Electrical Machines - I
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Lecture - 93
Simplex Wave Winding

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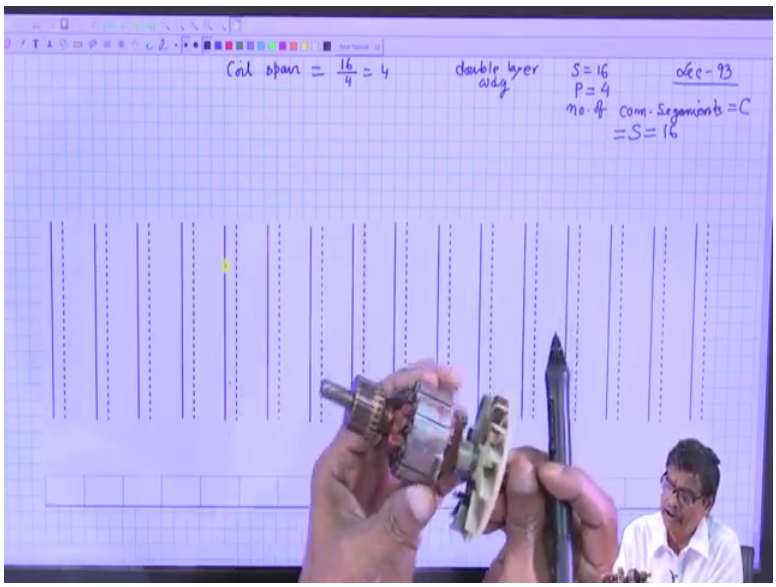

Welcome to lecture number 93, and as I told you; I will spend some time on armature winding of which lap winding we have discussed earlier. Let me quickly go through that and the convention that I will follow. So, that windings can be done with ease. For example, in case of say lap winding, suppose there are number of slots are suppose 16 total number of slots 16. What are the things I will be using? Double layer winding, double layer winding. DC machine always double layer and suppose number of poles of the machine is 4.

And suppose and number of commutator segments, number of commutator segments is equal to C which is equal to S that is equal to also 16 [FL]. Now this diagram is what, these diagram is there I have drawn two vertical lines side by side. They are nothing but, coil sides in a particular slot this is suppose some slot number 1. This is slot number 2 which will also carry 2 coil sides. Coils of course, they will be coil, but to begin with let us imagine in this way, in each slot there will be 2 coil sides on the upper deck there will be a coil side on the lower deck there will be a coil side.

So, that way if you call this is slot number 1, this is 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 slots are there. And it is in each slot there will be 2 coil sides ok. Now, while making a winding 2 things are important in case of dc machine windings particularly.

What are the 2 things? Each coil will have 2 coil sides. And, they will be separated in space in terms of slot numbers the coil span is a term coil span should be how much? It should be number of slots per pole always. So, that full pitched coil 16 by 4 is equal to 4. We are just revisiting some of the things we have discussed earlier so, that we can also discuss about wave winding fruitfully.

Therefore, this is the coil span and each coil at the end we will have 2 terminals. And these 2 terminals are to be terminated on these copper strips. These vertical lines are mica insulations. So, in case of in case of he this is the thing these are these slots armature ok. These are the teeth. This portion is teeth ok. And in these slots the conductors multi turn coils are placed and this is the commutator segment which is connected on the shaft. Both armature and commutator segment will rotate.

And brasses will be in space they will touch different commutator segment that we have discussed earlier. So, this is the arrangement mind you. And so, commutator segments will be nothing but, a replica of these slots only at a lesser diameter at a distance from this. Now, the thing is that the induced voltage it depends on the coil sides. Flux will be present only in this portion [FL].

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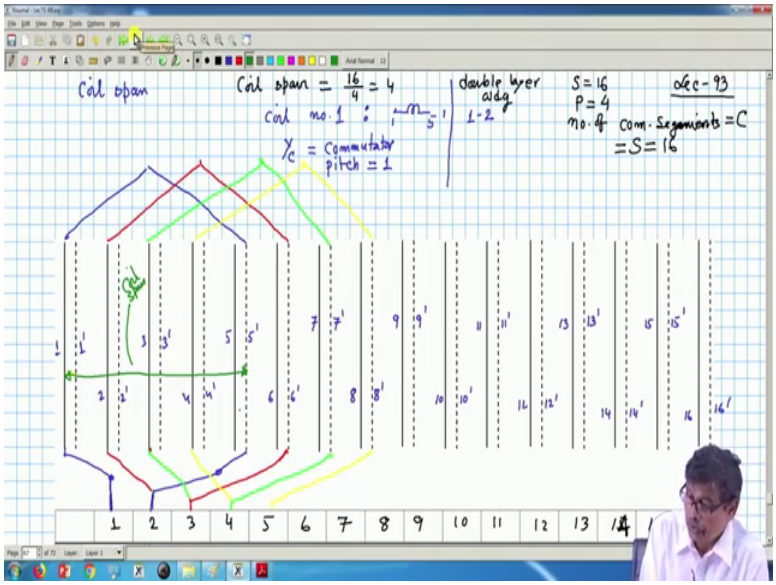

