Electrical Machines - I

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Lecture - 69
Ill Effects of Armature Reaction

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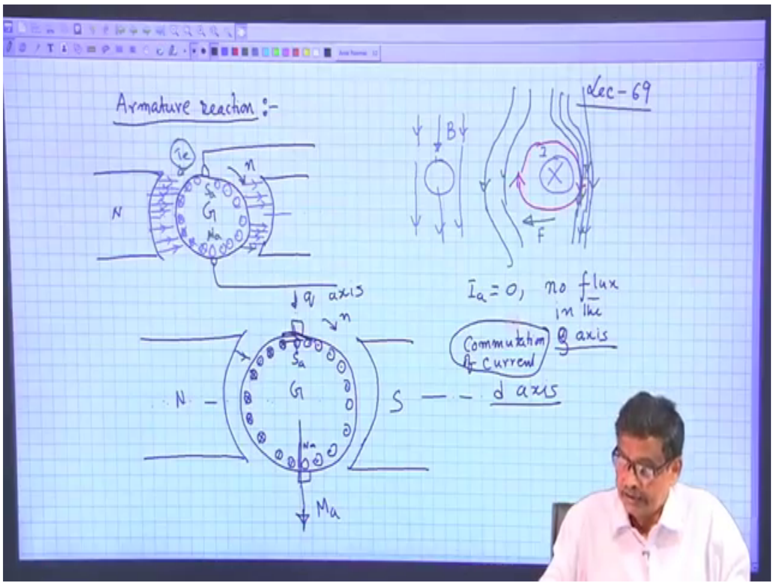

So, we have been discussing about Armature Reaction in DC machine and for that I took a generator mode of operation and assume the this direction of rotation and assume that this pole is north pole and then this side is south pole, I am not showing the field winding. So, under no load condition when armature is not carrying any current then the lines of force will be uniformly distributed over a pole that is the flux density will be same.

But, the moment armature is loaded this side of the conductor all will carry cross current, all will carry cross current here and this side of the conductor will carry dot current got the point, but the moment armature carries current this there will be a concentration of lines of forces on the on this side half to half it will be something like this and then it will be ratified here in this zone. Opposite thing will happen here the lines of force will go concentrated is not because of this here dot current it is like this and it will be ratified here.

So, half of the pole will have more flux per pole I mean more flux and so, there will be an increase in flux in one half and an another. In this context I will tell you just one very basic information all of us are having, suppose you have a magnetic field and suppose it is carrying a current I in this direction. So, it is a suppose uniform magnetic field; when it was not carrying a current it was uniform like this ok. When it was not carrying any current that is fine uniformly distributed.

But, the moment I to the same conductor you pass a current I the lines of force will be like this, lines of force will be like this. And, you can easily see the lines of force here will be more now after it carries current. So, lines of force will be thicker, I thicker means concentrated here because whatever lines of force was provided by the original field will be strengthened and, here it will be in the opposite direction, it was downwards here lines of force will be ratified that is what I am trying to tell.

And, another interesting thing is if this is the picture this is some current the conductor is carrying and you just imagine that these lines of forces are elastic sort of thing. So, if you just pull them like this then the conductor will experience a force this side force. This is of course, I know from left hand rule this is what is going to happen by applying left rule this way. Current B and this is the direction of the force, that is conductor will always move from high concentrated field to low concentrated field, in this case also same thing happens.

So, that is the electromagnetic torque will be in this direction consisted with the prime mover torque which has said the rotation. So, prime mover torque is also in this direction, electromagnetic torque would be like this. So, so this picture is like this and the argument was in general for low value of armature current, increase in flux in one half and decrease in other. If they are equal then flux per pole will remain same and nothing appreciable is going to happen. Also you recall the direction of the torque can be also found out the; I told you earlier.

Because, of the interaction of the two fields of the armature and that of by this stator poles. In this case the this side of the iron of the armature will become N north pole and this side will become armature poles will be Na Sa and, you can see this Na will be repelled by this N, the position of this Na and Sa in case of DC machine is same with time it does not change, it will not move because of commutator and brass arrangement that is the beauty. In so, many ways you can explain this armature reaction.

