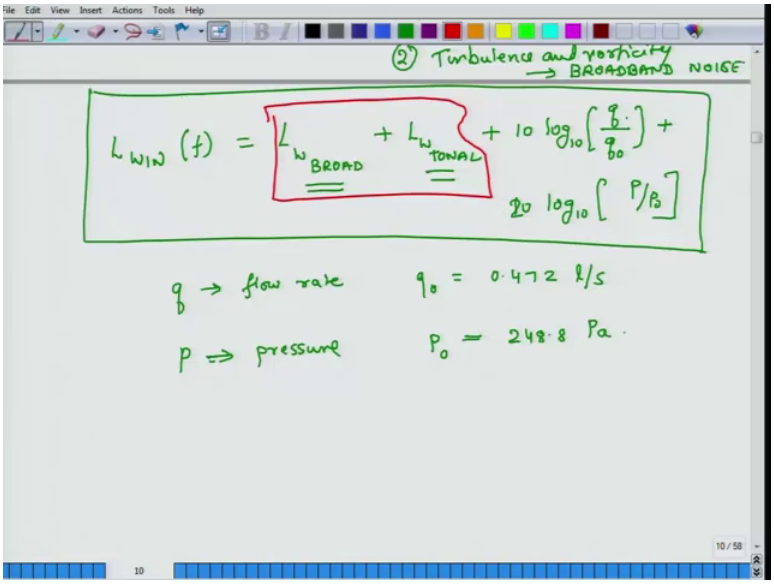

So, we have to figure out if L w in and if we know L w in, I can compute L w outlet people have come up with a relation for L w in and this based on experimental observations and what is it and this is again a function of frequency and this is equal to L w broadband noise. So, I am just writing it broad, because there is a broadband component to noise plus L w tonal plus 10 log of 10 divided by q divided by q naught plus 20 log of 10 p divided p naught. So, this is generated based on some experiments lot of experimental data, but it is consistent with the physics of the problem, with this reality of the problem.

So, that is why I did not show this directly. So, what does this relation say, that the amount of noise which will be inside the system L w in sound power level, will have a broadband element. It will also have a tonal element and what is q? q is the flow rate. What is the purpose of fan to provide air? So, if it provides more air, it will generate more noise, if it provides less air, it will generate less noise. So, that is why there is this factor q and q naught is a reference flow rate and it is value is 0.472 litres per second and similarly, p is the pressure air which comes out of the fan. p is the pressure of air, which comes out of the air. So, it is air pressure if the air comes out with a lot of pressure, we will have higher noise level. If it comes with less pressure will have lesser noise. So, that is what this relation is about and p naught is again a reference value and this is equal to 248.8 Pascals

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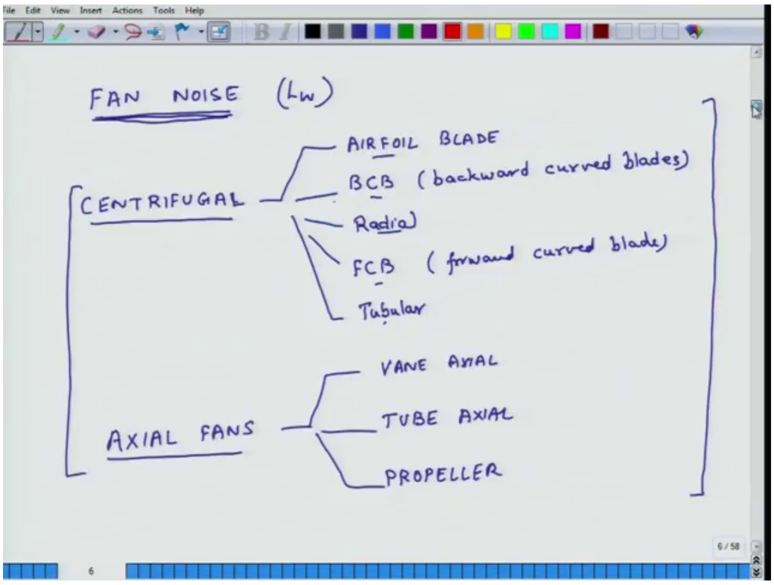

And then you will say, well what is L w and l tonal and the value of this, it depends on the type of fan, that is why I said earlier, we have to first thing is we have to know what type of fan, we are talking about. So, people have developed some tables for different fans, they have different values of L w broadband and L w tonal.