Now, let us see how to start the lap winding. So, coil span is 4. Suppose I say that this is commutator segment 1, and this is commutator segment 2 3 4 5 6 7 8 9 10 11 12 13 14 15.

Student: 13

13 14 15 16. This is the, and then this is 16 what is this number.

Student: 16.

Once again 16 understood because it is I have developed the diagram [FL] now this coil sides I will number in a interesting way the upper coil side this is suppose slot number 1. And I will number the coil sides as 1 and 1 dashed top one is 1 below one is 1 dashed. This is 2 2 dashed. This is mind you 1 slot number 2. This is slot number 1 like that, 3, 3 dashed 4, 4 dashed 5, 5 dashed 6, 6 dashed 7, 7 dashed 8, 8 dashed this is slot number 8. This is 9, 9 dashed this is 10, 10 dashed. This is 11, 11 dashed 12, 12 dashed 13, 13 dashed 14, 14 dashed 15, 15 dashed and this is 16, 16 dashed. After that this slots will be once again 1, 1 dashed like that ok.

So, now where is the first coil first coil if suppose it is this one what will be its end it ends will be on 5. So, coil span is the world coil span all coils fortunately they are identical. If you understand 1 coil other coils are same. So, first coil it is this coil side is 1 on the upper deck of this slot number 1. It is return is on slot number 5 and that is 5 dashed. So, if you now complete this coil it is 5 dashed. So, it will be like this and it will go like this 5 and it will come here.

Now, the question is these are the 2 terminals of this coil. Where should I terminate here on the commutator segments? In case of lap winding; if you the coil side 1 terminate it 1. And its return finish of this coil that is 5 dashed. You terminate it suppose on 2, got the point. This is how the coil sides are terminated.

This is coil number 2. In case of series motor we know I am in dc motor, we know that all coils are to be connected in series and the circuit should be closed. And we will tap the voltage intelligently by putting some brasses on the commutator segments that is what I told. So, this is coil number one is over. So, coil number one is if I draw it like this I will draw like this 1 and 5 dashed 1 5 dashed.

In case of dc machine another it is better to keep track of that, this coil ends are terminated in which commutator segments. I will write side by side 1 has been terminated 2 commutator segment 1 and 5 dashed has been terminated into commutator segment two.

Now, these 2 ends where they are terminated the difference in the number of this commutator segment is called commutator pitch. So, Yc which is called commutator pitch, commutator pitch is equal to we say it is 1. Next commutator segment. Now this thing then what I will do. I will start the next coil I am drawing with a other colour. So, that it you can easily distinguish.

So, it should be connected in series. So, I have started my journey from this come here then I will connect it like this and this 2 will be returning through 6 dashed. Therefore, it will go like this it will go like this and come back to 6 dashed here. And then this 6 dashed, I will terminate it on commutators, next commutator Y c is 1 3 minus 2 1. And then I will further proceed. Do not consider it to be r y b no just to distinguish. So, that I can trace this is the second call that is all and then you connect the third coil in series it goes like this. It will come back through dashed 7 dashed here and it will be terminated on 4 then 4 starts got the point. And this way it will continue I will not draw further

4 then 8 dashed it will go this last one let me draw 8 dashed it will return and it will be terminated of this. In this way I will go on completing the winding diagram and you will find the winding diagram will be completed. And so, with this in mind. So, I have to calculate what will is the coil span coil span is this length mind you, take any coil say coil number 1 this is the coil span. This is coil span and what is this? This is Yc Yc commutator pitch which is plus 1. They say plus minus 1 you could also terminate it to this terminal winding will be happily progressing no point.

But let us restrict to discussion on 1. So, it is called a simplex lap progressive lap winding progresses from left to right. If Yc is assumed to be minus 1 it will progress in the opposite direction [FL]. These things in this way this elaborate diagram instead of drawing I also told you.