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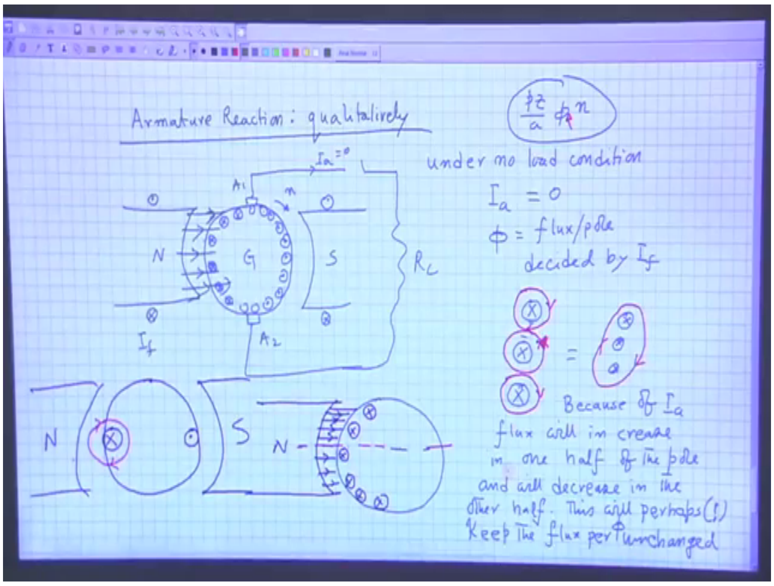

Now, as I mentioned in my earlier lecture that increase of flux in one half will really not be compensated by decrease in the other. In fact, decrease will be less than the increase in one half. I mean increase will be less than the decrease in the other half because, of saturation effect. If that be the case then the induced voltage will suffer a loss of voltage. So now, new flux for pole will be not by a very large amount flux per pole will decrease because, after all in one half increasing another half decreasing.

But only thing is this; the increase in the half where increment take place that is likely lesser because saturation effect. There will be a net reduction in flux per pole, some people what they do; they will simple say that because of armature reaction flux is reduced by 4 percent. By that some problems may be sent with experience flux per pole becomes or you measure the generator voltage, try to estimate the generated voltage.

And, from that you see that effective reduction in flux per pole may be 2 percent, 3 percent, 4 percent. So, original flux was phi, it will then become 0.95 phi 5 percent decrease with respect to the no load field present in the machine. So, apart from the loss in voltage there are other ill effects of armature reaction that I am telling you now and these are much more problematic; you see that in the machine I will redraw this, nothing wrong in re-drawing.

So, that you understand better and better, this is the armature it was there and there was the brasses, there were the brasses and here are the conductor. Now, these points are important for DC machine I mean very important. See this was your poles, good they are not permanent magnets in a practical DC machines, windings are there ok. Now, under no load condition lines of force will cross the armature then reach the south pole, complete its path through the F portion of the iron of the stator.

What will be the flux in this axis at sometimes I mentioned this to the my direct axis d axis, along which the stator field operates and this axis some people call it q axis, quadrature axis. When the armature is not carrying any current, what is the field? Here the field strength is how much? Ok. Whatever is this; what will be the flux in this direction; 0.

When I a is 0, no flux in the quadrature axis in the q axis where brasses are placed therefore, no flux in the quadrature axis. However, when there will be armature current flowing armature mmf I do not want to let me disturb this. So, suppose these are carrying cross generator mode, this direction it is moving and these are all cross. These are dot nice no problem, the moment you do this the armature mmf effectively it is cross, it is dot.

So, it will be like this, this way. So, that is why this fellow has become a north pole on the rotor iron. So, lines of force will be like this and this will be the armature mmf along the quadrature axis which was either to absent when the machine was under no load condition I a was 0 but now there appears a field here. Therefore, I would now expect there will be some flux per pole here, some flux be present here because of this armature mmf along the quadrature axis and therefore, the coils this coil when it was under the influence of north pole its other coil side was under the influence of the south pole having cross dot currents.

After the crosses these comes under south pole they have to carry current in the opposite direction and it is conditioned, you cannot do anything about that. The moment it crosses to this side from left to right crossing the q axis or brass axis, it has to carry this dot and cross current it has to. When armature current was 0 but it has to pass through this zone q axis. When armature current is present, when this coil will come here in the q axis it will also having least voltage in it; with what polarity; It was under the influence of north pole, this is the armature mmf; so, still under the influence of another north pole as if.

