Noise Management & Its Control

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Lecture - 61
Large Acoustical Enclosures – I

Hello, welcome to noise control and its management. This is the start of the eleventh week, of this course and over the period of this week. We will cover three specific topics. Last week, we finished our discussions by talking about enclosures and specifically, we had discussed, how to calculate the insertion loss associated with the enclosure, which is small in size and we had defined in mathematical terms what is the meaning of the term small.

So, this week, we will talk about large enclosures and what kind of transmission loss can be attributed to these large enclosures, not transmission loss, the insertion loss and then we will also talk about barriers. So, in open air spaces or closed, air spaces you may not necessarily sometimes have an enclosure, it may not be required or it may not be feasible and such cases, a lot of times we use barriers. So, we will talk about, how to figure out you know noise reduction, due to a barrier in open air spaces as well as in closed spaces.

So, once again we will start our discussion by talking about large enclosures.

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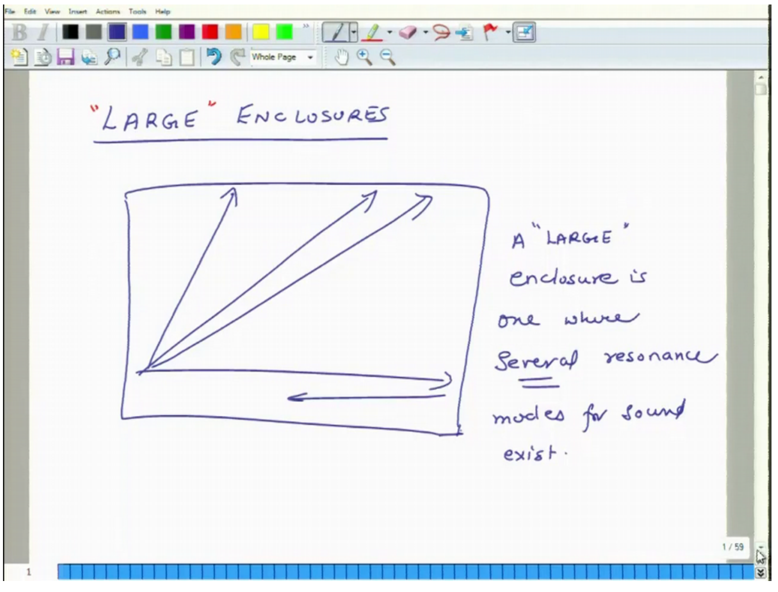

So, large enclosures. So, the term here is large. So, what is a large enclosure the answer to that is, if the size of the enclosure is large enough. So, let us say, this the internal size of the enclosure and as sound moves from here to it gets reflected and then it may also be going in all directions and it may be getting reflected and depending on the wavelength of it. It could be possible that there may be some resonances happening, because of travel of sound waves inside the room and if those resonances occur and the number of those resonances is large, then we say that it is a large enclosure.

So, from a physical stand point a large enclosure is one where several resonance modes for sound exist. So, as I keep on number increasing, the size of the closure the number of resonant modes. It keeps on increasing and if this number is large then we say that the closure is large, but then mathematically, how do we figure it out.

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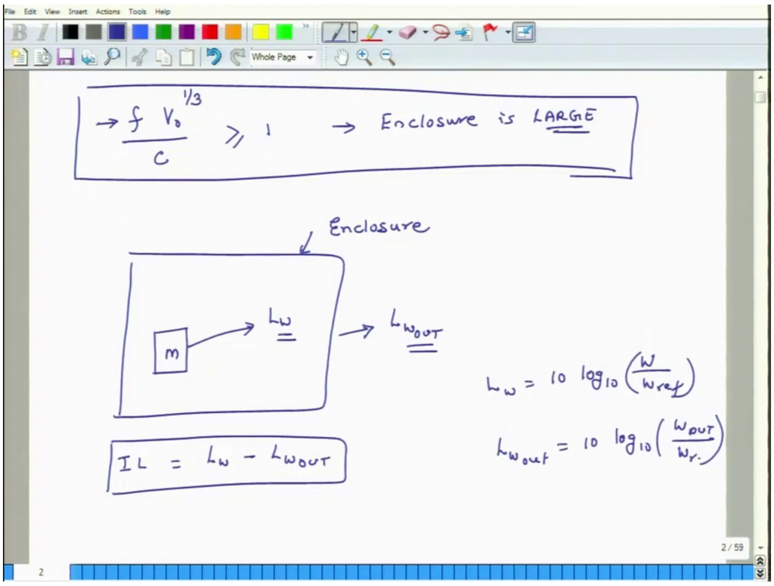

