Electrical Machines – I
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Lecture - 61
Armature Winding of D.C Machines – III

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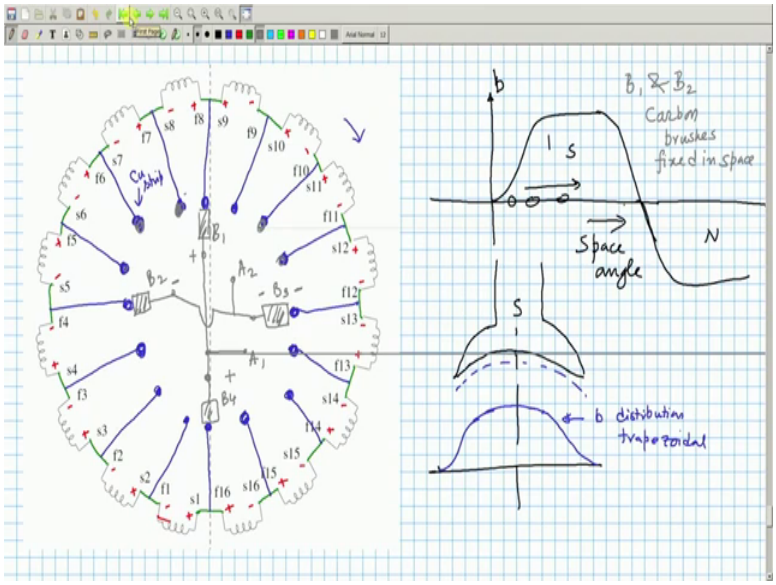

Welcome to lecture 61 and we are going through Armature Winding which is more complicated than an AC machine winding. And you recall that to convert it to DC we have to do these things that is spatial distribution of polarities of induced voltage existing across each coil. We have taken 16 number of coils for convenience to explain the things out and assume the stator poles to be 4 mind you P is equal to 4 and this way I did it. I will just tell you that suppose we say that it is a 2 pole machine 16 coils, how this will look like.

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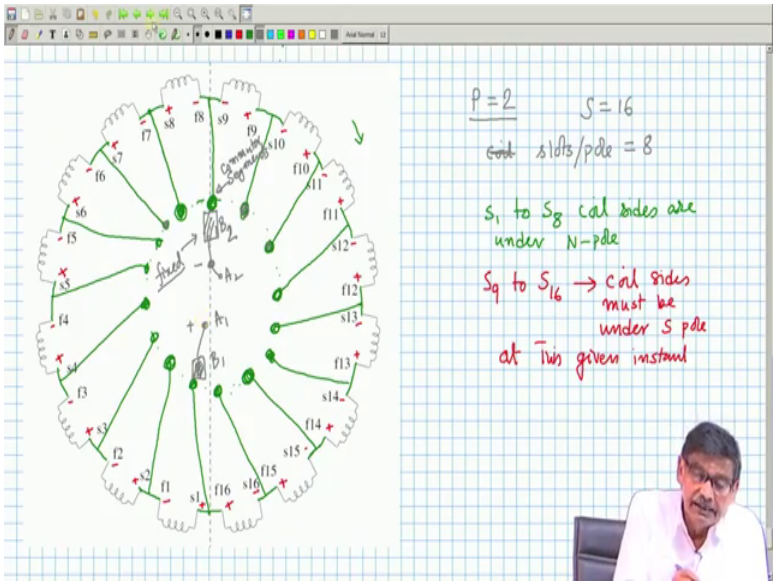

So, that you understand the previous one much in a better way. So, if it is a 2 pole winding and total number of slots are 16, then I will first calculate coil span, number of coils a number of slots per pole this is what I have to calculate slots per pole that will then become equal to 8, is not? And with that understanding that the start of the coil under North Pole and all the coils are connected in series of course, so, that thing I quickly do. So, that you, what will happen if the number of poles is equal to 2 not 4.

So, as I told you all the coils should be connected in series nothing like that. So, these coils have connected in series, will there be any circulating current? No, although each coil will become seat of emf, because if I show the polarities of the voltages as many plus minus voltages we will see in that series closed thing so many minus plus we will see they will cancel each other.

So, if it is a 2 pole machine therefore, I would expect the starting coil sides of say the first 8 coils s1, s2, s3, s4 up to s8 they will have a fixed polarity. They will be under North pole I have taken a snapshot when this 8 coils coil sides that is s1 to s8 coil sides are under say North Pole and direction of rotation is such that polarities of s1 s2.

If s1 is plus f1 must be minus because f1 is the other coil side must be under South pole that is how I have made the windings plus minus plus minus plus minus plus minus plus minus plus minus and plus minus and s9 to s9 to s16 this coil size must be under South

pole coil. At this given instant of time; at this given instant see coils are moving, but on an average 8 coils will be under North pole s1 s2. So, it will be like this.

