Electrical Machines - I
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Lecture - 74
Demagnetising & Cross Magnetising MMF for Brush Shifted Machine

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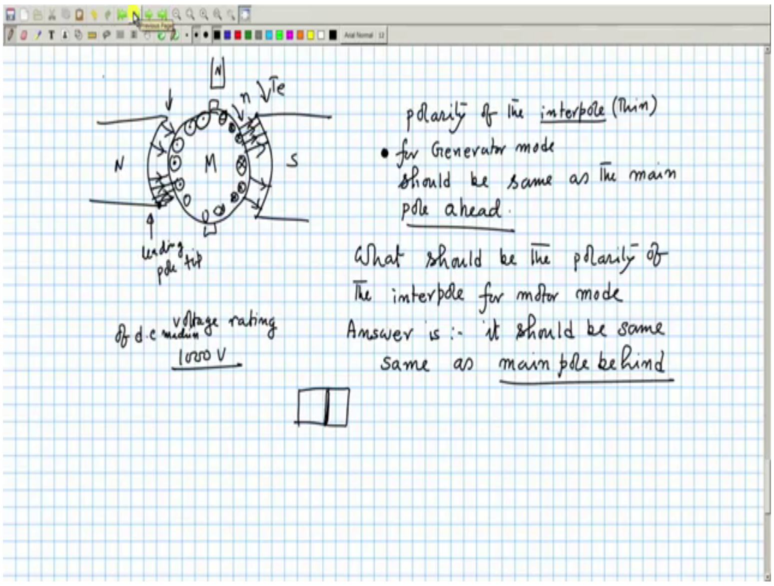

Welcome to the next lecture on Electrical Machines – I. And you if you recall, we have been discussing about the armature reaction in general, and then how to get rid of the effect of armature reactions in our last lecture, both for motor and generator mode of operation.

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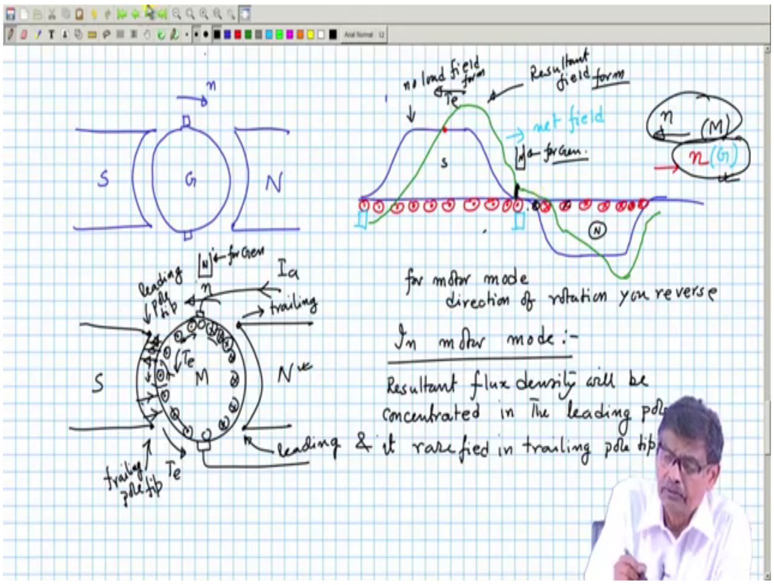

And this lecture was important and please try to go through it carefully and there also I told that a coil which is undergoing commutation will get affected by the quadrature axis flux. And therefore, for generator I can put some inter pole thin poles on the quadrature axis that is where the brushes are placed, current changes from dot to cross.

Polarity of the pole should be same as main pole ahead, because South Pole is positive. So, here some positive pole, you have to nullify it. And sometimes the strength of this pole is slightly made higher not only it compensates, but gives you a negative flux like North Pole here. In order that the conductor starts getting the feeling of what is ahead, the generated voltage wise, so it improves commutation and these are the thinner pole.

The important point is if you have drawn it for a generator mode, all the things you do is the same diagram can be used as a motor pole, as a motor description of different fluxes like no load flux because of field current, armature flux simply reverse the direction of rotation. So, for generator mode from left to right and for motor mode the speed is right to left. And as you can see the in case of generator mode the polarity of the inter pole should be same as main pole ahead, but in case of motor mode the direction of rotation is like this right to left. So, this is the, as if the conductor moves, the polarity of this of course the inter pole remain same in same. So, it is same as main pole behind which is living behind this you must understand.

