Noise Management & Its Control
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Lecture - 55
Noise Spread Mechanisms

Hello, welcome back to noise control and its management. Today we start the tenth week of this course. And during this week and the remaining portion of this course, we will focus our efforts on different strategies which are used very commonly in industry to control and manage noise. So, till so far we have learned some fundamentals about acoustics and noise, and then over the last several weeks we learned how to estimate the noise levels at a particular point in space, you may be outside, a closed room or in free space then how would one go around estimating the overall noise level. Assuming if the person is knowledgeable about the noise emitted by a particular machinery, which could be characterised by the parameter L W.

So, if L W is known, we now understand how to estimate noise the outside the room or inside the room. And in terms of estimating the noise level emitted by a source, which is L W, we have done several examples, we have done the example of a pump, a compressor of a fan. And likewise there are several other machines and this abundant information available in literature how to estimate the parameter L W. So, I will not now focus our efforts in terms of understanding how to estimate L W because we have already done several examples and that I am certain would give you a fair idea as to how to estimate L W. And once L W is known how do we estimate L P at a far distance is something which is something we have also covered in our earlier lectures.

So, now, as I said earlier we will focus our efforts on how to reduce the overall L P the sound pressure level at the point of interest. So, let us look at the in a board sense what are the overall different noise reduction strategies used to manage and control noise. And to understand that or to figure out how do you control noise we have to understand how does noise spread.

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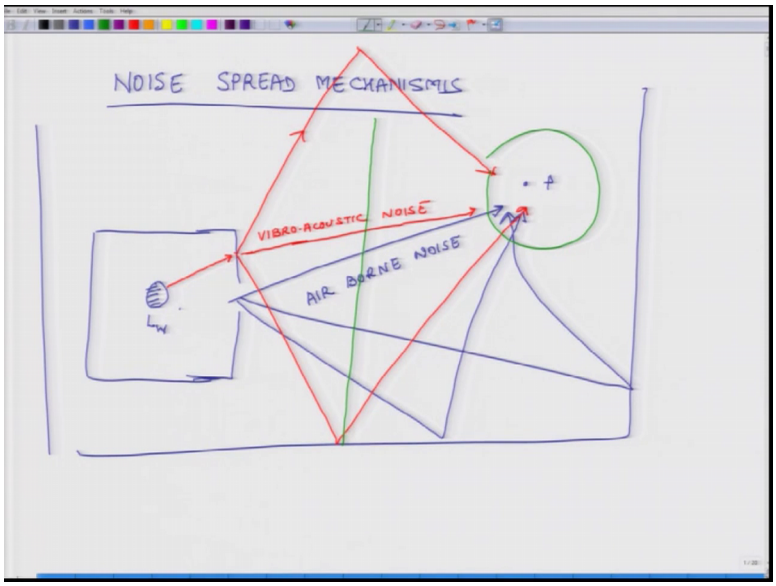

So, let us see that. So, noise spread mechanisms. So, consider some object which is generating noise, and it could be in an enclosure and maybe a part of the enclosure is open. So, this is the sound source and let us say it generates a noise level sound power level is L W; and the noise of it and we are interested in how much noise is coming to this point p. So, how does noise reach this point p, one is that you have direct transmission of noise. So, in this case, it is the median, so noise is travelling through the air, so it is propagation in air airborne noise. And then of course, as noise suppose it is an enclosed room then noise will also come here, and again it will go here. So, all this is air borne noise. So, noise could reach the point of interest either directly or it could reach after getting reflected from several surfaces.

The other mechanism through which noise can reach this person is noise, let say it reaches this enclosure, let say the enclosure is made up of some sheet metal. So, because of that the sheet metal object starts vibrating and then the because of these vibrations noise gets generated outside the enclosure. So, this is not direct transmission, but it is because of vibrations. So, we can call it vibro-acoustic noise. Now, this noise also could reach the point of interest directly or it could get to these places after getting reflected. So, air borne noise direct air borne noise can reach directly to the point of interest and. So, can vibro-acoustic noise, it can reach the point of interest.