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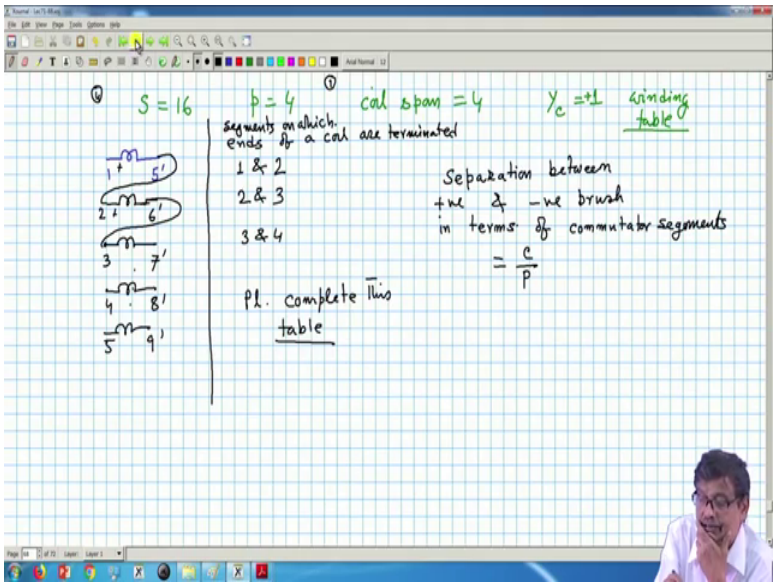

So, let us go to next idea, that I have taken s equal to sixteen number of polls equal to 4 coil span should be 1 pole pitch, because of to maximize the induced voltage in a coil if one coil side is under north pole other coil side you try to see it is under south pole center of the south pole, like that. Coil span is equal to 4 and winding commutator pitch is 1 that is what plus 1 I have taken.

Now, this thing I will draw in this way. I now know what it is. Suppose I will make a winding table now. Winding table and say that the first coil I will draw it like this 1 and 5 dashed is not. And then as I told you, it is better you keep track of where these 2 ends are terminated. So, here you write commutator segments on which on which ends of a coil are terminated.

So, where this 1 is terminated at 1 and 2 and where 5 dashed is terminated in commutator segment 2 go back here one is terminated on one then it comes out from 5, but you are bringing it back to 2 to commutator segment 2. Then the next coil you have to connect it in series.

So, what you will be doing? The next coil, second coil, second coil is which coil? 2 and 6 dashed red one 2 and 6 dashed. So, 2 so, commutator segment 2. So, from 2 this is 6 dashed and 2 is this coil ends are terminated between which 2 points 2 and what 3 look here. 2 it goes it comes back 6 dashed it is terminated on 3. And this way it will produce it will go on this will be three.

So, coils span is 4 write a 4 here and here it is plus one only commutator segment. So, 3, 3 plus 4 7 dashed. So, this will be 3 and 4 these 2 ends where they are terminated. In this way I will proceed and then all the coils I have connected them in series is not. I will go like this.

So, this is how we discussed about lap winding now in a much visually attractive way this is how things will go and doing like this and then the last job that will remain is on which commutator segment brasses are to be placed. I told you. So, the polarity of the voltages where plus sign will converge there you put a positive bar.

And where the negative voltages will convert put the negative brass. And in case of lap winding if the number of poles are 4 you can put 2 positive brasses and 2 negative brasses and that will divide the armature into as many parallel paths as the number of poles of the machine that I am not going to discuss.

But why I have once again discussed this lap winding is simply because to understand what we are going to do in wave winding. One thing you must understand, after you complete this winding put the brasses separation between the brasses in terms of commutator segments it should be how many commutator segments separation.

We have seen this separation between positive and negative brush in terms of commutator segments number. Commutator segments should be equal to how many C by P C is equal to S that is ok. But, so a positive slot is somewhere here. Because, it depends upon which are plus which are minus. So, we have discussed this earlier.

So, if it is 5 see the earlier notes on the lap winding. Then in terms of commutator segments this 16. This is also hello once again stop this diagram this in terms of this brasses in terms of these you count if it is plus here. then after C by P is the number of poles of the machine that is there 360 degree.

So, 180 apart it should come. So, in terms of commutator segments. If it is positive brasses here in space negative brass will be C by P after that, that is all. And, we have seen that in case of lap winding number of you know parallel pass equal to number of poles of the machine.

Now, I will discuss about the wave winding ok. Lap, we have understood earlier I have just reviewed that. Now, in the wave winding; what we will be doing. So, please complete this complete it is your job. Complete this table. See in fact, after you have drawn several things it becomes a simple number gain. That is why where the coil sides are numbered in that way ok.

