Electrical Machines - I
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Lecture - 75
Calculation of Compensating Interpole and Series Field Turns

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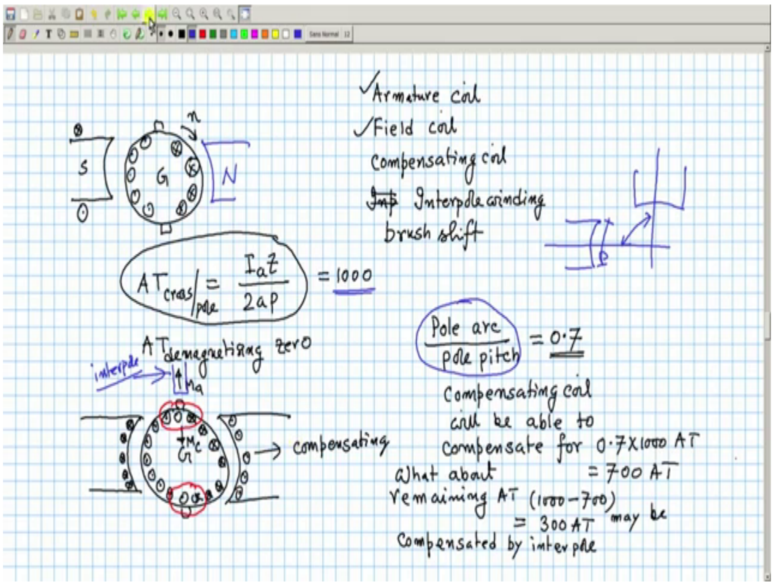

So, we have seen that in the context of DC machine we have generally armature and field winding it is there, but we know that when the DC machine will be loaded there will be armature current, for example, generator mode we have seen This side will be dot current and this side will be cross current etcetera this we have seen and provided it is running in this direction generator mode, this is south pole ok.

And, so, there is field winding here field winding here and field winding current only one pole I am showing, it is like this. Now, the point is then I have used several term terms like several other windings apart from armature. So, there is armature coil armature coil or armature winding, there is field coil field coil and then I use the term compensating coil compensating coil and then interpole winding ok.

Now, let us try to and I derived several formulas and then I used brush shift. Let us understand this sequence in which these terms have been used earlier. Now, let us first consider only armature coil and field coil nothing else. In this case there will be only ampere turns which will be cross magnetizing because the flux will be armature ampere turns cross magnetizing field and we have seen it is equal to I a Z by 2ap; AT demagnetizing is 0; zero. So, which case I am considering? Only armature and field winding is present, nothing else. This is the situation. What happens, the field flux is deformed because cross magnetizing field will be along q, there will be no demagnetizing component because of this current.

Now, how to and suppose I want to avoid this deformation in the flux the consequence will be there may be a little reduction in flux per pole for large machine if it is high we will try to see how it can be done. For example, AT cross magnetizing is this much now suppose I say that I will use compensating winding. And, compensating winding are put on the pole faces as we have discussed earlier. So, there will be coils here and this is the armature coil and these are the.

And, follow me carefully. What I am telling there must be logic somewhere on basis of which these things are to be put. So, this same generator running here and I decide I will put compensating coil. Why compensating because compensating coil too will produce flux in the q axis along the q axis. So, this is cross if it is I must connect this coil such that this becomes cross. So, this field the armature field is in this direction and armature field and compensating field you see it is in the opposite direction, is it not? compensating filed M c.

And, I want to make this M a vanish, but as I told you this coils compensating coils cannot completely compensate for all the dot currents here or cross current here. I told you there may be 70 percent of the armature mmf that can be compensated based on the ratio pole arc to pole pitch ratio. Suppose, this ratio is 0.7 then I will say the total of this cross magnetizing ampere turns per pole 70 percent of that will be can be compensated by compensating coil because these are the in the vicinity this dot currents will be there.