So, there is a relation for that, if the frequency of interest times, the cube root of volume internal volume of the enclosure divided by c is more than or equal to 1 then we say that the enclosure is large .

So, what does that mean as f keeps on increasing? Frequency keeps on increasing, there could be an enclosure, which may not be large for same frequencies, but for higher frequencies, it can be large. So, whether an enclosure is large or not it depends on the frequency or frequencies of interest. So, whenever we start working on large enclosures, we have to make sure that our assumption, which is related to this relation, it holds valid for all frequencies of interest for which the enclosure is supposed to work.

So, with that understanding, we will try to get a relation for insertion loss of a large enclosures. So, what is insertion loss? Suppose, you have a small machine and it is emitting L w it, the sound power level is L w and suppose, I put it inside a large enclosure. So, then the sound which comes out of this enclosure, will be L w out, the power level which will be L w out and this L w out will be less than L w. So, the insertion loss, this is something, we have defined earlier also insertion loss associated with this enclosure. So, this is my enclosure insertion loss is nothing L w minus L w out, but we know that L w equals 10 log, 10 of watts. Acoustical watts generated by the machine. So, let us say w divided by w ref and L w out equals 10 log 10 of whatever is the number of watts, which are present outside the structure divided by w ref .

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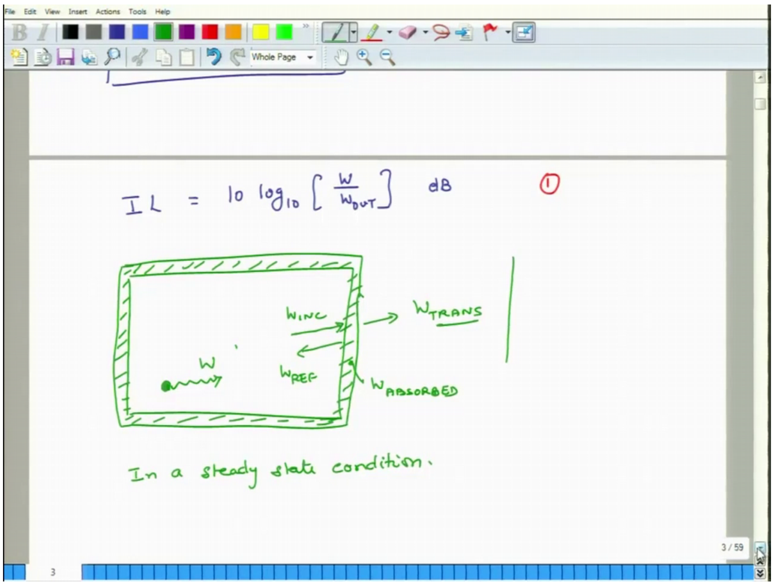

So, we can also write the relation for insertion loss as 10 log, 10 of w divided by w out, here w is the watts acoustical watts coming out of the machine and w out is the acoustical watts coming out of the enclosure. If there is no enclosure then w out and will be same. So, then insertion loss will be 0, but if we have the best possible, you know a very good enclosure then w out will be every small compare to w and I L will be high. So, this unit is again in decibels. So, this is let us say this is our first relation. Now, what we are trying to understand is that how do we figure out this ratio for a large enclosure.