So, the overall, so how would you go around containing this noise well I mean there are two things to control airborne noise you have to do something; and then to control vibro-acoustic noise the source is vibrations, so you have to reduce vibrations.

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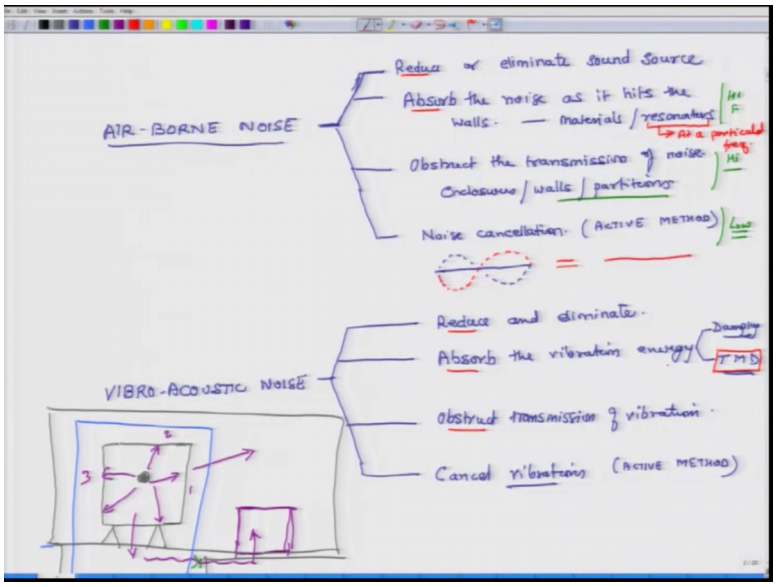

So, let us look at broad strategies for controlling airborne noise. So, the first method could be reduce or eliminate the sound source. So, in this case, what is the original sound source - this machine. So, if I can somehow we have a better machine which produces less noise or I can somehow eliminate this and still get my things done, then that is, but in a lot of cases this is probably not a very practical solution. Well, there is not much we can do with this machine because we need it and we cannot change its design.

The second method is absorb the noise as it hits walls. So, what does that mean. So, we see that some noise is reaching directly to this point. But a lot of noise is also reflected noise and if during the process of reflection some of it gets absorbed by the walls then less noise which will reach the person or at the point of interest, so that is what I mean that absorb the noise as it hits walls. And this can be accomplished by either noise absorbing materials. So, we can use specific materials to absorb noise. So, we can do either through materials or we can also absorb or suck in noise through resonators. So, this is something will maybe we will talk maybe in the third week from today. So, we can have materials which absorb noise or we can have some acoustic devices known as resonators which can suck in this noise.

The third approach could be create obstructions, obstruct the transmission of noise. Now, how would you obstruct the transmission of noise. So, if noise is reaching here, one way to obstruct the transmission of noise which we have actually already done in this case is we have built an enclosure around the thing. Now, here there is some small area through which noise is going out, but if you make a perfect sealed enclosure then very little noise will leak out. You will still have vibro-acoustic noise, but direct transmission of noise will be very less. So, this could be one approach. Other approach could be you can have maybe an enclosure here or you can have a wall here, all these approaches are basically essentially routed in the same method that you are creating obstructions for the transfer which reduce the amount of noise which gets transmitted to the point of interest. So, this obstruction of noise can be accomplished through enclosures, it can be done through walls, it can be done through partitions. And we will discuss these methods this week.

And the fourth method is noise cancellation noise cancellation. So, this is called an active method, while all other methods are passive methods. And what do we do in noise cancellation suppose the type of noise which reaches the end point is something like this. Suppose, it is a perfect sinusoidal wave; and at that point itself if you generate an anti noise signal, which looks like the curve in red then the sum total of this will be a 0 noise level so the sound, because these two things will cancel out each other and we will have noise cancellation of. So, no sound will be heard or noise will be heard at the point of interest, but here it requires a lot of electronics and control algorithm, so that is why we call it an active method, but all other methods are passive methods and that is there. So, these are the broadly speaking four different approaches how to reduce air borne noise.

