Electrical Machines – I
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Lecture - 84
D. C Motor Braking

Welcome to lecture number 84. So, I talked about since you must not forget that, DC generators a now a day's not used because of so, many reasons : their ratings are restricted, voltage rating cannot be beyond say 1000 volt, because of committed or segment brushes, etcetera that put a restriction. And secondly, if DC is required DC cannot be transmitted over a long distance therefore, AC it is all along in our country 50 Hertz see.

Therefore, if at all you required a DC supply you better use a converter to get the DC supply. So, use of DC generators are restricted, nowadays practically not use; however, DC motors are still there, because of the fact this pit control of DC motor can be done with very ease maybe by connecting a resistance in the field circuit; field circuit power is also less.

So, higher speed smoothly control the field and armature resistance of course, is once again out of question, but you can vary armature voltage fixed AC is there, make it a DC supply with diode which rectifier, then you some controlled rectifier to supply the armature and smoothly you will be able to vary the armature voltage and that is why and smoothly it can be controlled. And when you have a such a scheme, another point I must tell you also kill another problem; see this is your field circuit; field circuit.

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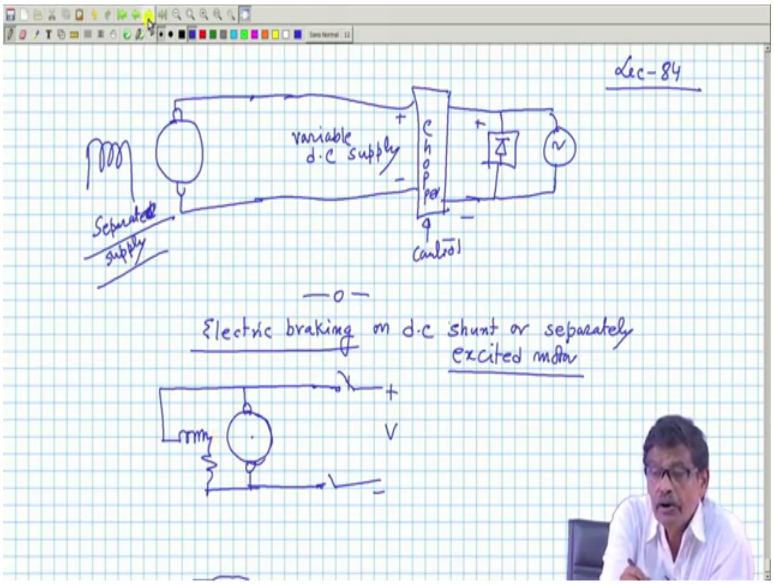

Here suppose you have a variable DC supply suppose available variable DC supply; DC supply how do you get these variable dc supply? AC supply is there use a rectifier block, make it DC and then use some chopper circuit or straight here, control rectifier circuit say chopper, DC chopper circuit here you will get DC and this one you connect here.

So, that you have some control here, ok. It will be able to vary the applied voltage you make it 0, increase it slowly like a buck converter this that. And then you can go up to rated voltage and field you connect separately that is there separate; in this scenario separate supply, in this scenario you can easily see you do not require any starter, 3 point bulky starter is not necessarily, because I will why this starter was necessary?

Because we are applying full rated voltage armature resistance small therefore, you incorporate some resistance in the armature circuit like 3 point starter then gradually cut it out, applied rated voltage, machine will be running with some protections, these that. But here if I start increasing applying the voltage across the armature from the very low value slowly by using this control then no question of high current in inflow into the armature take place.

Go on increasing the applied voltage speed will smoothly increase and finally, settle down. Therefore, armature voltage control is a very popular method not only controlling the speed, but also this one. [FL] Today what I have planned, before I discuss about series motor with this DC motor there is electrical braking can be also executed on DC motor, ok.

For example, if a motor is running, DC shunt motor so, electrical braking I will just briefly discuss electric braking to give you the ideas how it can be done and ideas are simple and interesting. Electric braking on DC say shunt or separately excited motors shunt or separately excited motor.

Suppose you have a what is the idea of this electrical braking? This is the thing, this is the field and here is your supply and suppose there is a switch; where from you have connected it to supply voltage. And, suppose initially the machine was running steadily you want to stop the motor. If you want to stop the motor then what you will do, you will simply disconnect the supply and a machine will eventually come to a stop; how long it will take?.