So, in today's class first I will tell you that sometimes what is done is that some brush shift is given to the machines to facilitate the commutation process in a better way. For example, what I mean to say is this so go to next new page here, like this is the page lecture 74.

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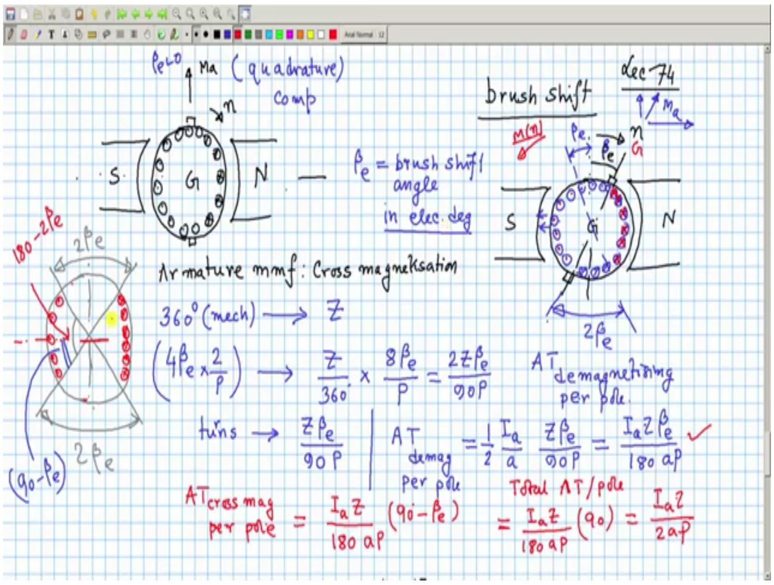

For example, if you have a DC machine like this and let it operate as a generator S and this is North Pole, [FL] I am not showing it is there. And here the brass axis is there and if the generated direction of rotation is like this in RPS, then these conductors will have be induced voltage as well as direction of the current under the South Pole, it will be all dot all dot is dot, so that electromagnetic torque becomes opposite to prime mover torque and these are cross, this is what we have seen clear generator mode.

Now, in this case the armature mmf whatever will be acting will be along the q axis is not this is cross dot, so field will be acting in this direction armature mmf. And in the quadrature axis the reluctance is high, so the corresponding flux will be less that is good thing; but armature mmf will be acting like that and this is called cross magnetization. And I told you, this is the geometrical neutral plane was defined as the main field axis is horizontal perpendicular to that is the geometrical neutral axis. And also the magnetic neutral axis coincides with this in this case, when armature is not carrying any current.

Now, what is done is this to have better commutation sometimes they, and all the armature mmf is of cross magnetization that is perpendicular to the direct field axis; so flux gets distorted this side it will be higher, and so on. So, now what is done brush shift, a little brush shift from the usual position of the brushes is sometimes given to the machine what for, let us see. Suppose what you do the same generator it is acting as a generator, this is the normal position of the brushes and these are the field axis, and this is suppose south north, this is the direction of rotation n for generator mode.

Now, the brushes instead of placing it here what is done, brushes are given a shift by some angle beta electrical. Mind you it is the representation of a multi-polar machine, because under two poles same thing is going to happen. So, people prefer to always draw a two pole diagram and showing all the angles to be electrical that should be cleared in mind. So, beta e electrical is the brush, so brush is placed here. In case of generator brush shift is given along the direction of rotation, the reason we will easily understand right now, so this is the thing and these are the conductors, armature conductors.

Suppose the little brush shift is given. Now, these conductors many of the conductors here, most of the conductors are under the influence of the South Pole that will dominate and few conductors might have gone to the North Pole. Particularly the conductors which will be undergoing commutation, that is I am training this conductor about what lies ahead already so, it looks like commutation process will be easier.

So, however the currents in the conductors they are all in series, so up to this point it will be dot; I am not telling the induced voltage here is once again dot, in this portion I am confident dot dot dot. But the current is delivered by the machine and few turns which has going to under North Pole influence, they has to carry same current. Similarly currents here will be cross up to this point cross and here is the conductor which passes this magnetic neutral axis, it will be the quadrature axis now this is the quadrature axis it is now shifted here, so you give some brush shift.

Under this condition why brush shift I have given, because the conductors induced voltage under South Pole is of dot polarity, but I am and this conductor is going commutation its current will switch over from plus I to minus I, as it crosses this brush position. Therefore, I will say that this conductor is started inducing voltage which will be dictated by this North Pole a little earlier, when it crosses the brasses. These conductors are under the influence of North Pole; these are under South Pole like that. And this conductor is under no poles that is fine, but the current will be here perhaps the induced voltage is 0, but these are all series, current has to be same no doubt, so it will be like this.

