Course Name: Design of Electric Motors

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Title: Design of Switched Reluctance Machine: Stator Design -2 and Rotor Design

Greetings to all. In this lecture, we will continue the stator core design and rotor core design like geometrical specifications. We will discuss the coil height and coil width, how to calculate and rotor pole height and rotor pole widths and flux densities at the different parts of rotor iron, etcetera. Let us consider the suture reluctance machine, where the coil width is nothing but, wc. We can see here coil width and coil height is hc. So, we have to calculate the height as well as width of the stator coil dimensions.

The coil area is nothing but, hc into wc, height into width. It is equal to total number of conductors placing in the slot or we can represent with respect to the cross sectional of the conductor into the number of turns placed in this area. This is the coil area, this blue color highlighted one.

In this, how many conductors we place? That many conductors into cross sectional area of the each conductor will give this area.

So, the total number of conductors with respect to one coil will be N phase by 2. If the total number of turns per phase placed on two poles means N phase by 2 will come. If total number of turns per phase is placed on n poles means N phase by n, we have to consider. So, this N phase by 2 representing the number of turns are placed on two poles. That is why N phase by 2.

So, this equation will give the coil area. Here, AC is nothing but, cross sectional area of the conductor in mm square and hc is in mm and wc also in mm coil width. Now, with respect to the perimeter of the bore diameter in terms of coil width, let us consider this is the arc length with respect to the stator pole Warc length and the coil is placed here, this side as well as this side. Consider here, one more coil is placed with respect to the other winding and the distance between these two coils is nothing but, wcs and wc is nothing but, width of the coil. So, this is with respect to one pole and two windings.

That is total width with respect to one particular pole. So, if you will define the perimeter with respect to inner diameter of the stator that is with respect to this point with respect to the inner diameter or bore diameter. The perimeter is nothing but, pi into Dis is equals to number of poles into this total width capital w. Capital w is nothing but, total width with respect to the two coil sides and distance between two coil sides and arc length. Two times the coil width plus distance between two coil sides plus arc length because, under each and every pole two coils are like two coil sides are placed from this point to this point.

That is nothing but, w. If you will consider coil placed on this side as well as this side and this is the width between like distance between two coil sides. Then this distance also will be same from this point to this point also it is capital W because, it is wc it is w arc length and it is also wc and this length will be wcs. So, the W capital W with respect to one particular pole length will be same. So, that length I am representing with respect to the perimeter.

So, Dis pi into Dis is equals to number of stator poles into two times the coil width plus distance between two coil sides and arc length is nothing but, what angle into radius right radius is nothing but, dis by two. So, if you rearrange the terms the width of the coil wc is equals to pi into Dis divided by two into number of stator poles minus beta s into Dis by two this total term will be arc length plus wcs by two.

So, this is equation number seventeen this equation will give the width of the stator coil. So, if you will substitute this width of the stator coil in the above equation with respect to the coil area hc into wc is equals to ac cross sectional area of the each conductor into number of turns per phase divided by two right. In this equation if you will substitute the wc from the equation number seventeen then we will find the hc is equals to height of the coil.

hc is equals to ac into cross sectional area of the conductor into number of turns per phase into Ps stator number of poles divided by pi into Dis minus number of poles at the stator side into arc length beta s into Dis by two just solve the this equation seventeenth equation I am substituting in this equation then we can find the height of the coil.

So, this is the final equation to find the height of coil and type of winding which type of winding we are utilizing means concentrated winding concentrated winding where all turns are conductors placed at one particular place that is on top of the with respect to the stator pole we are placing the conductors and as per the number of poles the winding has to be selected. Similar to the induction motor here also the length of the coil and phase resistance and volume of the coil and copper weight we can calculate since it is a concentrated winding the length of coil with respect to one turn this is with respect to one turn l coil with respect to one turn will be is equals to two times the length of the core plus two times the width of the stator pole here this is the width of the stator pole right and this is also width of the stator pole plus one to five percent of stator core length we have to select then this will give the length of one turn coil this is single turn coil. So, this length we can calculate in this fashion this is le and this arc length we can define with respect to the width of the stator pole and extra length I am considering on top of one other we are placing the N number of turns right and the straight portion which is coming outside the stator core that will be one to five percent I am considering empirically. So, this will give the length of one particular turn and if requires exact length of coil we can calculate as per the electromagnetic electromagnet example what we have discussed in the earlier lectures.

