Electrical Machines – I

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Lecture - 73
Filed Patterns for Both Motor and Generators

Welcome to 73rd lecture on Electrical Machines I.

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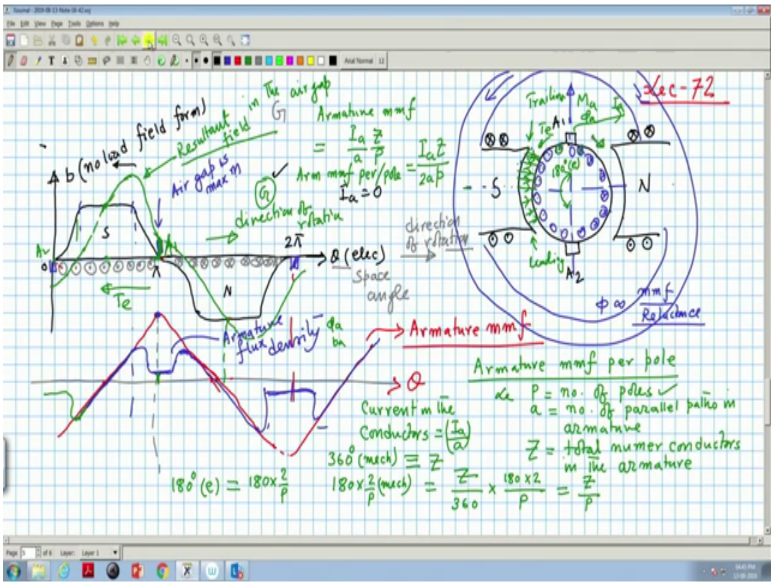

And in our last class I told you how to get the resultant mmf distribution or b distribution in the machine and the conclusion was that in the trailing pole tip flux density will be concentrated which we understood from our qualitative way of discussing the things. But, it is also corroborated if you would or the actual field distribution resultant field distribution with this green curve lines, of force would be concentrated here electromagnetic torque will be this way, then generator mode this is generator mode ok, and then we try to calculate the how much mmf is produced this, from this we will start once again.

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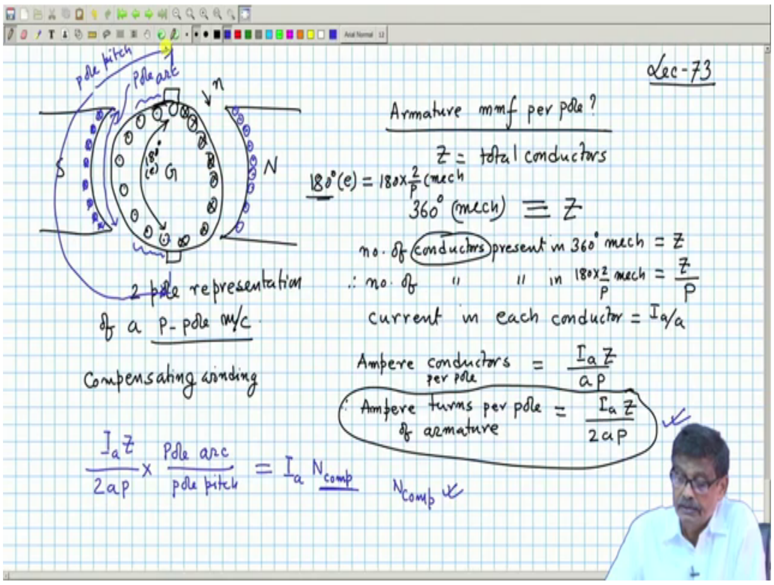

Student: [FL].

No, it [FL] just [FL].

Student: (Refer Time: 01:40).

So, this was the scenario and this is South Pole, North Pole generator mode I assumed rotating in this direction and these are the brass axes and these are the conductors armature conductors and these are all dot ok, these are cross,. So, this is how we got this. Now, I told you in my last class that this is a all angles error electrical angle because it is 2 pole representation pole representation of a people machine, I should be just careful about that only thing.

