Noise Management & Its Control
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Lecture – 46
Measuring Sound Power Level - Fan Noise - Part I

Hello, welcome to Noise Control and its Management. Today is the fourth day of this week which is the eighth week of this course. And what we have learnt till so far in this week is how to calculate sound pressure level inside a room far away from a noise producing object? We also discussed how to compute industry standard octave bands, central frequencies and how are they related with the band number and the remaining part of this week and also the next week we will focus our efforts on understanding, how to compute the value of L w for different noise producing sources. So, our focus is how to compute L w.

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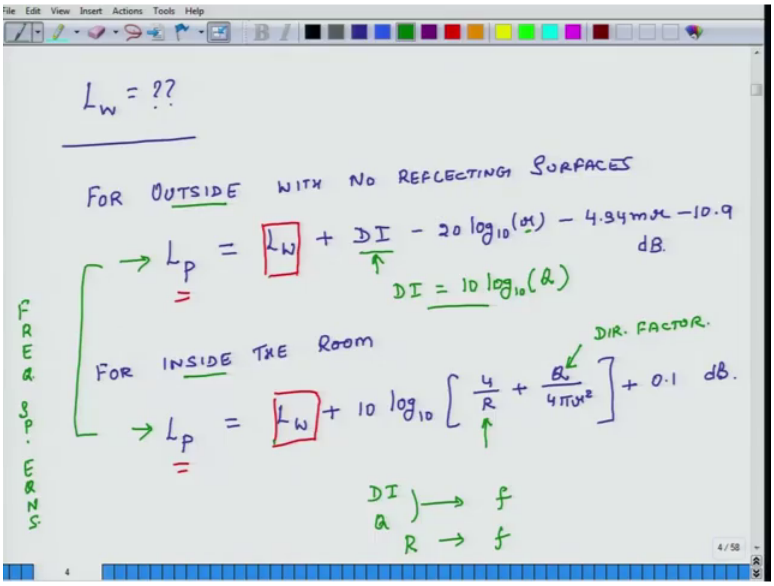

And, what is the context? The context is, that if we are outside in the space then for outside conditions, we had with no reflecting surfaces; we had developed an expression that sound pressure level equals sound power level in decibels plus directivity index and, that is also expressed in decibels minus the effect of the distance we are separated by from the source and that is minus 20 log of 10 and of R, where R is the distance between the source and the place of measurement and then I also subtract the amount of sound attenuation due to presence of air. So, it is 4.34 m r and then of course, there is a constant number 10.9 decibels.

So, all this is in decibels. And, if I am inside the room which may have may or may not have a lot of reflecting surfaces for inside the room. My sound pressure level is equal to the sound power level of the noise producing machine. So, that is L w plus 10 log of 10, 4 of 4 divided by R plus Q divided by 4 pi r square plus 0.1 decibels.

So, in both these cases, if I know L w, then I can calculate L P. So, the question is that if someone tells this is the type of machine do you have in a room or outside what is the sound pressure level I have to know how to calculate L w? But difference between these two relations this is for outside and this relation is for inside both these relations account for directivity, but here we use directivity index and you should remember that directivity index we have defined as 10 log of 10 of directivity factor. So, it this way so, if we are outside the relation uses directivity index as a parameter. If we are inside we use directivity factor. So, Q is directivity factor.

For an Omni-directional source directivity factor is 1 and for an Omni-directional source directivity index is 0. So, this is important to understand. So, I will go back to our original question, that if I know whether I am inside or outside and if I know this value of R or if I know the properties of the room which help us understand the value of room constant I can calculate L P as long as I know L w. Please remember that both these relations; so directivity is a function of frequency. So, directivity and Q both these things depend on frequency.

Similarly, R also depends on frequency. So, the sound pressure level which I should be will be calculating it will be frequency specific and then the overall sound pressure level I have to somehow add up all the contributions for different frequencies and then I get the overall sound pressure level, but this equation these two equations are frequency specific equations which means when I am calculating L w, I cannot just say that the total sound power level is 100 decibels. I have to specify that sound power level for this machine for the 500 Hertz octave band is so many decibels for the 1000 Hertz octave band it is so many decibels and so on and so forth. And for each of those octave bands I also have to know directivity and I also have to know room constant and then only I can use these two equations. So, I have to calculate these I calculate L P for specific frequency bands, I just do not calculate it an overall senses right away. Once, I have frequency specific data then I can add up all those frequency specific data to come up with a final number. So, this is something important to understand. So, so I will go back.

