Electrical Machines - I
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Lecture - 70
Compensating and Interpoles

Welcome to Electrical Machine I course and we discussing about the armature reaction and its ill effects on the performance of a DC machine and that too I am not using primarily any mathematical things with physical reasoning trying to understand that.

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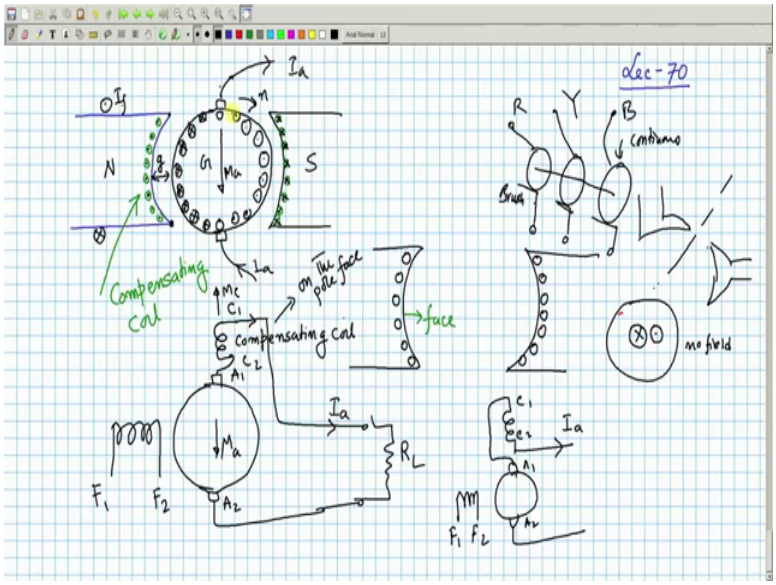

And we have seen that these are the poles, this is the armature, and there are brushes here in the quadrature axis which is otherwise a magnetic neutral zone, there is no B in this direction when the machine is under no load condition; this I assume north, this I assume south and so on.

And then I told each coil has to cross from this side to that side; a little while ago, if a coil was here carrying cross and dot current, after sometime the same coil will come here and has to carry dot and cross current; therefore, current changes from plus I to minus I and mind you that there is, there will appear a quadrature axis flux along this direction M a because of so many conductors.

I will slightly digress, because I cannot resist, but say another interesting thing. I told you that, these are the things dot, these are cross and this coil is now undergoing

commutation, direction of rotation I assumed like this generator mode that is the thing. Now see while studying induction motor all of us know that, suppose it is a slip ring induction machine; slip ring induction machine how do I access the rotor terminals? Rotor terminals of a slip ring induction motors are accessed by slip ring and brush arrangements.

Slip ring is a continuous ring, and brush is touching; is not slip rings are continuous rings three slip rings will be there and there will be fixed brushes which I am showing like this; three slip rings and three brushes these are continuous ring and why it was necessary because I want to access the rotor terminals it is going to R face of the rotor, this ring is connected to Y face of the rotor winding, B face of the rotor winding.

So, that this rotor terminals R, Y, B becomes stationary here and you can connect external resistance this that, in case of slip ring machine. In case of DC machine also because the armature conductors is moving; how to assess the armature terminals? We have not accessed it through slip ring and brush, because if you access it by slip ring and brush you will get AC voltage. It was necessary that commutator segment and brush arrangement intelligently connected will convert a DC voltage.

So, in case of a DC machine I access the rotor terminals through brush and commutator segments. What is the fundamental difference between these two connections? Here each terminal from the, this is brush in this machine, it is always connected to a particular coil end; has the coils move etcetera it never it is always connected to that coil fixed coil, one side of a fixed coil. Similarly this fellow is connected to one side of a fixed coil, but in this case this brush through commutator segment is getting connected to different different coils.

So, when a coil comes to a particular position then only this brush gets connected to that, it is not connected to a fixed coil end; otherwise you would have got AC like this fellow. So, that is why the rotor terminals in a DC machine is accessed by commutator segment and brushes to make it DC and also when a particular coil come in this position then only this two ends gets connected to brush and different different coils at different different times comes. That is why this space; in space what is the position of the coil? Whoever comes to that particular position in space that gets connected through brush, that is known ok, that is there.

