Course Name: Design of Electric Motors

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Title: Lab Session on Re-winding of Induction Motor (Example: Double Layer Winding)

Greetings to all, myself Dr. B. Prathap Reddy, I am working as a DST INSPIRE faculty fellow at the Department of Electronic Systems Engineering and TA for this course is Shyam Sundar Nair, he is a PhD student and he will assist to do the rewinding of electric motor in this lab session. So, we will consider a motor with 36 slots and 6 pole and it has to rotate at a speed of 1000 rpm synchronous speed and with respect to the slip the speed will vary from 950 rpm to 1000 rpm and I will show the motor and then we will dismantle the motor completely and we will identify all parts of the machine and then we will remove the completely the whatever the winding existed inside the machine. Then we will start making the coils as per the given voltage rating and given power rating, after making the coils as per the voltage rating how many number of turns required and what is the gauge as per the theoretical lectures we will calculate and we will do the rewinding and after that one by one we will insert into the machine and we will again assemble the machine completely then we will test it. And now I will show the motor, this is the motor 3 phase induction motor and we are going to rewind this motor for a power rating of 200 watt and 100 volts and here we can see the terminal box 3 phase star connected terminal box star connection will be done inside and 3 wires are coming outside R, Y, B and from the scratch how to rewind the motor we will see step by step.

So first step we have to dismantle the motor then we have to remove the winding completely. So as per our power rating and voltage rating we have to make the coils and one by one we will insert the coils again and then we will do the stubbing and other things then we will do the threading and varnishing and other things and again we will assemble the motor and then we will test the motor with no load V by F control. Now we will dismantle the motor, so this is shaft side and this is non-shaft side, non-shaft end side. So, this side generally fan we used to fit for thermal management, here for this motor fan is already removed.

So, as per the motor we have to dismantle front side as well as back side like drive end as well as non-drive end. After removing the screws we have to remove the enclosures with by hammering and we have to remove the terminal box also, but before doing these things we have to wear the gloves as a protection issues. For removing the screws it may be required or may not be required no problem, but from this step onwards we have to wear the gloves for safety issues. Now I will remove the enclosures on both sides by doing little bit hammering on both sides by doing little bit hammering on both sides. Now we can see here this is the rotor, this is the squirrel cage rotor and this is the enclosure and non-drive end side and drive end side enclosure will be this thing that also we will remove.

So, this is the drive end side enclosure and bearings also we can observe here, these are the bearings drive end side and non-drive end side also bearings will be there, this is squirrel cage rotor and after removing the rotor we have to remove the terminal connections also. These are the terminal connections going to the supply, so that also we will remove. Just make sure that this motor is decoupled from the supply and after turning off everything then we have to remove one by one. So, three connections are there, one by one and the other two connections I have removed, the terminals which are going to the supply and these are the three wires which are coming from the three phase bindings after making the star connection that also we have to remove. So, these are the three wires which are coming from inside of the motor.

Now we will see how many number of slots are there we have to identify first. So, we have to count from 1, 2, 3 like that up to, so I am counting the number of slots to design the winding. Let us say after counting the number of slots I got 36 slots are there as per the problem statements, three phase six pole is the problem statement for 100 volts and 200 watt. So, with respect to the three phase six pole and 36 slots we can design the double layer winding, slots per pole per phase will come 36 divided by six pole into three phases. So, two slots per pole per phase will come.

So, after this thing we will remove the threading and in industrial motors and practical motors varnish also will be there. So, if varnishing is there we have to use the thinner to remove the varnish such that it will one winding to other winding the smoothness will come like it the hard attachment will come with respect to the varnish that will be removed with respect to the thinner. First as a part of re winding we will remove the threading. Like this we can remove the complete threading and same way on the other side also we can remove the threading. So, this is white color one is the threading and we have to remove the complete threading in order to remove the coils.

So, after removing the threading on both sides we have to if varnish is done we have to cut the winding at one particular side and then we have to remove the threading. So, we have to cut the winding at one particular side and then we have to remove the winding.

So, we have to remove the sticks first then we have to remove the enclosures and everything in practice varnish also applied in that case first we have to apply the thinner then we can use some petals to remove the windings here there is no thinner that is why I am doing directly. Like this we have to remove all sticks first what we have we have to utilize it for smart then we can remove this insulating paper this white color one then it is easy to remove the conductors from the slot. After removing the stick we have to remove the sticks and slot enclosures this insulating paper then one by one we can remove the coils from the slot here there is no varnish that is why we can do from slot itself directly like this fashion.

So, whatever the way we have inserted same way we can remove the windings. So, this is first winding I have removed. So, the next we have to remove with respect to that particular winding. So, here top side conductor first we have to remove after that we can remove this coil easily out from the slot. So, like this we have to remove all the ice.

So, first we have to remove this is the winding we can remove this coil also. So, remove like this one by one all coils out from the machine otherwise we can use the cutters to remove the winding directly. So, this is on the cut. So, like this all the coils we have to remove from the slots. Generally we will apply the varnish that this much easily windings will not come outside.