Because what happens is this, when the machine was running it acquired some kinetic energy is not, half j omega square where omega is the speed. So, how fast this rotor will come to a stop, depends upon how fast you are your kinetic initial kinetic energy is taken out from this system. Eventually the kinetic energy has to become 0, when it comes to a stop and that initially energy stored in the rotor must dissipate somewhere.

So, what do you think? If I removed this supply where that initial kinetic energy will be dissipated? It will be dissipated; because you see you switch off the supply field current becomes 0, ok. So, there is practically no flux, very little residual flux maybe there as you disconnect it, ok. And, it will be like in the friction on the shaft of the machine it will be dissipated. Will come to this, but the point is you have to dissipate this energy somehow. So, depending upon how you are doing that different methods of electrical braking is there?

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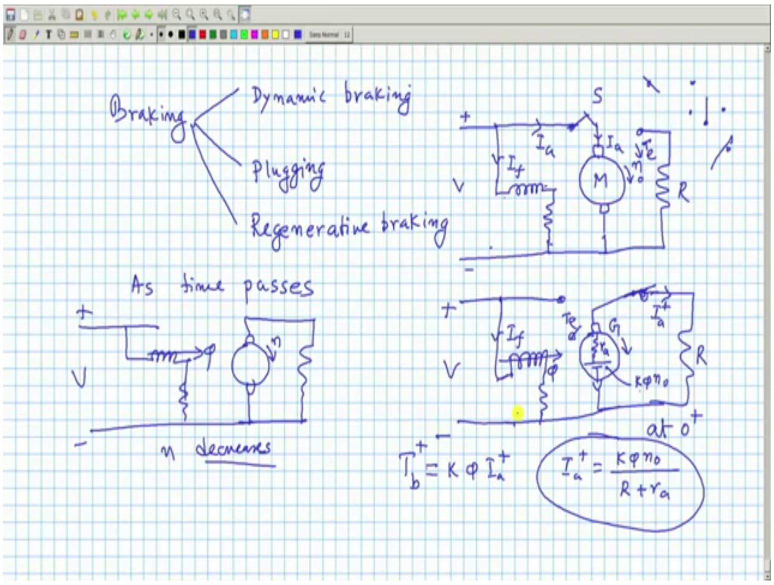

One is called braking, there are various method; one is called a plugging, another is called regenerative braking, regenerative braking and a there is another method will come to this. So, plugging and regenerative braking or it is called dynamic braking (Refer Time: 09:25). Let us see what does this mean? See here is suppose I will make a connection like this. Only see the ideas will not of course, we can analyze it we will do a little bit of analysis. This is suppose your field coil and this is the thing.

And, here what you do and here is your supply and these are one switch we will also do, ok. Remove this switch and what you do is this? You connect very interestingly a resistance here, R external resistance. When you want to run it as a motor this switch is connected here, this switch is connected here and this is the supply voltage, shunt motor this fellow is outside the circuit. So, there was some armature current like this there is some field current and it was running as a motor, drawing armature current was like this.

Now, suppose I want to break the electrical machine; initial kinetic energy if you bring the switch S just like this neither connected to this point to this point, if I just disconnect like this suppose it has got this switch has got 3 positions; one is this, another is this and another is this. So, suppose you keep it in the neutral position do not touch it here, then what will happen?

I a will be 0 is not and there will be no electromagnetic torque developed by the machine, because electromagnetic torque is product of I f and I a if you keep it vertical the switch I a becomes 0, electromagnetic torque develops 0 and a initial kinetic energy stored will be dissipated in the friction. Strictly speaking it will be not only dissipated in the friction, but also there will be cold losses in the armature, because field flux is present excited these I have not changed.

So, all the kinetic energy stored here will be dissipated in the friction measure and then in the rotational loss that is in the rotational loss will be supplied, because flux is there armature is rotating it cannot come to stop immediately. So, like that it will happen it will take some time, but that is a thing.

But in this method what is done is this; when you execute the braking you connect the switch here, bring this switch here this is R and this is your field circuit. This switch it was here you have put it suddenly there this is R and here is your supply voltage V. So, field is energized field current I have not disturbed initially; it was running in the clockwise direction. Now, when you put this switch from this to this point what is the equivalent circuit of the armature?.

