Noise Management & Its Control
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Lecture - 50
Noise Coming From Motors

Hello, welcome again to noise control and its management. Today is the second day of the ninth week of this course and what we planned to discuss today is the noise coming from motor specifically what we will be discussing in details is to how to estimate the sound power level L w as it emanates from different types of motors.

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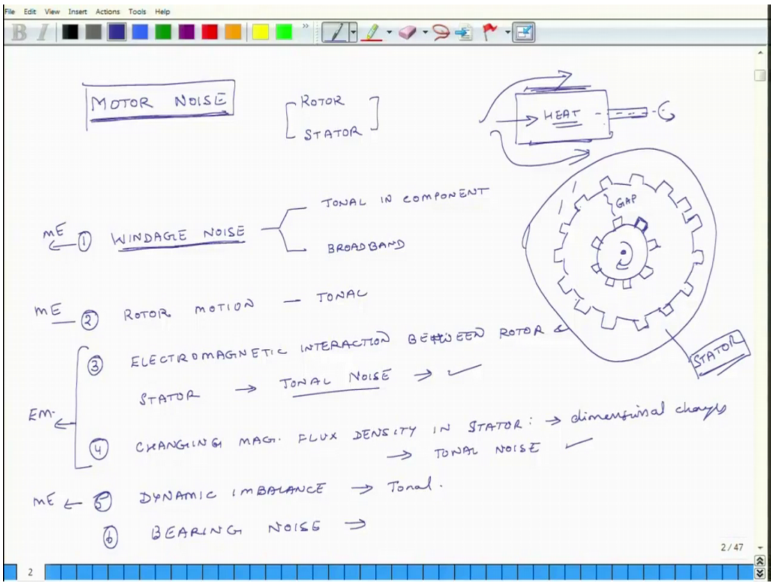

So, what we will discuss today is motor noise; now what are motors? Motors are basically machines which convert electrical energy into mechanical energy and a typical motor has a winding inside it which rotates and that is called the rotor and this winding, it rotates in static magnetic field and that is called a; it is not a by static, I mean a non moving mechanical part which has the a winding.

So, it this rotor move moves in a stator. Now the noise. So, as I said when we want to understand what kind of noise comes from different machines we have to understand some basic working principle and some details of that particular thing because that will help us give some better understanding. So, nice from motors is attributable to several phenomena. So, the first thing is noise from windage. So, what is windage; essentially suppose you have a motor and of course, this is the shaft of the motor and this shaft is rotating on the this axis and then of course, we have some electricity going in and because of electromagnetic interactions the rotor moves and that motion, it is transmitted to the shaft which delivers power; wherever we wanted, there is a lot of heat generated in it because a lot of current goes in the windings and the current windings have resistance.

So, there is a lot of I square R loss which is generated in these motors, even though motors by themselves are very efficient machines some of the sometimes the efficiency could be as high as 95-96 percent, but even when even if 3-4 percent of the overall energy gets converted into heat sometimes the power rating of these motors could be 400-500 horse powers. So, 5 percent of even a small that large number can generate a lot of heat and the motor has to be cooled all its windings and the internal mechanism it has to be cooled otherwise it can destroy itself very fast. So, what happens is that there are 2 ways to cool the motor in one way the air blows on the outside and in another.

So, you have fins on the outside and these as air blows on from the outside they take away the heat and its cooled in other cases air is also fed inside the motor to cool it down now as air blows through the motor with outside and or inside its basically wind blowing across some components. So, that is the noise because of this effect is called wild windage noise and this noise. So, this is the first type of noise and this noise is of 2 categories part of this noise is highly tonal; tonal in component because is time the rotor cuts across a particular wind or wind cuts across a particular winding it gets pushed by certain amounts.

So, that happens at of constant frequency. So, that is why part of the noise is tonal and then other part is broadband which means all the frequencies are present and that is because of eddy ca eddy losses and vericities as wind blows pass different obstacles. So, this is the first type of noise the second type of noise is the because of rotor.

So, consider a rotor suppose the rotor has two. So, how does a rotor looks like. So, it is like a moving it is the cross section of the rotor is something like this and suppose when it is rotating each time it rotates each time a blade passes a particular area a puff of air gets generated. So, because of the rotary motion of rotor if the rotor was not moving then that will not happen, but because the rotor is moving each you can call it blade, but these are not blades be these are some short metallic things popping out from the mean surface. So, each time a particular rotors element moves pass a certain point it generates a puff of air and it depends on the number of these slots and also the RPM and this rotor motion is highly tonal in nature because of this the second thing then the third component is the interaction electromagnetic between rotor and stator now this rotor moves in a stator and what is. So, the stator is.