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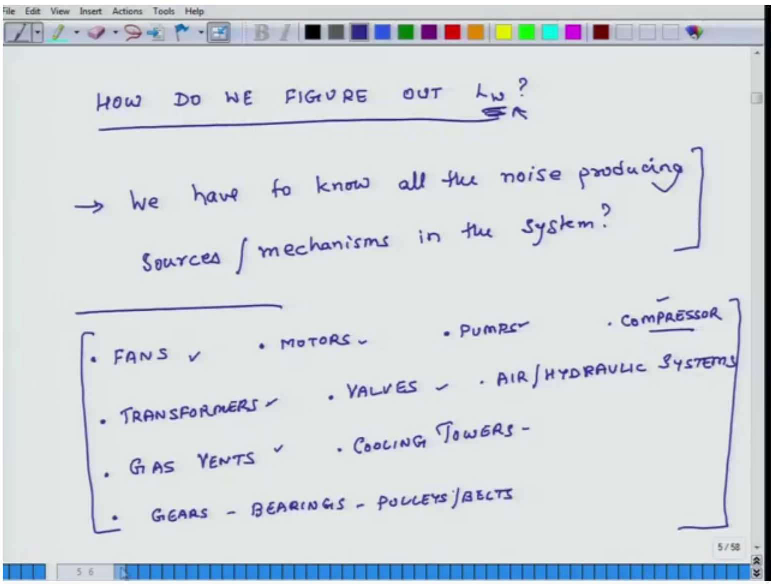

So, our question is, how do we figure out L w? And the question; the answer to that question is that we have to know all the noise producing mechanisms sources and mechanisms in the system? So, for instance if there is a power generator set you know diesel generator set which generates power and it is put in a big room and if I want to figure out what is the value of L w? Corresponding to that gen set. I have to know what is that gen set made of. Does it have an enclosure? Does it have a motor? Is the sound coming from motor allowed to exit? So, I have to know all the details of the system.

So, just knowledge of acoustics will not be able to help me to compute value of L w. I have to know all the so I have to be a specialist in that system; to find out the value of L w. This is very important. So, if I am working in a factory and I want to estimate the noise level or so or the sound power level associated with let us say a milling machine, I have to understand what kind of different motors it has and then when the machine is running there may be some fluid falling on the in the you know machine to as a coolant. So, I have to know all those details and all the knowledge detailed information about the system will help me estimate L w in a methodical way.

Now, typically most of the machines what are they made of? They are made of some important building blocks. So, they may be made up of fans, they may or may not have a fan, but lot of machines have some fans, then there may be a motor or some motors may be involved; then there may be some pumps, what else are there could be some compressors.

So, these are building blocks for large factories or complicated machines and things like that. There could be also be some transformer. There could be some valves the valve may be getting actuated and it may cause motion in a particular direction and it may be reversing. So, there is valves may be opening and closing there could be some air systems. So, air is getting compressed and it is being pushed through some pipe and things like that so there could be some air or air slash hydraulic systems.

There would be some gas vents. In large plants there could be some cooling towers. And then there may be some mechanical different small mechanical components and the reason we are listing is that we should be aware that these are the components which create noise. So, the overall noise which we hear is a some of individual noise coming from each of these parts. So, what are those different mechanical components which may generate noise gears, then bearings, pulleys and belts and things like that? So, if we have to understand this L w, first thing we have to look at is the overall details of the system and we have to identify what types of fans are there, motors are there, pumps are there, compressors are there, transformers are there, all these things generate noise on their own. You have a transformer you may not think, but when high current goes through. So, I am not talking about small transformers; transformers may be on the streets or large transformers when large current goes in it generates a this type of humming noise.

So, then similar here we have valves, air and hydraulic systems, gas vents, cooling towers, gears bearings, all these things. For an instance you have an air conditioning unit what is it made up of? It is made up of a compressor, it also has a fan which blows air, it also has some duct through which air passes through. So, we have to figure out how the whole thing is configured and then we have to look at it case by case, part by part, basis and compute L w for different frequency bands for each of the thing and then come up with a total estimate of the noise.