Now, consider an enclosure and there is a machine or sound source and it is emitting w watts of energy per second w watts of joules or w joules per second or w watts of power. Now, what happens when it hits the wall of the enclosure? So, this is the enclosure, you know and it has some thickness. Now, this w the sound goes and strikes. So, there is an incident watts and then it is of there is also reflected watts.

So, some sound energies impinging upon the wall, some sound energy gets reflected, some sound energy gets absorbed and whatever is left it gets transmitted out. Now, in a steady state condition,

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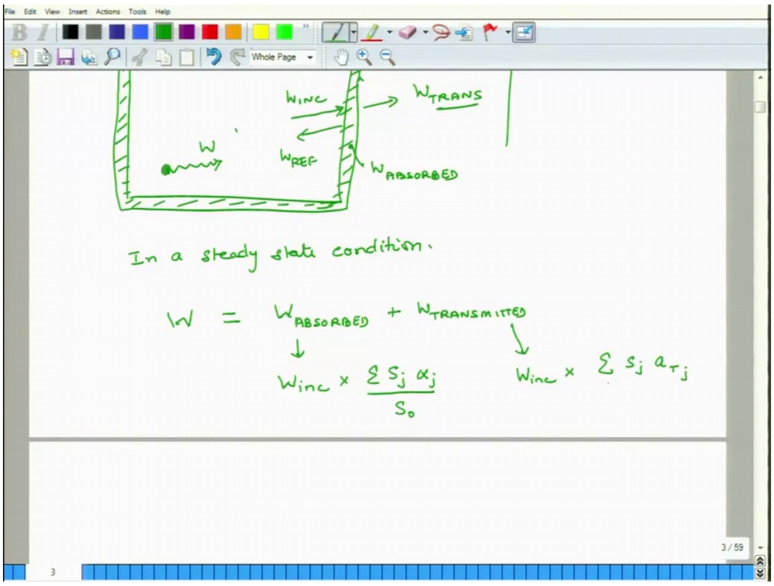

I can say that total number of watts, which are being generated by this machine. What will happen in a steady state conditions, when nothing is changing inside the enclosure? What will happen? This has to equal w absorbed plus w transmitted, because the sound level inside the room will not is not increasing. So, whatever is being extra energy is being generated, either it is getting absorbed or it is getting transmitted out.

Now, w absorbed this guy, what is this w absorbed; is what, whatever is the energy which is striking the inside surface of the enclosure right. If that inside energy power gets doubled, then w absorb will get doubled. So, w absorbed depends on incident energy incident watts and times, what else it will depend on how large the surfaces and how much is the absorption coefficient of the inside surface. So, it is equal to s j, if there are lots of surfaces times absorption coefficient of the surface specific surface divided by the total surface area, internal surface area.

So, this is w absorbed and how much energy is getting transmitted, this is equal to again incident power. So, this is the amount of power, which gets transmitted in to surface area. So, we have to choose each surface area and then each surface area is associate with the transmission coefficient and I will say a t and for jth surface. It is a T j and this again I divided by the total surface area.

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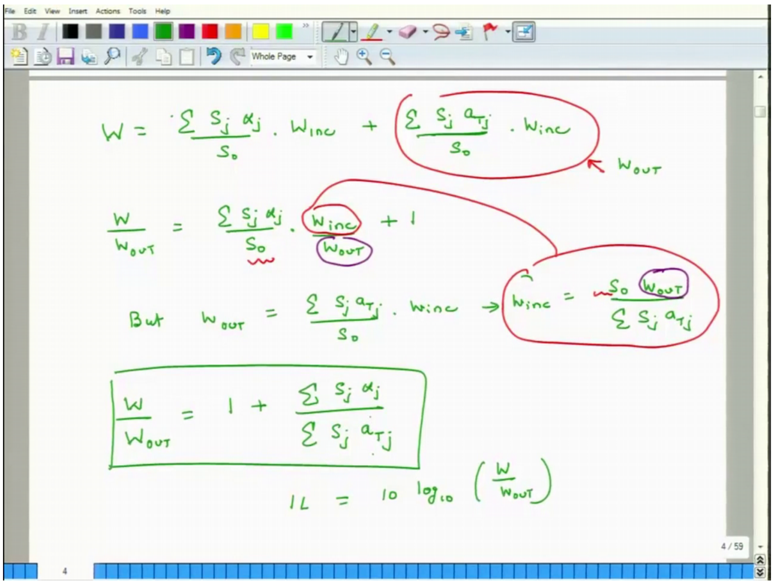