So, I have just increased. So, this is I have amplified the gap between the stator and the rotor typically its very small to improve the efficiency of the machine. So, this gap is negligible, but the status looks something like this and pardon my drawing, but I hope you get the idea and this gap is very small I mean the smaller the gap is the better and the more efficient the machine becomes. So, this gap is very small now what happens is that in the stator you have a strong magnetic field and this rotor is moving in it and rotor has metallic ferromagnetic components.

So, as these components come close and go away from the magnetic field; there are contractions and expansions happening in the whole structure and the frequency of those expansions and contractions because of electromagnetic interactions happening is dependent on the number of these blades the number of these slots and also the RPM. So, then because of this thing this is also very tonal in properties the fourth one is change in magnetic flux density change in magnetic flux density in stator.

So, in this whole area this is our stator the magnetic flux density changes and because you have it is this whole thing is emerged in ferromagnetic parts where the whole thing contracts or expands because of change in magnetic flux density when magnetic flux becomes more strong contractions are higher when it becomes weak things come back to their original positions. So, there is lot of contraction and expansion happening because of magnetic flux density in the stator. So, this is because of dimensional changes happening and this is again tonal noise see this first guy it was not about expansions and contractions rather because the rot rotor is moving inside the stator sometimes it comes close sometimes it goes away and when it comes close it experiences larger electromagnetic forces you know because of those forces its rotating and.

So, these forces because of electromagnetic interactions they are also changing cyclically. So, that is why this noise get generated and the this noise gets generated because ferromagnetic particles materials and B a elements they shrink and expand shrink and expand and as they shrink and expand noise get generated because it pushes out air the fifth component of noise is because of dynamic imbalance. So, these are these 2 guys are because of EM effects this is because of mechanical effect this is because of mechanical reasons this is also because of mechanical reasons dynamic imbalance. So, what is dynamic imbalance? So, suppose this shaft and the rotating parts are not perfectly symmetrical about their axis maybe they are slightly off balanced and then they are off balanced they will vibrate crazily at very large amp amplitudes and that will generate a lot of noise.

So, this is and this is again tonal and the last one is bearing noise. So, what is the deal about bearing noise all these moving parts are resting in bearings and when you rotate the bearings also rotate and in the bearings we have little balls they are also rotating and they have third, this type of noise. So, this is there is bearing noise. So, it is important to understand what a different types of reasons are there to which are at which create generation of noise the second thing will like to understand is what types of motors are there.

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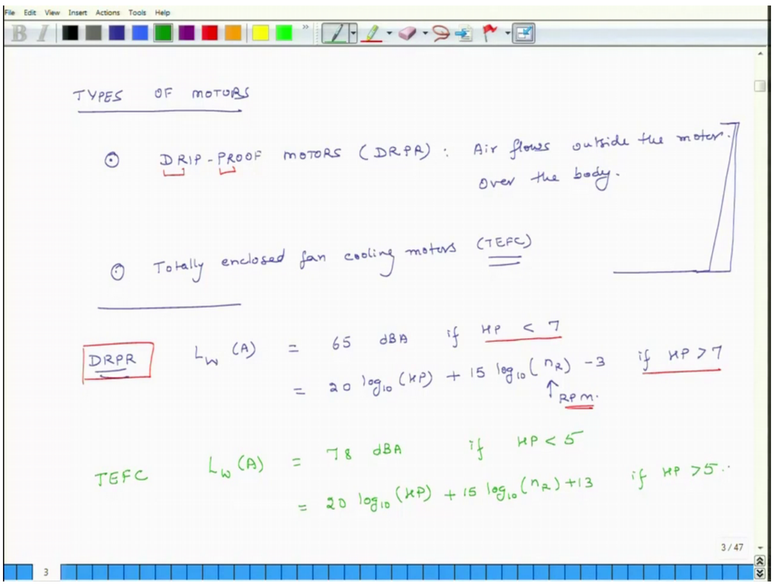

Now, you can classify motors in all sorts of ways, but today we will focus on a classification which is related to noise production. So, from that standpoint there are 2 categories of motors the first one is drip proof motors and they are known as DRPR motors.

So, what is DR and PR is from the proof DRPR motors, what happens in these motors these motors the air flows outside the motor flows outside the motor and over the body. So, there may be an external fan which is attached to the casing of the motor and it blows air over the motors casing. So, goes there the second category of motors are known as totally enclosed totally enclosed fan cooling motors in short TEFC motors here the encasing there is an internal fan in the motor and that pushes the air and that mixture that all the windings and internal things get cool down. So, based on these 2 things the noise generated by motor gets heavily influenced.