There was R a and it was running at some speed n 0 initially therefore, speed cannot change instantaneously at t equal to 0 plus, what is 0? 0 is the instant when I have moved this S to this one. So, 0 plus it is corrected there, but this flux is there it is running therefore, there will be generated voltage that back EMF which was present and the value of that is some K phi n 0 at t equal to 0 plus, because switch cannot change instantaneously.

Therefore, in this circuit there will be a current I a, how much will be the current? This K phi n 0 divided by R plus this smaller n, I a plus it will be equal to K phi n 0 divided by R plus r a. What is n 0? N 0 was the speed at t equal to 0 minus. So, this much will be the armature current, but you see the armature current direction has reversed with respect to this case when it was running as a motor.

Now, this machine is running as a generator local generator supplying R and in case of generator the electromagnetic torque is in the opposite direction, it will also develop electromagnetic torque how much is the value of the torque? K t phi into this I a. But in this direction in this case electromagnetic torque was in the direction of rotation.

Therefore, the moment you do this on the shaft of the machine opposing torque was load torque present plus now, I find there is an opposing torque which we will try to put a braking torque on the machine rotor and therefore, machine speed is expected to decrease why not, it will come down gradually, but as pit false this a not will not remain constant it is only at t equal to 0 plus.

So, as time passes these back EMF will be K phi into n is value decreases this current decreases braking torque 2 will be decreasing this is at t equal to 0 plus t braking torque at t equal to 0 plus will be K phi I a plus a highest braking torque. With time as time passes the circuit remains same. Plus minus, I have executed the braking; switch is this side, but speed with time it will start decreasing in the same direction.

So, there is phi present, so as time passes, speed decreases; speed decreases much faster than the case when the switch is just put in the neutral position, because no opposing torque I have put extra only the opposing torque was the friction torque present, got the point. So, machine will come quickly to stop compare to these earlier case; that is a DC motor is running you disconnected from the supply it will eventually come to stop it will take it is own time depending upon the inertia of the rotor, it is kinetic energy gets dissipated somewhere maybe in the friction and it will come.

When we apply mechanical brake what do I do? I put a opposite torque and your what happens is this your kinetic energy stored, we will be dissipated as heat in the brake shoes that is what we do. So, in this case initial kinetic energy will be dissipated in R and also there is flux, got the point. Therefore, this is how electrical braking can be executed.

One simplest method is this one although the kinetic energy I am not using for any useful purpose, but heating this resistance dissipating it, ok. Therefore, you see if you want to execute electrical braking you must put a torque in the reverse direction of rotation of the machines that is why it must operate as a generator during braking mode is not.

Therefore, I can analyze a I can always find out how armature current will go on decreasing, these will be function of time n will be also function of time, but eventually speed will be 0. To stop the motor to get more braking torque that is suppose, because it is sometimes necessary you know a motor is running in the clockwise direction a 1000 rpm then you your operation demands that it must be brought very quickly to stop condition, then once again restart the motor. Situations like that often take place not that continuous running.

I want to in so, many seconds I must bring the machine back to stop condition and then I will restart the motor. So, in those kinds of operation therefore, it can be executed like that another interesting method is called plugging. What is plugging is; plugging, what do you do is this here is your supply these the field circuit, I will keep field circuit energized got the point.

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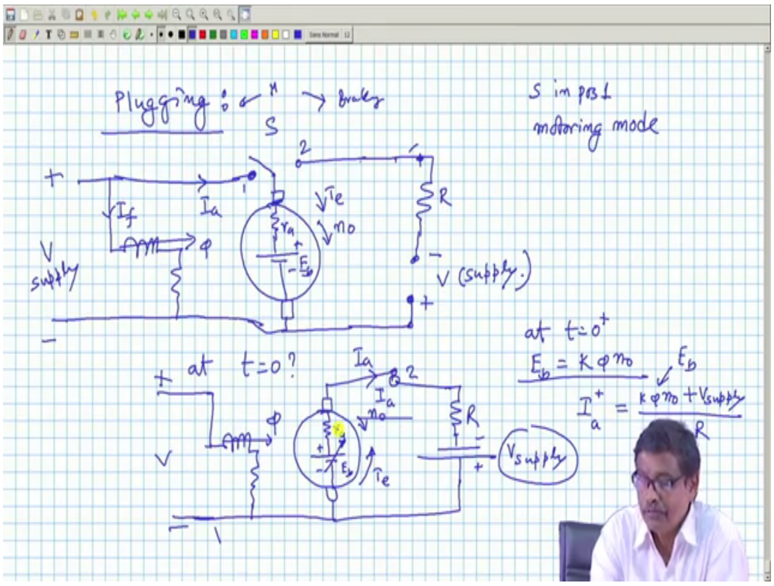

