Course Name: Design of Electric Motors

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Title: Electric Machine Sizing Equations-Output Power Equation in terms of $D^{2.5}L$ Product

Greetings to all, in the last lecture we have discussed the sizing equations of an electrical machines with respect to the D square l product equation and D cube l product equation. In this lecture, we will discuss D power 2.5 into l sizing equation and then by considering the rotor geometry, we can see here. The rotor geometry we will consider flux densities at the different parts of rotor core. The flux densities at the back iron, flux densities at the teeth and flux densities at the air gap we will consider and then actual current density of the rotor also we can consider.

Based on that we will derive the power equation. As of now, we have not considered the rotor geometry like slot information as well as flux densities at the rotor core. We have not considered and we have derived the power equations with respect to the D square l product D cube l product. First we will see the output equation with respect to the D power 2.5 l equation and after that power equations in terms of rotor geometry we will see. First the power equation in terms of D square l product is equals to some output constant into D I s square into l e. This is the output power equation into synchronous speed will be there and then output power equation in terms of D cube l terms constant c 1 into D naught s cube l e into synchronous speed. That is what we have seen in the last lectures. Based on these two equations, we will derive the power equation in terms of D power 2.5 l. We can utilize this equation or D cube l equation to find the different dimensions of the machine like inner diameter of the stator and outer diameter of the stator and length of the core. Just multiply these two equations p naught square that is output power square is equals to c naught into C 1 D naught s cube into l e square and D I s square will be there into N s square. From here, substitute lambda value in this equation. Here lambda is equals to D I s by D naught s that means, D I s is equals to lambda into D naught s.

So, c naught c 1 the output power constants in place of D I s square substitute lambda square into D naught s square and then D naught s cube into l e square N s square. Now, take the square root output power is equals to C naught and C1 square root into lambda square D naught s outer diameter of the stator power 5 and length of a core square and synchronous speed square. So, finally, we can see output constant C naught and C 1 square root into lambda and then D naught s power 2.5 into length core length and then synchronous speed. This is the power equation in terms of D power 2.5 l e. This term we can represent it as a constant C 2. Then the power equation C 2 into D naught s that is outer diameter of the stator power 2.5 into length of a core into synchronous speed. This is the third equation, final equations with respect to the D square l and D cube l and D power 2.5 l.

These are the power equations with respect to the stator side to find the key dimensions like stator core length and inner diameter of the stator and outer diameter of the stator. In these equations, we have not considered the rotor geometry like what is the flux densities at the back iron, flux densities at the teeth and flux densities at the air gap. Different flux densities we have not considered. We can observe in this figure. These are with respect to the stator side flux density at the back iron is nothing but Btr, Bcr.

Flux density value at the back iron is Bcr and flux density at the teeth is nothing but Btr and flux at the air gap will be same. So, we have to consider the Bg, Btr and Bcr, flux density at the teeth and flux densities at the back iron and slot information or slot geometry. The procedure is same to analyze the power equations. First, we have to write the slot area of the rotor Ar. We know the slot dimensions.

The slot opening is nothing but D naught r and the radius at the top side of the slot is r 1r and the depth of the rotor slot is dsr and the radius at the bottom side of the slot is nothing but r2r and back iron length is nothing but dcr and width of the rotor teeth is tr. Based on these dimensions, we have to calculate the slot area. Find the slot area by considering all these dimensions and then find the Bgr value, Btr value, flux density at the teeth, flux density at the air gap, flux density at the back iron. Calculate these three values and find the ratios and third step, calculate the width w1r that is nothing but this one and this is w1r and this is w2r slot width like we are seeing the slot in this manner. Here, this is r1r and this is dsr, this is r2r and back iron will be dcr.

Width of the slot will be w1r w2r. Calculate the w1r w2r and dcr and teeth width similar to the analysis what we have done for the stator side and then derive the slot area equation Ar in terms of Dr, D naught r, inner diameter of the rotor and outer diameter of the rotor. Derive the area of the slot and represent the function copper function with respect to the rotor fr of lambda and finally, find the power equation with respect to the rotor side. Consider the lossless system and power is in terms of f naught r of lambda. This is the output function.

Then, remaining terms will be in terms of d naught r cube into le. Some constants will come. So, same procedure we can follow to derive the power equations at the rotor side by considering the rotor geometry. The final power equations will come in this manner. Output power equals to C 1 or C 3. I will take C 3 into D naught r cube le and C 4 D naught r power 2.5 le. Output power should come in this manner into synchronous speeds. This is equation number 4 and equation number 5. I am not deriving these equations.

We can derive these two equations by similar procedure with respect to the stator side. So, with this, I am concluding this lecture. In this lecture, we have seen the equations with respect to the D power 2.5 le sizing equations and then, rotor side sizing equations procedure we have discussed. The same procedures we can follow for deriving these equations are the power equations with respect to the rotor side.

Now, we will conclude this lecture. Thank you.