Electrical Machines
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Lecture-17
DC Machines – Introduction, Construction Features

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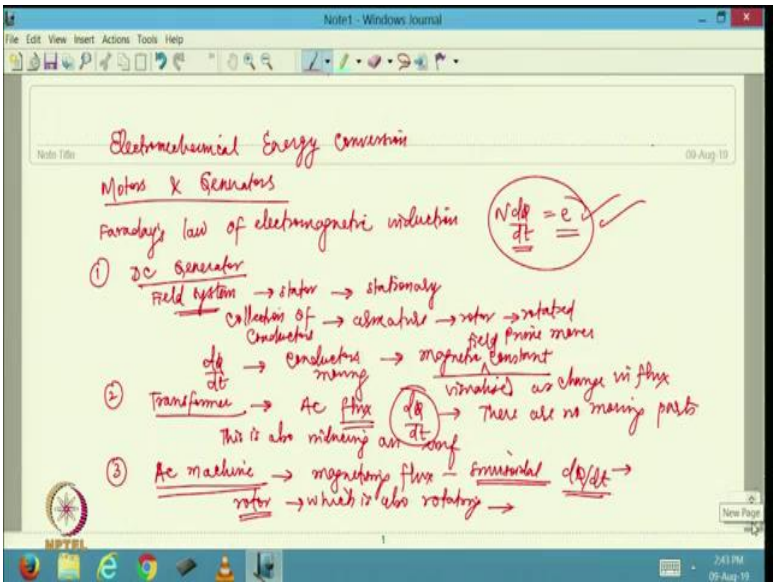

So, we had seen already all the principles of electro mechanical energy conversion. Now we are going to start actually on motors and generators. So, when we are talking about generator, we are going to use Faraday's law of electromagnetic induction. So, this essentially says whatever we had seen in transformer the same thing holds good here also, which is saying

$$N\frac{d\phi}{dt} = e$$

So, whenever we need generation of a voltage, we need rate of change of flux this can be done in different phase. For example, if you look at the DC generator what we have is a field system in the stator that is the magnetic field is created in the stator. So, the magnetic field is stationary, this is going to be stationary. So, because of which we are going to actually have a bouquet of conductors or a collection of a conductors, which is known as armature.

This is actually going to be housed in the rotor. So, this is going to be rotated, this is going to be rotated with a help of prime mover. So, the prime mover conductors they are going to look at this magnetic field as though it is having the rate of change. So, the rate of change of the flux is created by the conductors which are moving, and these look at the entire magnetic flux which is actually constant, this is not going to have any variation in the flux at all.

So, the magnetic field is constant this is going to be visualized as the change in flux. So, this is going to induce an EMF. So that is going to result in whatever is the generated EMF. We can have a different thing like a transformer for example, where we are going to actually create an alternating flux? Because it is an alternating flux, we will have definitely a $\frac{d\phi}{dt}$ created all though there are no moving parts, there are no moving parts at all.

The entire $\frac{d\phi}{dt}$ is created essentially by the alternating flux which is having a $\frac{d\phi}{dt}$. So, this is also inducing an EMF but this is inducing an EMF in secondary and that is also essentially due to the electromagnetic induction. The third type of the generator action or EMF induction action can happen in an AC machine.

Be it an induction machine or synchronous machine there what happens is I am going to have actually a magnetising flux which is also sinusoidal. So still you will have a $\frac{d\phi}{dt}$, no doubt. So, this $\frac{d\phi}{dt}$ is essentially going to create an induce EMF no doubt. But apart from that there can be a rotor which is also rotating. So, if you look at the synchronous machine you are going to have a flux which is DC flux.

Whereas if it is an induction machine you are going to have sinusoidal flux. So, we can have simultaneously rate of change of flux because of sinusoidal flux as well as we can have a rotor which is visualizing the flux as a modified flux or rate of change of flux because of the rotor position itself is changed. So, we can have simultaneously transformer action as well as DC generator action that is what happen in an AC machine.

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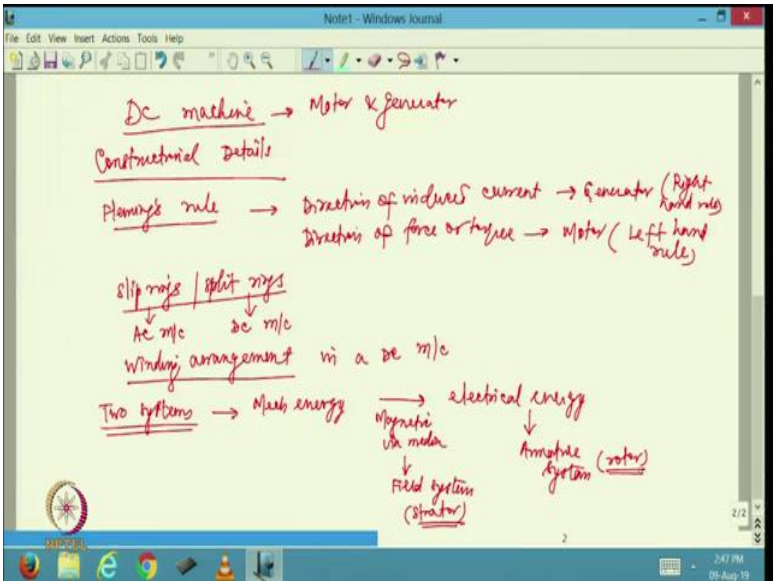

