Basics of Noise and Its Measurements
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Lecture – 48
Reverberant Room

Hello. Welcome to Basics of Noise and its Measurement. Today is the last day of this course and we will capture two small, but important concepts. One is a Reverb Chamber, and the other topic which we are going to discuss today is how we use a Reverb Chamber to measure absorption coefficient of general materials.

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So, that is what we are going to discuss. What you are seeing here is in the source of this is this website, this is the picture of a reverberant room and this is just the opposite of an anechoic chamber. So, in an anechoic chamber, your whole approach is to make sure that there is as little as possible there are as the amount of Echo’s or reverberations are as small as possible.

In reverberant room what you want is just exactly the opposite. You want that if a sound hits the wall, it gets reflected to the maximum possible extent. So, in an anechoic chamber, you are actually having theoretically zero reverberant time and then, in ideal reverberant chamber, you would have a very long reverberant time running into several seconds.

So, this is the picture of our reverberant chamber. Couple of things about reverberant chambers are, first thing is that their walls and doors and all the surfaces to which sound strikes, they are extremely hard and you try it to make them as hard and as rigid as possible. So, whenever sound hits, it comes back and it does not get absorbed a whole lot. So, that is the first thing.

Second thing is important consideration. Why you are designing reverberant chambers is that the noise or the sound in the reverberant chamber should be diffused and isotropic. What does that mean that if I measure the sound pressure level at point A, then I go to another point and then, I go third point, then I go to a fourth point. If my design is perfect, then all the measurements of these sound pressure levels will be same in magnitude and in their spectral content. So, this is a very important requirement.

So, you ensure that reverberations keep on happening by making sure that all the reflecting surfaces are very hard. Lot of times people use grey night surfaces for these reflections, but to make sure that the field is diffused, but that is very tricky thing to achieve and there are couple several considerations or several guidelines which you follow to make sure that it happens.

So, first thing is that if it is just a rectangular room, there will be natural modes of the room you know and that will generate standing waves and once you have the standing waves, what that will mean is that there will be high pressure at some point and low pressure at some other point. There will be nulls and peaks at difference points. So, you do not want to have any standing modes in the room and the first level to achieve this is that you make sure that all the walls in the reverberant chambers, they are not mutually parallel. There are some inclined arbitrary you know some not random angles, but they are not parallel to each other. So, the modes do not develop very easily. That is one thing.

The second thing is that you not only have straight reflecting surfaces or flat reflecting surface, but you also make sure that sound gets reflected not only at specific angles, but whenever it hits a surface, it gets reflected in several directions at the same time. Now, if I have flat surface and sound comes and hits, its angle of incidence will be same as angle of reflection. So, it will go in a particular direction, but I do not want that to happen. So, what I also do in a reverberant chamber is that at several locations I put curved surface and these types of curved surface reflecting surfaces are known as diffuses.

So, when sound hit diffuses, it spreads out and it gets diffused. It is not like a focused beam, but it gets diffused and it gets spread evenly into the whole thing. So, that is another way to achieve a good reverberant chamber and through these diffuses and then, there are some other tricks to achieve this in addition to that because we want that the sound field should be diffused and it should be isotropic which means that at every location, the sound pressure level has to be the same. Otherwise I will not know where to take the measurements because some location measurements will be more, some location measurements will be less and I will get confused and I will not be sure what is happening. So, this is one thing.

The other thing to make sure that this diffusion of sound happens in the whole field is that people have suppose you have the room like this and then, people have big panels like this. Now, this is a small rectangle, but they are very large panels and these panels act as reflecting surfaces and they are hugged to the ceiling and then, they rotate slowly like this. So, sound when it hits them, it gets reflected at all sorts of angles because sound is bouncing of all the time and each time it hits, it is hitting them at a different angle and sometimes they also put diffuses on these. So, this is like a mixer.

You know it is like a mixer, where you have lot of material and you are mixing it and you make sure that the whole sound is getting mixed and it is getting mixed uniformly and it is spread uniformly in the whole room. So, that is exactly the concept. So, this is like a mixer, not an audio mixture, but mixer which we use in our houses. You have several ingredients and mixer and it mixes things uniformly.

So, this is another concept which approach people use to make sure that sound is isotropic in the reverb chamber. So, these are some of the methods and this is the picture of a particular reverb chamber and what you see here is if I am interpreting this correctly, see these are all hard flat surfaces and these are all diffuses and then, there may be some other diffusing elements also in this thing and this is what make sure. Then, once you have done the design of the room, when we have constructed the room, then the way you have to characterize the room correctly, so you have to make sure that you take measurements at different points in the room and if you have done your job correctly, then the response of the room at all the points should be similar.

So, if it is pretty close to each other, then your room is not only reverberant, but it is also truly isotropic. So, then you have good room to use for your experiments. So, like anechoic chamber, a reverberant chamber is also a tool, in the tool kit of an acoustic engineer. So, anechoic chamber is used to characterize the directionality of a sound source or a noise source and also to measure and characterize a particular noise source and things like that.