So, what happens is this I want to calculate how much is the armature mmf per pole. So, my target is to get armature mmf per pole, how do I calculate. It can be done much more simply, but I will do it in this way because of reasons I will tell you later, armature mmf per pole how to compute. So, the thing is Z is the total number of conductor's total conductors and this is these that over 360 degree mechanical angle number of conductors distributed is Z.

So, I first calculate this one therefore, over 180 degree this conductors; over 180 degree how many conductors are there? So, I will write it like this number of conductors present in 360 degree mechanical is equal to Z. Then, I will calculate number of conductors present in this 180 degree electrical this is 180 degree (Refer Time: 04:56) this is 180 degree electrical 80 degree electrical. So, over this 180 degree electrical, but 180 degree electrical is equal to 180 into 2 by P mechanical.

So, I first calculate how many conductors are present here. So, in that is 180 into 2 by P mechanical degree how many conductors will be present, which will be equal to Z by conductors mind you, this should be highlighted Z by P it will be, ok, this is the thing. Currents in each conductor is equal to I a by a [FL] there therefore, ampere turn; ampere conductors will be then I a by a P, then I will say ampere conductor. And this is for ampere conductors ampere turns per pole will be I a ampere conductors per pole, it will be divided by where is Z gone where is Z, here ampere conductors Z will be top.

So, I a Z by a 2 a P this is the thing, this is the ampere turns per pole; ampere turns of armature of armature, field is separate thing, it is there. Now, I told you that I suppose do not want to have this distortion, because it causes problem in commutation this that therefore, I will put what to nullify this. I will put some conductors here on the pole face winding and that is called compensating winding; you recall, compensating winding and where the conductors are placed on the pole phase. These are the compensating and I will make sure that the direction of the currents if it is dot I will make it cross.

So, that their effects will be nullified we discussed last time from physical reasoning because air gap is small in the close proximity you put this, with the hope that the effect of this dot currents will nullify the effect of the cross current. But the point is that with the help of compensating winding you cannot compensate for these conductors which are outside the tips of this pole, got the point; for example, this conductors present in this zone and in this zone cannot be compensated by this.

So, and why this in which way this knowledge that ampere turns per pole produced by armature is this much will help me to design the number of turns I will put here that is what the reason is, [FL]. This length you try to understand what is this length; what is this length? This is the pole pitch is not and the pole actually exists within this zone. So, this one is called pole arc; this is called pole arc therefore, this I a Z by 2 a P is the armatured turns per pole this into this ratio pole arc to pole pitch you calculate either in angle or in distance, it does not matter ratio can is a number less quantity.

So, this one only can be compensated by this got the idea. So, this is the thing while designing how many turns this compensating winding I should make it equal to I a into N compensating, got the point. The armature conductors per pole, I will because compensating winding I will connect in series with I a and therefore, I will be able to calculate what should be the number of turns of the compensating winding that is the whole idea.

So, what I did, I calculate the armature ampere turns per pole of the armature, it covers all the conductors between one pole pitch this is the pole pitch and I will put compensating winding, and compensating winding can only compensate for the conductors covered under this pole arc, this is pole arc over this pole arc. Therefore, how much of this can be compensated this into pole arc by pole pitch this ratio and I will then say per pole you have to put how many conductors, I a N compensated; where N compensated is the number of turns of this compensating coil.

Hence, N compense compensating turns can be calculated, it will help me to calculate that. Therefore, a portion of this uncompensated field will still be present that is because of the unattempted unattended armature conductors present under the influence of the poles, that is done to be done by what is called the compensating winding. We will come to this, once again after we discuss about the idea of brush shifting ok, that that formula helps me to estimate the value of the number of turns to be provided in the compensating winding that is the thing we will discuss [FL].