But now we are primarily going to concentrate on the DC machine. So, let us actually proceeds somewhat like this in a DC machine. We are going to look at first of all the constructional details in a DC machine which is common to both the motor as well as generators. So, we will look at both motor and generator, so we should look at the constructional details.

We will also look at Fleming's rule which is left hand and right-hand rule. Which will give us exactly the direction of induced EMF or induced current, and it will also give us the direction of force or torque, if we are talking about motor. So, this is for motor and this is for generator for generator we will normally use right hand rule Fleming's right hand rule. Whereas for motor we will use left hand rule.

So, these two will be looking at, then after that we will be looking at exactly what is the difference between slip rings and split rings. So, slip rings are normally used in AC motor or AC machine, whereas the split rings are normally used in DC machine. So, we will look at both of them after which we will be looking at specifically winding arrangement in a DC machine. So, this is what we are going to cover in this particular lecture.

So, winding arrangements specifically in a DC machine. This is what we are going to look at. First of all, we should know that in any machine we will require two systems unless there are two systems it is not going to work very well, because we will require first of all mechanical energy to be given and that is going to be converted into electrical energy or vice versa. This is what we talked about when we talked about electro mechanical energy conversion.

But this happens always through a magnetic via media, So, if we require magnetic via media first of all I will need a field system which will create the magnetic field and whenever electrical energy is ultimately given out in generator or electrical energy is taken in a motor this will be through bouquet of conductors which is generally known as the armatures system. In a DC machine field is located in the stator whereas in the armature system is located in the rotor. So, stator is going to have the field and armature will be housed in the rotor.

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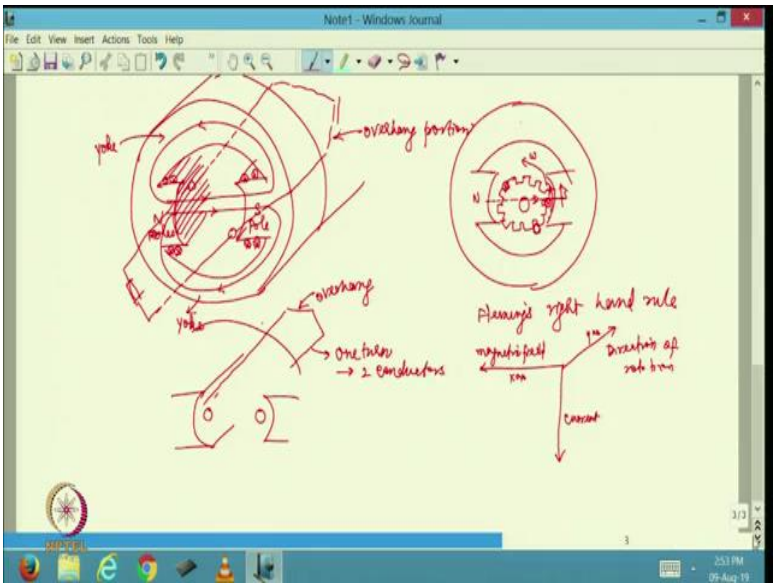

This is what is generally the DC machine structure. So, if I try to look at the DC machine, I am going to have the field system somewhat like this, this is my field system you can say may be this is north pole this is going to be south pole and it is going to actually be the stator. So, it will be the external cylinder. So, you can imagine as though it is extending into the board, so it is essentially going inside the board and we are going to have, essentially if it is an electro magnet we will have conductors here.

So, conductors here as well. So, you can imagine as though the conductors are going in to the board like this. So, you if I am going to have a dot here and cross here obviously according to the right-hand rule that is screw rule, I can say the basically magnetic field lines are going to go like this. So, if I have a magnetic field line like this it will actually complete part through this. So, this is how magnetic field lines are going to go this is how magnetic field lines are.

So, if it is like this now, I can say basically just to complete the magnetic circuit path I will need electromagnetic, ferromagnetic substance which is actually known as the Yoke region. So, this is Yoke this is also Yoke and these are going to be the field. So, these are the poles

the basically, so this is the North Pole and this is the South Pole. So, I have shown a 2-pole machine.

Now because I have the magnetic field here if I put the conductor here let us say there is a one conductor here and one conductor here you can imagine as tough the conductor is going inside and it has to turn around and then it has to come through this portion and ultimately here I am going to connect may be the load, the load will be connected here, This portion is outside the preview of the magnetic field you can imagine that the pole is going here.

