Electrical Machines - I
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Lecture - 91
Efficiency Calculation

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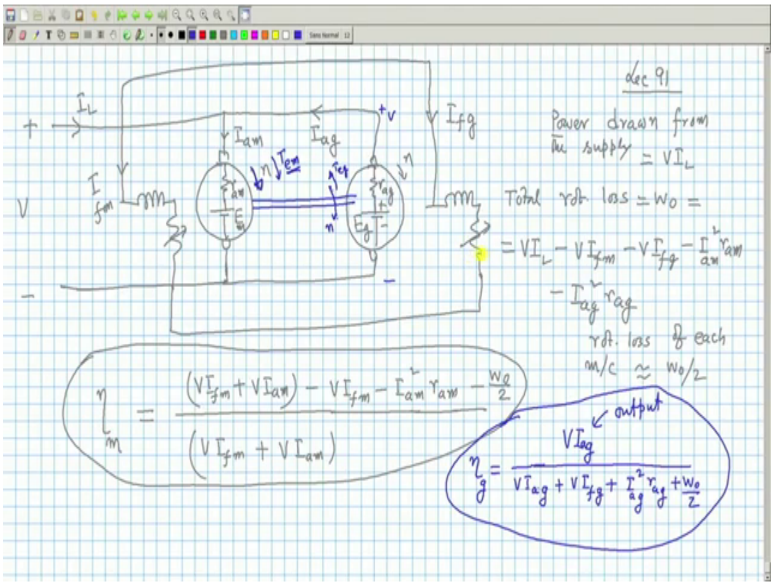

So, welcome to this lecture; we have been discussing with the Hopkinson test. And the connection I will better draw once again very quickly. So, one machine you connect it as a shunt machine like this, like this. And another machine whose armature is this and whose field is this, this field and here is your supplied the rated voltage. And this one you connect it here and so, field winding of both the machines are separately excited from this voltage right this current is I fg and this current is I f f that was there.

And this machines this two armatures are eventually paralleled. Some conditions to be fulfilled that I told you it is like this connected. And this two motors are mechanical coupled. So, they cannot, but run at these n speed n ok. And it is adjust the field currents of this machine; such that, here is your r a g and the polarity of the voltage should be like this, this is E g. And similarly, here it is r a m and polarity and this is the back emf of the motor E m.

And the I will make e g greater than E m. So, that current will flow. This is the armature current of the generator as you can say this is the armature current of the motor. And this is the current drawn from the supply. Now, obviously this total current, total power drawn from the supply, power this we did last day only power drawn from the supply; supply is equal to v into I L, ok.

And from this power; if you total total rotational loss of both the machines is suppose W naught is equal to input power, power drawn from the supply and then go on subtracting the losses; that is field copper loss. We did it last time minus V into I f g field copper loss of the generator. Armature copper loss I a m square r a m minus I a g square into r a g.

Then we say that ok, this we have estimated the total copper. So, from the supply, the power drawn whatever power it draws must be all the losses that is what I am telling. Although there is armature current now, sufficient armature current there is sufficient generator current. But power drawn from the supply will be only all the losses taking place in the machine. Let us go ahead, so this is the rotational loss.

Now, suppose I want to so, this generator is armature current is no longer no load current it is I can adjust the field; field resistance of the generator and motor such that E m is less than E g. And current directions will be like this. Therefore, I can now calculate the efficiency of this machine and that machine. See, I told you this two machines are similar or identical in that case r a g and r a m will be equal. But I have taken a most general case; even if it is little difference let it be like that.

So, I will say, see how I am writing. I will right straight away the efficiency of the motor to be. For a motor which thing is easy to calculate? The input power is very easy to calculate. You calculate input power output by input is the efficiency. So, what is the input power to this motor? It is input will come in the denominator. So, it is V into I f m field copper loss plus v into I a m. This will be the total input power to this motor, got the point. Input power to the motor.

And what will be the output power? Output power will be V into I f m input plus the losses minus the losses minus. Input power minus the losses. What are the losses? Filed copper loss V into I f m. Motor losses minus I a m squared into r a m, copper loss of the armature minus the rotational loss which is W naught by 2. So, we after this we say that rotational loss of each machine will be approximately W naught by 2. W naught I estimated rotational loss of both the machines. Because there will be eddy current loss in the armature frictional, loss on the shaft of the machines

Why I am saying it is approximate? Simply because, see although this is this experiment is nice, but you see the field current of the machine, which is acting as a generator is greater than the field current of the motor. Therefore, flux level in the both the machines are not same. Although speed is same, but anyway this is how I am estimating.