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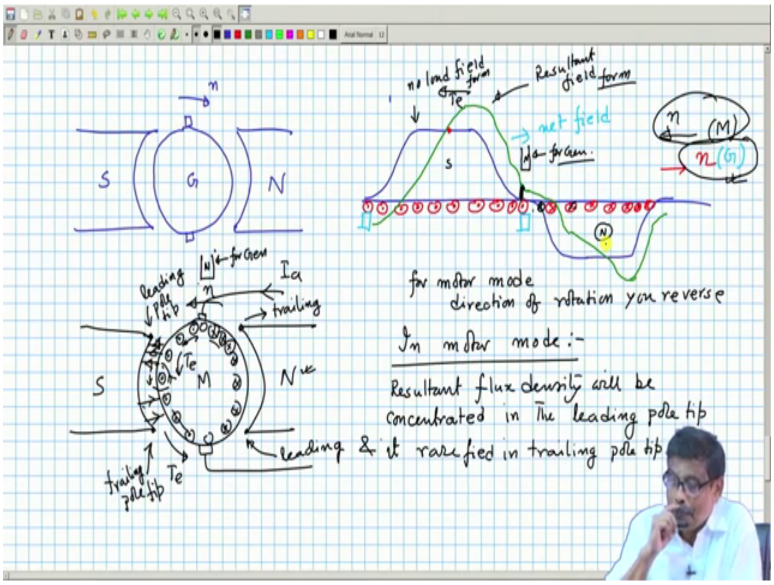

Now, it then comes that one thing is this. These are the poles main poles and this is the armature ok, same diagram we will draw this is the field, this is north, this is south and these are the brasses. Now, another important thing I will tell that this is the generator mode, this is the direction of rotation and I have assumed you know this is South Pole let me become consistent with this diagram this is north. And we got this one, this is the no load field form, this is the field (Refer Time: 15:25) field distribution because of these magnets; and we have seen that I will, and this is the conductors let it be read armature conductors.

And this is the direction of rotation; conductors direction of rotation red colors and these are the armature conductors and then I know these are dot and these are cross. And the resultant field after getting the armature mmf added to this one will be shifted, not that is what we got it will be somewhat shifted, there will be a q-axis flux present and things like that, and here are the brushes; this is one brush and there is another brush presented, this is the net field net field and this is generator mode.

Now, what happens if it is a motor mode? So, if it is motor let me draw quickly and I will tell you one very useful tips. So, that we need not struggle anymore this is suppose motor mode. And motor mode if it is and suppose the direction of rotation is N here and these are the brasses, these are the conductors.

Now, in motor mode we pass current from a supply to the armature and suppose the direction of current is such that this is dot; mind you, this is the direction of the current no not the polarity of the induced voltage that back mmf is not that. It is the forced current into the armature in this direction and this way has to be cross, is not this is the direction of the current. And the direction of the torque is in the direction of rotation, apply left hand rule you will get that. So, this is for a motor mode.

Now, look at this diagram; this is the no load field form, this is the resultant field form then, what I am telling now is that this the same field waveform can be attributed to motor only thing is for motor mode direction of rotation universe that is show the. So this is generator, you just write like this same diagram, write in this way reverse and right motor, very good; I mean, absolutely no problem that is what it means. Therefore I need not always draw for motor and generator mode separately, but only thing is important is this one.

See in case of motor mode which one is the leading team; motor mode this conductor coming in you are sitting on this, you will first see. So, this is for motor mode this is the leading pole tip; leading pole tip and this one is the trailing pole tip. Similarly, this one is the leading pole tip other pole leading whichever pole tip first you see of a given pole that is the leading and this is the trailing pole tip.

In case of motor mode you will see that lines of force if you go from fundamental physical rule lines of force for this dotted line will be like this with this arrow is not dotted and lines of force are really entering here. So, it will be concentrated here this side and it is in opposition to this so, this will be ratified.

So, in case of motor mode you are sitting on the armature conductors you are moving this pole start South Pole and you find lines of force are concentrated here, that is why electromagnetic torque in this direction. Electromagnetic torque will be in this direction from higher concentration of b to lower concentration of b everything is consistent. And electromagnetic torque in whichever direction acts in the same direction armature moves, this must be understood in one stroke you can say that.