So, this shaded portion is essentially the pole similarly this is going to go inside. So, this will extent only as long as the cylinder is there after that the conductor whatever the portion here, this portion is essentially folding up and then coming out like this. So, this portion is known as the overhang portion. So, the overhang portion of the conductor is not going to be useful as far as the electricity generation is concerned or torque production is concerned because this is preview of the magnetic field.

So, you can imagine basically that if I am going to have the magnetic pole like this I am going to have the magnetic pole extending only until the machine ends after that wherever I have a conductor the conductor is going to bent like this and then come back like this this overhang portion becomes useless. But it is a necessary evil because otherwise I will not be able to get the conductor back.

Now if I look at one conductor side here the other conductor side here together this entire thing is known as one complete turn. So, one turn consists of two conductors, two conductors make up for one turn. Let us say I am going to rotate this rotor which is actually the rotor is going to be somewhat like this let me draw the whole thing here. So, this is actually the magnetic pole this is completing it is a circle whatever the cross section here I am going to have the rotor here.

So, rotor is going to have slots in the external periphery like this. You can imagine this is what is the rotor stampings. So, several stampings together are going to be stuck together ultimately to make the rotor. So, I am going to have if there is one conductor here exactly opposite, I will have one more conductor here. So, let me consider only two conductors here. Now the rotor will have a shaft in the middle and this is going to be rotated with the help of a prime mover.

So, this is the direction of rotation let us say the speed is omega (ω). Now this is the North Pole and this is the South Pole. So, I am going to have the magnetic field lines going like this right. Now Fleming's left hand rule actually tells me for the motor operation which is going to be the torque direction and Fleming's right hand rule essentially tells me something like this.

So, let me explain Fleming's right hand rule. So, in the right-hand rule I am going to have let us say the magnetic field like this, this is the magnetic field and probably this is going to be the direction of rotation then in that case I am going to have the current induced in this direction. So, this is the magnetic field direction, and this is going to be essentially the direction of rotation,

In which case I am going to have essentially the current direction like this. So, in which case I can say if I am looking at the magnetic field direction like this. So, this is the magnetic field direction which is opposite of the magnetic field direction I have shown here, and I am going to look at the direction of rotation somewhat like this, so which is actually perpendicular so I am showing this as the direction of the rotation. So, let me take a conductor here which is actually showing a vertical direction of rotation.

So, If I say this is the X-axis and this is the Y-axis the other one is the Z- axis. So, Z-axis will show me the current either going into the board or coming out of the board. So, I can say if the current direction is showing like this here this is going to be dot and this is going to be cross.

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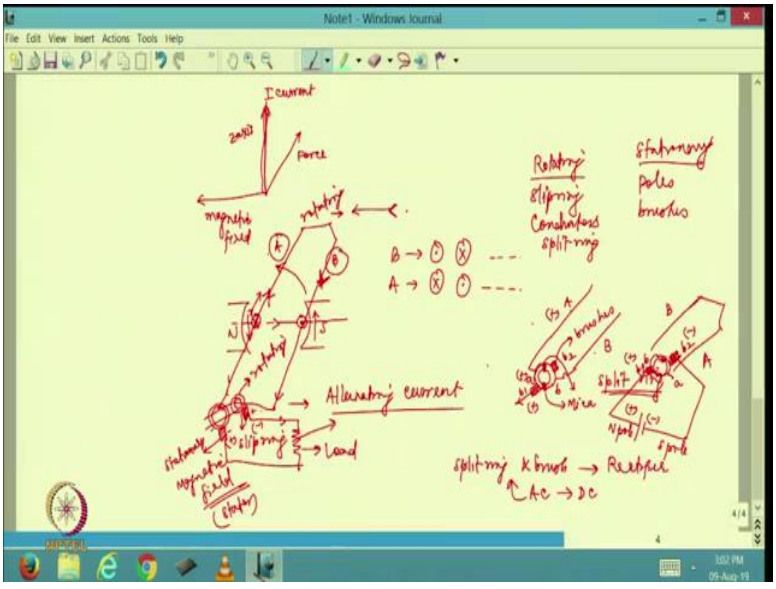

Let me explain it once again separately drawing a diagram, somewhat like this, I am going to have actually the magnetic field direction like this, and I am going to show actually along the Y-axis may be the force in which case I am going to have actually the current direction somewhat like this, this is perpendicular to this, this is the Z-axis.

So, this is the current direction. So, I can look at it again when I had the magnetic field here this is the North Pole and this is the South Pole I am going to have the magnetic field direction here like this, and I am going to have let us say one conductor here and another conductor here and I am talking about the direction of rotation in this way.