So, this will be the efficiency of the motor that is all. Similarly, so this is efficiency of the motor. Similarly, I will be able to write down the efficiency of the generator. In case of generator; it is easier to calculate the output first. For example, what is the output power of the generator? This voltage is V. So, this is also V, V. Is not? V into I a g is the output power; this is the output of the generator. And to this output power, you go on adding the losses to get the input power of the generator.

So, output V a I a g, V I g I wrote or I a g I a g I am sorry v I a g is the output power. So, output plus the losses. What are the losses? Field copper loss; V I f g plus armature copper loss; I a g square into r a g plus the rotational loss W naught by 2. This will be the efficiency of the generator.

So, you see in this experiment compared with swing and test. Here you will be able to load the machines to their rated current. But supply will never know; supply will only supply the losses. So, current drawn from the supply is not large. Little current, I l which comprises of the copper loss of this two field coils and armature copper losses and rotational loss that is all.

Now, it may looks surprising, why it is happing like that. But still I am telling the output of the generator V into I a g will be large. Input to the motor is large V into I a m; I a m is no load current, it is I a m. The answer to that is this one that what is happing, this two machines are coupled. Is not? [FL] Motor this is n, speed and electromagnetic torque developed by the machine will be same direction as that of that is not. Similarly generator; direction of rotation is same n. But electromagnetic torque developed by the generator will be in the opposite direction T e g.

See for this motor; motor does not know it will only see on the shelf there is an opposing torque that is why it is behaving like a motor. It will draw more current; whether, this torque has come by your direct belt loading, the thing I discussed that it cannot distinguish. It will see on the shelf there is now some opposing draw more current. Similarly, for the generator mode; this electromagnetic torque, produced by the motor is in the same direction. So, this is the prime over torque of the generator T e m is nothing, but the prime over torque of the generator.

T e m is provided by whom? By the motor. Load torque is provided by whom? Is by the electromagnetic torque of the generator. Therefore, the motor will always see, ok, this generator is nothing but, mechanical load to me, similarly generator will see this motor is nothing but, the prime mover to me, got the point. Therefore, this motor will run this generator as a as a prime mover. Similarly this generator will give supply to the motor. Therefore, this is how they will manage to survive with sufficiently large armature currents.

So, but our purpose is to see that their carrying rated currents, then calculate efficiency. Rated current means if it is 20 mpr rated current you can adjust the field current. So, that this current are really 20 mpr. So, armature currents will be rated current, but the current drawn from the source will be only very little, that is the advantage.

So, this is how elaborately you can calculate. But only thing I must tell that this assumption that the rotational losses are same is not exactly correct. But any way that will cause a little error, at least you get this performance of the machine temperature rise etcetera will be can be well documented by really passing directed currents to the machine armatures, that is the greatest advantage. But another thing is you must have two machines together which are mechanically coupled. Otherwise you cannot do it. So, this is how it can be done sometimes what people say.

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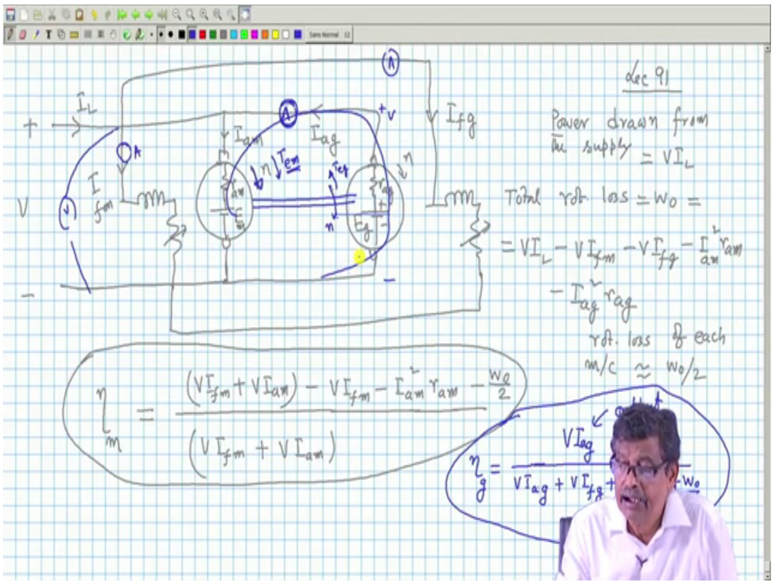

So, in this experiment you must understand that; if you connect you have to connect several meters you know. Suppose you connect an ammeter here this ammeter. Connect an ammeter there this is this records will currents of the generator connect a voltmeter there to record the volt meter those meters connections, I have not shown you can connect a meter here to record the field current of the motor this that. But the interesting thing is that; when the setup is running with all meter showing I can conclude that the read from the readings of the motor and generator field current whichever field winding is carrying higher current that will be acting as a generator.