Therefore s9 to this one it will be on opposite polarity, it will be like this. Then the next step is series closed then from the junctions I will draw it in a much better way now what I will do I will draw a circular my god this one I will draw. Now, from the junctions I will bring out some wires physically connecting it to this one and this side it will be a thick copper strip, here there will be a thick copper strips, there like that and this is how I will complete the diagram like this and here will be another 16 coil sides.

And then what I am telling? I will put carbon brushes in space which will be fixed that will not be rotating with this armature coils rotating this copper strips 2 will rotate in a particular direction. Then I after drawing these take after taking a snapshot and this thing with time I am telling you this distribution of plus minus this will remain intact whoever comes in position of s1 f1 after sometime a 16 f16 will come here and s1 f1 will advance to that side, but it is destined to have this polarity plus minus that is the crucial point. Then what I will do? I will put a carbon 2 carbon brush I will take which are fixed where plus plus has come I will call it B 1 and where minus minus has joined this is also this carbon brush it is positioned in such a fashion that this copper strip will be touching this whenever it moves fast.

And this is say B 1, this is say B 2 carbon brush and these 2 I will say this is armature terminal 1 and armature terminal 2 and this time only 2 brushes we will do no 4 brush is required, because you want to maximize voltage all the emfs here, no matter which coils which 8 coils are on the right which 8 coils are on the left polarities of the voltages is such that across B 1 B 2 you will always get DC voltage, got the point. Now, this is fine so, far as understanding is concerned this is what you have to do, but in a practical DC machine this type of arrangement it is to be made more solid I mean constructionally ok, what is done is this in the actual DC machine.

So, brushes are to be placed in proper positions in space that is whoever has made the winding he will tell you put the brush here put the brush there. So, that you will get DC voltage in this case, this A 1 become plus voltage it will give it will give minus voltage rotate the armature in that field produced by the stator coils and you will get DC voltage. So, that is very nice. Now, this one instead of doing like this it is to be done in this

fashion. This copper strips in effect I will I must tell that these are to be called commutator segments, each coppers thick copper strips in this representative diagram and these are fixed brushes; fixed brush.

So, in the armature winding of a DC machine coils are closed connected in series then you will have 2 additional thing, one is a commutator segments as many commutator segments has the number of slots and there will be 2 or 4 brushes or 6 brushes depending upon the number of poles if the winding is lap winding that is what I told you. Now, let us see how this commutator segment is to be connected see from the junctions you have to drop this one.

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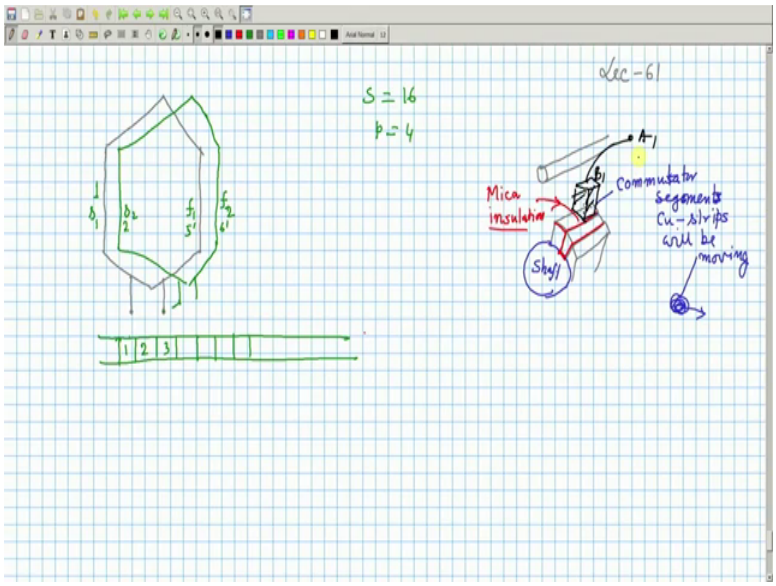

Now, let us come to this diagram that is suppose this is one coil let me draw in this develop diagram, this is suppose one coil I will henceforth show with true terminals it is a multi term coil ok.

Now, what is to be done is this, below this on the shaft of the machine this is the shaft I will put another thing like a ring whose which will look like this one. These are copper strips the one I told showed with a circle it is on the shaft of the machine I will put it like that these are called copper strips or called commutator segments. Copper strip conducting, but each copper strip there will be as many commutator segments as the number of slots because number of those circular thing we have seen it is equal to the number of slots.