This is the south pole of armature, this is the north pole of armature. So, flux lines it is coming like this therefore, it will still have cross voltage induced in it. Therefore, the switching of current from cross to dot will be delayed, I will explain that in a much more simpler way. But, before that you understand that earlier it was like this cross under no load condition, it comes here, voltage becomes 0, current is 0 then you asked to carry dot current that was one thing.

So, it was getting some time, current become 0 then became dot but here it is almost; when it is present here in the otherwise magnetic neutral zone when I a was 0, this was the magnetic neutral zone.

There was no induced voltage in this conductor and because, but with armature current I find oh this is cross, this is dot still it has to carry current. So, this process of changeover of current deduction for a particular coil, each coil will undergo this process after sometime this fellow cross to dot current, it has to become.

So, this process is called what is known as commutation, commutation of current. An important term in the DC machine it has to, [FL] this is one thing and another thing is which while explaining the DC machine armature winding what I told is this, I will draw a very rough figure.

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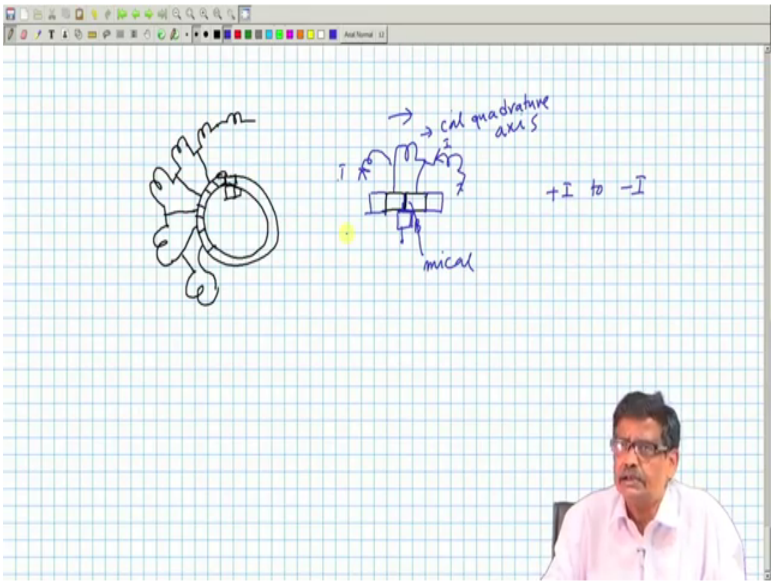

Now, see there were several coils I drew like this, I will draw a few of them, it was like this and there were commutator segment, commutator segment I am now drawing bigger ok. So, that we understand the process and there are so, many commutator segments and all coils are connected in series is not and the coil ends are terminated, this junctions on commutator segments, you recall that. Like that it went on and there are brasses here, this side is under north pole this starting etcetera.

So, brasses were here, brass width is same as the commutator segment, while calculating the voltage per coil in the armature I told you one thing ok. It is running at a high speed assume half of the coils it is expected, half of the coils is under north pole, half of the coils is under south pole and based on that I calculated the armature voltage but I did not tell that there may be a situation one coil will be in the quadrature axis also at sometimes it has to; but since the number of coils are more to calculate the induced voltage it will not cause any problem. Suppose, there are 100 coils, 1 coil will be undergoing such a process 1 or 2 coils.

When they will pass quadrature axis and go to that side and interestingly under no load condition the coil which will undergo commutation, I will draw it what I want to say. There are two committed segments, brass width is same as the commutator segments width and here is a coil on the quadrature axis, this is coil in quadrature axis. This is the brass, these are the commutator segments insulated by mica insulation and there is other coils here like that, it is under north pole that is next coil that is under south pole and so on.

But, you see this coil is then it is the direction of rotation, this coil is now undergoing commutation. Earlier it was carrying some current this way and after it crosses, it will carry current in the opposite way same current but in the opposite direction and I now find that the and this coil is undergoing commutation, when it is undergoing commutation in the this coil you see it gets shorted. By whom? By the commutator segments which is moving in space, but at that instant it will be shorted by this brass and this commutator segment and here.

Under no load condition there was no induced voltage, no problem. But, now when the armature current is moved in the quadrature axis, it is not true that the flux is 0. There is some flux some B some B is there therefore, B l B B l B induced voltage there and induced voltage will be there and that induced voltage will circulate some short circuiting current. Not in the other coils, but only the coils which are which is undergoing commutation but the boundary condition is when the coil was this side it has to carry current I in this direction and when it goes to that side it has to carry current in this direction, this is boundary condition nothing to in.