So, for motor and generator mode if you draw for one for the other, you just show the direction of rotation to be reversed keeping the polarity and the deduction of the current same, you get everything in place and your conclusions about other things are ok. But only thing in motor mode, we must not forget in motor mode, in motor mode resultant flux density will be concentrated will be concentrated in the leading pole tip and it will be ratified in the trailing pole tip opposite, it will be always happening.

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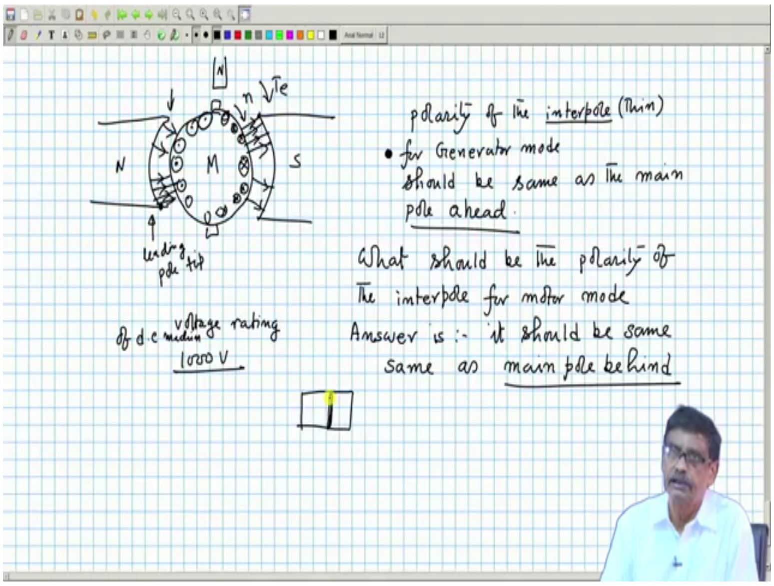

If I say that somebody is saying this is the; I mean, I just to tell you in other somebody says ok, it is acting as a motor it will be; I will now arbitrarily say suppose this is North Pole, this is South Pole and I say this is the direction of rotation of the motor it is motor mode, this is the direction of rotation. Therefore current in this conductor this side should be dot left hand rule this is not I have drawn for a change, I have done like this you should not get disturbed about this at all.

Suppose he says that it is operating as a motor it is running in this direction, then first thing I will do is electromagnetic torque has to be in this direction therefore, I decide about the current by applying left hand rule, that I do. Which one is the leading pole tip? This one is the leading pole tip because these are the conductors it is moving; so, it will first see this one this is leading pole tip and this is trailing pole tip it has nothing to do it north or south that is what I want to emphasize trailing pole tip.

Then I will say that look here torque is in this direction has to be; that is why if the currents are dots and lines of force will be concentrated here in this up and it will be ratified there. Similar thing happens here which one is the leading pole tip this one lines of force will be concentrated and it will be ratified there. So, do not get disturbed by the fact that somebody has done like this, but it remains same. In any case one can always go to the fundamental to see really it will be concentrated because in the North Pole it is like this, you see this side it will be concentrated and it will be.

Therefore, this diagram is handy you draw for motor or generator mode correctly in the field form drawing, I am telling draw it correctly then the other one you just show if it is you have drawn for motor then for generator, it will be with reverse direction you show everything will be correct, [FL].

Now, therefore, compensating winding will be here and it depends upon the arc of the pole divided by this pole pitch, this ratio will decide how much of this armature conducted mmf can be nullified by that and this is it will be obtained like that. This will never be able to nullify this flux in the q-axis because this will remain unattended got the point. Therefore because of this cross dot; cross dot that there will be a flux here because this portion of the conductors has not been nullified.

So, compensating winding at best can maybe 70 percent, if this ratio this length divided by this length is 0.7; 70 percent of this armature mmf can be compensated. However, this cross this dot will give a current here flux there, this flux will be there and it causes problem. And to compensate for that you have to bring interpolar winding a small thin pieces of poles will be also placed here which will be called interpoles.

