Noise Management & Its Control
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Lecture – 53
Noise Coming from Compressors

Hello, welcome to Noise Control and it is Management. Today, is the fifth day of this particular week which is the 9th week of this course. What we will cover today is the noise as it comes out of compressors. So, compressors are machines which; however, function very similar to that of a pump the difference is that pumps are used to increase the pressure in liquids while compressors are used to increase pressures in gases fluids. And based on this particular fact it itself, that compressors are used to increase the pressure in gasses by virtue of their function they are extremely noisy machines. So, it is important to that, whenever we are trying to develop estimates on noise from compare noise in a room or outside.

If they are compressors around it is you should be very important with the we do consider their presence while estimating the overall noise levels. Compared to compressors pumps are a little less noisier; and compare to pumps motors are even lesser noise making machines, but amongst the four machines which we have considered till so far fans, compressors, pumps and motors. Motors are probably the least noisy, while fans and these compressors they produce awful amount of noise.

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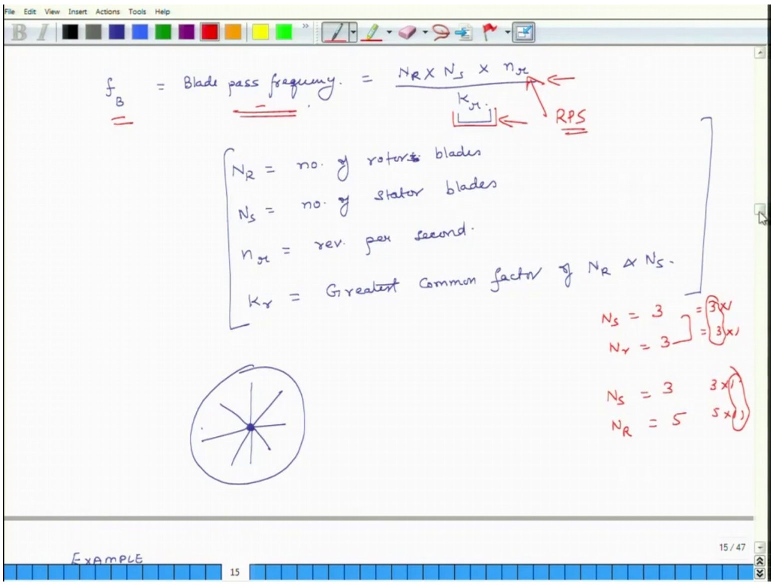

Let us talk about compressors. So, like pumps compressors also have a stator and a rotor. And as the rotor moves past the stator; now status has different slots and the rotor has different blades or projections and as it passes through that it generates a lot of puffs of air which gets pushed and the frequency of this thing is let us call it f B. So, what does f B mean? It means blade pass frequency it means bay blade pass frequency. So, it is basically the number of puffs which a compressor generates as it is pushing out air it pushes out air every second in so many number of steps.

So, what is this number? This is equal to N R times N S times N R. So, this is divided by K r and how do we get this relation? So, imagine. So, first we will define what are these terms? So, N R is equal to number of rotors or actually rotor blades, and then N S is number of stator blades and then N R is not RPM it is revolutions per second and K r equals greatest common factor of N R and N S. So, this is r relation this is the blade pass frequency. Every second air or whatever gas is being compressed it will be coming out of this compressor in these so many puffs. So, why; where this is this relation coming from? So, let us try to understand this later when you develop deeper interest into noise control management. A lot of noise can be resolved in terms of blade pass frequency and it is higher order harmonics.

So, consider just simple. So, let us say this is the shaft and let us say there are 8 blades

So, the shaft is rotating and I have made a very simple picture and it is rotating. So, attached to the shaft are 8 blades and through these 8 blades. So, whenever and these 8 blades are passing and as I you rotate. So, suppose it is rotating like this. So, this is one blade number one, this is blade number two, then you have two blades are here and then four blades are at 45 degree angles and when it is rotating all these 8 blades are rotating and in front of these 8 blades, let us say there is one stationery blade.

So, that is a stator blade. Suppose, you just consider one stationary blade which is the stator blade and then these eight blades are rotating. So, when this first blade passes there is some air which gets compressed between this rotating blade and the first blade. Then the second blade comes then again you have a second interaction between the aerodynamic interaction between the stator blade and the rotor blade, then the third blade comes we have the third interaction. So, when the, so every, if the so one revolution, how many interactions are there between the stator and it will be 8 interactions. Now, suppose there are two stator blades.

So, one blade is like this and another blade is on that side, then there will be 8 times 2, which is 16 interactions each revolution. So, that is why? So, if there are n a; N R and N S rotor blades and stator blades the total number of interactions will be N R times N S. And if in each revolution in each second there are N R revolutions the total number of interactions will be N R times N S times N R, but then there is a term in the denominator K r which is the greatest common factor. So, consider this. So, why are we dividing it by K r? So, to understand this let us look at this picture again. So, suppose you have let us say you have only three blades you have only three blades.