Now another interesting thing I will tell, we have now learnt what is the ill effects of armature reaction; generator mode. Now suppose I want to say large machine armature reaction will be quite heavy, is not, armature flux this M a depends upon I s straight away. If it is a large machine, large current M a will be large, this quadrature B will be large, there will be large voltage, circulating current, and induced voltage in the coil, undergoing commutation two will be large because of inductance effect, more flash over is expected.

So, in a large induction machine, you cannot just have only field winding and armature winding and we feel happy; no, it is not going to happen, there will be very large flash over. What is to be done then, see without doing any maths and this that I want to nullify the effect of armature mmf. Suppose I say that the here is a conductor which carries cross current, and it produces field around it, like this we have seen fine.

Now suppose I say do something, so that there will be no filed because of this current. What is the answer to this? You will say, that I will then place this was the original conductor, and in the close proximity I will place another conductor carrying same current in the opposite direction and there will be no field external. Field will be 0, this fellow will produce this, this fellow will be produced in the opposite direction; net field in this will be at least will become substantially small. Field is 0 to the external world, if you have placed two conductors side by side includes proximity, not sure circuiting each other, then this field will not be there, no field; approximately no field better to say.

Therefore, if I want to, I know armature current will be carried, the moment you load the machine; conductors will carry armature current, M a will be produced. Is it possible to play some additional conductors in closed proximity of this armature conductors, which will carry opposite currents and of roughly same strength say; but where to put the additional conductors, here is a place to prove those additional conductors. See this is air gap, air gap g, air gap length is very small few millimetres things like that, is not.

And here is a space on the pole face, that is what I will do, what I am trying to tell on the pole face I will cut slots and put conductors, like this; on the other side also I will do like that oh sorry, on the other side also I will do like this that is this one. I will put conductors like this; conductors this is stator structure mind you, and this is suppose one turn, this is another turn these are all stator coils.

So, what can be done perhaps is common sense tells, I am not giving any mathematical calculation, that on the pole face this is called pole face on the face of the pole you have slots, grouped in, and place conductors like this, it turns like this, and this coils are called compensating coil.

So, what is the situation now in the DC machine, there where filed coils, it was carrying I f; there were armature coils carrying current armature, current I a in the conductance of course, that is I a by a parallel paths and there is now another coil which I will pass to nullify this mmf currents in this direction, this is cross, and this side dot.

Learning from this example cross dot nearby you place, so, it was producing, armature was producing flux like this; compensating coil will produce flux in the opposite direction and they will nullify and they will nullify they will be in a position to nullify provided this compensating winding is connected in series with the armature. When armature current is 0 this compensating coil will not carry any current, it is not needed; when armature current is growing up you are loading the machine up to rated current, then this current also increase, this current increases, so that for all currents you can compensate the armature winding.

Therefore, I showed now use like this to draw a machine winding, represent a DC machine, large DC machine; for small machines this is not done, because cost will be much more for such machines additional winding. So, what you do there is, it is shown like this symbolically field winding; this is F 1 F 2, here is your armature coil A 1 A 2 and the compensating coil magnetic axis of that is also along the quadrature axis, because these are the turns cross turn; are you getting me, cross coil comes here another turns, another turns and this runs on the stator structure through that you make this winding; therefore, compensating coil can be shown like this, its magnetic axis is along the quadrature axis and so, while connecting.

So, this is compensating coil, where it is physically present on the pole face, it is present here; and say C 1 C 2 like that and then you say that a large DC machine, large capacity DC machine, you connect this in series with the armature this and then connect the load this is what you do got the idea; therefore, it is always ensured that this is I a, I a the compensating coil winding current is proportional to I a, armature current is always proportional to I a.

So, you choose suitable number of turns of this one. So, as to nullify the effect of armature mmf; we will talk about selecting the number of turns later, but the point is this is the thing. The idea is very simple, that is what I am telling not really calculating how much should be the number of turns of the compensating winding. Another practical thing is you should be very careful when compensating coil is there, you have to connect correctly; what I mean to say, that I could also connect the compensating coil like this, this is the armature for the same machine, somebody this is C 1, somebody connects like this and C 2 with x and this is the field coils.