Now, under this situation you find that the armature mmf will be not along vertical, but along this line, this will be armature mmf. And we can easily see this armature mmf will have two components, one is along the d axis another is along the quadrature axis, it will be like this. Now, lines of force here South Pole it is like this therefore, we find the there will be a direct demagnetisation now taking place. There is a component which will directly try to oppose the stator pole, pole strength, which was not the case here, there was all quadrature component, here the components were quadrature; it distorted the flux no doubt, quadrature component only.

But here it is having both direct and quadrature component, this armature mmf. Therefore, there will be a direct reduction in flux per pole not because of saturation this that a little drop in flux per pole not like that the moment you ship the brush to have better commutation. The moment you do it, I will say oh there will be now some component of armature mmf acting in opposite direction of the field flux, because armature mmf flux will be like this which is directly opposing this lines of force and there will be a quadrature component, these two components should be there.

Now, what people do is this how to estimate how much is demagnetization and how much is cross magnetization. What do you do, you draw another line here such that you imagine this line such that it is also beta e, you imagine another line, this is beta e same as the electrical beta here, so that this angle will become 2 beta e. And people then say that the conductors in this 2 beta e and in this 2 beta e will give you the direct axis ampere turns produced by armature. This forget about this one, these conductors and this conductors cross cross cross dot dot dot, spanning over 2 beta e here, 2 beta e here what is the direction of the flux, horizontal. So, by considering this group of conductors here from that I will be able to calculate how much is the demagnetising ampere turns, so it is called ampere turns demagnetising.

Similarly, the conductors in this and in this portion this cross and this dot will produce mmf as if in the quadrature axis, and that will fairly give you the idea about the quadrature component of the armature flux. In this case what was there all was quadrature, how did I calculate armature mmf, I a Z by 2 AP like this is not, there was no direct confrontation with the stator flux it was not doing that, but it was only deforming the armature mmf. But here when some brush shift is given in case of generator in the same direction of rotation, beta e is the angle I know from the normal position of the brushes I have given a shift beta e electrical degree.

Then I will draw a line another beta e here, then I see that this is dot this is cross. And this mmf which are lying in this 4 beta e angle will be along this direction, directly in opposition with the direct axis flux. And it is this conductors which will be responsible for computing how much is the demagnetising ampere turns per pole, per pole we will calculate. Similarly this conductor cross and this conductor dot will give you the quadrature axis like this, this is how the computation is to be carried out.

Now, the calculations are pretty simple, Z is the total number of conductors Z, so I will write straight away, because we have some idea how to write. Over 360 degree mechanical degree, 360 degree mechanical angle this angle is mechanical, number of conductors present is Z, no doubt about that total number of armature conductors. Then I have to calculate how many conductors are present in this 4 beta e angles. So, 4 beta e convert it to mechanical into 2 by P, how 4 beta e comes in how many conductors, which will produce demagnetising ampere turns per pole and my goal is to calculate that it will be then Z by 360 degree this is also in degree.

So, beta e let me write, beta e is the brush shift angle in electrical degree, because all angles I will show here electrical, you must understand. So, how many mechanical angles it means, it means 2 by P, P is the number of poles of the machine; so Z by 360 into 8 beta e by P if I make a mistake point out, so this is like this. And this is equal to 2 Z beta e divided by 4 you multiply 90 P, it will be like this.

So, this is conductors placed in this angle how many turns, you divide it by 2, this will make 1 turn, this will make 1 turn. So, turns present over this angle is Z beta e by 90 P is not this will be the; so this is turns say turns. Therefore, ampere turns demagnetising will be current flowing through the turns that is I a by a into this one Z beta e by 90 P, and this ampere turns will be in these two air gaps it will be dropped. So, per pole it will be half of this. So, this will be I a Z beta e by 180 a P this will be the thing.

If beta is equal to 0, no demagnetising mmf that is here beta e here 0, I have not shifted the brushes here you get the same beta is 0 0. How much will be the cross magnetization, that will calculate also from this. So, this is ampere turns demagnetizing ampere turns per pole I a Z beta e, while using this formula remember beta e is the brush shift given in electrical degrees, whatever is suppose 2 degree, a small brush shift is given, ok.