So, based on the electromagnet examples we can calculate the length of coil in a accurate manner. So, the total length of coil is equals to lc is nothing, but length of one single coil is nothing, but or single turn is nothing, but l coil into total number of turns per phase this one turn length into total number of turns will give the length of the total coil this is equation number 19 and equation number 20. And phase resistance and volume and copper weight and other things we can calculate similar to the induction motor like resistance rho l by a and volume l into cross sectional area of the conductor this is l length of the each coil or total length of the coil and weight is nothing, but density into volume into total number of phases this will give the copper weight.

And finally, we have to this equation similar to the induction motor we have to analyze and window check we have to verify. So, the total slot area to place the conductors into window factor should be greater than the 2 times the number of turns by 2 into area of cross section of each conductor or we can represent this complete term 2 into hc into lc because in each slot we are placing 2 coil sides.

We can see here this side 1 coil side is there this side also another coil side is there each coil side area is hc into wc. So, 2 times the coil area we have to consider and it should be always less than the actual slot area and window factor the window factor will be generally 0.5 to 0.75 k w with respect to this thing we have to verify the window check equation. And finally, for stator design what is the outer diameter of the stator then inner diameter of the stator plus 2 times the pole height that is dss or slot height and 2 times the back iron width that is dcs then we can get the outer diameter of the stator.

The next in order to design the rotor circuit the air gap we have to select air gap length that is lg lg for small missions small and low power applications it is in the range of 0.18 to 0.25 mm again these are the empirical consideration values and for high power applications it is 0.32 to 0.75 mm and depends upon the power rating type of coolant or cooling arrangement and speed of the rotor and magnetizing current we have to select the length of the air gap.

Next we will discuss the rotor design. Similar to the stator we have to calculate the height of the rotor pole and width of the back iron that is dcr and height of the rotor pole is nothing but dsr and inner diameter of the rotor and outer diameter of the rotor. First outer diameter of the rotor is equals to inner diameter of the stator minus 2 times the length of air gap will give the outer diameter of the rotor.

Next the pole width is nothing but this one that is wrp rotor pole width similar to the stator here also the angle with respect to the rotor pole arc angle with respect to the rotor is nothing but beta r. So, with respect to the rotor arc angle pole arc angle sine beta r by 2 is equals to width of the rotor pole by 2 divided by radius that is outer diameter of the rotor divided by 2 which will give the width of the rotor pole is equals to outer diameter of the rotor into sine the angle with respect to the rotor pole arc divided by 2.

This equation will give the width of the rotor pole. Next height of the rotor pole and the back iron thickness we have to analyze by considering the Bg peak value and Brp rotor pole flux density that is at this particular point and then this is Bg and this is B rotor pole flux density and this is Bcr. So, in the back iron it is flux density Bcr back iron of the rotor flux density will be Bcr at the rotor pole flux density will be Brp and the air gap flux density is Bg peak. So, we have to analyze this equations like phi is equals to B into A in this form with respect to this equation we have to analyze these three equations and take the ratios similar to the stator design find the back iron width that is dcr and height of the rotor pole. Then we can find the dcr and dsr equations the generally the thickness of the back iron dcr will lie in the range of 0.5 times the stator pole width to 0.75 times the stator pole width. After knowing the all these quantities like rotor pole height and back iron width that is dcr. So, after knowing dsr this one and dcr is nothing but rotor back iron width and dsr is nothing but rotor pole height. Then we can find the rotor inner diameter that is Dir is equals to outer diameter minus 2 times the rotor pole height that is dsr and 2 times the rotor back iron width that is dcr dsr and dcr.

Then we can find the inner diameter of the rotor this is the final equation to find the inner diameter. Earlier equation if we will solve this thing then this equation is nothing but 27. So, finally, we can find the inner diameter of the rotor. With this I am concluding this lecture. In this lecture we have discussed the rotor design like geometrical parameters like rotor pole height and pole width and back iron width and air gap how to select air gap length. Thank you.