Electrical Machines - II

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Lecture - 47
Types of Induction Motor – Slip Ring Type

So, we were discussing how this torque slip characteristics gets modified, as you apply at least change two things; one is the supply voltage, you can change. You can change means? Supply voltage can have a downward change only. You should not apply a voltage greater than rated voltage and if you vary the supply voltage, you should be very quickly drawing. This is the torque slip characteristics, this is at rated voltage and if you change the supply voltage to half it will become V 1 by 2 and on put s equal to 1, s equal to 0, this is torque the T max. So, supply voltage variation.

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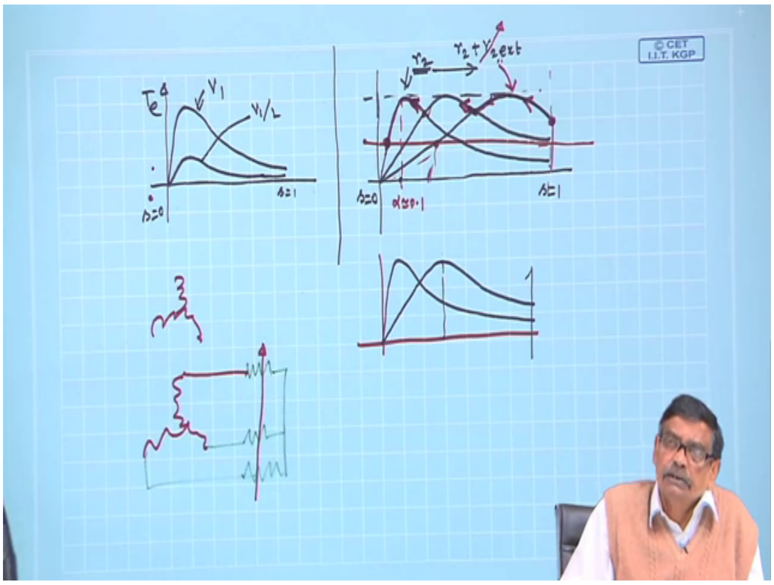

Then we discussed about what happens, if this rotor resistance varies? If rotor resistance is varied how the torque slip characteristics changes? So, suppose this is the torque slip characteristics with inherent rotor resistance r 2 that will come as r 2 dashed with a constant multiplied. This is s equal to 1, this is s equal to 0.

Now, if you increase this r 2 by connecting some external resistance r 2 external per phase then we have seen that T max remains same, it does not change, but this slip at which maximum torque occurs that changes. So, a number of curve can be drawn and the slip at which maximum torque changes that increases and, but the question is how much r 2 external should we connect?

It depends upon the situation, if you are too greedy, you say that I want to get the T e max to appear at s equal to 1 yes, you can do that, because all the equations are with me. I will make then for example, look at this equation, that torque equation in general where you can play with this numbers expression of the torque is after all this one, this one.

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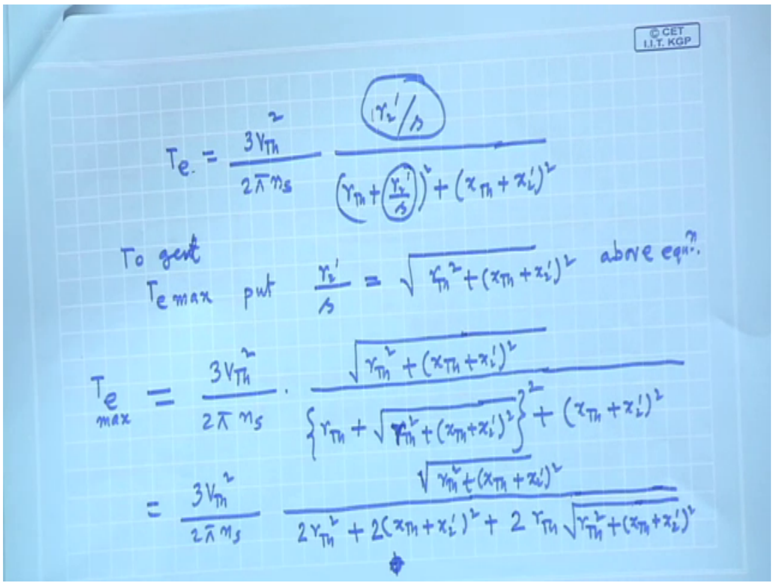

So, T e max can be calculated assuming only r 2 is present and then if you want to get at starting that T e max so, I will write Te max here put s equal to 1, this will become unknown then r 2 dash plus r 2 external and from this equation I will be able to predict the value of r 2 external. That is there, that equation should be used r 2 dash equal to alpha and what I am telling is suppose, I want to make T e max remain same, T e max to appear at certain value of alpha then you can put that alpha to be equal to 1, 1 and from this expression you will be able to calculate its numerator.