So, if I look at the direction of rotation it will tangentially look like this here tangentially look like this here, So, if I am going to have the direction of rotation like this I am going to have the current which is actually coming out this is showing the direction of current coming out and whenever we look at the current we look at it like an arrow head like this. If arrow head I am visualizing from here it will be a dot.

If am looking at the arrow head from here it is going to be a cross. So, I am going to have the dot here whereas cross here. So, this is going to be the direction of current basically. So, if am looking at the conductor like this I can say the current goes inside like this and comes out like this, this is how it is going to be, So, I am going to see the current actually sorry the current will come out like this and it will go in like this.

We are looking at the arrow like this, so that is why this is going to be a cross and this is going to be a dot, the same way when I am looking at actually the conductor actually rotating like this after some time this conductor will reach here and this conductor will reach here. So, the current if I look at it actually along this it is going to be alternative current. If I call this conductor as A and this conductor as B, I am going to see an alternating current continuously going through B and A.

Because some for time I am going to see that B is under the influence of South Pole after some time the same conductor will rotate, will be rotated by 180 degrees because of which it will occupied the position of A. So, you would see that the current has become cross. So, you would see that B itself will be carrying dot current and cross current and so on and so forth.

Whereas A will be carrying again cross current and dot current and so on and so forth. So, if I try to collect the current directly from these two, I am going to see that I will get only alternating current. So, that will not work really if I want to really construct a DC machine, so

what I will do is normally this particular conductor will be connected to a ring and this particular conductor will also be connected to a ring.

So, these two rings will be connected along with a shaft. So, normally these rings are known as slip ring. So, in an alternating current machine normally we use slip ring and along with slip ring we will be having brushes. So, these brushes will be fixed, or they will be stationary. So, brushes are stationary the magnetic field will also be stationary.

So, magnetic field along with brushes will be stationary because magnetic field is essentially located in the stator. So, this is also stationary whereas the conductor will be rotating and simultaneously the slip rings will also be rotating. So, to retreat what are the rotating parts the rotating parts are going to be slip ring along with that I will also be have conductors. Whereas what are the stationary parts?

The stationary parts are going to be the magnetics poles or magnetic field and I am also going to have the brushes which are stationary. Now if I am going to have the brushes collect the current, I will be able to actually to make an external connection with a resistance. So, this is my load, so load I can connect directly that will be possible, but I will have alternating current supplied to this loads.

Because if you look at it the conductor are continuously changing polarity the slip rings will be changing polarity the brushes which are actually pressed against the slip ring to collect the current, they will also be changing polarity sometimes this will positive and this will be negative then after sometime this will become negative and this will become positive. So, it will be alternating.

So, I do not want this to happen in a DC machine. So, what I will do is if I am going to have the conductor here, I am going to have a ring only 1 single ring that ring will be actually having two portions. Which are insulated from each other. So, this is going to be made up of mica this will also be made up of mica. Let us say this is conductor A and this is conductor B. So, conductor A will be connected to this portion of this split ring which I am calling as A and this portion of this split ring please note this is split ring.

Because the ring is split into 2 portions and they are insulated from each other with mica. So, I am going to have essentially this portion of split ring is known as B. Now I am going to have one brush let us say connected here and another brush connect here the brushes are

made up of carbon which are little soft material whereas the split ring will be made up of copper and mica.

Mica is meant for insulation and the copper is essentially braced or welded with the conductors. So, now I am going to have a again the split ring will be rotating. So, whenever A is under the influence of split ring, I will have split ring portion of A also is going to be both these things are going to be positive whereas the brush which is actually connected to this particular split ring portion A that is fixed stationary.

So, that will also be connected positive side. Whereas when I am going to have this B rotating on to the other side along with that this small portion that is B of the split ring that would have also rotated to the other side. So, I would rather show B is here A is here which has rotated by 180 degrees now if I look at the split ring. I am going to have the split ring also connected like this.

So, this is going to have B and this is going to have A this has rotated along with the conductor. Now this brush let me call this as B1 and this as B2 but B1 would still remain here that would have not changed its position, and I would have had similarly B2 he is still remaining here. So, this is split ring A now which is connected to B2 previously B was connected to B2 and A was connected to B1 now B is connected to B1 and B2 is connected to A.

So, if you look at this still it will be positive, and this will be negative. So, if I look at the affiliation of B1 and B2 respectively I am going to have always B1 under the influence of North Pole and B2 under the influence of South Pole. So, I am going to have negative here and positive here this is how it is going to be. So, split ring and brush arrangement works like a rectifier it essentially is converting the alternating current in the conductors of the armature in a DC machine to DC.

So, AC to DC conversion is done automatically by using split ring and brushes. So, this is the basic working as far as the DC machine is concerned, but I am not going to have just 2 conductors I am going to have multiple number of conductors.