See after you have parallel them you can do it like this. I will reduce the field current increase the field current of this one, then this fellow will start acting as a generator and this fellow will act a act as a motor got the point. It is the fight between e m and e g, who is larger. That will decide whether this fellow is motor or generator. Generally the field current of the machines whose field current is larger that will act as a generator whose field current is small it will act as a motor.

And finally, one thing is I will tell that in this experiment people say that, so motor is driving the generator as a prime mover and generator will see that it is supplying a load to a motor like that it is happening. One interesting way for quick calculations people sometimes use this.

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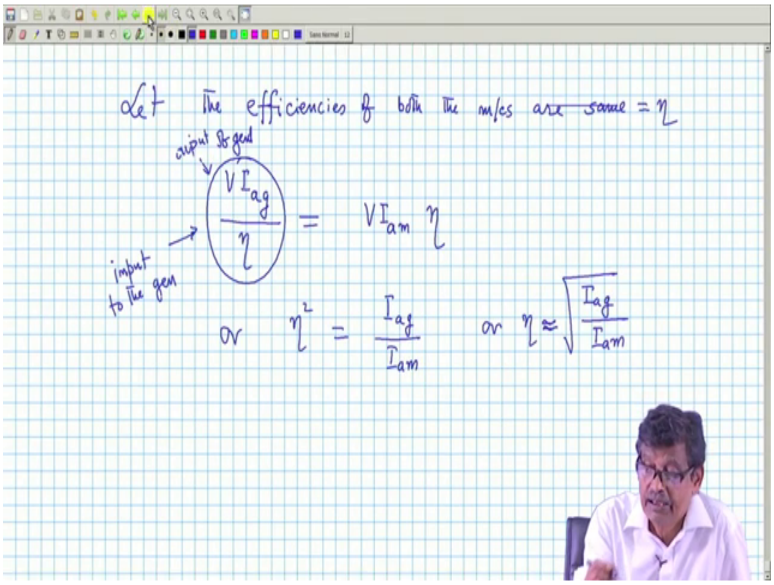

That, suppose let the efficiencies of both the machines are same. Suppose efficiencies because they are similar machine I assume the efficiency of the machine they are same here coming back suppose efficiencies are same. Then what I am planning to do is this, that what is the output of the generator? Output of the generator is how much? V into I a g oh sorry I somehow this page was this page let the efficiencies are same.

So, what is the output of the generator? V into I ag. Output of the generator. What will be its input? Input must be divided by efficiency are same and equal to eta suppose. So, this is output of generator; output of generator that divided by efficiency this quantity is input to the generator is not, this must be the input to be generator. Now, input to the generator is coming from where? Input to the generator is coming from the output of the motor ok.

So, what is the output of the motor I want to calculate? What is the input to the motor input to the motor is armature input to the armature is V into I a m that into efficiency I mean roughly it should be same. Or I will say that eta square is equal to I ag by I am or efficiency of each machine very quickly if you want ok detail actual calculation I do I can get the correct efficiencies, no doubt about that. But only what I am telling is if you have connected all the meter readings you know I f g you know I a g you know I a m suppose you have connected an ammeter here also.

Then you see the efficiency of each of the machines will be under root approximately the armature current of the generator by armature current of the motor, approximately as a first calculations you can say like that. So, anyway read about it particularly the connections is very interesting armatures are connected in parallel, field windings are also connected in parallel.

So, it will give you a fair idea. It will further strengthen your operations of Dc machines either as a motor or generator whatever it you can do it. In this context I will just point out one thing you must have solved problems in the mean time. Suppose you have a machine, ok; you have a, which is separately excited.