Now, the next one is that noise from this machine it comes and hits the enclosure the enclosure vibrates and the enclosure becomes a source of noise. So, this vibro-acoustic noise at least the transmitted part we can still control through all the methods which we have done, but another way to up manage this noise is also by managing the vibrations. So, vibro-acoustic noise how do we manage it. So, once again the first method is reduced and eliminate I mean whatever is the source of the noise which is causing it to vibrate we somehow reduce its power level or eliminate it. In this case, the machine is the source, so that is what we are thinking about.

The second one is and the methods are overall same, but the mechanics works in a different way. Second one is known as absorb. So, absorb the vibrations - absorb the

vibration energy. Now, what do I mean by this. So, here when this sound waves hit the enclosure the sheet metal surface starts vibrating and I hear the aim is that somehow I reduce the energy which is going into the vibration which is causing vibrations of which is causing the enclosure to vibrate somehow I reduce the overall vibration level. And how do I reduce the vibration level by somehow using whatever is the energy which is causing it to vibrate I direct it in some other way.

Two broad methods are there one is through damping. So, what happens. So, suppose I have a sheet metal object and it is vibrating, and suppose I reduce that replace that sheet metal by let say some plastic. And I design the plastic in such a way that it may have the same stiffness and the same everything else, but because plastics have a lot of damping. So, when the object vibrates back and forth especially at its resonance, it will suck in all the energy of the vibration and it will convert it into heat because these plastics have a lot of damping properties, they have a they have good damping properties. Metals in contrast have very little damping. So, they will tend to vibrate at higher amplitudes at their resonance points, but plastics and other non-metallic objects have higher damping characteristics. So, even if their resonance point was the same, they will still tend to vibrate at a far lesser amplitude, because they have damping and because of that the amplitude is less, so that is what I imply by damping.

The other thing could be using some specialised methods known as tuned mass dampers. So, these are special devices which suck in the energy at the resonance and put it in some other system. So, these are tuned mass dampers, and we will again later when it comes we will get a chance we will discuss this tuned mass damper also later, but these two methods help us reduce the overall vibration energy and because of this reduction, the overall amount of vibro-acoustic noise which is generated by the system becomes less.

So, as you say I mean the methods are same. Here we have talked about reduce and eliminate same thing here, but the details it is the difference is in the details. Second one is absorb and this one is also absorb. The third one is again obstruct transmission of vibrations obstruct transmission of vibrations. What do I imply by this, let us say I have a body which is generating a lot of sound, and I put it in an enclosure and let us say this enclosure is in a larger room. Now, I can place this enclosure in the room in several ways one is I just put this enclosure in the room, and what will happen is that the sound energy as it goes and hits all the walls of the enclosure, it will cause all the walls to vibrate.

Now, of course, these walls wall number 1, 2 and 3 when they vibrate the sound energy will get generated and it will go out into the air in the room.

Now the other thing is that vibrations from here could also go into the ground and they can propagate in the ground and then suppose there is another machinery here which is sitting here then these vibrations will come up again, and they will cause this the walls of this machinery also to vibrate. So, the point is that if I can somehow obstruct the transmission of these vibrations from this machine to other machine then that is what I imply by transmission of vibrations.