And, this conducting current, this group of coils which are outside the purview of this 0.7, they will not be compensated, is it not that that is the idea? Let us for example, with some numbers let me tell it. For a for example, suppose for a given machine this AT cross you calculate from this formula and I am now using this formula and what is their that suppose it is equal to 1000 ampere turns cross magnetization per pole is this much.

Then, what I am telling, this compensating coil setting coil will be able to compensate able to compensate for 0.7 times 1000 AT, 700 AT can be compensated because they are in this vicinity close by. So, about 70 percent of this it depends upon this ratio 700 AT will be there.

Then, if I know the armature current and compensating coil I will connect in series with the armature therefore, by dividing this AT with the total armature current not I a by Z because this compensating coil will be connected in series with the armature. So, I can fix up the number of turns needed for the compensating coil that is over. Now, the remaining 30 percent, what about remaining AT? That is it was 1000 minus 700 or 30 percent of the 700 that is 300 AT, what do I do with that?

See, both these the axis of the compensating mmf is along q axis armature mmf along q axis see it must be then only we can compensate and then this remaining portion mind you here is no brush shift nothing I have used. This fellow, this cross dot will also produce mmf here and these I will compensate by the compensating I interpole coil that is this 300 AT may be compensated by interpole.

Therefore, there will be a compensating coil which will compensate for about 70 percent of the total cross magnetizing ampere turns per pole of the armature. And, remaining 30 percent will be compensated by the compensating interpole winding; here I will connect interpole. Interpole is to be also connected in series with the armature. So, if I know the total armature current, then per pole how many turns I have to put I simply divided this 300 by that armature current and get the number of turns.

Therefore, I am repeating what I have done here in this slide that there is no brush shift there is the machine is here field coil, armature coil; then, I know there is ampere turns cross per pole total and it with deforms the field form and if at rated current large machine we know flux per pole effectively will be slightly reduced and so on.

Therefore, out of this total AT how much of it can be compensated by compensating coil? Maybe about 70 percent to be very precise, it should be depend it will depend upon this ratio pole arc to pole pitch that is this is suppose pole, this is another pole; pole pitch is this one this one is pole pitch and pole arc is only this much like that anyway.

So, 70 percent then compensating coil it has to compensate for all the armature current. Therefore, it must be connected in series with the armature and how much mmf per pole it has to provide I can then calculate 770 percent. Suppose, this number becomes thousand suppose this number then 70 percent whatever number it come then 7 0 percent of that and remaining 300 percent what should I do? If you want to make a very good DC machines, so that there will be no deformation of armature field at all then also compensate this by using an another interpole coil and get it like this is one aspect.

So, second aspect is so, I think you have understood second aspect is that then what happens when you demagnetize the armature?

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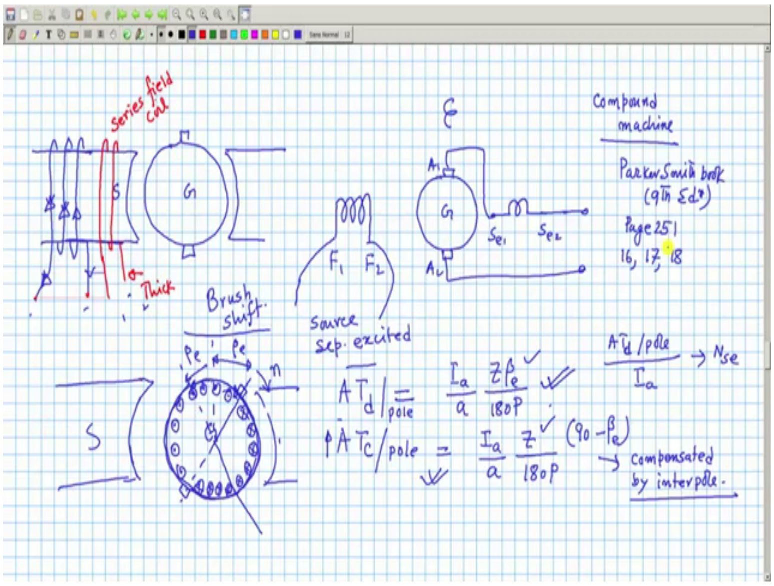