So, I can say that w equals s j alpha j divided by s not times incident power plus s j a T j divided by s not times incident power.

So, in this relation the first term is the amount of power, which is absorbed by the walls and the second term is amount which is being transmitted by the walls. Now, if this is getting transmitted, then this is what this is w out, this is w out. So, I can say that w by w out. So, this is w out, this is w out. So, this is. So, if I divide the entire equation by w i, what do I get, I get s j alpha j by s not times w incident plus 1 and there is a w out here yes, but we also know that w out equals again I am just going to write this relation s j a T j divided by s not times w incident, or I can write w incident equals, what s not w out divided by some of s j transmission coefficient of jth thing like this.

So, what I will do is, I will put this thing in this term. So, if I do this, what do I get essentially, I get w by w out equals. So, s not and s not this s not and this s not they will cancel out right. Also w out and w out will cancel out each other. So, what I will be left with is 1 plus sum of jth area multiplied, it is absorption coefficient divided by sum of jth area multiple by it is transmission coefficient in terms. So, this is w over w out. So, if we know the transmission coefficient of each surface, if we know the transmission coefficient of each surface and if we know the absorption coefficient of each surface, then we can calculate w over w out and then the insertion loss will be nothing, but 10 log of 10 w over w out. So, the question is how do we know transmission coefficient and how do we know the absorption coefficient. Now, absorption coefficient, we know that it depends on the material and based on the frequency and material of interest, we from tables, we can figure out.

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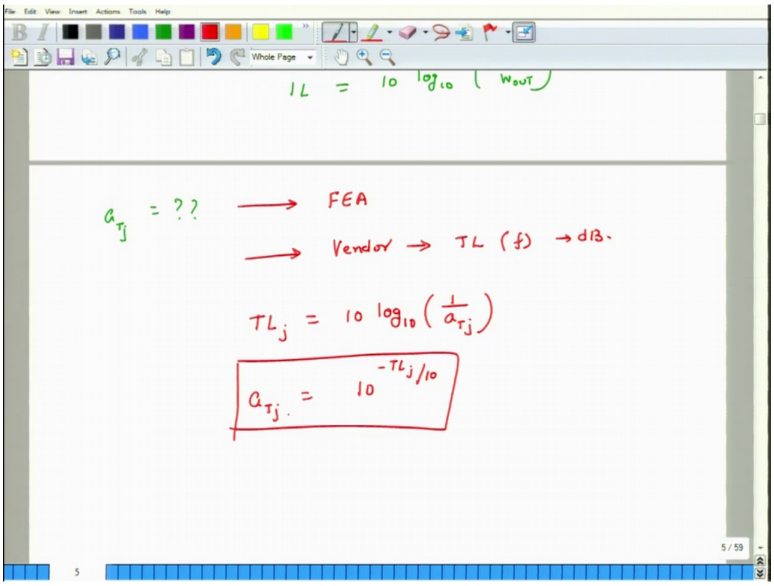

The value of transmission coefficient how do we get this? So, this usually, if we are designing the enclosure ourselves, then this transmission coefficient can be calculated by finite element analysis or some other analytical methods. So, we have to calculate it, there is no standard readymade formula for that. It depends on the size, thickness, shape of the overall panel and things like that or if we are buying it from some vendor, then the vendor should give us a T j, but usually vendors do not give a T j rather they give us the transmission loss. They give a parameter known as transmission loss and the relation between transmission loss. So, this is again a function of frequency and this is in decibels.