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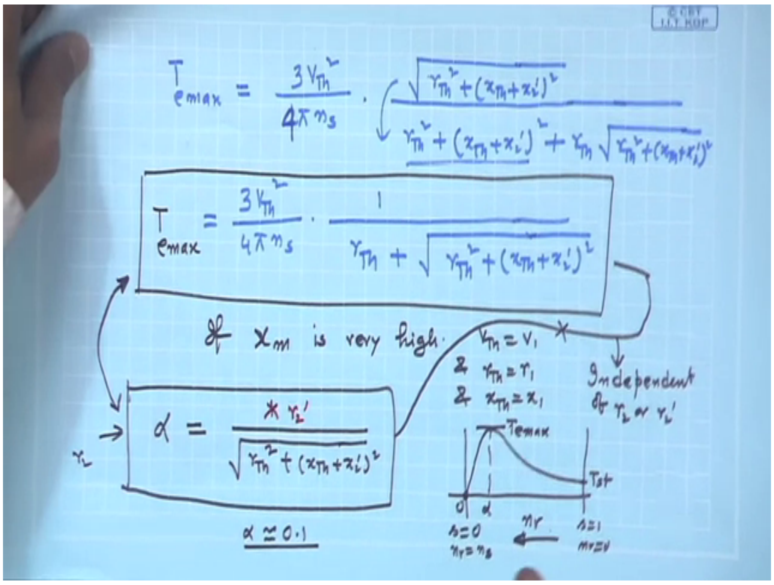

If you put r 2 dash here, something was wrong r 2 dash, a here it was r 2 dash. In fact, and sorry I made a mistake here r 2 dashed. So, this r 2 dash should be r 2 dash plus r 2 external and get the values of that. We will solve several problems will give in the tutorial also. So, these are the two important variation that people generally make with induction motor may be reduce this supply voltage, which is not done very much, because you then scarifies T e max to a large extent. And therefore, it reduces the capability of the motor to supply any substantial meaningful load torque ok.

And another thing is you can play with the rotor resistance and you can get these are the starting torque of different values. After telling up to this point, I have decided that it is better now to talk about the types of induction motor. So, remember one thing is important that rotor resistance should not be kept permanently connected. That is you connect r 2 external, exploit that you can get higher starting torque depending on that you select r 2 external, connect it no doubt. This is stator. Let us draw it what I was telling you connect that r external here, short it.

Some are r external, but as the machine picks up speed finally, that is why I showed it variable bring it down to 0. So, that finally, machine will operate at r 2 with inherent rotor resistance, because if you keep this rotor resistance in the circuit, there will be additional copper losses. And, that copper losses additional; means efficiency of the motor will be reduced and machine will be running at a much lower r p m, because if this is the load torque suppose, this is the load torque if you keep this resistance, it will run at this higher value of slip and things like that. That is why motor maximum value of this alpha with its own r 2 inherent resistance is about 0.1. This number is decided based on that.

If suppose somebody designs a machines, whose inherent rotor resistance is such that it is like this the T e max of occurs with this inherent rotor resistance is such like this, then we are talking about an induction motor, whose rotor resistance per phase is higher and therefore, such machines will be not that efficient. Therefore, people try to see up to when it will be operating, it should be low. So, that rotor copper loss is reduce to a great extent and that is why you selected this value of alpha, which depends upon inherent rotor resistance.

It should be like this and full load torque, whatever it is point of intersection will decides this speed and which I know will be close to synchronous speed. Now, in this case so, suppose this is r 2 r external you have connected and you wanted this much of starting torque, which is greater than this machine will accelerate. How the operating point will shift? It will shift like this, but as it shifts what you do? You cut out this resistance; so, if you have cut out this resistance here, then it will travel to this, it will go like this.

Suppose, I reduce the resistance a bit that r 2 external, which is variable then it will follow some torque slip characteristics, which is decided by r 2 plus r 2 external now. Then once again suppose, you cut out the resistance further r 2 external make it 0, it will move like this and it will settle down finally here. I think you have got the point that is you should always think that this external resistance is to be cut out and the how the operating point will move, you come here you vary the a decrease this resistance suppose, and some torque slip characteristics based on all the r 2 external exist.