So, one is at 0 degrees, then the other one is at 120 degrees the third one is 240 and then when they rotate every 100; so you have three blades and you have. So, three rotating blades and one stator blade, so in each revolution the number of interactions with the stator blade will be 3. Number of interactions will be 3. Now, you consider that instead of one stator blade there are three equally spaced stator blades also. So, when this guy interacts with one stator blade the other a blade is also interacting with the other stator blade right. So, the interactions does not go up number of interactions is not going up. So, that because the greatest common factor between three stator blades and three rotor blades is 3, but suppose you had three stator; three rotor blades and two stator blades, then the number of so in. So, with one stator blade there will be three interactions and the second set of interactions will happen at 180 degrees off.

So, in the first case N S is equal to 3, N R equals 3 and what is how do you found out the greatest common factor? N S is equal to 3 times 1 and N R is equal to 3 times 1, what is the greatest common factor? 3 is the greatest common factor. So, that is how, but if it was in second case, if it was N S and N R; let us say this is equal to 3 and this is equal to 5, then this is. So, what is it 3 times 1 and 5 times 1 what is the greatest common factor 1. So, in that case K r would be 1. So, that is the reason why we divide it by K r.

So, this is the blade pass frequency this is extremely important parameter lot of rotating objects we are asked what is the blade pass frequency, because a lot of times the sound has a very strong tone I mean it the sound could be broadband plus tonal in nature, but a lot of times it has a very strong tone associated with this blade pass frequency and this is not only true for compressors it may will be also true for all rotating machineries where ever we have blades and static objects and a moving object passes through a stationary objects.

You will have this blade pass frequency tone come again and again.

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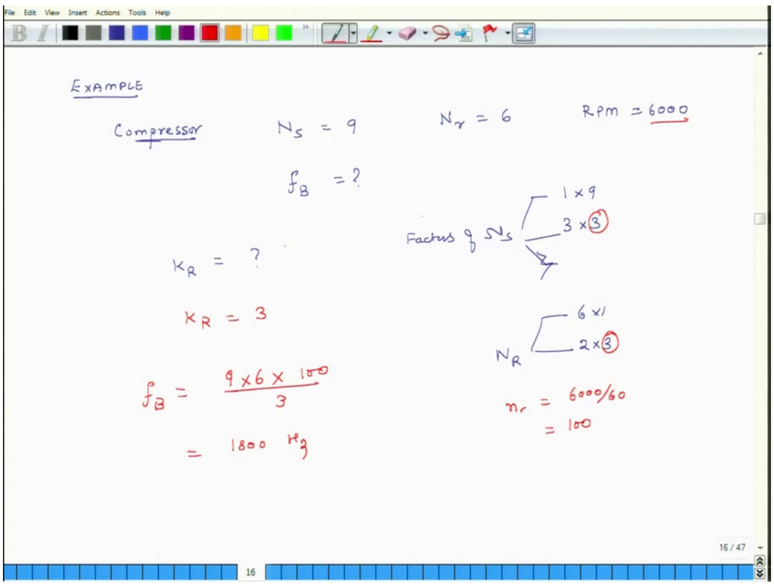

So, let us do one example very quickly. So, let us say we have a motor or of compressor and it has 9 stator blades and N R equals 6 RPM equals 6000, then f B blade pass frequency what is it. So, we have to first compute K r. So, K r what are the factors of N S? Factors of N S so one is 1 times 9 you can factorize it at you can also factorize it as 3 times 3 and the third way you can factorize is it as is 9 times 1 and for rotor 6 times 1, 2 times 3, 3 times 2. So, this is all repeating.

So, I will not repeat it. So, these are four possible fact four factors for N S these are four factors for N R. So, what is the greatest common factor? Greatest common factor if you look at it is 3. So, K r equals 3. So, our f B equals 9 times 6 times, our RPM is 6000, but we have to multiply it by N R is RPS in the RPS. So, 9 times 6 times and the RPM is 6000. So, N R equals 6000 divided by 60. So, I get 100 divided by 3. So, I get 50, 400 by 3 which is 18000 Hertz.