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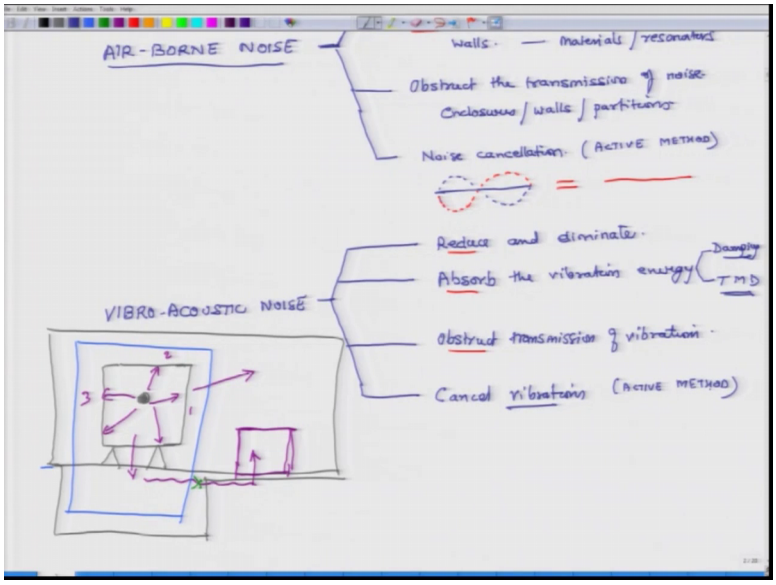

Now, the way people do it very effectively is they make sure that this machine is on a different foundation. So, maybe this is on a different foundation. So, when I look at the foundation of the structure, it is like this. So, this is on a different foundation than the other machine. So, when the foundations are different then the transmission from this side to the other machine becomes very less because ultimately the ground is not connected the ground below this machine and the other machine they are not physically directly coupled. So, as they are not coupled vibrations cannot go from one part to the other part, so that is one very effective way of ensuring obstruction of transmissions. So, this is the third strategy.

And then of course, the fourth strategy is to cancel the vibrations. And this is again an active method. And the basic philosophy of vibration cancellation is very similar to that

of noise cancellation. So, these are the overall methods. Now, you should have a very somewhat a broad base understanding on how good are these methods, and that depends on the frequency range. So, typically this absorption works well for high frequency noise, absorption of noise. Because a lot of materials absorb a lot of sound energy and they do that job very well especially at high frequencies, but at low frequencies they do not do that job very well.

Same thing is true for to a certain extent for obstruction of transmission of noise. So, suppose you build a wall in a room and you have a machine and it is suppose that machine is generating low frequency as well as high frequency noise, the high frequency noise will very effectively get blocked, because of the presence of the wall. But low frequency noise will tend to still get transmitted to a larger extent than high frequency noise. So, this obstruction and transmission of noise also works well for high frequency noise.

In contrast, this noise cancellation works very well for low frequency noise, active noise cancellation and then mathematical reasons for that essentially because the wavelengths are large and the phases introduced because of that are large. So, you can easily calculate and even if there are small errors that does not require that does not create a lot of problem. But at high frequency, the noise cancellation approach starts having problems because of mathematical limitations. So, if you were to design a system which was really having a very little amount of sound and it worked very well at high as well as low frequency maybe you will have to do a combo of these two.

The other thing is that in the absorption method we have also talked about resonators. So, overall the absorption strategy works for high frequency noise, but in case of resonators it is not only high frequency, but more importantly it only works at a particular frequency, at a particular frequency. So, if your noise is of a particular type, if it is of a particular type of a particular frequency then you can use these resonators. But if it is having several frequencies then a particular resonator may not necessarily work. Same thing is true for tuned mass dampers also. If you want to kill a particular frequency you can use tuned mass dampers, but broadband vibrations cannot be killed by tuned mass dampers; for those vibrations overall strategy could be based on damping or obstruction or vibration cancellation. So, this is important to understand.

So, I hope this gives you a broad overview of important noise and vibration mitigation strategies. What we will do starting tomorrow is we will start looking at a specific noise mitigation strategies, and the way we will start it is we will first start looking at materials and how can we use this specific materials to reduce the noise level in a room. So, that closes our discussion for today, and I look forward to seeing you tomorrow.

Thank you.