So, we have DRPR and then we have TEFC where we have an internal fan which pushes air and it actually cools the whole thing. So, now, what we will do is our original goal is to compute L w because if I know LW, I can calculate LP. So, we have to figure out what is the value of L w now it happens that lot of people have done experiments and they are come over some empirical relations, but not for LW, but they have come for L w A weighted that is why it is important to understand the concept of weighting. So, so for DRPR motors L w a weighted, this is a weighted is equal to 65 dBA if the horsepower of the motor is less than 7.

So, this is the important condition if it is less than 7, then lot of cases people have observed and this is what you have come up with if it exceeds 7, then we have you can estimate the that noise through this relation 20 log of the horsepower of motor plus 15 log to base 10 of nR minus 3 if HP exceeds 7 and what is nR this is RPM. So, it is important to remember, sometimes, we use RPM sometimes we use rotations per second. So, this is the relation for DRPR motors drip proof motors for TEFC motors L w A is equal to seventy 8 decibels a weighted if horsepower is less than 5, it is less than 5 horsepower or if the motor produces more than 5 horse powers, then it is 20 log of 10 of horse powers plus 15 log to the base of 10 nR plus 13 if HP exceeds 5.

So, there you have it. So, now, we have the relation for L w A for both the motors for

DRPR motors if we know, it is RPM and the horsepower we can estimate the sound power level, but what type of sound power level a weighted and what we are really interested in is LW.

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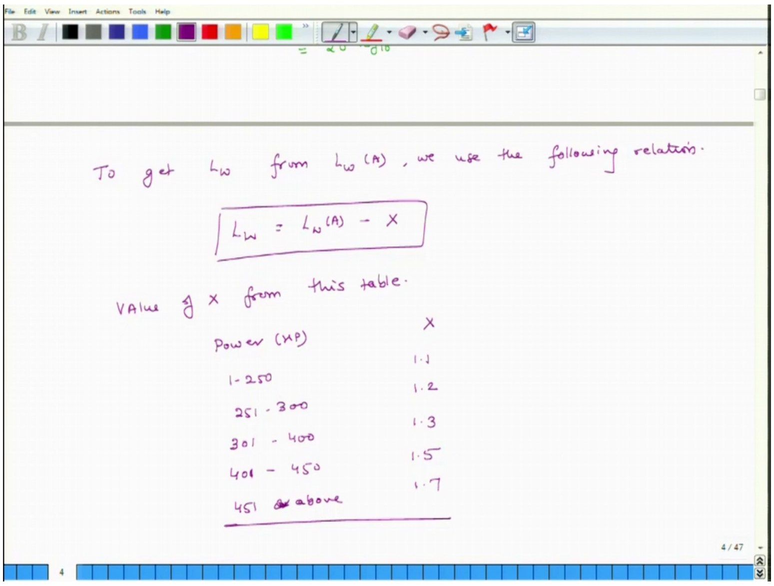

So, to figure out what is the value of L w we use some conversion factors. So, to get L w from L w A we use the following relation and what is the relation L w is equal to L w A minus a factor known as X minus X and how do we find out x. So, so value of X from this table and I will just write the table it is not very complicated. So, in the table, I have 2 columns power in horse powers of the motor and the value of X.

So, if it is 1 to 250, the value is one point one if it is 251 to 300, it is 1.2, if it is 301 to 400, it is 1.3, if it is 401 to 450, it is 1.5 and if it is 451 and above, then it is 1.7. So, first you compute L w A per motor from this table then you compute L w and then this L w will help you estimate the sound pressure level at a distant point and the last thing is. So, this is this tells us how to calculate Lw.

So, with this understanding, we can and please understand that the all these ext values of L w are not exact values they are just giving a some broad estimate of the sound power level suppose you are developing a factory and you have to figure out what will be the approximate sound power level, this will give you some estimate later you will have to do some detail measurement to actually find out actual values, but this will give you some broad idea rough idea as to what will be the value of Lw. Now in a lot of cases we are not only interested in finding out Lw, but we also find are interested in what is the energy content sound power level in different octaves right in different octaves .