And, here I connect a two way switching this switch is connected here, like this. Here what I will be doing is this is plus minus supply voltage, I will do a little bit of varying so, that this supply voltage also comes here like this. So, I will connect resistance no doubt and I will this one, between these two point I will connect the here is your R a, here is your generated EMF and I will connect a supply voltage like this. The same V, I will do a little bit of wiring here this negative I will bring it here this positive I will I will keep it ready supply with this polarity.

Then initially, with S in position 1, S in position 1 it is doing motoring, motoring mode at that point what is this circuit this part is not there, this part is not there in the circuit only this one S in position 1. It was drawing armature current like this like a motor it was operating, there was some back EMF generated flux per pole was there, field current was present like that it was nice.

And, it was developing some electromagnetic torque equal to load torque, running at some speed suppose in the clockwise direction and so on. Now, what you do is this at t equal to 0 what you do? You bring move this switch to position 2 very quickly. So, that your circuit will then look like this is position 2 got the point put it here, here is R here is V supplies same supply here with this polarity it is like this V supply this is the equivalent circuit for t greater than 0 and this is r a and back EMF was like this, your fields circuit mind you it remains energized, like this plus minus V supply it will be like this flux.

Therefore, in this case at t equal to 0 minus; machine was running steadily the moment you connect it here at t equal to 0 plus speed cannot change instantaneously. So, how much is the at t equal to 0 plus the back EMF is still your K phi n naught and it is the local circuit, flux is present there. So in this case the direction of the current has to be like this and how much will be the current?

I a at plus at t equal to 0 plus the current will be this back EMF K phi n naught plus V supply divided by r a plus R external and the direction of current has reversed that is what I want. What will be the electromagnetic torque developed? It must be in the opposite direction; because current has changed it is reduction earlier it was running as a motor electromagnetic torque was in the same direction of n naught so, the moment you connect armature to this site with field energized back EMF will be there this back EMF plus this voltage will be r a.

And, this method is called plugging when you are applying a reverse voltage across the armature compared to its motor mode, ok. Motor mode you applied plus here minus here now, you are you have change the supply polarity across the armature. So, that these supply and back EMF together decides this armature current this plus this.

And, electromagnetic torque will be in direction opposite to that of n naught that is what I want to execute electrical braking, and following it is dynamics speed will fall, compared to the DC dynamic braking it will come to rest at a faster rate, because you see in the previous case the current at t equal to 0 plus only K phi n 0 divided by R, some sufficient current was there.

But this time it is K phi n 0 plus V supply by K phi n naught. So, braking torque will be much higher than the braking torque due to DC dynamic braking and therefore, machine will try to come at a much faster rate. Similarly, here the decay of the current see as time passes pitfalls this EMF falls current fall fail here also that magnitude of the current will fall no doubt, because E b will decrease as time passes, because E b depends on this fellow E b at t equal to 0 plus it was n 0, but I eventually this n becomes function of time it decreases.

There about this E b will be decreasing wearing, but your V supply is large value that will maintain large a braking torque during this process of slowing down of the machine. So, if sufficient opposing torque will be present on the shaft of the machine and machine will come faster to close, but only thing is you should be careful that, it comes to stop; it time will come eventually machine will come to a stop, but after that what will happen?

If you if it gets connected like that then machine will start running in the opposite direction, because field is not change it as a separately excited DC motor is not, therefore, if you want really braking to bring the machine come to a stop very quickly. So, it was motoring this side, switch was motoring and this side it is braking then you must keep a watch at what speed the machine has reached, when it has reached close to 0 speed disconnect it from this supply you once again.

That can be done by using some speed relay to disconnect this switch from the supplying, otherwise it will start running in the opposite direction. These are very interesting observations so, during braking mode you are essentially running the machine as a generator. 5 minutes break [FL]. We will continue with the next method next time.