So, it will switch over to the new torque slip characteristics it will move there till you further reduce this r 2 external and finally, machine will be operating on this torque slip characteristics where r 2 is the inherent rotor resistance, which has been optimally designed. So, that the copper loss is reduced and the you have desired efficiency level of the motor. So, this is how it is to be done. Now, what I will tell is types of induction motor ok.

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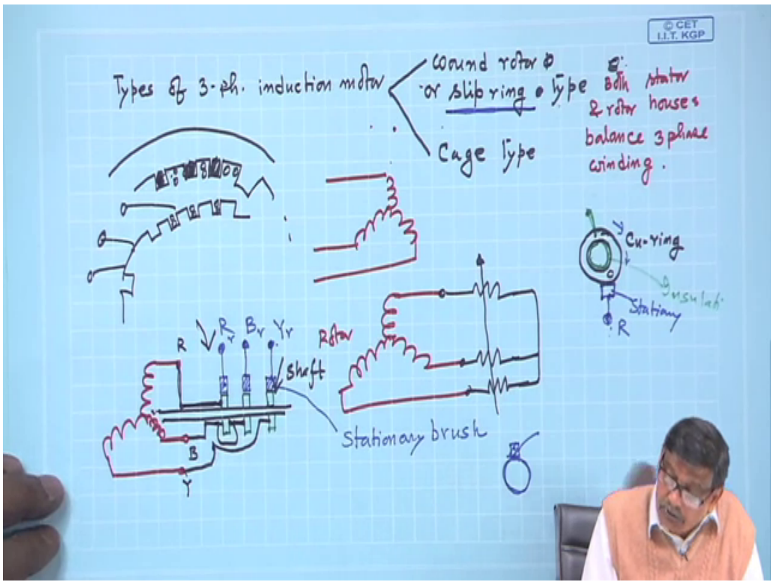

Now, this is it is at this stage I am introducing it, so that you can understand. Types of 3 phase induction motor; there are actually two types; one is called wound rotor induction motor, wound rotor or this is also known by this name slip ring, slip ring induction motor slip ring type, wound rotor or slip ring type and another is what is called the cage type, cage type rotor. It is based on the rotor. This induction motors are classified into two groups; one is called wound rotor type and slip ring type, some changes in the rotor only.

Stator of course, how does the balance 3 phase winding in both the cases, but it is in the rotor something we are doing, there is difference between these two kinds in these so, far as the rotor is concerned ok. Now, first, in fact, so, far we are discussing is slip ring induction motor, although the name I have not told, because what I have assumed is that is the stator is like this. These are the stator where there are windings, I am sorry I will always make a (Refer Time: 12:17) this is the stator, these are the windings ok.

This is the slots, these are the teeth and here are the slots. This is this stator winding. Similarly, in the rotor you have slots here, I am showing the air gap a larger, which is not the case, this is air gap and there is also a similar 3 phase balanced winding on the rotor. So, both stator and rotor in this machine, both stator and rotor houses balanced 3 phase winding; both of them, it is and that is why I was drawing like this. This is the stator winding suppose, they are connected in star, rotor windings also, a balanced 3 phase winding.

This is how, this is the rotor and we also learn that this terminals can be shorted, then the motor is said to be running with its own internal inherent r 2, but it may be necessary sometimes if you want to start the induction motor against full load torque. From the where it go that is s equal to 1 then it is it will be necessary to connect some external resistance in the rotor circuit. So, these terminals are available to you and you connect some resistance, to improve the starting torque and then short it rotor should be closed, otherwise how rotate field will be produced.

So, they can be closed either directly short circuiting or you connect some external resistance of equal values in each of the phases. So, that can be also done we have seen. Now, the question is this rotor structure where some 3 terminals will come out from the rotor winding. As the rotor will be moving, these 3 terminals will be also moving. Therefore, this terminals, when it was stationary if you connect the resistances just like that this terminals, which I know that will be also moving. And suppose, somebody connects some stationary resistance here, on the ground with this 3 terminals like this, then as the machine will rotate this resistances too, will start moving and creating curves is not.

Therefore, to access the rotor terminals properly, it cannot be like this, that rotor terminals are there and I will connect resistance. There must be some intermediatory things, which will make these 3 terminals, which will be rotating to appear stationary to the user of the motor. So, that he can connects comfortably the resistance ok. So, how this can be done? It can be done very nicely like this and suppose, this is the rotor and this structure will rotate so, also this term, this terminals will rotate, we know. This is suppose a sketchy diagram, but you can get the feeling. Suppose, this is the shaft of the motor shaft of the motor, idea is important. Now, what I will do?