What do you think, the polarity of the interpole will be if it is acting as a generator; suppose it is acting as a generator this one and I want to because this flux is going to induce voltage in the conductor which is undergoing commutation. What is commutation? The conductor has to cross this zone of q-axis where it feels that there is no induced voltage no flux, but when armature carries current there is a flux, there will be induced voltage, there will be short circuiting current and also it has to change the current from dot to cross in a very small interval of time.

So, it will be better if this is made 0; so, what should be the polarity of the interpole for generator mode, it is still South Pole. So, I have to if I want to make it 0, I must put a North Pole here for generator because South Pole is I have shown going in. So, I must here I will connect and interpole which must be north for generator mind you, that is polarity of the interpole should be same as the polarity of the main pole ahead that is this conductor in this diagram, it is going to be under the care of North Pole it is living South Pole.

So, polarity of the interpole should be same as this fellow then only it can be brought to 0 with some number of turns I will adjust there, ok; so, that is there. Therefore, I will conclude that polarity means, whether north or south polarity of the interpole for generator mode should be oh, should be same as the main pole ahead as the main pole ahead. Main pole is the main poles big poles, interpoles are very small; polarity of the interpole which are very thin only provides you this one should be same as the main pole ahead, these are bullet under this bullet we write.

Now, what if it is a motor that is the question. What should be the polarity of the interpole of the interpole for motor mode? Come to this diagram straight. For motor mode this is the thing direction of rotation from right to left, you are here cross current and here is a pole here. You will be seeing for motor mode direction of rotation is from right to left, you are coming in from the influence of the North Pole, is not; you are coming from influence of the North Pole and what should be the polarity of this interpole you want to, but this positive direction is South Pole.

So, to nullify this you require a North Pole here which is same as been pole behind got the point. So, for motor mode the polarity of the interpole for motor mode answer is it should be same as main pole behind main pole behind, got the points. Therefore, if it is a motor mode it is moving in this direction, I will say I want to have a interpole here; I want to have an interpole here for this general problem I have changed everything north, south, currents ok, these are cross current, dot current.

I will say this is the direction of rotation this coil is suppose moving has to pass through this q-axis it goes there and I know there will be a field existing here, even if you use compensating coil some flux will be there along the quadrature axis. But the question is what should be the polarity of the interpoles? It says that it should be same as main pole behind that is North Pole, got the point.

So, with this I stop today, but please go through this so many interesting thing you can with very simple logic can explain in a DC machine. DC machine one of the important thing is drawbacks or whatever you call it is because of the commutator segment and brasses and the commutation; commutation should be as smooth as possible.

Commutation means a conductor carrying plus current will be immediately after some little bit of time when it crosses the q-axis it has to carried the dot current. We must do it uniformly; otherwise, what happens there will be flashover between the brasses and a thin strip of mica insulation is there that may break.

In fact, with this last word I will in fact stop. You will here for example, induction motor its rating could be kilovolts, in synchronous machine also of the order of kilovolts motors are available very large voltage synchronous and induction motors are available 6.6 kV induction motor in industry is very common.

But in DC machine the voltage rating you will never hear of that level. Voltage rating of a DC machine may be at the best 1000 Volt that is all; voltage rating of a DC machine maybe at best a 1000 Volt. You will never hear a machine 3.3 kV DC machine; no, out of question. Why? Because of the fact at that high voltage this the commutation problem will be severe you cannot do anything with this, that is why for example, Kolkata metro they use DC motors, supply voltage is how much 750 Volt or 800 Volt maximum is not.

Therefore DC machine with armatured I mean voltage rating is about 800 Volts, 750 Volts, 600 Volt, but in case of induction or synchronous machines they can we have very large voltage ratings because there is no commutator segment neither brasses. Commutator segments as you know these are thin copper strips and separated by thinner mica insulation.

So, mica is a breakdown voltage of its own and two commutator segments side by side with a thin layer of insulation; with large voltage means, the voltage existing between the commutator segments will be also large and machine will fail. Anyway with this note, I stopped today we will continue with this and next class. I will discuss that about the brush shift that can be giving to a DC machine to improve commutation that will be in the next class.

Thank you.