So, we have to use the thinner otherwise directly with some cutters we can cut the winding at one side then from other side we have to remove from the from other side we have to remove the windings. So, here there is no thinner that is why I am doing directly in this manner. Now, I have removed all windings from the machine. So, we have to remove this papers also. These are the insulating slot liners we used to call that will insulate the conductors and the machine frame or conductors and slot.

So, this is the empty 36 slot core. So, from this point we will start designing the rewinding of motor. As per the given power rating and voltage rating we will design the winding. So, after removing everything like all windings we have removed this is the empty core 36 slots are there. So, we have to design the winding for 6 pole and 3 phase double layer winding.

So, first we have to calculate the number of turns as per the voltage rating. Voltage rating is given per phase rms is 100 volts and 200 watt rating and current rating we have to calculate accordingly it will come 1 ampere 0.8 to 1 ampere it will come. So, as per the pole number of poles we have to calculate the pi d by p based on that we have to calculate the arc length of the coil and then based upon the current rating 1 ampere to 1.5 ampere for safety side we can consider and then swg related to that is 23 or 22 swg we can select based on that swg we will make the coils that we will see now.

So, this is the winding making machine with this we can make the number of coils as per the machine. So, based upon the arc length like pi d by p we have to calculate one complete turn length based on that thing we have to fix depends upon the step this step has different circumference this step has different circumference this step also has different circumference. So, based upon the machine we have to fix the mean length then let us say I am considering this second step. So, with respect to the second step here number of turns will be visible. So, let us say per coil 50 turns are coming.

So, based upon the 50 number of turns per coil we have to make 50 turns in each and every coil. So, like this we can make the coil. So, 50 turns per coil. So, this is after making the coil as per the number of turns we have to tie and go Is it in session of grindings? This is coil one as per our design like this 36 coils we have to do per double layer winding with respect to 36 slots. So, like this 36 coils we have done now.

So, these 36 coils we have to insert in the machine one by one. After making the all coils we have to insert the slot liners like this insulating paper we can take and we have to measure the length of the core based upon the length of core we have to cut the this insulating paper then one by one we have to insert inside the slot. See after placing all slot liners the core will be like this fashion then whatever the coils we have done like this 36 coils we have to insert one by one and slot opening will be two to three times the conductor cross sectional area in some machines two to five times it will be there. So, I am inserting the conductors in the slot one by one. So, this is one coil side and this is second coil side.

So, first coil side we have to insert in the slot one bottom side and next coil side we will insert in some other slot. We have to do slowly one by one otherwise there is a chance to there is a chance of enamel removal. So, after placing the coil we have to place the slot separator. So, this is the coil separator then we will take one more coil. So, this is one dash conductor which is placed at the bottom side the second end we will place at the end, but top side we will place the conductor now.

So, this is the coil side which are what we are placing in slot number one top side. We can use stick to insert the conductor into the slot. So, after placing both coils we have to place the another slot liner at the top side that is this one. So, first slot is filled with both coil sides we can see two coil sides are placed in slot one. Then we have to place the stick for closing the slot.

So, we have to place the two coil sides at the bottom side. So, we have to place the two coil sides at the bottom side. So, we can see here this slot is filled. Next the second side of this coil we have to place in slot number seven bottom side. So, this is first, second, third, fourth, five, six, seven in seventh slot we have to place the coil side.

So, second coil side I am placing here. So, second coil side is placed then we have to place the slot liner or coil side separator this one. So, slot seven bottom side conductor we have placed. So, we have to go in sequence. Now slot seven top side we will fill because it is a double layer winding.

So, whatever the slot we have filled. So, from that slot we will start again. So, we can use the stick like this fashion to push the conductors inside the slot. After placing the coil side we have to place the slot closer like this fashion which will insulate the slot and conductor. So, we can see here the slot closer is placed.

After that we have to insert the stick slot closer that is this one. So, depends upon the motor size and slot size we can select the stick and we have to insert to close the slot such that conductors will not come outside the slot. So, we have to use the rubber hammer such that enamel will not go bad. So, after placing the slot number seven top side the coil side then from seven to six right coil pitch seven to thirteenth slot it will go thirteenth slot bottom side. So, from here thirteenth slot bottom side means this one we have to place.

So, this is the thirteenth slot. We have to do the winding carefully the enamel should not go bad. So, so so so so so so so so so so so so we can see here now after placing all coils whatever the coil we have inserted first that we will place now at the top side of the slot where we have placed the last coil. so so we can see now all six coils we have placed with respect to phase a then adjacent to this coils we have to place another six coils such that a phase winding will be completely done before placing those coils we have to mark these ending terminals of each and every coil. So, now six coils we have placed right.

So, total twelve terminals are there. So, these twelve terminals we have to mark it with stickers. So, based upon number of like whatever it may be the slot where we are placing. So, we have to mark it like one is top side and one dash is at bottom side like that. So, so so so these are the twelve terminals now everything is marked. So, let us for example, slot one two coil sides are there.