So, again the relation between transmission loss and a T j is this. So, the transmission loss for jth wall is nothing, but 10 log of 10 over 1 over a T j. So, if we have to calculate a t j, what do we do? a T j is equal to 10 to the power of minus t L divided by 10, this is for the jth. So, this is for the jth surface. So, it is minus transmission loss for the jth surface divided by 10. So, if we are designing the enclosure on our own for each wall. We have to compute this, using finite element analysis. If we are buying something from an outsider, then that person should provide us, this value transmission loss and once we know transmission loss, we can calculate a T j.

Couple of other things a lot of times when we design enclosures.

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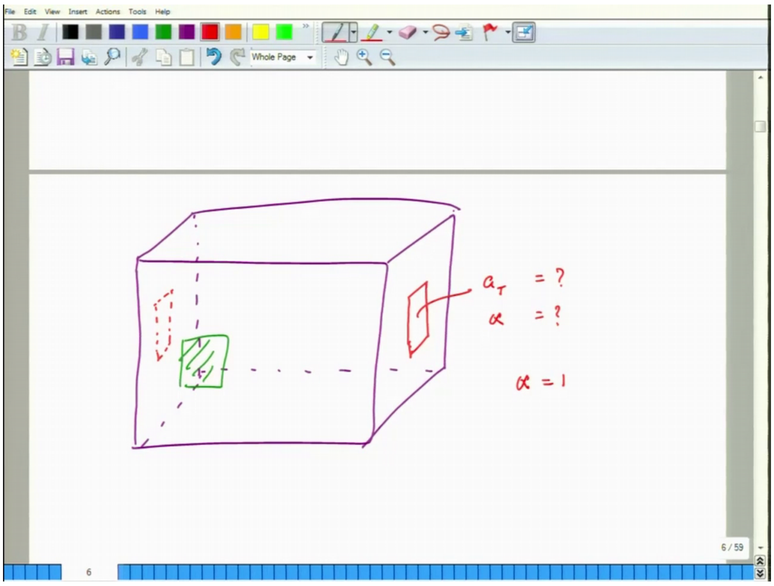

So, suppose you have a machine and the machine is put in an enclosure and this enclosure, let us say, this is a box like enclosed something like this a lot of times, it is not practical to have the enclosure, which is perfectly sealed, because you need some places from where wires have to go and you may have to put your hand in. Suppose, you have a big milling machine and you want to put it in an enclosure right then from some point material has to be and put in and some other point material has to, you know machine material has to come out. So, lot of times people make windows in the enclosure.

So, let us say this is window number one and then there may be another window. So, it depends, how many windows do we need, now once we make these windows which are cut outs, sound comes out from these windows in large amount. So, the question is what is the value of transmission coefficient for the window and also what is its alpha? Now, earlier we had said that, if there is a window, which is perfectly open then, we take that it is alpha is 1, because alpha which is sound absorption coefficient is the amount of energy absorbed divided by (Refer Time: 20:01) amount of energy, which hits that area.

So, whatever energy hits this area, it is gets out. So, the alpha is for a window is one and the absorption coefficient, this transmission coefficient a t at for a window. It depends on how it is not 1, rather it is different and it is different, because of the following reason.