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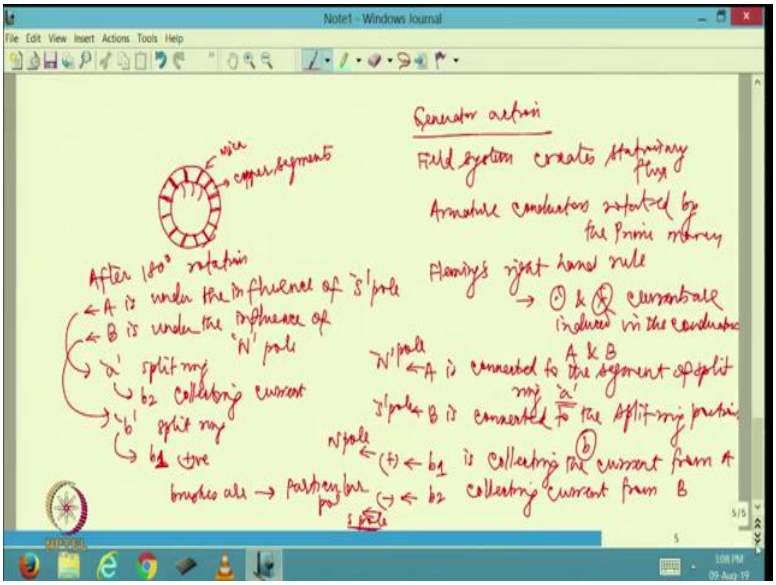

So, that is why what I will do is to have several numbers of conductors connected together. So, I will have essentially the split ring divided into multiple number of copper segments which are insulated by mica. So, I am going to have multiple segment like this and each of them is actually insulated with mica. So, each of this is going to be mica and these are going to be copper segments,

So, now I am going to see that the conductors each of the conductors are going to be connected like this you are going to have the conductor connected like this of course they will go round and round because of the overhang portion. So, let me try to draw the winding diagram also towards the end. But right now, I am essentially looking at the generator action. So, just to repeat the generator action works as follows the field system creates flux.

So, it creates stationary flux, Now I am going to have the armature conductors rotated by the prime mover. Now when the armature is rotated with the help of prime mover I am going to see essentially as per Fleming's right hand rule, I am going to have dot and cross currents are induced, in the conductors. So, I have only showing only two conductors let us say A and B. Now A is connected to the segment of split ring 'a' small a and B is connected to the segment or split ring portion small b,

Now on A there is brush B1 which is being pressed. So, B1 is collecting the current from A and I am going to have B2 collecting current from B. Now so B1 will be positive and B2 will be negative but what is going to happen is after 180 degree rotation I am going to see that A is under the influence of South Pole because initially it is so started that A was under the influence of North Pole and B was under the influence of South Pole.

Now after 180 degree rotation A is under the influence of South Pole and B is under the influence of North Pole, Now after this happens I will have alternating current basically in A and B but I do not want alternating current as the output. So, A is still connected to a part of the split ring but I am going to have to this I will have brush B2 is collecting current from this particular portion. But I am going to have essentially as far as B is concerned I am going to have B is connected to b portion of the split ring.

But I am going to connect the current from here through brush number B1. So, B1 will always be positive which is under the influence of South Pole. So, all I can say is brushers are basically going to be affiliated to a particular pole. So, I can say basically B1 is always affiliated to North Pole and B2 is always affiliated to South Pole this entire thing is possible because of commutator and brush arrangement.

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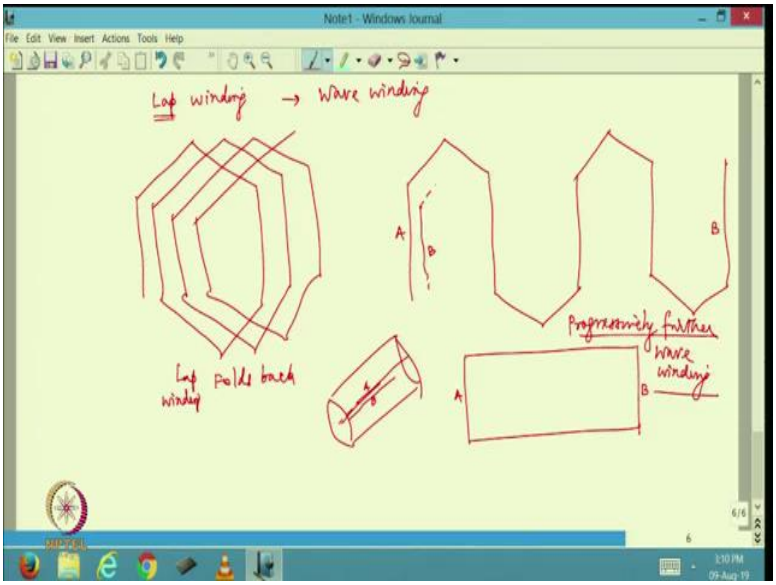

So, we will try to look at the winding arrangements, likely there are 2 types of winding that are used in DC machine one is called Lap winding the other one is called Wave winding. The lap winding has the name of Lap because the coils are such that let us say this is going to be the beginning of a particular turn. It is going to go round like this and then it will come back and it will fold back or overlap on the coil.