So, this is the overall philosophy which we will consider as we are trying to figure out value of L w. And, in this course what we will do is? We will select some of these components. So, that you learn how to compute L w for different components specific components and then you can use the same methodology for different components and for complex systems. So, today an also may be for our next couple of days, we will focus on efforts related to fan noise. Noise when it comes out of fan.

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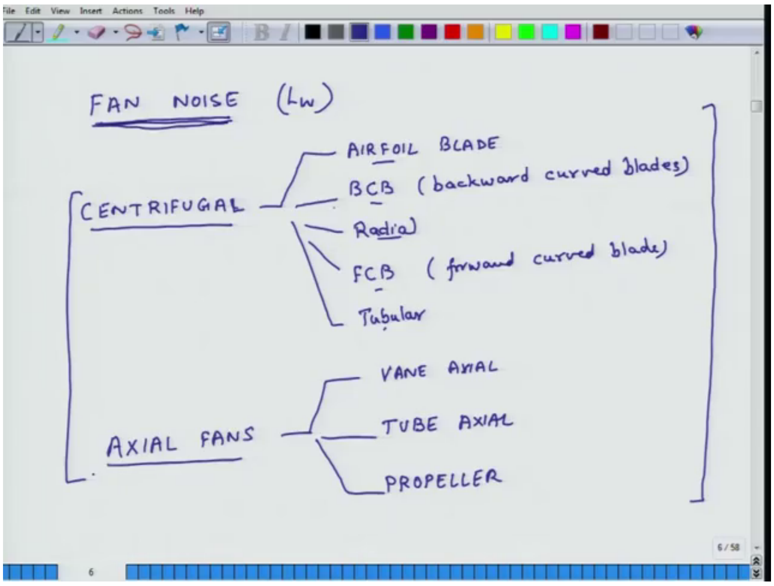

So, we will work on fan noise. What is the value of L w? If there is just a single fan and by fan I typically do not mean this rotary fan which we have in our rooms, because that is not a typical industrial fan. What is the purpose of an industrial fan? An industrial fan sucks in air from outside and it pushes in the inside may be there is some need for some big combustion chamber or something where air is required. So, it sucks in air and pushes it in an area where it is required. So, lot of times it is also called a blower air blower ok.

So, there are different types of fans and let us look at different classifications. So, there are broadly speaking two types: the first category is centrifugal fans. And these centrifugal fans themselves they come in different flavours. So, we can have an air foil, blade fans and you please go over the net and some books on fans to understand what these things mean. So, air foil, blade fans. So, their blades are designed like air foils. So, that is why they are known. Then there are fans which are known as B C B fans. What does it mean? Backward curved blades so, these are B C B fans.

Then another category of centrifugal fans is radial fans. Then there are F C B fans. So, F C B is forward curved blade. Then we have tubular fans. So, these are different varieties of centrifugal fans and then there is another broad category of fans and they are axial fans. So, we have centrifugals and axial. The typical fan which we see in our rooms it is an axial fan; it pushes air in an axial direction. So, they are vane axial, then the second is tube axial and then the third one is propeller type. So, the point here is not to make you experts in fans, but the reason I am listing all these different categories of fan is, that if you are interested in computing the noise coming out of a fan, the first step you have to do is identify which type of fan is there in your building or in your machine which is actually generating the noise.

So, we have to see whether it is a centrifugal or an axial. And once you make that identification you exactly figure out whether it is an air foil type or B C B or radial or F C B and tubular, that is the first thing. That you look at which component is generating noise and which exact category this component is off. So, that is the first step. Next, we look at different mechanisms of how sound is produced by a fan ok.