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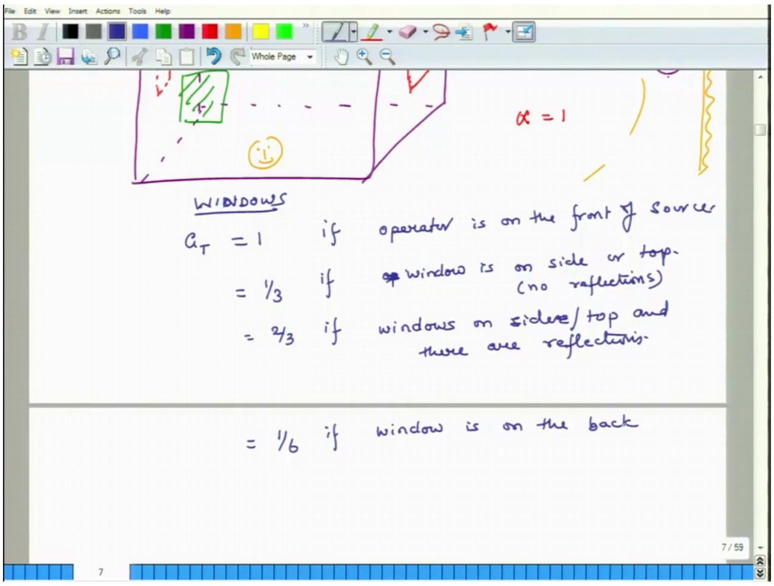

So, suppose the person is who is listening is on the, in the same direction as the window, then he will hear all the sound, which is coming. So, in that case a t. So, for windows I am going to write down the values of a t. So, a t equals one if. So, let us say this person is the operator, then I will say that then operator is on the front of source.

So, suppose the surround is travelling in this direction and operator in the same direction, then we will say a t is equal to 1, because he will here all the sound which is coming out a t equal 1 by 3, if window is on side or top relative to the operator relative to the operator and there are no reflecting surfaces, what do I mean by reflecting surfaces, that suppose, the operator suppose, operator is on this side window is on this right, window is on this side so; obviously, he will not here all the sound, which is coming out. Some sound will travel after reflections and all that and he will, it will reach this guy in this way, if they are reflections. Suppose, there is a reflecting wall, here then he will, here larger amount of sound, if there are no reflections, then a t is equal to 1. If there are reflections, then it is equal to 2 by 3 windows are on side or top and there are reflections and finally, a t equals 1 by 6, if window is on the back side.

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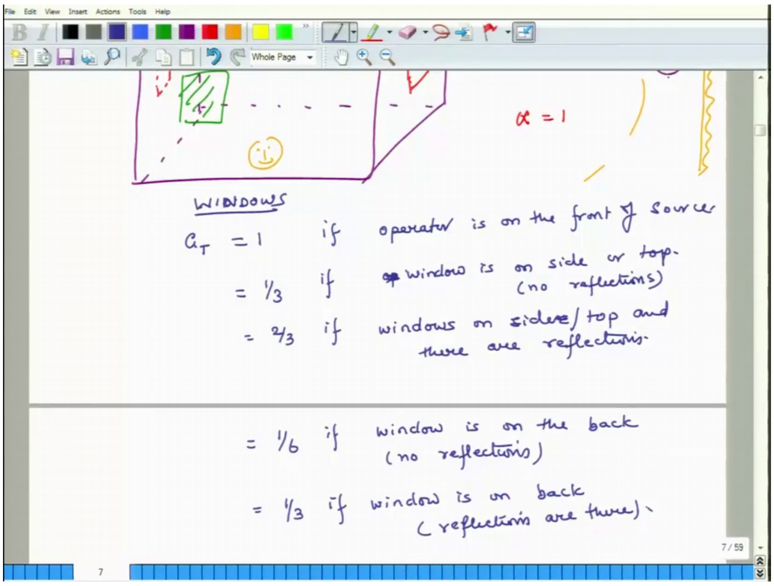

So, sound is being emitted in the other direction. You are looking in the other direction then it is and of course, when there are no reflections and this is equal to 1 by 3, if window is on back and there are reflections are there. So, with this understanding I think, we should be able to calculate the transmission loss of an enclosure and we know, how to find out alphas and also aTs and if there are windows, we want to design into our enclosure, we know how to account for those windows also.

So, with this we conclude our discussion for today, tomorrow we will continue this discussion on large enclosures and we will actually do an example which will help us understand and design such enclosures more effectively. So, that concludes our discussion and I look forward to meeting you all tomorrow.

Thank you.