1 5 dash 2 6 dashed 3 7 dashed. I will not now refers that is sign. I will simply say ok. Then it will be 4 and 4 plus 3 8 dashed that is all. Next one will be 5 9 dashed and so on. There will be 16 coils and all of them are in series. And assume coil size 1 2 3 4 under north pole put plus here and so on we have discussed that. Now let us come to wave winding here 7 17 are there.

Student: (Refer Time: 22:39).

[FL] wave winding. What it is? 1 2 3 4 [FL] previous 16 [FL] 16 are there. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 say 16 slots are there. Now, I will just mentioned before that in world what this winding lap winding and Y wave winding in which particular in which particular way they are different really.

What happens is this all the coils are identical it has got a coil span the difference in different types of windings that is lap wave etcetera is that; how the ends of the coils are terminated on the commutator segment in case of lap winding you terminate the two ends of a coil in the consecutive commutator segments ok.

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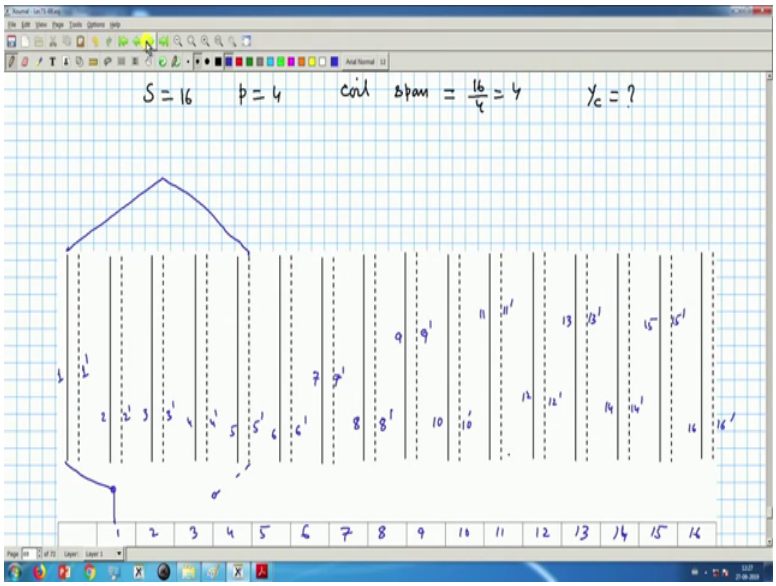

For example, what I am trying to tell is this; suppose the same problem S is equal to 16 P is equal to 4 ok. Coil span is equal to say 16 by 4 is equal to 4. And winding pitch I have not yet decided a commutator pitch means what you start with slot number one this is commutator segment.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 and after that once again 1 will come. And we have seen that this numbering I will do like this 1 dashed 2 coil sides will be there in each slot then 2 2 dashed 3 2 dashed 4 4 dashed 5 5 dashed 6 6 dashed and so on 7 7 dashed 8 8 dashed you may feel slightly bored, but better do it like this 9 9 dashed 10 10 dashed.

Each slot this is not number 10 2 coil sides 11 11 dashed 12 12 dashed 13 13 dashed and they are occupying same position dotted line, because it is below the upper coil side. 14 14 dashed 15 15 dashed 16 16 dashed. Now the first coil you have started with this one 1 commutator segment 1 and its coil span is 4. I I must sees to maximize the voltage. So, it should be 5 dashed.

So, you go to 5 dashed its return must be 5 dashed it comes here and then it comes here. So, these are the 2 terminals of the coil which this terminal I have terminated on commutator segment 1. In case of lap winding I was terminating it in commutator segment 2. Now what I am telling the ends of a particular coil I will terminate in a different way in case of wave winding. What they say you terminate this end at 2 pole

pitch apart in terms of commutator segment number, got the point/ So, I will do that, that is this 1 [FL] I will 1 this once again another is there 16 same thing [FL].

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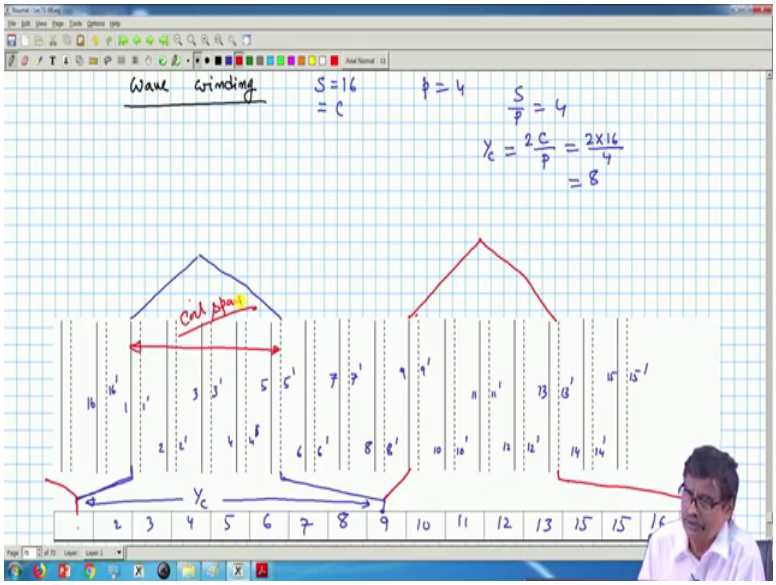