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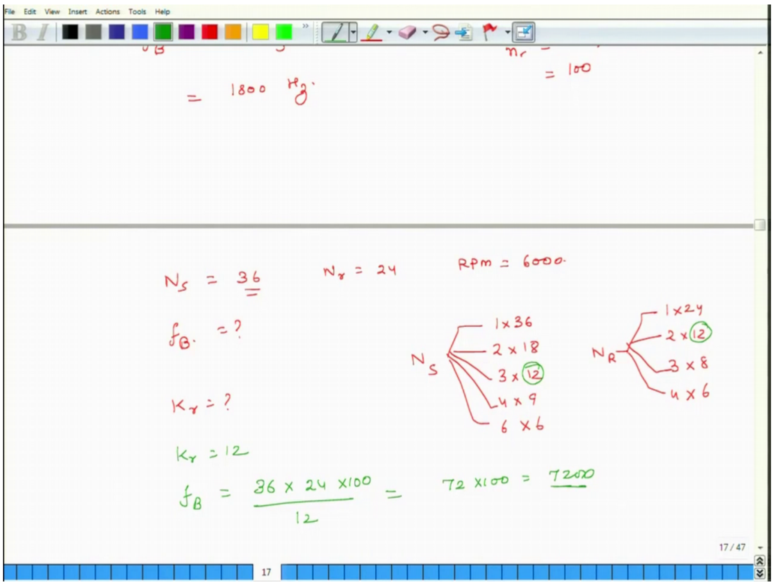

Now, let us consider another case. Now, this could be an extreme case, where N S is equal to 36 and N R equals 24 and RPM is this still 6000, then what is f B. So, again we have to compute K r and just to recap. So, how do we compute? So, K r is equal to what?

So, once again we factorize N S, in all possible ways 1 times 36, 2 times 18, 3 times 12, 4 times 9, 6 times 6 and then if I go down then it just repeats. So, these are and then for N R, what are the factors 1 times 24, 2 times 12, 3 times 8, 4 times 6 and everything else gets repeated. So, what is the greatest common factor 12? So, K r equals 12. So, f B equals 36 times 24 times 100 divided by 12. So, I get 72 into 100, 7200. So, this is the blade pass frequency, but like in other situations, in other cases as in case of fan, pump, motor our basic interest is not to just find out blade pass frequency but also find the sound power level of the overall compressor.

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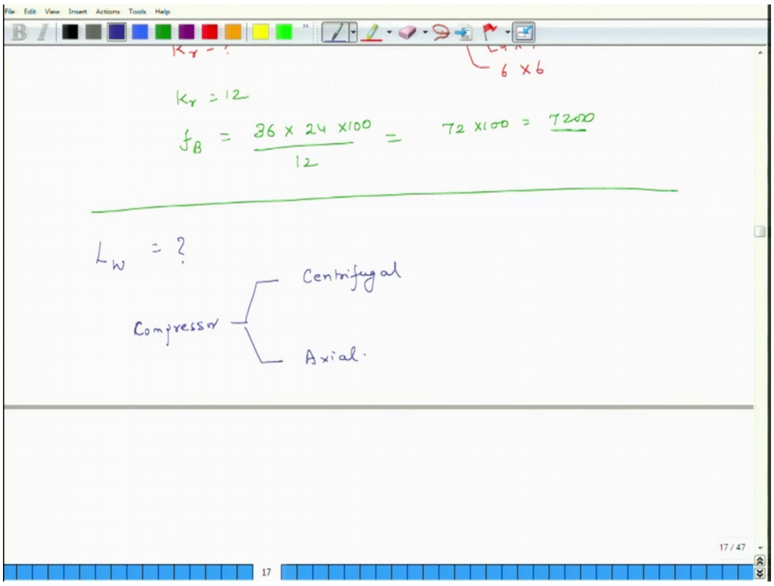

So, the question is L w, what is the value of L w for compressor. Now, this compressors are of two types and depending on what type of compressor we are using. The relationship for L w will change. So, the first one is centrifugal, and the other type is axial.

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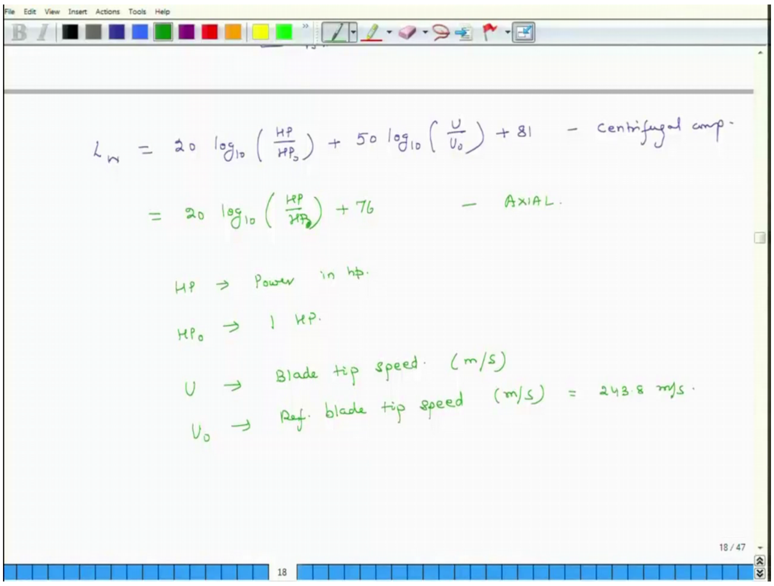