So, it is going to go like this, so this is essentially the cracks of lap winding this is how it is going to be it is overlapping repeatedly. Whereas in wave winding this goes progressively, so it will not fold back it will rather go progressive like this. So, this is essentially wave winding after going through the whole thing it will come back and fold back you can imagine that if

this is a cylinder I can always cut it here and spread it out when I spread it out it will look somewhat like this it will look like a rectangle.

You get my point, if it is a cylinder if I cut it and spread it, it will look like a rectangle if this portion is A and this portion is B So, this is essentially A and this is essentially B and when I fold it, it can become like a cylinder. So, you can imagine when this winding is folding back if I say this is A and this is B it will essentially come closer to B this is what is actually B. So, this is going to go further and further. So, lap winding essentially folds back, so this is essentially lap winding whereas I am going to have essentially this is going progressively further and further. So, this is essentially wave winding.

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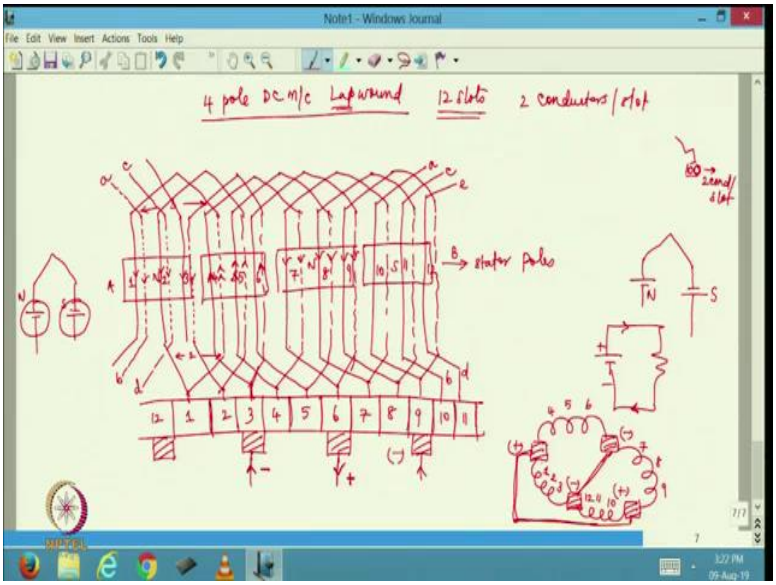

So, when I look at lap winding and wave winding like this let me draw one winding structure for a 4 pole DC machine lap wound and let us say I am going to have 12 slots you understand what is a slot? In the rotor we show like this, this is how the stampings are. So, this is essentially a slot inside which conductors are placed. So, here I am talking about a 12 slot DC machine.

So, I am just going to erase this, so if I take a 12 slot DC machine and I am going to say 2 conductors per slot. So, if I am going to talk about a slot like this in this slot, I am going to have 1 conductor at the back 1 conductor at the front. So, essentially 2 conductors per slot, this is how it is going to be. So, let me try to draw this particular winding lap winding for DC machine.

So, let me say maybe I am going to have a North Pole like this after that I am going to have a South Pole again I am going to have North Pole and I am going to have a South Pole please understand this is essentially stator, whatever I am talking about is stator Poles. Now I am going to have 4 Poles and 12 slots, so there will be 3 slots per Pole. So, let us say I am going to have a conductor here another conductor here and third conductor here I have to show the back coil and front coil.

So, I am going to have the back coil doted and front coil front conductor solid. So, I am essentially showing conductors like this this is how the conductors are. So, this is 1 this is 2 this is 3 and similarly I am going to have 4, 5, 6, 7, 8, 9, 10, 11, 12. So, similarly I am going to have the conductors that are put at the background so those are shown with dotted lines those are shown with dotted lines like this.

So, I am going to have essentially here also the conductors which are shown with dotted line. So, let me number them also correctly this is 4 this is 5 this is 6 this is 7 this is 8 this is 9 and I am going to have 10 here 11 here and 12 here. So, please understand previously whatever I have shown I had shown that this cylinder is cut and then spread out the same A and B let me show here.

So, this is the A portion and this is the B portion. So, it is essentially cut out and spread out cylinder. Now because it is a lap winding whatever start from North Pole it has to actually go and end up in a South Pole winding. So, I can say if I am going to have a voltage generated like this in a North Pole I will have on the other side voltage generated like this on the South Pole this is how it is.

Now these 2 are connected together you can very well see that they are connected in series, So, I am going to connect like this in series this is how it is connected this is the North Pole side voltage generation this is the South Pole side generation. Now this is North Pole this has come out like this it has to go back essentially and it will end up in this. So, you can understand that from 1 it has gone into 4 backward conductors, from 4 it has come back to 3.