So, what we will do is, we will look at a table one such table, this is a part of a table.

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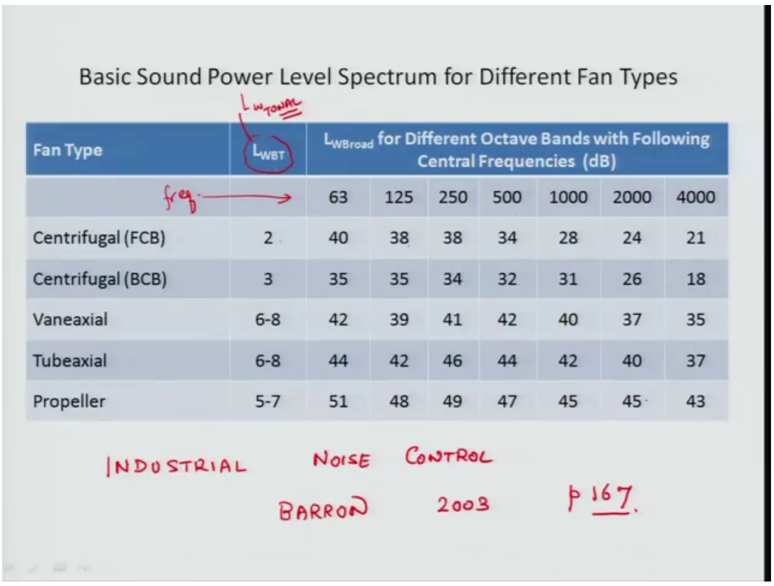

Basic Sound Power Level Spectrum for Different Fan Types

Fan Type	L_{WBT}	L_{WBroad} for Different Octave Bands with Following Central Frequencies (dB)						
		63	125	250	500	1000	2000	4000
Centrifugal (FCB)	2	40	38	38	34	28	24	21
Centrifugal (BCB)	3	35	35	34	32	31	26	18
Vaneaxial	6-8	42	39	41	42	40	37	35
Tubeaxial	6-8	44	42	46	44	42	40	37
Propeller	5-7	51	48	49	47	45	45	43

So, this is a small part of a table there are 5 6 more lines in this table, but I have just reproduced, this from a book and the I have taken this data from this book industrial and noise control actually industrial noise control and the author is barron b a r r o n the book which I looked at was published in 2003 and this is from page 167. So, this book has a bigger table, but I just have captured lines for 5 6 different 5 different types of fan. So, if it is a centrifugal fan with f c b blades forward curved blades, then L W B T B T is tonal. So, I called it. So, this is L w tonal, the value of the L w tonal is 2, 2 decibels and what is the value of broadband L w it is at.

So, these are frequencies. So, these are frequencies. So, in 63 hertz band. So, these are central frequencies 60 hertz, band L w broadband is 40 decibels in 125 hertz, it is 38 decibels 38 and. So, forth similarly, for different fans L w tonal is given, in this table and also for different frequency bands, the value of broadband frequency is also broadband, noise power level is also provided. So, you can get L w broadband and L w tonal form tables like these and once you get this information from here, what you do is you go back to this relation and compute L w in, for different frequencies and once you know L w in you can find L w out and then you can find out other things.

So, what we will do is we will now do an example. So, that things become clearer. So, here is the example we are going to do.

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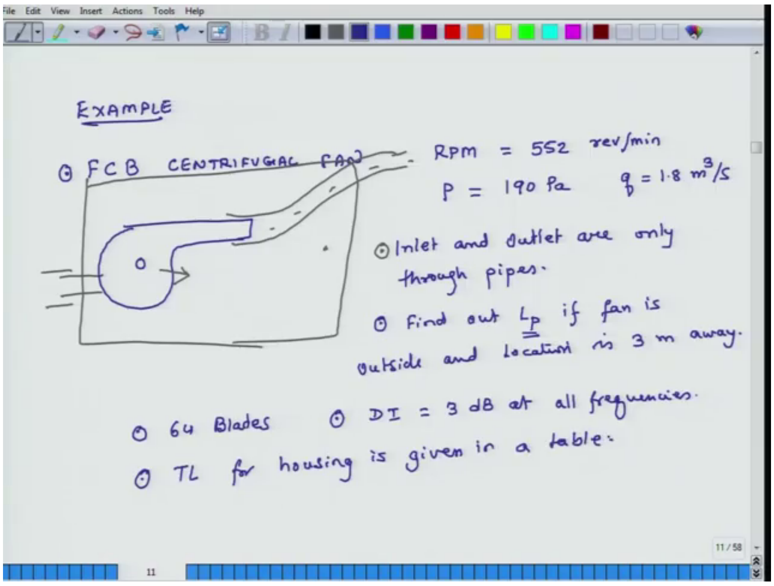