Student: (Refer Time: 27:29).

Seventeen does not matter anyway let it be there. So, suppose what I am telling is; suppose, I say that, you just be with me and try to understand what I am telling. That is suppose, I say that this is I can arbitrarily number them it does not matter 1 1 dashed 2 2 dashed 3 3 dashed 4 4 dashed sorry 5 5 dashed 6 6 dashed 7 7 dashed 8 8 dashed 9 0 dashed 10 10 dashed 11 11 dashed 12 12 dashed. This is slot number 12. This is 13 13 dashed 14 14 dashed. This is 15 15 dashed is not. Then this should be numbered as.

Student: 15

15 15 dashed then.

Student: 16.

Have I missed 1 2 3 4 5 6 7 8 9 10 11 dashed all are now. 15 15 dashed and then this should be 16 16 dashed is not. But there were total.

Student: (Refer Time: 29:12).

Now, that is 17 I do not want to have. What I mean to say 15 15 dashed and then suppose there are 16 number of slots what I am telling I will not number them.

Student: (Refer Time: 29:39).

Which one?

Student: (Refer Time: 29:43).

It will be decibel (Refer Time: 29:45).

Student: (Refer Time: 29:46).

4 5 6 7 8 9 10 11 12 13 14 15 15 I will tell that this is suppose 16 slots are there. Then I will say this is 16 this is 16 dashed. And this is not there suppose there are sixteen slots got the point this you forget there are 16 slots 1 2 3 4 5 6 15 16 once again 1 1 dashed [FL].

Here what I will do is this. Suppose this is slot number 1 and I will start my winding like this 1. Then its return is 5 dashed pole is 4. So, slot per pole is 4. So, its returned will be from 5 dashed no doubt. Now this one of what I am telling I will terminate it Y c. I will terminate it after two pole pitch apart.

So, what is one pole pitch a part C by P same number of commutator segment is equal to C. So, C by P 1 pole pitch 2 pole pitch apart I will. So, what is this number? This will be 2 into 16 by 4 that is equal to 8. So, this commutator segment number this 5 dashed, I will terminate it after 2 pole pitch apart means since slot in commutator segment number one plus 8 9.

So, 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16. This will be once again 1 this is not there this slot is not there 16 slots. So, these I will terminate it on this segment 9. Will it change the induced voltage magnitude? No. Induced voltage takes place only in the coil sides. These are outside the magnetic field north south here these are overhang of the coil.

So, it will be terminated here. That is the commutator pitch this is Y c this is Y c is 2 pole pitch apart. This is the first coil then the next coil I will connected in series where should I start the next coil from this commutator segment dictates me the slot number I will go. So, 9, I will connect it to next coil.

I will connect it here and each span is 9 plus 4 13 dashed is not. So, 9 plus 4 is 13 dashed. It will come over here and then it comes over here. But I am not going to terminate it on 10. This time commutator pitch is 8. So, 9 plus 8 is how much.

Student: 17.

17 means?

Student: 1

1. So, it will be terminated on 1. 1 means here right. So, after tracing 2 coils you have finished I mean what to do winding is closed. Therefore, you see in case of lap winding number of coils bit 2 consecutive commutator segments is equal to always 1.

But in case of wave winding I am trying to do using a full pitched coil and I find that if I plan to choose my commutator segment Yc to be equal to 2 pole pitch 2 C by P. Then after tracing 2 coils you come back to the same starting point here this was 1 [FL]. Here, we started from here place these 2 coils and come back here and 2 coils are in series and closed.

But so, many slots are still remaining to be made use of it cannot do anything. Therefore, we will see that, we have to make a little bit of a compromise to implement the wave winding, when we when we shall try to use full pitched coil span is this pole coil span. That is 4 we chose coil span. At least we conclude that this way if somebody tell me to complete the winding is known not a better solution. Only 2 coils everything is over. So, we will continue with this in the next class.