Noise Management & Its Control
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Lecture – 59
Acoustic Enclosures

Hello again, today is the fifth day of this week and we will complete our discussion on noise from an adjacent room. And yesterday we were doing an example in which there was a large room, which was separated into two zones. The first room which was relatively larger; has a machine and the noise from that machine is coming to the adjacent room, the operator room and these two rooms are separated by a partition.

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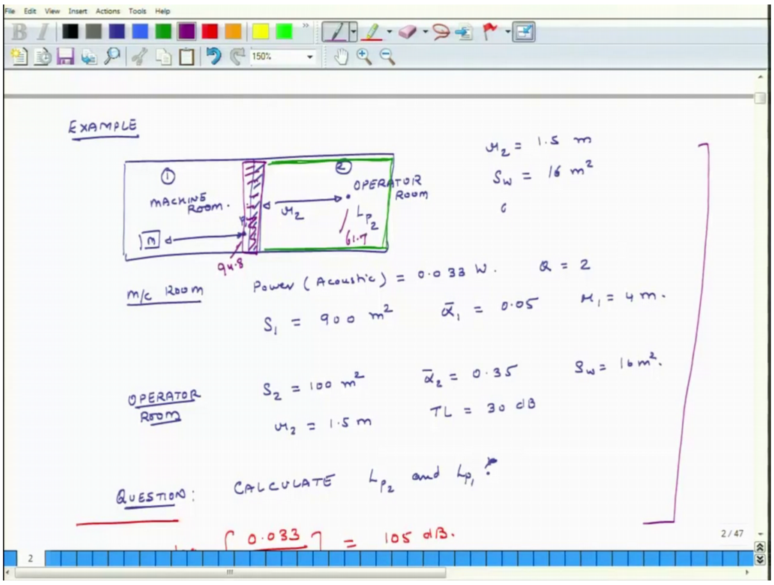

So, this is the problem definition; which we had described earlier and to compute the values of sound pressure level in room 2 and room 1, we had to compute three important parameters; L W, r 1 and r 2 which are the room constants.

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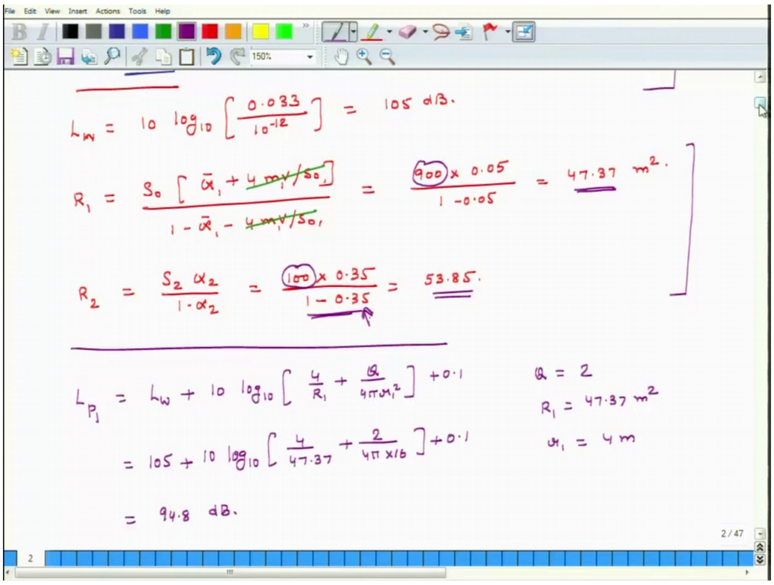

And now that we have done those calculations, we will continue our discussion and will computer the sound power level in the two rooms. So, L P 1 equals L W; plus 10 log 10; 4 over R 1; plus Q divided by 4 pi R 1 square plus 0.1.

So, here Q 1; Q is specified as 2, directivity factor. It is given as 2; we also have computed the value of R 1; that is the room constant. So, R 1 equals 47.37 square meters and little R 1 is 4 meters. So, with this I compute; so L W is 105 decibels plus 10 log 10; 4 by R 1, plus directivity factor divided by 4 pi into 16; plus 0.1; and this comes to be 94.8 decibels.

So, what does that mean? That in the first room; in the machine room; if I am four meters away from the machine then the sound pressure level will be about 94.8 decibels and this is pretty high sound pressure level. If a person is exposed to this hide sound pressure level for sustain period of time, he will have serious hearing damage. So, to mitigate that a partition has been introduced, a wall and the transmission loss of this wall is 30 decibels. So, our next step is to compute the sound pressure level at a point; 1.5 meters away; in the operator room. So, our next step will be to compute L P 2.