So, those circle thick these lines we talked previously nah these I am telling these are the copper strips in actual machines it is done like that ok. I have not brought that armature winding today unfortunately next time I will show you, but this is on the shaft of the machine it will be inserted this way it will go and this is the shaft of the machine shaft got the point.

And each commutator segment adjacent commutator segments should be insulated from each other they should have their own electrical identity. For example, in the previous diagram these 2 are insulated by space they should not be if they are touching purpose will go very purpose will be lost. therefore, what happens is this with a different color I will show. The rate portions are called mica insulations.

So, that these 2 each segment has it is own electrical identity, it is not sharing anything up with the adjacent commutator segment, they are insulated from each other, got the idea. Therefore, commutator segment 1 2 3 like that 16 commutator segments will be there on a circular cylindrical structure and each one of them is separated by a layer of mica insulation. And from the shaft also they will be separated insulated not that otherwise shaft will become electrically aligned and it will be in fact, shaft all the commutator segments not because shaft is metallic. So, insulations are provided so, each one with a weight like this then a thin mica insulation thin and then another commutator segment.

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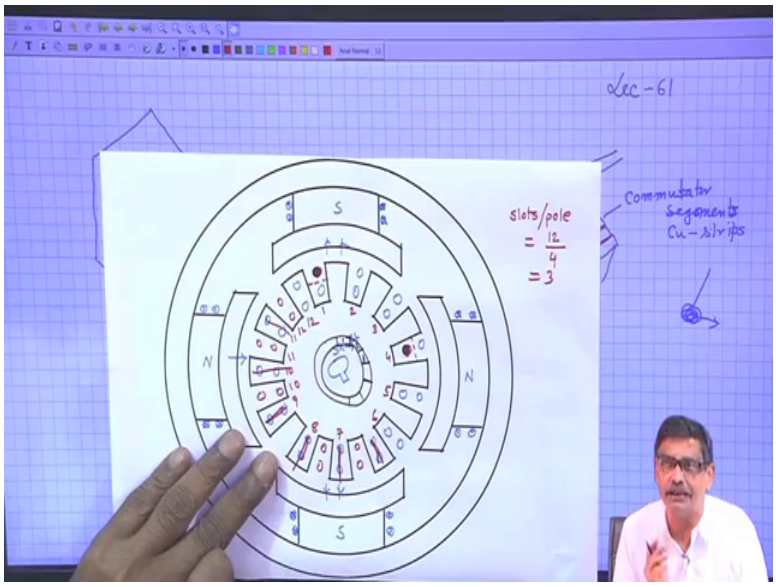

So, it will be the replica of this stator armature like this it will be the replica of this one here and it will be shown like this that is suppose this is the shaft in this sectional diagram what I will do, I can show it like this, 16 such 1 2 3 each one is commutator segments these lines are mica insulations like that. So, on the shaft it will be shown over a small radius.

So, it will be replica of the rotor to slot arrangement only, but anyway these are all commutator segment 1 2 3 4 16 got the idea ok. So, this is one coil, then there is a you know another coil like this second coil is there I will draw with a different color, second coil will be in the next slot it will start from here and it will return from the next slots like this is it.

So, first coil and this is the second coil, this is the s1 and it is return f1 in terms of slots this is f1 and this is start of second coil finish of second correct this is the thing. In terms of slot number it will be in slot number 1 if s equal to 16, p is equal to 4 then this should be f2 should be in terms of slot number 15 dash I sorry 5 dashed is not.

Student: 16.

1 plus 4 number of slots.

Student: 2 plus 1.

No for first coil for first coil. So, it will be 1 5 dashed 1 5 dashed and this is 2 6 dashed and this coils are to be connected in series that is s1 f1, then I will start with this join s2 f2 and this process will continue it gives you a lap winding.

Now, below these I will try to show the commutator segment like this 1 commutator segment also I will number them, 2, 3, how many commutator segments will be required? As many slots are there, as many coils are there, because you recall that from the junctions I need 1 commutator segments there are 16 coils. So, for each junctions I require a commutator segments. So, this junction I will connect it in commutator segment suppose 1 that is where is the junction, first coil and second coil the junction I will drop it to 1, then second coil I will drop it to 2 and so on ok.