Now, the question is how much will be then the cross magnetising per pole. Now, I will not once again calculate like these, because this is for so the conductors are spanning over 2 beta e 2 beta e, 4 beta e angle. So, what should be done is this one cross magnetising mmf will be calculated because of these conductors, this red marks I am doing now because of these conductors and because of this conductors, because it is indeed it looks like this is the cross magnetization; only this red cross dot conductors will be responsible for that.

So, here the thing is it is like this I will separately draw here, so that this figure does not become very clumsy what I am trying to tell is suppose this is your some circle here ok, this was this and we have this sort of thing, this is 2 beta e electrical degree, this is also 2 beta e, this is beta, e this is beta e. So, this angle is 180 minus 2 beta e. So, this I write it as this angle is 180 minus 2 beta e all angles electrical. Therefore, and here at the conductors; here at the conductors for which I have to calculate and these are all dot, and while calculating cross magnetising I do not have to consider this. This I have already considered for demagnetization, so these are cross oh, these are all cross here. I am sorry; this will I will not consider is not this is the thing.

Now, in the formula beta e comes should I derive another new formula no for this angle if you know, over which the conductors are sprayed you just substitute there. So, in this case this angle will be half of that is not, that is this angle will be 90 minus beta e half of this. So, ampere turns demagnetising per pole is this one. So, I now write the different color is that ampere turns cross magnetising per pole, I have to calculate per pole will be simply replace beta e by 90 minus beta this calculations are now, 180 minus 2 beta e by 2, because this angle is this up of this angle.

So, it will be then equal to I a Z by 180 a P only for beta e, I will write 90 degree writing is not necessary, because numerator degree denominator degree that was 90 minus beta e, this will be the cross magnetising amphere turns, is that clear. If you add these two; if you add these two, so ampere conductors if you add these two, then total A T per pole will be how much this plus this. If you add these two, it will be equal to I a Z by 180 P a

P comes common, 180 a P. And if you add these two beta e, beta e goes and only 90 will be left. So, it is equal to I a Z by 2 a P as expected, a total ampere turns per pole.

Therefore, total ampere turns per pole is known how much of it is demagnetising is this one, and how much of it is cross magnetising is this one is not I will be able to calculate that. And what should I do if brush shift machine is being used, then demagnetising portion of the ampere turns, I will try to get rid of using some coils which will produce flux along this line. And the quadrature axis component of the flux by interpole is not, I will cross magnetising ampere turns I will calculate, cross magnetising is this. If I want to nullify that mmf, I will put some interpole there also.

Similarly, the demagnetizing amphere turns this way if I want to reduce its effect; I have to perhaps what should I do, compensating winding. So, compensating winding may be used or in some machines you know compound machines where there will be apart from series field, some field there will be an additional field and that will also try to nullify that. We will come to the compound machine later, but what I am telling we have learnt, how to calculate, how much with a brush shift here, how much is the cross magnetising ampere turns per pole and how much is the demagnetising ampere turns pole for a small brush shift angle; do not give brush shift to a large amount.

And also note that this brush shift angle for generator is to be given along the direction of rotation. What if somebody generator mode if somebody gives here, the brushes he puts it here what is going to happen, the opposite thing is going to happen that is this conductor which is undergoing commutation will be still under South Pole is not direction of rotation is in. So, one should be very careful while giving a brush shift for generator it should be like this. And obviously, this everything remains same for generator the direction of rotation is this, for motor mode just show the direction of rotation there, dot cross everything will remain intact.

And you see for generator mode brush shift is to be given opposite to the direction of rotation. We have shown that now, in case of once you have shown the current direction, field poles, polarities for a generator with a assume direction of rotation. The same diagram can be used to tell you things about motor mode, only thing then you it is this direction of rotation show this to be the direction of rotation right is motor that is what I am telling same diagram. These for generator mode direction of rotation, this is for motor mode direction of rotation.

I think you have got this idea. So, this is here I will stop talking about armature reaction and things like that for the time being. And now, I will take up some as some problems can be solved from Parker Smiths book that is for a given DC machine, what should be the ampere turns per interpole or how much is the cross magnetising ampere turns needed in this case, you kindly try to solve this problem; which I will also put in the problem sheet there.

But here the important point is that the segregation of this conductor is done rather arbitrarily. Arbitrarily in the sense by looking visually to it, I just activate it beta e, beta e, then 2 beta e here, 2 beta e here gives you the demagnetising component. And this 90, 180 minus 2 beta e and 180 minus 2 beta e here, will give you cross magnetizing ampere turns pole. Henceforth, we will take some regular and rather usual stuff that is I will discuss about now motors and how to calculate torque, power about speed control, breaking those are very interesting stuff.

Thank you.