So, backward side pitch is 2 slots behind that is 4- 2 =2. So, this is essentially 2 slots behind whereas this is 3 slots forward. Now it has come to 3 to 2, from 2 it has to come to 5, 2+3=5. Now from 5 it will come back, and it will go back to 3 now from 3 it will go progressively in the front to 6, from 6 it will come back to 4. So, it has to come back to 4 from 4 it will go to 4 plus 3, 7.

From 7 it will go back to 5, from 5 it will go like this 5+ 3=8. So, it is going 8 and 8-2=6. So, it is going to 6 from 6+3=9 it will go to 9 from 9 it will go back to 7. So, let me complete the drawing 7+ 3=10, 10-2=8, 8+3=11 from 11 it will go back to 9 from 9 it will again go to 12. From 12 it will go back to 10 now from 10 it should go to 13, 13 is actually 1 because it is folding back,

So, from 10 it will go to 13 so I should say 1 the backward conductor. So, if I call this as 'a' this should also be 'a' from here this is 13, 13-2 so which go back to 11. So, I should show this is b this should also be b. Let us say this is c so it should come back to 11 it should go back to 11- 2, 11+2 that is 11 + 3 = 14, 14 is actually equal to 2. So, this is going to be c.

Now from here this is 2 so if this is equal to 14, 14- 2 =12 so it is going to go back to this place which is 12. So, this will be d this will also be d, Now, from here it is, it has to go back to this is the friend side again, so 2+3 which is actually 2 is 14, 14-2= 12 so it has to go back here. So, this is going to be let us say e, So, this is going to be e so this will go back to e here essentially.

So, that is essentially e so it will essentially end up here as e. So, this is how it is completely the winding is made. So, let me draw the commutator segments also so these are going to be the commutator segments which are coming up like this. So, I can say this is 1 this is 2 this is mica this is 3 this is 4 this is going to be 5, 6, 7, 8, 9, 10 and 11 and this will be actually 12 which will be connected to, the next one which is coming out we have not still shown what is coming out of here.

So, that should also be connected elsewhere, so this is how the entire thing is going to be connected. Now if I assumed that all the currents in North Pole are actually coming this way and all the currents in the South Pole will be going upward like this, So, you will have 6 conductors carrying currents upwards 6 conductors carrying current downward. So, if I am connecting commutator segment 1 like this let me look for where both conductors are carrying the current in either downward direction or upward direction.

Please see here this is carrying current in upward direction this is also carrying current in upward direction. So, I am going to connect one brush here. So, the brush here is going to carry current in upward direction. So, if there is a brush here, I will also have a brush here let me see how the current are here this is North Pole. So, I am going to have all the current in downward direction.

So, if I look at this this is connected to conductor number 9 backward conductor this is connected to conductor number 7 both of them are carrying current in the downward direction this is carrying the current in the upward direction. So, by just extension I should be able to draw a brush here and one more brush here this is how it is connected. So, if I try to look at this this current is actually going inward, and this current is going outward.

So, if I am thinking of it as source this will be plus and this will be minus please imagine if I am going to have a source and I am connecting a load here I will be connecting the current like this. So, from plus the current is emanating in the minus the current is reaching. So, that is why I am calling this as plus and this as minus, between the plus and minus if I look at it let me try to look at the coil.

This is one coil this is going like this, this is the second coil which is going through 5 and this is the third coil which is going through 6. So, 4, 5 and 6 coils are connected between 1+ and 1- this is 1+ this is 1- this is 4, 5, 6 similarly I am going to have, if I try to look between these two I will have actually 7, 8, 9 connected like this 3 coils will be connected like this and I will have a brush here.

Which will be actually a positive brush again, and between this plus and another minus which is going to be connected actually in commutator segment number 9. I am going to have 3 more coils connected which will be 10, 11 and 12 three coils will be connected obviously between these 2 I will be having 1, 2, 3 these are the coils connected. So, what is going to happen is if this is minus and this is minus these 2 will be connected together and similarly this is plus and this is plus. These 2 will be connected together this is how they will be connected together.