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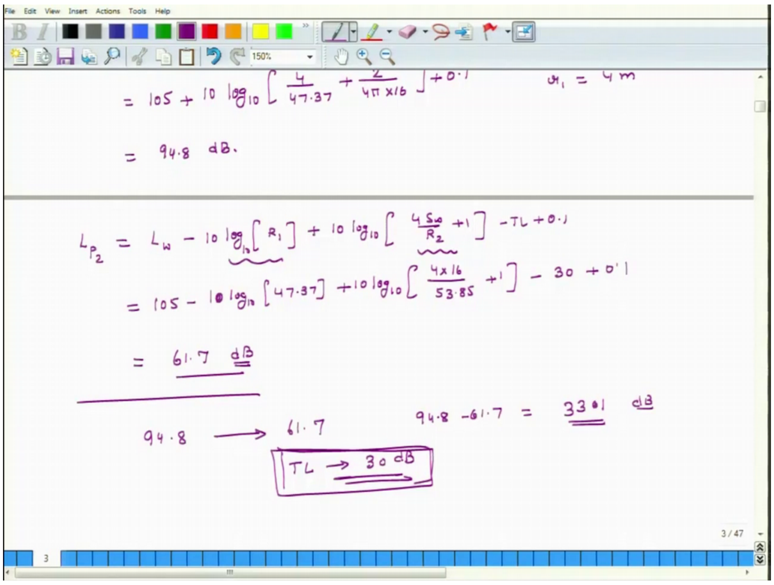

Now, we know that the relation for L P 2 can have two possible relations; the first if you go back to our problem.

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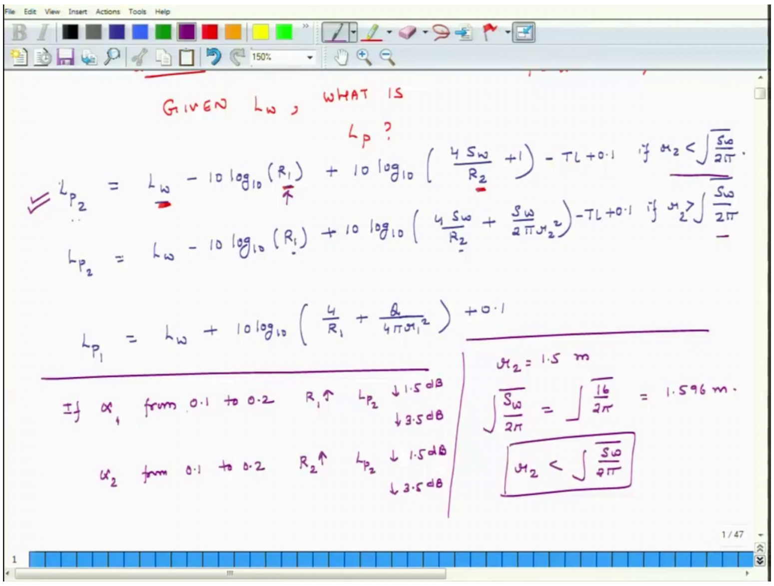

If R 2 is more than this parameter S W divided by 2 pi; then we use the first relation and if R 2 is; if it is less and if it is more then we use the second relation. So, let us calculate what is R 2 and then we will make a choice; whether we want to use the first relation or the second relation. So, R 2 equals 1.5 meters and S W divided by 2 pi and S W is the surface area of the wall. So, that is equal to 16 divided by 2 pi and that is 1.596 meters, so what does that; that R 2 is less than S W divided by 2 pi.

So, if because that is the case; so we will use the first equation and that is equal to L w minus 10 log of R 1; plus 10 log 10, this is also base 10; 4 S W divided by R 2 plus 1, minus T L plus 0.1. So, L W is 105 minus 10 log of 10 of R 1 and my R 1 is 47.37; plus 10 log of 10; 4 S W. So, 4 times; S W is how much? 16 square meters; divided by the room constant; 53.85 plus 1 minus transmission loss, 30 plus 0.1 and that works out to be 61.7 decibels.

So, at this point; it is 61.7 DB and here it is how much? 94.8; now understand this, so from 94.8 to 61.7; most of the reduction in sound pressure level is happening because of this factor; because of transmission loss. So, what is the difference between 94.8 and 61.7; 94.8 minus 61.7 equals point, 1, 3, 3; 33.1 DB, there is a loss of 33.1 decibels and out of those 33 point decibels; transmission loss is responsible for 30 decibels in improving the sound pressure level and reducing the sound pressure.