Now, therefore, it looks like there will be some problem, problem means there will be some circulating current, if there is flux in the quadrature axis and, also coil carries coil has to change the current from plus I to minus I, it has to change the current. In any case this coil has also got some; however, small it is a small inductance associated with coil. Any coil is having some inductance which is proportional to n square etcetera, we know that.

The period of time during which this commutation will take place is very small because, machine is running at a high speed; everything is happening very quickly. Therefore, if I say a coil having some inductance l and the current is changed from plus I to minus I, in a very less amount of time do not you expect some induced voltage in the coil l d I d t, which will be very large because in a small time from one finite value of plus I to minus I it is changing therefore, there will be also induced voltage in the current.

What will be the polarity of the induced voltage? Polarity of the induced voltage will be such that it will try to oppose the very cause for which the voltage is due, that is it will try to oppose the change of current. For smooth operation of DC machine I would expect the changeover of current from plus I to minus I takes place very peacefully, plus I then it becomes 0 in the quadrature axis, then it becomes minus I.

But, inductance of the coil which is short circuited will prevent that, that is the induced voltage in the coil is such that it will try to still carry plus I current and that is why people say commutation is delayed and not only that there will be large induced voltage in the conductor l d I d t will be large and this voltage may even because it is a thin mica insulation may cause a flux over between the commutator segments.

See there are so, many things happening here; the coil which undergoes commutation get short circuited in the quadrature axis. By whom? By the commutator segments and the brass in the quadrature axis that is one aspect that will be we expect some circulating current which I do not like because current still persist and the polarity of this induced voltage because of rotation of quadrature flux I just told in the previous diagram, it is saying like this.

It cannot distinguish north pole it was under still north pole under and they that is I am making a situation coil still carries plus I. Although finally, his task is he has to carry a minus I current and minus I current it will do in any case and the price we pay for that is the large induced voltage across the coil l d I d t and that large voltage may compare this, there maybe a direct flash over between the brasses and there will be arching taking place between the brasses flashes.

It is a common practice, if you see a DC machine running and if you can see the commutator segment moving at a high speed there are brasses and you switch off the light you will find there are arcs between the commutator segments. It is because those coils which are undergoing change of current from plus I to minus I, under a short circuit thing environment like this there may be a little flash over. That is why you want disadvantage of DC machines is that it cannot, it is ruled out you cannot make use of it inside a mind for example.

There may be explosive gaseous and because of this flash over there will be fire, out of question DC machine because it is bound to have some flashover between the commutator segment, even for normal operations. Apart from it may affect the your nearby communication network, it will radiate energy all these things because high speed it is running. If you have a radio set or TV on and nearby a DC machine is running, you will see that disturbance will be picked up by your TV set, picture will be spoil disturbed.

So, all these things I am telling is that armature reaction has a far reaching consequences in terms of various things. It will delay the commutation, it will not make a smooth change over a current; although plus I to minus I the moment it causes it has to carry minus I and you are giving it a very small time, high speed it is running; suddenly it was there, it goes there; large voltage will be induced that may function at the insulation mica insulation this is a thin mica insulation and it may it will cause problem and it cannot be use DC machine, this is the reason.

In normal case also there will be a little bit of flash over and you ruled out you rule out the use of DC machines in a hazardous, in the environment with I mean particularly mines etcetera; DC machines cannot be used, conventional DC machines ok. So, these are the ill effects of armature reaction, for small machines people do not care a little bit of flash over will take place between the process. Every time a coil undergoes computation say up to few kilo Hertz you tolerate it.

But, suppose there is a DC machine of large capacities, suppose 20 kilo Watt DC machine, a DC motor or DC generator. Their armature current will be very large, if armature current is very large there will be armature flux also very large is not and commutation will be further delayed, larger voltage will take place, will be induced in the quadrature axis; whoever passes that zone it will have additional induced voltage. In normal case if I a is 0, nothing no flash over nothing because I a 0, no quadrature axis flux everything is fine; but the moment large machines, large armature reaction you cannot avoid this. Therefore, you must do something to avoid this armature reaction and this I will discuss in my next lecture.

So, qualitatively I have explained with simple logic ok, these are the things going to happen and these are going to cause problems, please understand that. Then we will actually draw the armature mmf diagram also, super impose it with the field coil mmf and see ourselves in fact, it is happening that is in the next class.

Thank you.