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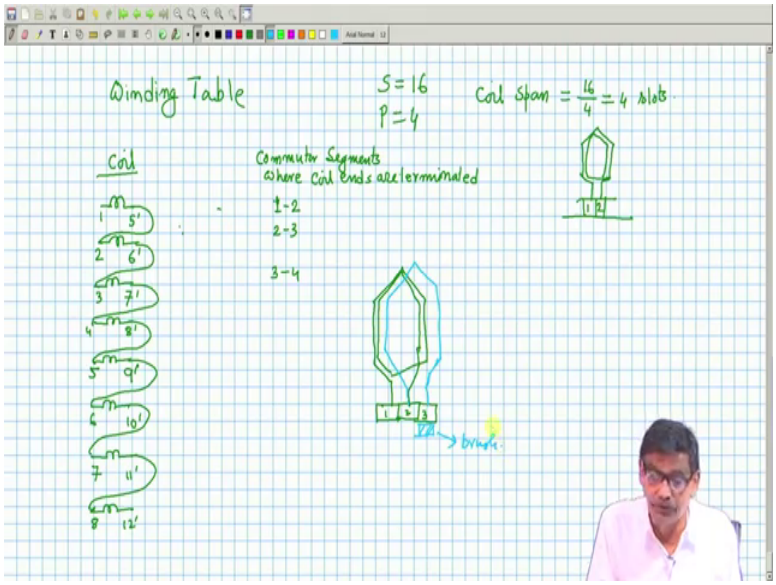

Now, I will go straight away to winding table in it is full form winding table, slots equal to 16, p is equal to 4, coil span for maximum voltage is equal to 16 by 4 in terms of slots 4 slots. So, here now I do like this coil and here I have to do another thing commutator segments 2 things must be there. Let me try to explain to you, suppose this is first coil 1 5 dashed, this one I will connect 2 commutator segment to 1, where coil ends are terminated. It will be in 1 that is one I will terminate it this is the coil I will terminate it in commutator segment 1 and next one I will it is return I will terminate it in commutator segment 2.

So, commutator segments I will also numbered 1 to 16. So, 1 and 2, 1 will be terminated here 5 dashed. Next coil 2 6 dashed this junction I will terminate it in commutator segment 2 and it is other end 3 like that, 3 7 dashed in this way I will carry on for let us draw the full thing 5 9 dashed, 6 7 dashed, these are coil ends mind you start finish start finish.

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4 I have to add here, 5 9 dashed this ok, 6 10 dashed is not 10 dashed, 7 11 dashed, 8 12 dashed, then another 8 coils are there, 9 13 dashed. Actually what will happen is this anyway up to this point I will just do and all these coils are connected in series and continued like this. So, it is 1 2 2 3, then 3 4 like that, this way I will complete my

winding tables up to 16, next time I will bring the complete diagram in a PDF form so, that I do not have to spend much time.

Then what I want to tell is this there are now several coils connected in this way, that is this is coil one each sides are connected in commutator segment 1 and next is 2, it is return. Then next coil from 2 I will start next coil. So, next coil first thing is commutator segment 2 this blue one and it is return will be I will just show this one, it will be terminated in commutator segment 3.

So, from the junctions those vertical lines are coming to the commutator segments and these commutator segments because it is connected to shaft it will also rotate. Then I have to take carbon brushes which will be not rotating and they will touch this commutator segments at the appropriate place that I have indicated how it is to be done after showing the polarities that I will do next time like this will be the brushes nothing else.

So, all in this diagram in this previous diagram this will be the commutator segment your commutator segments will be moving and you make arrangements. So, that carbon brushes will touch this commutator segments with the help of some spring and external thing. So, that this fellow will rotate, but carbon brush will remain stationary.

So, a typical brush will be connected like this at appropriate place that you have to decide where plus plus sign meets where minus minus sign meets negative brush and then from this armature terminals say A 1 say. So, I will continue this discussion next time, but go through it very carefully it is so interesting although complicated, but the analysis of DC machine is much easier people say construction wise AC machines are simpler analysis is difficult.

In DC machine it is opposite construction is rather difficult to understand particularly the armature winding field winding is absolutely fine no complications, but armature winding there will be slots there will be armature conductors. Armature conductors are to be terminated on commutator segment which are mounted on shaft on the shaft and there will be fixed carbon brushes which will be stationary and touching the commutator segment and placing up the brushes is an intelligent work I mean if you put the brushes at wrong positions you might get 0 voltage as well. So, this is how the complication starts, but nonetheless across the brushes you will be ensured about the DC voltage.

So, in our next class I will show a complete armature diagram lap winding I am discussing only wave winding I will do a little later and then 2 fundamental equations we have to derive. One is if you know the flux distribution, if you know the number of conductors present in the slots of the armature, then what will be the expression of the induced voltage if the armature is rotated at so much rpm or rps that will be the generated voltage equation.

How much DC do we expect on? What factors will it depend? And similarly we have seen that in case of DC machine for all machines in case of DC machine as well whenever generated will supply power it will experience some electromagnetic turn when armature will carry current, how much torque will be developed, these fundamental emf and torque equations once we derive then life is rather easier for DC machines.

Thank you.