So, we have to know which compressor we are thinking of using. So, next ill write on the relations and w equals 20 log 10 H P over H P 0 plus, so these are all empirical relations; U over U 0 and I will explain all these terms. So, this is for the centrifugal compressor and if the compressor is axial, then it is 20 log 10 H P over H P 0 plus 76 this is for axial. So, this is H P 0. So, what is H P? H P is power, used by compressor in horsepowers. H P 0 is a reference horsepower level and that is equal to 1 H P is equal to 1 H P. So, in the denominator we just put 1 U is called the blade tip speed, what does that mean? It means that so in a centrifugal compressor you have all these rotors that basically blades and they are rotating at high speed.

So, what is the speed of the tip of the blade as it rotates? So, if you know the RPM and if you know the diameter of the blade, then you can calculate the blade tip speed. So, this is in meters per second. And then U 0 is the reference blade tip speed. And this is again in meters per second. And what is the reference blade tip speed? It is a strange number and that is 243.8 meters per second, because the original computations, they were done in foot pound system foot pound second system. So, it comes to some good number in foot pound second system, but when you convert it into meters per second this is the number 248.83 meters per second.

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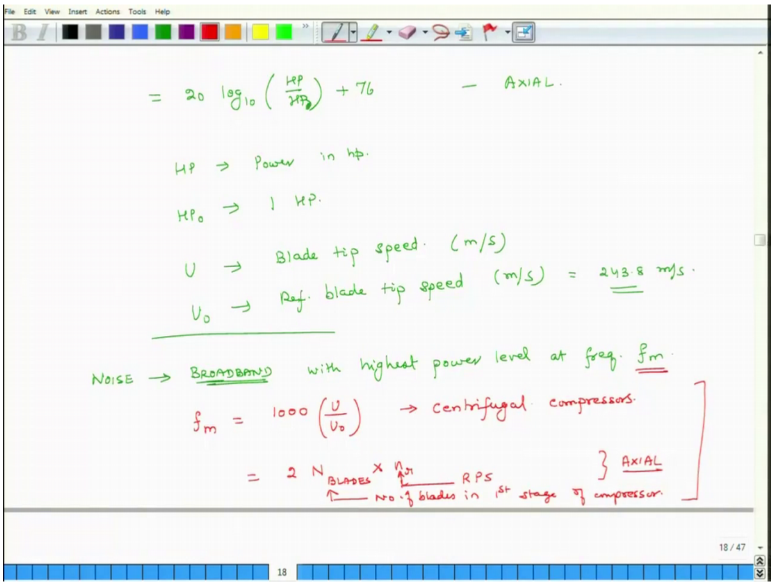

So, that is there the other thing to understand is that, this noise from compressor is in general broadband.

It is broadband in nature, but it is not necessarily that at all frequencies the sound power level will be the same; for all octave bands. It is broadband with highest power level at frequency f m. Now, this frequency fm is different than the other frequency which we had talked about which is blade pass frequency this frequency f m is different. So, if you look at the noise coming from a compressor in general; it will have all sorts of frequencies is coming out in the noise, but one particular frequency will be the highest and that frequency we call it has f m maximum frequency corresponding to maximum amplitude. And what is the value of that f m? So, f m equals 1000 times U divided by U 0, then U is the blade tip speed in meters per second and U 0 is reference speed this is for centrifugal compressors and if we have an axial compressor, then it is equal to 2 times number of excuse me number of blades times N R.

So, this is number of blades in first stage of compressor, because all these a lot of these axial compressors they just do not two compression in one go your first stage where you go from some pressure to higher pressure then you take that as the input and then again. So, they are multi stage compressors. So, first number of blades in the first stage compressor and this N R is revolutions per seconds. So, it I should write [FL] r little r RPS. So, what I have explained to you is you can calculate for; so this is for axial. So, what you have learnt is how to compute sound power level for compressors and there are two different relations one for axial compressors, another one for centrifugal compressors and this noise which comes out of compressors is typically broadband, but it has maximum amplitude at particular frequency called f m and the value of that f m is approximately in can be computed by these two relations.

So, that is what I wanted to discuss today? Tomorrow, we will continue our discussions on compressor we will also learn how to break this energy l the sound power level into different octave bands for the compressor and then also we will do an example. So, that we understand the problem of finding out L w from compressors in a better way. So, that closes our discussion for today and I look forward to seeing you tomorrow.

Thank you, bye.