The remaining three decibels are attributable to this parameter and this parameter. Bulk of the sound pressure level reduction is attributable to just this thing. So, the point what I am trying to make is; that the room constant helps makes things better. But if you have a partition in the wall and the thicker the wall is and the more rigid and the robust the wall is; that is going to be the predominant factor, which can really reduce your sound pressure level in the operating room or the adjacent room.

So, a lot of times; people in the operator room, I mean this is a very common problem; people ask that a lot of times their operator room is lined by this sound absorbing materials. And still they think that the sound level in the room is very high and they want to reduce the sound level. And a lot of time the question is that; if you increase the quality of the sound absorbing material in this room; Will that reduce the sound pressure level in this room significantly? And the question to that is; no, because bulk of the sound reduction does not happen because of absorption of sound by these materials, but rather because of the wall.

So, if you have the flexibility to make up more robust thicker, fatter, heavier wall; that will have a much better chance of reducing the overall sound pressure level in this room. So, this very important to understand that the transmission loss is a very significant factor, which will help you reduce the sound pressure level in the operator room and this a very common problem.

So, you may also be experiencing in your problem, in your particular industry and if this is the problem and if you have the flexibility to make the wall heavier and more robust; then go for it. So, this is our discussion for today; also I wanted to give you some understanding of what kind of reductions we can achieve, if we play with room constants.

So, we had seen that the sound pressure level in the second room is dependent on R 1, it is also dependent on R 2. So, here is some estimate; typically if you increase alpha bar from 0.1 to 0.2; as alpha increases, what will happen? R 1 will go up and as R 1 goes up; L P 2, and you keep everything else same and; then what you will find is that; if L P 2 will go down by 1.5 DB, if you are using the first equation. And it will go down by 3.5 DB; if you are using the second equation.

So, if you double that sound absorption coefficient; your L P 2 will reduce by one and half or three and half decibels; based on how far you are from the wall, so this is the case for alpha 1. Same thing is also true for alpha 2; if you increase alpha 2 from 0.1 to 0.2; R 2 will go up and L P 2 will also go down by 1.5 DB; if you are very close to the wall and it will go down by 3.5 DB; if you are far from the wall.

So, do not expect a lot of magic I mean of course, 3 DB is a significant reduction in the sound pressure level 3 and a half decibels. But we are expecting reductions; something like 10 DB, 20 DB, 30 DB; then it is important to figure out, how can you seal of this area, where there are noise making machines and you can have a partitioned room.

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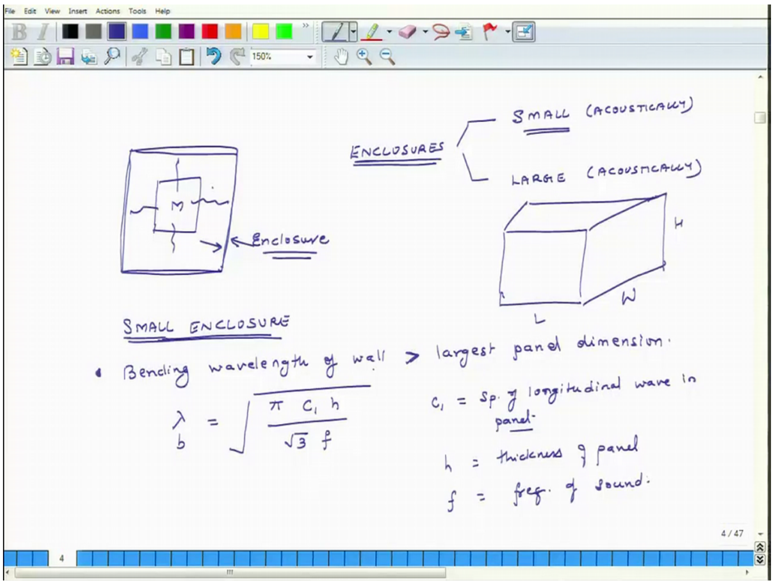

So, that concludes our discussion; the next topic we are going to discuss today or we are going to introduce today is acoustic enclosures. So, what is an acoustic enclosure? So suppose, you have a noise making machine. So, it is generating a lot of; it is radiating a lot of noise; one way to control the noise reduced by this machine is; by enclosing this machine itself in an enclosure.

You can enclose this machine in a covering; this covering may have some holes, may not have some holes; it all depends what kind of needs are there. But if you encase it into an enclosure, the amount of noise which will leak out to the outside; it will be only through this; if it is perfect enclosure with no openings then only vibro-acoustic noise will be able to get out.