The compensate, what I want to mean is this; compensating coil is to be connected with appropriate terminals in relation to A 1 A 2. Suppose for the same machine I connect in both the ways separately, I will do testing; in one of the case it will compensate, that is armature C 1, suppose in this position generator mode this is M a, M c must be in this direction. Suppose in this position when current leave C 1 it produces M c, then only M c can balance M a of and reduce your armature mmf along quadrature axis; hence voltage induced in the quadrature axis in the coil undergoing commutation.

But if it is true, then in this case this is C 2 sorry. In this case, what is going to the happen; if this is the direction of I a oh, if this is the direction of I a through C 1 current enters therefore, it will produce mmf also in the downward direction and M a was also in the down ward direction, situation will be worst.

Therefore, while connecting compensating coil you must properly connect, so that the mmf produced by compensating coil opposes the mmf produced by the armature coil and then you get some relief, so far as the commutation problem is concerned. Do I get really a 100 percent relief? The answer is may not be; because see the pole face only extends not up to this zone the pole is there from this to this, while calculating pole face you know this is one pole, then there is another pole here, I drew it flux bar pole calculation, this is the magnetic neutral axis.

So, in this zone; however, armature conductors are there that is it is up to this point, but after that also cross dot is there. Can it fully compensate this? No, most of the armature mmf will get nullified in this process, no doubt but if you want to get perhaps there will be some still quadrature flux, which will be reduced no doubt, but may be present.

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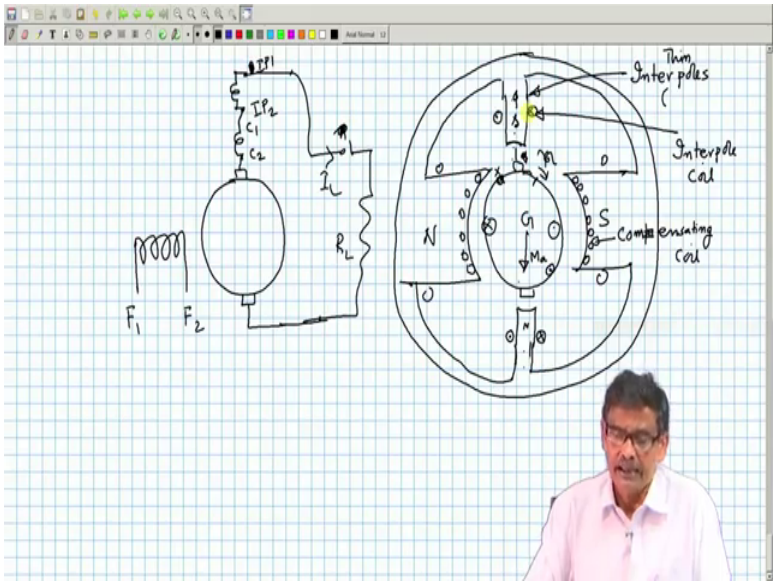

So, in that case what is done is that you this is the armature coil, this is the armature conductor, here is your field coil F 1 F 2 and here is your compensating coil, this can be compensating coil I will draw later.

What is done is this; let me draw here, also the poles so that you then get the idea of the term. So, this was the main poles, these are called main poles; north, south created by field coils, this is the quadrature axis. Now what you do is this; in this inter polar zone that is around the q axis, you produce some small poles, thinner poles very small width; and that is your stator will look like this one this is the yoke is and these are called inter poles, thin interpoles not this much large only small this thing and these are what field coils, these are what filed coils, and these are what, you put another coils here.

So, this is called interpole coils, for large DC machine you will find interpole coil. So, armature if it is generator mode, generator rotating in this direction; we know this currents will be crossed, this side current will be dot only drawing two representative conductors and your armature flux should be when armature carries current, armature flux should armature mmf will be like this.

So, what should be the polarity of the current? So, that this flux, I will not tolerate ; what should be the polarity of the current, to oppose this quadrature axis flux it if interpoles were not there, there would have been a flux that causes the problem therefore, I must pass cross current here and dot current there, is not. Similarly cross current here, dot

current there, like that I have to put, because there will be some quadrature axis flux present.