Demagnetization as such will not happen for normal machines this is your field coils oh sorry. Two pole I will draw electrical degree 360 degree. So, so this is suppose two poles, by simple arguments you can say that is the idea and this is the thing. Now, I am telling you that I know the increase of flux no brush shift, no compensating, no this that thing, but another solution to this whole problem perhaps could be because what happens is this when the machine will be loaded there will be armature current.

The there will be a reduction in half of the pole of flux and increase in other half, but the increase in other half is less than the decrease in the other half. So, effectively there is a net reduction in flux per pole. Suppose, it is acting as a generator therefore, the no load voltage generated p z by f i into n that will get reduced. So, what people do is this is your sun field winding this point you listen suppose this is your sun field coil which has lot of number of turns here this you want to make south pole. So, current must be like this then no, current should be like this. This is a south pole original.

So, what people do they say compensating coil interpole coil they are costly thing for large machine you might have to do it, but you can also do another thing. On the same field pole you connect another set of coil separate coil of few turns thick coil, this is thick and say that this coil I will connect in series with the armature. Field coil in parallel if it is shunt machine, but this coil I will connect in series with the armature, so that when armature current is 0 this current will be 0 therefore, flux total flux produced by the pole will be solely decided by this coil. This is called shunt field coil and this is called series field coil.

I can connect it like this and these are my field coils original field coils F 1, F 2 and this will be marked as S e 1, S e 2 of course, on the other poles also it will be like this I should not write these are terminals of the field of the machine series then the two terminals ok. These are the field coil terminals let me not write that you have understood what I want to tell these are the series.

Now, when you connect it in this way then it looks like that when the machine will be loaded if there is a net reduction in flux per pole, then this series field coil will provide you automatically additional ampere turns per pole perhaps to keep the flux per pole remaining same. That is why people talk about compound machines that is a generator might have a shunt field winding as well as a series field winding and it may be connected like this for example. So, I am now using another term called series field winding.

So, a DC machine could have then this is the field coil original field coil and this series field coil I am drawing it like this, few number of turns thicker coil, but their positions are on the same poles; on every pole it is like this. So, these two are field terminals and these two are series field terminals and then it is called a compound machine compound machine and these are the armature terminals without any interpole and compensating coil it is like that.

One of the easiest way to somehow make up for the loss in voltage is to have a series field winding and these two then connect if it is a separately excited machine excite it from a separate source separately excited machine or and the armature winding you connect it like this. This is A 1, A 2 if it is generated then connect to your load. So, if load current is not there this coil that is the red coil is not carrying any current, all the flux like this and when it is connected in this way it will compensate for this flux per pole. But, distortion of flux will still be there and on the q axis there will be some voltage induced. I think you have got the point.

Therefore, I can say that when the machine is having only this one series field, no compensating and interpole, then this interpole flux really cannot be compensated only thing it will maintain flux per pole same. So, this is one aspect, then the next aspect is which I have discussed at length that sometimes the brushes are shifted, for what? For improving commutation, is not? When the now brush shift I am telling. When you do brush shift brush shift is done because of what because to improve commutation.

For example, in case of generator brush shift is given a forward brush shift along the direction of rotation. This we have discussed and brush shift angle from the original that is geometrical neutral plane, this angle is measured to be beta e. The moment you do it, then the current distribution of the armature if you look at this all becomes dot. I am always talking in terms of this is south pole and this dot will continue up to this and these are cross up to this.

So, I have given a shift in brush and beta e means in electrical degree I have given. Then, I see this armature has both demagnetizing ampere turns as well as cross magnetizing ampere turns that is what I did. If you give a brush shift the demagnetizing ampere turns straight away comes and this formula we have derived it as A T d per pole as I a that is what we did a little earlier I a by a Z beta e by 180 P, where beta e is in electrical degree mind you that is what and it will be demagnetizing ampere turns is accounted by these conductors over this 2 beta e this beta e because it is in direct opposition with this main pole.