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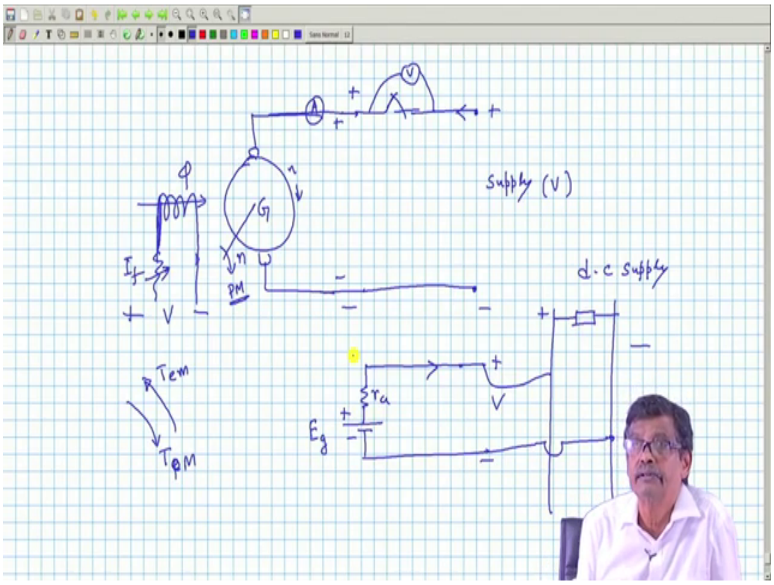

Try to; I mean with this you can now say that; suppose, here is a machine, separately excited machine ok, you run with a prime mover. Then here you will get voltage is not. Generated voltage k phi n prime mover it is driven by them. Now, suppose hear you have a supply say V volts. And I have planned to connect this to this supply.

So, before connecting of course, you must connect a just like Hopkinson test only thing this is not coming from the armature of another machine. This supply is there here is a I am running it as a generator first, adjusting the field current. I will also make this voltage to be plus V. Then what will be the voltmeter reading? 0. If it is 220 volt supply adjust the field current and speed whatever it is rated speed you are running, adjust the field current. So, that this voltage is also 220 volt with this polarity and connected ammeter here.

And the if I now close the switch; if I now, close the switch, what will be the ammeter reading? 0, because the equivalent circuit of this is this one. Here is some generated voltage E g, here is some r a and here is your supply. Is not? And the value of E g depends on this flux or the field current I f.

So, I can if I wish increase this E g above V. I will increase after connecting successfully connecting in parallel with this supply I will play with this field current I will increase this field current. If I do that, then the current will be like this separately excited machine mind you. Current will go to the positive terminal of the battery.

So, here is a dc bus dc supply plus minus. Therefore, if you increase the field current Eg will become Eg will win over V and it will start delivering current in this direction. That is it will pump power on to the bus and on the bus if it is dc bus you dont worry there must be load already connected some other fellows are using the dc supply.

Ttherefore, your generator will deliver power to the bus. What is the DC bus? To wheres where supply is available fixed voltage who had several other loads are connected you have know made this DC machine a member of this bus by doing this ensuring that the voltmeter reading is 0, parallel did it comes like that.

If e g is exactly equal to v then this I will be 0; then this I will be 0, if E g is equal to V. So, your this machine is neither acting as a motor nor as a generator it is just floating in the bus. If you seen nah this generator let it contribute some power to the bus where already load is present some other generators are maintaining those loads. Then what you do? You increase this voltage.

Then I will be flowing from left to right ok, got the point. Therefore, by adjusting this field current I can do it like that. What will happen if this prime mover is disconnected? It is connected parallel separately exited field is supplied. Suppose, because of some reason, it is prime mover means what some other engine it is driving the generator. Suppose the prime mover is detached then what is going to happen? Then this machine armature is already connected across this supply field is there, there is no prime mover. Therefore, it will run as a motor.

And, obviously; it will draw current from the supply. You may then say it was running as a generator, because e g was greater than V I have disconnect that the prime mover then how it can run as a motor steel will it not supply power there. Yes; it will for this for sometime it will supply power. But if it supplies power that opposing torque is present, but there is no prime mover torque, so speed will fall.

So, it will come to such a speed. So, such that it can draw enough power from this bus. So, that it will run as a motor and supply whatever no load power is present I mean shaft power is present like friction and rotational loss. Got the point, in case of generator electromagnetic torque and prime mover torque are in the opposite direction this is prime mover torque for this generator this is the electromagnetic torque.

Now, what I am telling suddenly I said T, T p m goes disconnected, no prime mover. Then what will happen? Electromagnetic torque it was doing. So, it will decelerate speed will fall E g will fall. So, that then V will become greater than E g at some time and then it will draw, drawing current from the bus.

So, these are some interesting observations. So, I stop here today you solve some interesting problem from Perches Myths book; a machine connected to bus. This why I have discussed after the Hopkinson test is similar to this only instead of supply.

So, I hope it will enhance your understanding of dc machine, particularly its operation when it is connected to bus another supply whether it is running as a motor or generator things like that. So, that you can decide on your own. Yes under this condition it may supply power to the bus or the other conduction it will draw power from the bus and so on, so.

Thank you.