A lot of times, reverberant chambers are used to measure absorption coefficients of materials for which we do not know value of alpha. So, we have discussed how to measure alpha earlier also by using an impedance tube, right. So, what does an impedance tube give? It gives us the value of Z which is the impedance and I know that the value of that Z is dependent on reflection coefficient, right and from that I can calculate the value of absorption because whatever is not being reflected, that is getting absorbed. We can also use these reverberant chambers to measure alpha for different materials and how do we do that is what we will discuss this in next several minutes.

So, suppose you have a reverberant chamber and if there is nothing in the room. It is just an empty room and it will have some room constant, right.

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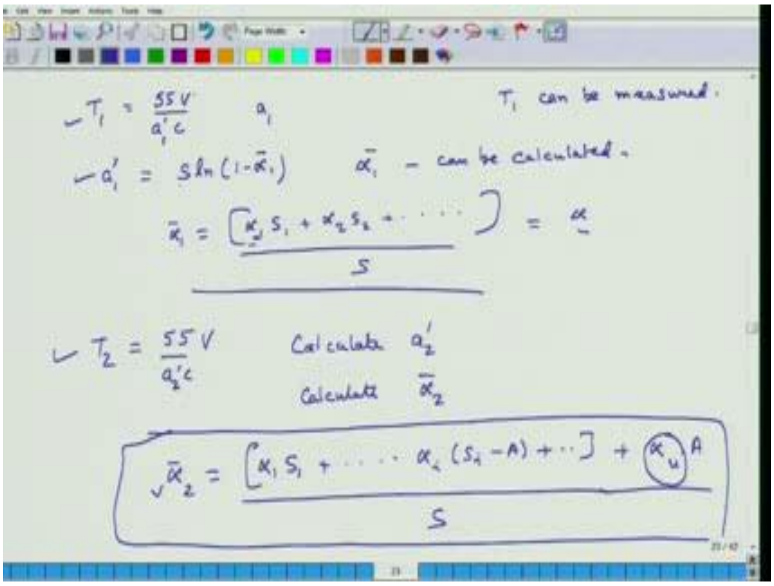

So, let us call this T1 naught room constants, the reverb time for the chamber. So, this is equal to 55 V over A prime C and T1 is the reverb time for reverb chamber which has nothing in it. So, that is T1 and it is a prime is A1. Now we know that. So, I can measure this. So, T1 can be measured. I can measure the value of T1. Once I can measure the value of A1, I can find A1 prime. I can determine it right from this formula. If T1 is known, V is known, C is known, then I can calculate A1 prime and this is equal to S times nature log of 1minus alpha bar. So, once I know this A1 prime, I can calculate alpha 1 bar because S is internal surface area of the reverb room. So, this can be calculated. So, alpha 1 has been calculated.

Now, I can assume that my room is all their reflecting surfaces. I can assume that if you have similar reflection characteristics, so all the values of alpha 1, alpha 2, c this alpha 1 bar was what alpha 1, s 1 plus alpha 2 s 2, right. So, I can also then divide by s. I can also say that all these alphas are some average value you know because all of these walls will be made of similar materials because we do not have chairs and sofas and all these things, everything is very hard. So, I know this alpha of different reflecting surfaces. So, I am at this stage.

Now, the next thing which I do is I take a big piece of material whose alpha is not known and I put that in the reverb chamber. Then, with that material I find T2 A 2 prime C and times V. So, V is still the same. T2 I have measured, C is still the same and I have measured T2. So, I calculate A2 prime and from this I calculate alpha 2 bar, I calculate alpha 2 bar. So, what is alpha 2 bar? Alpha 2 bar is alpha 2 s 1 plus, these are all the surfaces, but then there will be one surface where if there is say alpha I i-th surfaces and here S, then I minus area of the material plus all other terms divided by S plus. What is there? Plus alpha unknown times a, right.

So, I know all the terms in this equation because I have initially assumed that alpha and alpha 1, alpha 2 are same. I mean this is an approximation, but if you know individual specific alphas, then that is even better and then you know all the values of alphas except alpha unknown, this is also known. You can back calculate. You can calculate the absorption coefficient for the material with unknown value and this will again change with frequency. So, it will change from frequency to frequency. So, you have to be careful about that.

Now, there is about detail procedure for all of this. So, there are ISO standards. So, you can look at some of this ISO - International Standard Organization and we will help exactly figure out how this measurement has to be done. So, that is what I wanted to discuss in context of reverberant materials.

So, what you have learnt in this class is what are reverberant rooms and what kind of material I mean you can use in these rooms to characterize absorption coefficients of materials with different materials and that brings us to the closure of this course.

Over this 8 week period, I think hopefully it should have been helpful to you. We have covered several topics. We started with the wave equation, then we solved it, then we went to transmission line equation, from transmission line equation then we started discussing different measurement techniques, different ways to measure impedance. We discussed different types of microphones, what kind of microphones are good for what kind of applications, what makes a good microphone from the standpoint of taking measurements, then we also learnt how to analyse sound and noise signals. So, FFT and then Discrete Fourier transform and then, we also learnt quite a bit about short term Discrete Fourier transform and also this is spectrogram.

So, you learnt a whole lot of techniques and I hope you had a productive course and I thank you for all the patience for these 8 weeks, and please let us know if you have any feedback.

Thank you and best wishes for your future. Bye.