And, the cross magnetizing ampere turns this cross this is dot it will produce flux along the q axis that is the cross magnetizing ampere turns per pole and this formula also I have got to be is equal to how much cross magnetizing ampere turns I got it I a by a into Z by 180 p into 90 minus beta that is last time we got. Now, let us come to this problem then there is a direct demagnetization per pole. So, to compensate for that, compensating coil can only compensate for cross magnetizing ampere turns per pole, is it not; and 70 percent of that depending upon the pole ratio.

So, I will use compensating coil. So, I will calculate this ampere turns per pole compensating ampere turns per pole I will calculate, then I will say 70 percent of that is to be compensated by compensating coil. In the same way I will calculate the number of turns that will be the cross magnetization and demagnetization I will calculate based on this demagnetizing ampere turns per pole; demagnetizing ampere turns per pole comes here and how it is to be compensated for? This coil cannot compensate for demagnetization horizontal.

So, how this can be compensated, by may be series field, but the point is if I have the knowledge of this demagnetizing ampere turns pole and cross magnetizing ampere turns pole if I can calculate that then I can decide should I go for somebody says that I we will not connect compensating coil. Then, I will say the cross magnetization suppose, somebody says suppose somebody says that I will not use compensating coil. Brush shift you have given and this is the thing you have opted, then this cross magnetization which is not the total thing as previously perhaps can be compensated by the interpole, got the point? A T c per pole, it can be compensated by interpole; interpole alone.

I will compensate because it is not the full thing that this will be leftover. Earlier, I was telling 70 percent now that 70 percent is taken care of by this I have not taken care of from this to this. All the conductors cross magnetization only up to this and only this conductors are relevant, that is fine. So, I will calculate the number of turns of the interpole dividing this thing by the armature current I will do and the demagnetizing fellow I will compensate by connecting series field winding because demagnetizing this portion will produce flux along this direct axis. So, that I will connect series winding and do the compensation.

So, A T d per pole A T d per pole if you divide by the armature current you will get a number of series field turns. A T c per pole; here you mind, 0.7 I am not considering why because I have already given brush shift. So, it is not the full thing. So, it is a this fellow can compensate for this one. So, I will or I may use simply interpole to compensate for A T c per pole. So, ampere turns c per pole can be compensated, cross magnetizing ampere turns per pole by connecting say interpole only and you decide about the number of turns.

And, if you want to be completely free of any effect of magnetising current then you say, I will use interpole as well as compensating, then out of this a little portion should be compensated by compensating coil and the remaining portion if any should be compensated by interpoles. I think you have got the idea, but what I will request you and these are very simple problems algebraic manipulation, but this why this formulas are important you now know that is if a machine is having brush shift, then at least we understand the problem.

There will be demagnetizing ampere turns per pole not simply because of distortion some little reduction in flux direct opposition and brush shift I have done to improve commutation for large machines. If I have done that and this A T d per pole is to be compensated, this can be compensated by series field coil and see that is why series filed coil I have drawn like this, interpole coil I will draw like this – its axis is this; A T c always vertically, A T d always horizontally at demagnetizing.

So, I will request you to consult to try to solve this problem at least these three problem from Parker Smith's book which is I am having a copy of 9th edition and page number 251, 16, 17 and 18. Somebody even says like this that to instead of connecting series field you make an arrangement of extra shunt field turns when the machine will be loaded you increase the mmf of this or by increasing field current.

So, these three problems you try to solve and I hope you will be able to solve it nothing that is fewer calculations, but always remember this beta e is in electrical degree. If it is mechanical degree you have to convert it with a pair of pole turns to convert it to electrical, apply it, solve the problems straight ok. So, with that we will complete this.

Thank you.