And then and this will take care of this nearby conductors, so compensate, this fellow cannot compensate for all the armature mmf. Majority of the armature mmf, I will also connect compensating coil whose axis will be same as the inter polar axis; this is the compensating coil sorry this is the compensating coil. I am just telling about the ideas, perhaps there was problem when you have compensating coil ok, you get rid of the armature reaction problem for majority of the armature conductors; but still you cannot compensate for conductors lying in this zone because this fellow ends there.

So, to avoid this flux still whatever it is left you connect some interpoles in this zone and this machine therefore, maybe having can be shown one large machine maybe having C 1 C 2 compensating coil and also it is axis is also along quadrature axis and these are interpole terminals, right by which name should I call it compensating and this is interpole I P 1 and I P 2 and this fellow also is to be connected in series with the armature, so that it can react to any armature value of the current properly. So, that this then will become your armature terminals; I mean effectively to the load then this will be the thing.

So, to summarize what I am trying to tell, that qualitatively we are first seen what is armature reaction, and what are the ill effects of armature reaction; and then how to avoid the effect ill effects of armature reactions by connecting a compensating coil, compensating coil will be pole face coil and also by if you have enough money then go for a fully almost fully compensated DC machine, having both compensating coil and also thin poles, thin inter poles; poles to nullify the effect of armature reaction that is what I am to tell.

Under no load condition I a is 0 this fellow is not there, no poles; one should not be under the impression that ok, but at no load condition there will be induced voltage across the brushes correct. But because of this field also there should be induced voltage, but that field is not there, is not, I a is 0 that is why you have made it dependent on the load current. So, that it can compensate for all the currents. Of course, I have not told how to calculate the number of turns of inter poles, compensating coils etcetera; if

possible I will tell you, but the physical reasoning are very important then only you go for computation, what are the things happening in a DC machine.

If you want to connect it such a big machine as a generator, then treat these two as your armature terminals and connect field winding like that I think you have got the idea. There are compound machines, I am not mind you I am not yet told about machines which has both field coils and series coil; that is different thing altogether. These two coils are to be connected in order to avoid the armature reaction effect. That is what we have discussed today and in our following lectures I will in fact sketch this armature mmf, in space how it looks like, field flux in space, super impose them and same thing whatever I have got here will be also obtain there ok.

Only last point I want to tell that if you see this is not, this is this polarity has to be south, is not, this polarity has to be north interpole polarity cross dot, lines of force will enter. You see the conductors which is; this point is very interesting, if you connect like that how it will improve computation. This coil concentrate on this coil, it was here on the left hand side, it was having cross dot voltage, is not and you know after some time after a brief period of time it will cross this what is called this borderline, go to the other side and he is asked to carry the opposite current; this cross current is which ends to dot immediately after it crosses.

Now when it comes here in this zone, there will be induced voltage because of the armature reaction north pole that we have studied and also because of the south pole, I can choose the strength of the south pole. So, as to nullify that armature north pole here, opposite poles I have brought in and induced voltage will be 0. The direction of the field was like this earlier under no load condition because of the M a in this direction; what I have done I have put another coil, so that there will be a filed there, this two may nullify and therefore, quadrature B does not exist, no induced voltage etcetera; and then it cross current here the current will 0, then negative some sort of smooth change over takes place.

Now, I may make this compensating poles by selecting it number of times, a little higher then what is required to nullify this quadrature axis flux itself that is. Instead of north pole layer there when this conductor comes here it will see a south pole; that means, this conductor was carrying cross current, cross it has to get in cross, nothing doing because

these are in series here. Then it reaches here it carries cross current but I am already I have already started educating the conductors that look here you are going to face a sudden south pole.

So, I will rather start training him that you start experiencing from now onwards. So, that it will improve commutation, it will be accelerated commutation it will be very helpful to the conductor, it has to suddenly see a south pole you start in advance that. That is he in this case interpole is designed not only compensate this B but also over compensated slightly overcompensate, so that the same polarity which this conductor is going to face after a little bit of time start facing a little ahead.

So, these are the nice physical reasonings with which one can go to understand what is going to happen in a DC machine when armature carries current.

Thank you; we will continue with this in the next class.