So, bottom slide coil is marked as one dash and top side coil is marked as one. So, same way we have to place all thirty six coils after placing all coils and each and every coil we have marked as one one dash two two dash like that. For example, in slot one we have placed two coil sides as per the double layer winding top side coil is represented with one and bottom side coil side we are representing with one dash like that it is marked in each and for each and every slot. So, now we will do the stubbing then we will connect the winding connections at the end we will bring the three terminals outside and other side three terminals will make the star connection. Now, we will start with the stubbing and already we have placed the slot closers that is insulating paper this white color one

and sticks also to close the slot such that windings will not come outside and for stiffness of the winding we can make the varnish at the end and threading also at the end.

So, now we will do the stubbing. So, as per the winding diagram we have to stub the two coils that is slots per pole per face that two coils are first coil is one to seven dash second coil is two to eight dash to make one stubbed coil of these two windings we will connect one and seven dash and two we will connect because one is starting terminal and eight dash is ending terminal of stubbed winding. So, we will connect seven dash and two. So, this is the two and this is seven dash these two wires we will connect to make the first stubbed winding. First we will remove the enamel with sand paper. So, we have to remove the enamel completely and then the second end will be this thing this is seven dash.

Now, we will take the sleeve like this insulating sleeve. So, we will insert before making the joint and then we will connect these two wires this is nothing but stubbing. So, I am connecting seven dash and two and for better conductivity. So, this winding joint we will do the soldering also.

Now, we will do the soldering. You can pause on that. Now, soldering is done after doing the soldering and we can check the continuity with multimeter. Then this insulating sleeve will push it to here to cover the winding connection such that it will not come in contact with any other winding. So, like this we can place the insulating sleeve. In general we have to utilize the heat sleeve also before placing this insulating sleeve.

Here directly I am utilizing the insulating sleeve. This is first stubbed coil. So, this is starting and this is ending with respect to the first stubbed coil as per our winding diagram. Next stubbed winding will come.

We have to connect 13 dash and 8. So, here 7 is there that is starting and 13 dash is there here for the next under next pole that is first coil and then 8 and 14 is the second coil. So, these two coils we have to connect as one coil and we will make one stubbed winding. So, we will consider 13 dash and 8. So, this is 13 dash and then this is 8 we have to see.

This is 8. So, these two wires we will connect to make the stubbing. So, so now first take the sleeve. Here also we will take the sleeve before making the connection and then we will insert.

Then we will make the joint. So, this is the joint. Now we will do the soldering for better conductivity. So, after doing the soldering again we will do the same procedure like we will bring the sleeve to cover that winding connection such that it will not come in contact with any other winding. Same way we have to do the stubbing with respect to all coils. So, so so so so so so so so so so so so so so so so this is the star connection.

Now I am doing the soldering for better conductivity. So, after doing the star connection then we will cover that connection with the same sleeve. So, this is the star connection and these three connections we will extend this wire length and then we will bring it out from the terminal box. So, in order to extend this length we have to consider the copper wires like this manner same copper wire otherwise normal 5 mm cables also we can consider and then we can bring it out. So, so so so so so so then after soldering we will insert the sleeves like this fashion. So, we have to mark the terminals which one is R which one is B which one is Y like that or ABC.

So, this is A I am marking as per my convention and then this is B. So, so so this will be the C. Now we have to bring these three terminals outside from to the terminal box here there will be a hole near the terminal box from there we have to bring it out. I will show you that thing here we can see the hole from here we have to bring it out. You can see this is first A phase then this is B phase and then this is C phase.

So, at the end we will give the connections to this terminal box and then external connections to the supply also we will give from this point. So, this winding is done now we will assemble this motor by doing the threading and varnishing. Before doing the threading and varnishing we have to test each and every phase continuity and there should not be any short with phase to body that we can see now. So, if any short is there multimeter will give some sound like that just we are seeing from body to body. Now from each and every phase to body there is no short that test we have to do after that only we have to do the threading and varnishing.

So, like this thread also we can utilize or like this thread of cotton thread also we can utilize to do the threading. In order to make the needle take the copper wire and you can fold it in this fashion and then bend it in this manner and you can make it like some needle kind of thing to do the threading. Then we can cut in this fashion. So, this is the needle to do the threading. So, so so so so so so so so so so so so so so so so so so so so so so so so so so so so we have completed the winding of the motor.

So, after the completion of winding we have found that the motor is rated for 100 volt and 200 watt. This is the auto transformer which we are going to supply to this motor. This auto transformer is rated for 415 volt and 28 ampere. We have measurement instruments like current probe, multimeter, voltage measurement probe and tachometer to measure the speed of the machine.

So, we can start testing the motor under no load operation. Now, we will give the supply voltage as per the rating of the motor. The winding is done for 100 volts. So, as per that thing I am giving 100 volts phase rms. So, we can see the motor is starting slowly and here we can see the motor shaft is rotating and in the oscilloscope voltage waveform and

current waveforms are shown. The current is lagging behind the voltage as per the inductive type of load and here this is the current probe which is measuring the current and now we will see the speed of the motor with tachometer that is this one.

Now, we will measure the speed of the motor with tachometer and we can see the speed in tachometer display and speed we can observe that it is varying from 950 to 1000 rpm. Yeah, so now we can see that 970, 978 rpm and 980 like that it is varying.