So, what does the what is the question that suppose, we have a forward curved blade type of centrifugal fan. So, we have this type of a fan. So, we know, what type of fan and it is rotating at it is r p m is 552 revolutions per second; it is revolutions per minute that is the

R P M. It is throwing out air at a pressure of. So, what is the pressure is 190 pascals and the flow rate is 1.8 cubic meters per second. So, remember here it is units is litres per second. So, we have to convert that in litres per second and the, what else and then the thing is that inlet and outlet are only through pipes. So, what does; that means, that you are the fan and it is not that the outlet is just releasing air out in the open. You have a pipe connected to it and it is taking all that air somewhere else.

Similarly, the inlet is also connected to a pipe. So, I am in the room, I will not have noise coming from the outlet and neither it will come from the inlet. So, the only source of noise, which will be there will be from the housing, form the housing. So, that is why this is given. So, inlet and outlet are only through pipes and the other thing is find out L p L p. So, here actually I am not inside, actually it says, if fan is outside and location is 3 metres away. So, you are 3 metres away from the fan outside in the room, outside in the open, the noise is the outlet is going through some other pipe.

So, you are not exposed to outlet noise, same thing in the noise. So, you have to find out L P, this is question, what else some more data is given the fan has 64 blades, it has 64 blades, it is directivity index. Directivity index is equal to 3 decibels at all frequencies. At all frequencies it is 3, this thing and the transmission loss. So, we have to compute how much sound is coming from the housing. So, transmission loss for housing is given in a table. So, we will actually write those values. So, transmission loss, what are the. So, these frequencies and this is transmission loss in decibels.

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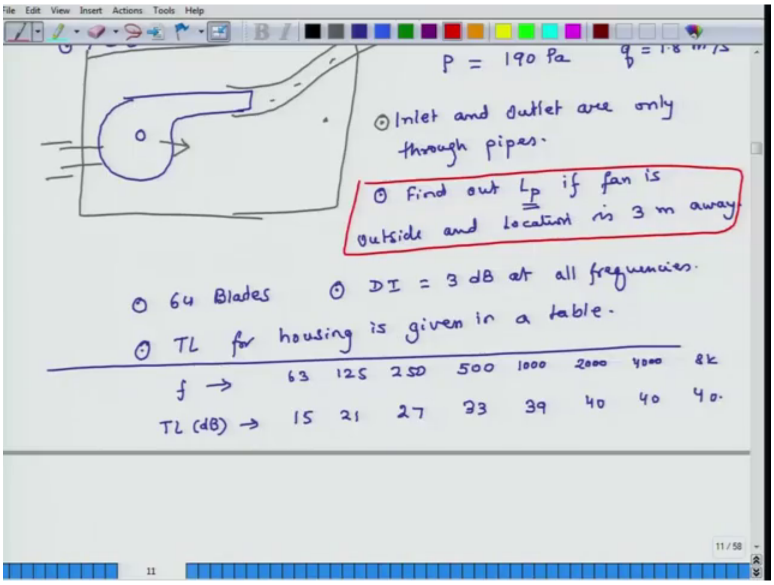

So, what are the frequencies, they have specified 63 125 255 100 1000 2000 4000 and 8 k. So, for these frequencies, what are the transmission loss numbers 15 decibels 21 27 33 39 40 40 and 40. So, all these data are provided and what do we have to find, we have to find this thing that if you place this fan outside no in free space in free space, then and you are 3 metres away from this fan, what will be the sound pressure level which is L p; that is what we have to compute.

So, I think the time for today is over, but we will continue this discussion in the next class and we will actually solve this problem in the next class. So, that will make things clearer to you, because now we have done a lot of background it is time to do some number crunching. So, that concludes our discussion for today and I look forward to seeing all of you tomorrow bye.