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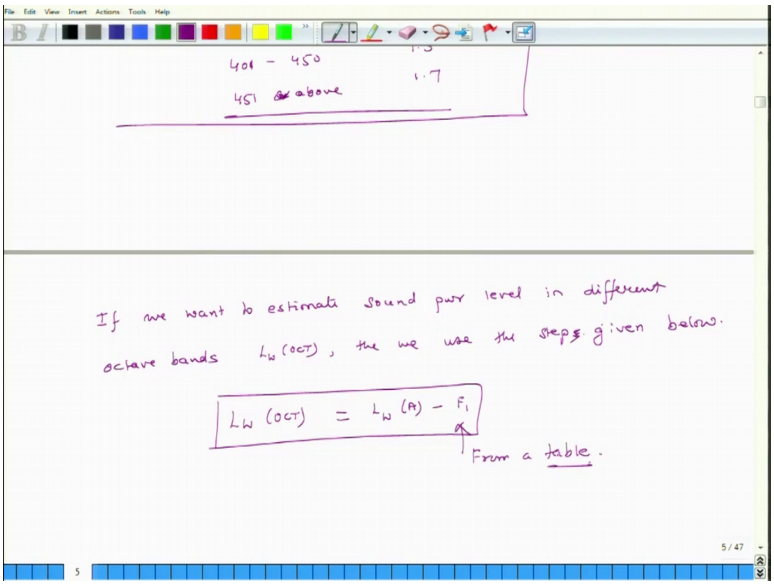

So, if we want to estimate sound power level in different octave bands and we will call it L w OCT, then what do we do, then we use 2 steps given below; step 1, actually it is not 2 steps, it is just a single step, we use the step given below. So, the step is what is the step L w OCT. Now these are different octave bands, right and the industry standard octave bands which we have discussed is 63 hertz, 125, 250, 500, 1000, 2000, 4000, 8000.

So, this L w OCT will have 8 different values at or it can be more if we are interested in more number of octave bands. So, L w OCT equals LW, but we do not use in use; in this case; L w we use the a weighted value and a weighted value we already know how to calculate it minus a factor F 1 and this factor F 1 will vary from one frequency band to other frequency band . So, it will vary from one frequency band to other frequency band [FL], it will vary from one frequency band to other frequency band, this F factor F 1 and you would be wondering what kind of numbers are these factors. So, so this F 1 is from a table which I will show you in a while. So, let us look at this table. So, this is the factor which will we call F 1.

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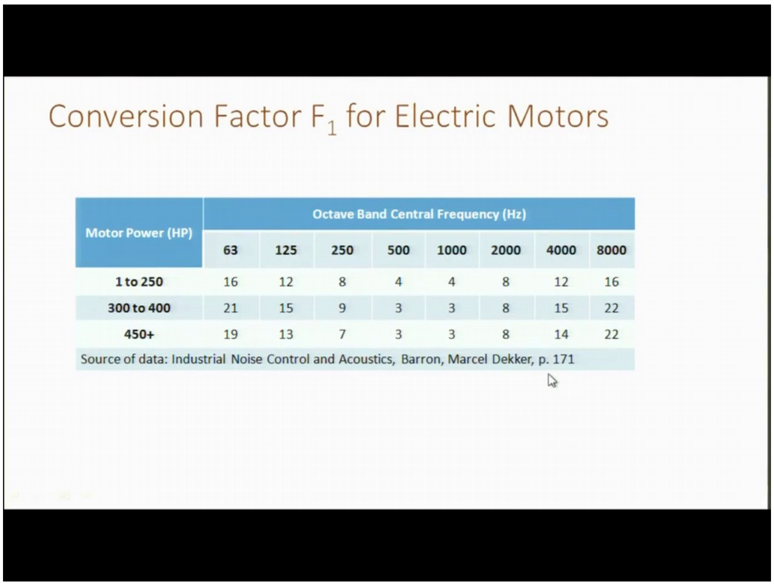

Motor Power (HP)	Octave Band Central Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
1 to 250	16	12	8	4	4	8	12	16
300 to 400	21	15	9	3	3	8	15	22
450+	19	13	7	3	3	8	14	22

Source of data: Industrial Noise Control and Acoustics, Barron, Marcel Dekker, p. 171

So, what you have in this table is and this is for electric electrical motors the horsepower of the motor 1 to 250, 300 to 400 and so on and so forth; there is a gap of course, 250 to 300; we do not have data; maybe you can look around or you would can do some approximation or interpolation from there from this, but for different octave bands with centre; frequency is these 63, 125 and so on and so forth; these are the values of F 1. So, you can pick up this value, F 1 F 1 from here and put it back in our equation and what you will get is the value of L w for each specific octave band for different octave bands. So, this is how we will do it. So, I think what we will do is will conclude our lecture for today and we will actually continue this discussion tomorrow also and specifically we will do a small example. So, those things become clearer. So, that concludes our discussion and we will meet once again tomorrow.

Thank you.