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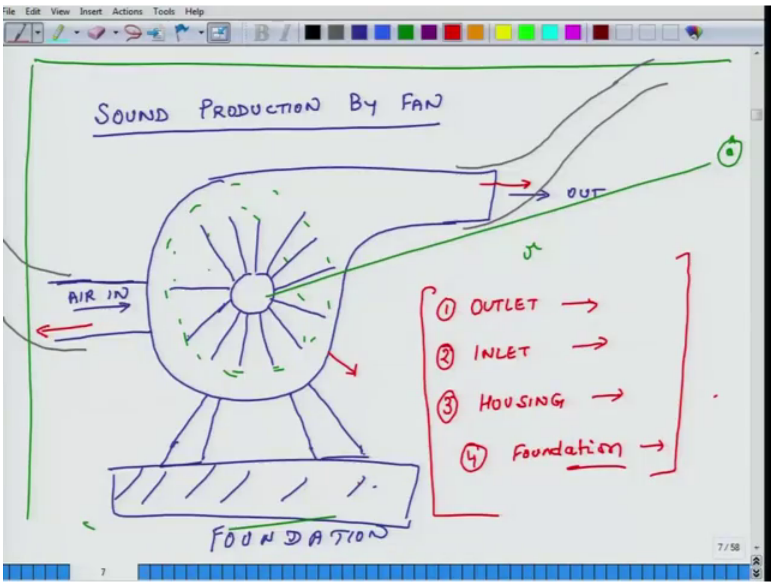

So, as air comes in and it goes out the fan generates noise and let us look at a schematic of this. So, this is a centrifugal type of fan. So, this is an industrial fan and you have air coming in from this side. So, it sucks in air from this side, this fan is resting on some foundation. So, this is a foundation. So, air comes in and it goes out and then you have to think. So, there may be blades here. So, they pull in the air and then they throw it out. So, there is a centrifugal mechanism, there may be lots of blades in here not just 2 or 3 blades which we see in our room fans.

There may be 60, 70, 100 blades and you have to again figure; out how does sound; so where is the sound getting generated? All the sound is getting generated in this right, inside the fan, because when air gets sucked in it just gets rotated and all that sound is getting generated, because of all sorts of turbulence and vorticity and all these fluid mechanics stuff. All the sound is getting generated and then you have to think, how does this sound? So, this is a fan let us say in a very large room and let us say I am in very far away or some at some distance away from the fan. Let us say this distance is r how will this sound reach me? What are the different mechanisms through this through which this sound reaches me? Because, all the sound is getting generated inside the fan, how does it get out?

So, there are three ways or four ways this sound can get out in the fan that is why you have to look. So, we have to have this understanding. So, the first path through which it can get out is through the outlet. If the outlet is open sound will come out. So, ways through which sound can get out. One is outlet; if the outlet is open and it is just throwing all the air in the room and I am also in the room I will hear that sound. The second path through which sound can get out; if the inlet is open then sound can also get out form here air is coming inside, but sound may get out from the inlet also.

So, inlet is another path. What is the third way? Suppose, I close my inlet as well as outlet of course, the what is the point or suppose the outlet is not open, but it has a duct may be there is a duct which takes all that air somewhere and similarly there is a duct from outside. So, all this sound which is getting out it does not get chance to come into my room, but still sound can come out from the fan where will it come from? It can come from the body of the fan, because all this sound is getting generated, because of that the body of the fan will vibrate, because it is of made up of thin metal thin sheet metal if it is like rigid steel block it will not vibrate, but it is thin flimsy material.

So, the body of the fan may vibrate right body of the fan may vibrate and that vibration can generate sound in the room. So, the third possible path is housing vibrations or the housing of the fan and then there is a fourth possible way, and what is that? This fan is sitting on a foundation and the whole fan is vibrating, when the fan vibrates it is connected to the foundation and these vibrations may spread in the room right.

So, it may also and when these vibrations spread in the room, all those vibrations will also generate sound in the room. So, foundation vibrations so, these are four possible mechanisms through which; so first step is identify. What is the noise making object? Fan, second step we have to figure out; what exact type of fan is there in place? Whether centrifugal, axial, which type of? Third thing is we have to figure out; how is noise coming out from the fan. So, this is a step by step methodical way of looking at noise control mechanisms. How is noise coming out? One way is it can come through outlet, another way is it can come through inlet, another way is housings can vibrate and the fourth thing is that foundation can also generate vibrations and all these and the noise can be can come out.

So this is the third step. Then, we go to the next level of what types of sound so where this is the sound path analysis. The next thing is we have to figure out what kinds of sound can come out form this fan. So, what we will do is we will continue this discussion tomorrow and hopefully tomorrow as well as may be the next day you will have a much better appreciation of just how to figure out the value of L w coming from a fan. So, this concludes our discussion for today and we will meet once again tomorrow bye.