Now, these encloses how much noise do they stop? Depends on their size, so there are small enclosures and by small I mean; acoustically and large enclosures, again this is acoustically; large enclosures. So, what we will discuss today are small enclosures and maybe next week we will talk also about large enclosures, but we will discuss today small enclosures and will also do an example on that. So, what is a small enclosure? So, an enclosure is acoustically small; if it meets the following two conditions.

So, the first condition is that the bending wavelength of wall is large compared to largest panel dimension. So, we will explain that; so this is the first condition it has to meet. So, what is the bending wavelength of the wall? So, this enclosure is made up of several walls; it could be a cubical box or a box with 6 sides or it could be in a sphere or in a cylinder, but regardless whenever you are having an enclosure; it will have some walls outside it.

And when the sound from inside hits it; what will happen to the walls? They will try to vibrate; the walls will try to vibrate and when they are vibrating, they will be bending; they will not do this, they will be doing this. When something vibrates, when this is going to vibrate; it will not just do this, it will also do this. So, the walls are going to bend; they are going to bend and this bending phenomena is associated with wavelength.

So, the bending wavelength of the wall should be larger than the largest panel dimension. So, suppose this is an enclosure and let us say this is the largest panel dimension. So, this is W L height and this is the enclosure; maybe in this case largest panel dimension is W. So, the bending wavelength of the wall should be larger than the largest panel dimension. So, this is one and how do you figure out bending wavelength? We will discuss that.

So, what is bending wavelength? Lambda b equals pi times C 1; h divided by square root of 3 times frequency, where C 1 is the speed of longitudinal wave in panel. So, sound travels in air; similarly sound travels in water, similarly sound can travel in solids also; the phenomena is similar, but in solids it not only travels in longitudinal way or wave, but it also can travel in different ways.

So, in air the transmission of sound is like this, but in solids it can move like this, but it can also move like this. So, this is the speed of longitudinal wave in the panel; h is the thickness of panel and f is the frequency of sound. So, if the machine is just generating a single frequency; then we will calculate the bending wavelength associated with that frequency. If it is generating a lot of frequencies, then we will complete the smallest possible wavelength associated with largest frequency and then we will see whether that smallest wavelength is more than largest panel or not; if it is more than; it is, it meets our condition.

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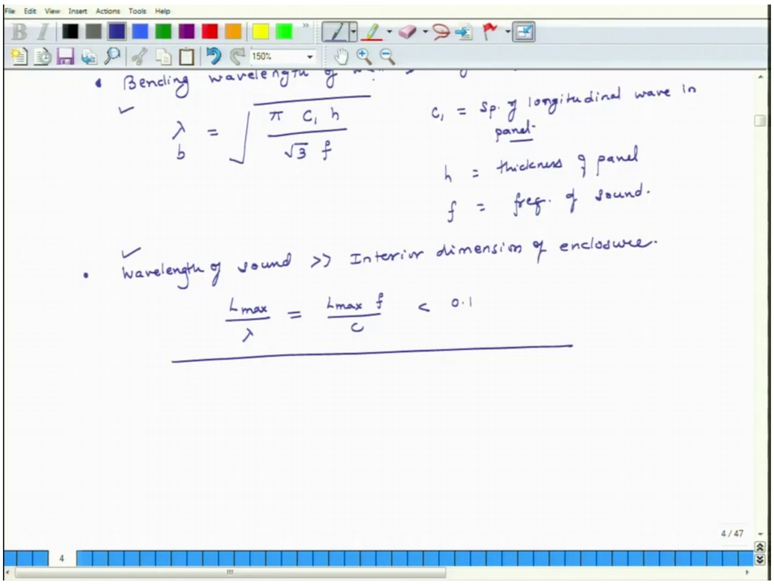

So, this is the first condition; that the enclosure is small and there is another condition. The other condition is; that wavelength of sound is very large; compared to interior dimension of enclosure, it is very large. So, for practical purposes; we can say that L max, L max is the largest dimension of the enclosure divided by lambda and that is; what is lambda? So, L max and lambda is what? f over C and that is small compared to 0.1.

So, if it is 10 times; the ratio is 10 times or more then we say that this is the case. So, the point is; that an enclosure is small, if it meets this condition as well as this condition. If it does not meet either one of those condition, then we will not consider it to be small. So, this provides us the context for small acoustical enclosures and what we will do tomorrow is; we will conclude our discussion on small acoustic enclosures.

We will see what kind of sound transmission loss we can achieve; through small acoustical enclosures. And we will also hopefully try to do numerical example so that we learn something practical about it. So, once I again thank you for your time and we expect that you will be here tomorrow for the concluding part of this week.

Thank you and have a great day bye.