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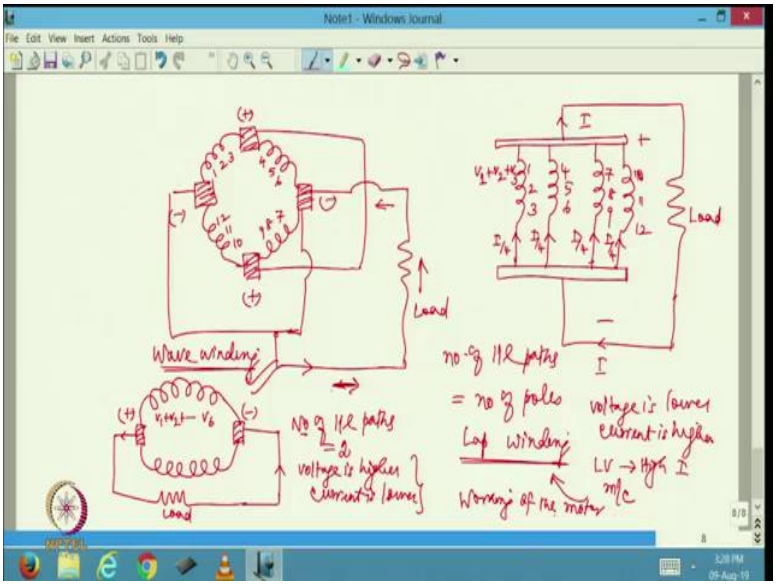

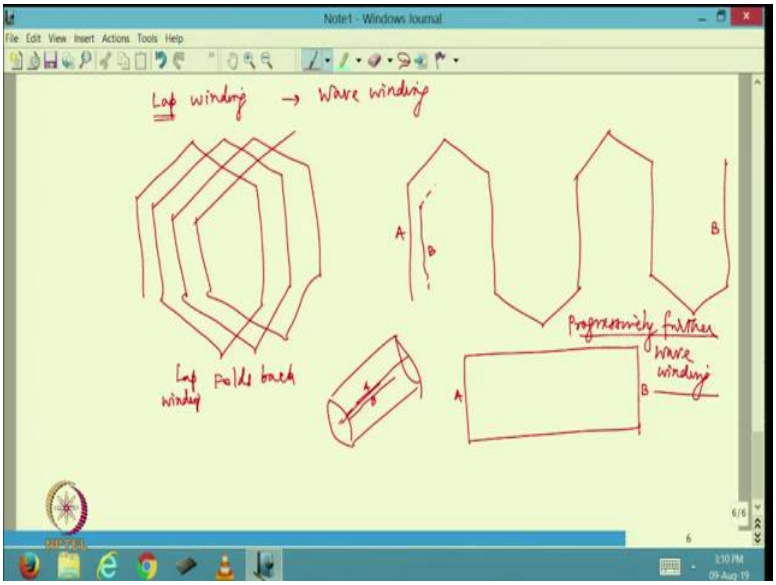

So, I can say basically just redrawing the whole thing I should be able to draw it somewhat like this this is the plus brush this is the plus brush this is going to be the minus brush and this is going to be the minus brush, Now these 2 are connected together similarly these 2 are short circuited together. As we showed it earlier between these 2 there are 3 coil which are 4, 5, 6 between these two there are 3 coils which are 7, 8, 9.

Between these two there are 3 coils which are going to be 10 11 and 12 and between these two there are going to be 3 coils which are 1, 2 and 3. Now the load will be connected between the plus and minus. So, I am going to have essentially a current emanating from here going through the load and going back ultimately to the minus. So, this is minus is not it I have shown the current direction wrongly.

So, I am going to have the current flowing here like this let me erase this let me erase this as well. So, I can just redraw this saying that from here the load is connected and this is going to be my plus. So, I am going to have the current flowing this way and from plus the current is going to emanate like this is how the entire load is connected. Now I can redraw this somewhat like this that this is my positive bus and this is my negative bus and I am going to have 3 coils connected here 3 coils connected here.

So, I can say 1, 2, 3, 4, 5, 6 then 7, 8, 9 and 10, 11, 12. It is all connected together now from here the current is going to emanate and I am going to have the resistance connected like this. This is the load right this very clearly tells me that there are 4 parallel paths in the current If I may call this as I/4 this is I/4 this is another I/4 and this is I/4 and the total current drawn here is I.

So, the current supplied to the load is equally divided among the number of parallel paths and here the number of parallel paths is going to be equal to the number of poles the way the winding is arranged in lap winding this is the norm. Whereas if I try to look at the wave winding I am going to have one positive brush and one negative brush that is it and because the winding is going progressively like what I showed here I am going to have many coils connected together like this.

So, 1, 2, 3, 4, 5, 6 coils will be connected here another 6 coils will be connected here if it is a wave winding so this is going to be positive and this is going to be negative irrespective of the number of poles I will have two parallel paths this going to supply the current here output and I am going to have essentially the current returning like this so here is my load so this is actually my wave winding.

So, in wave winding always I will have number of parallel paths equal to 2. Here because I have only three coils connected in series if I look at the voltage it is essentially V1+V2+V3 whereas here I am going to have V1+ V2 until V6. So, wave winding voltage is higher whereas current is lower. In this particular case I am going to have voltage is lower but current is going to be higher.

So, normally a high voltage low current machine we will use wave winding whereas low voltage high current machine we will use lap winding. So, these are the two different types of windings normally we adopt so we will look at actually the working of the generator and the working of the motor in the next class. So, we will take up specifically generator first then we will go into the motor.