I suppose this is R this is Y this is B, whatever it is rotor terminals, what I will do? I will take 3 copper rings ok, rings, copper rings, continuous copper ring copper ring and what I will do? I will insert those 3 rings on this shaft is metal, copper ring is metal of course, there will be some insulation between the shaft and the copper, it is understood otherwise how. So, this is suppose one copper ring like this, I will push it, this one push it here, the second one you push it there and the third one you push it there and this rings are continuous ring that is any point here.

Electrically means all the points here, because that is copper, that is whatever voltage a source voltage point you connect this one wire, you connect it here, voltage will remain same anyway. So, this is the and of course, this ring should be there should be a some insulation here um, some insulation and then this is insulation, then push it each ring you push it. Now, you do a little bit of wiring means this R phase, Y phase and B phase they will be moving know as the rotor move. What you do? A take a wire and once again all along the track, you take this wire and terminate it this R terminated to this copper strip you either screw it or weld it whatever some convenient way.

So, that this copper strip this copper ring this ring no matter where the rotor is this copper ring itself is the R terminal similarly you take another piece of wire from this fellow and run it along the shaft. Now, soon you get obstructed by this first ring. A hole in that ring and push that wire insulated I mean you have got the idea and you terminate it to the second one, you got the idea this one. I mean like this, I will show. Similarity this Y terminal, but this wiring is to be done along the shaft. How can we do it and put holes here? Bring it here, that I am not showing and it goes there.

Now, as the rotor will rotate and since these rings are on this shaft, these rings too will rotate. Does it solve my problem? Not really, yet. You have to do another extra thing. What you do is this. Now, you connect some brushes which I am showing it, with blue stationary brush. These are stationary brush, this blue one carbon brush, you connect with a spring holder arrangement, you push it on these rings. As the rotor will rotate as I told you this copper ring too will rotate, but let it rotate, I will touch something is rotating, I am putting a brush over here, that is what I am telling which is fixed.

So, no matter where this copper ring is right now this brush will make contact with every bit of copper ring as it moves. This is stationary mind you stationary. So, the and then the terminals of rotor is brought out from the stationary terminal that we marked as R, if it is this R. So, this is R. So, these brushes are stationary brush for R, this is B of the rotor, and this is Y r of the rotor. What I am telling, this 3 terminals are stationary, because brush is stationary brush is just kept over this copper ring with not. So, much of tightness, but it is the contact point is not very loose, but at the same time it does not obstruct the rotation of this rotor in any case. Therefore, it should be with a spring arrangement, you make a good contact with the copper ring which will rotate, but this fellow is stationary you can access a point.

That is why this machine is called a slip ring type induction machine. There will be 3 slip rings and of course, 3 brushes, stationary brushes, which are not moving they will touch there were no matter where you are R phase is as it is moving this fixed brush here will always indicate R phase. This fixed brush will always indicate B phase and C phase.

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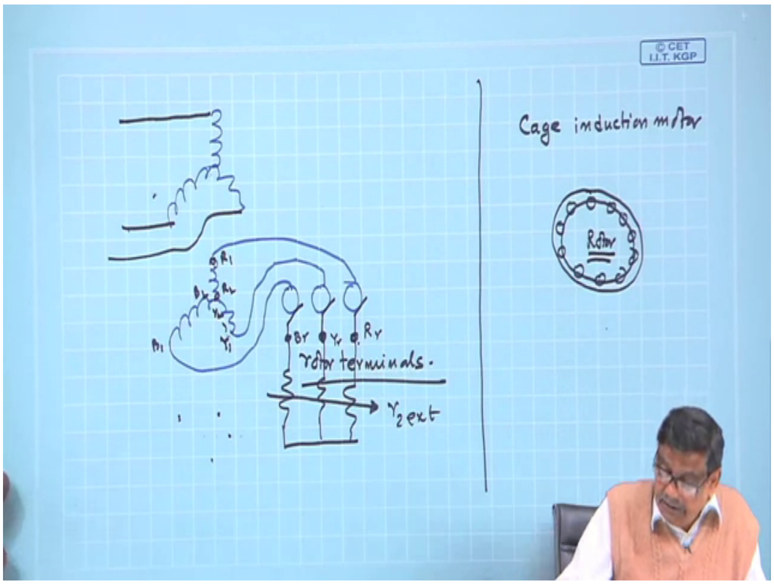

So, this is called a slip ring induction motor and it is then shown like this I mean like this, is this stator and rotor has got a 3 phase winding like this in some books you will find they will show the connection like this 3 slip rings. They are terminated this points here and there are fixed brushes which are indicated by this, not.

So, each these are just indicated of the things. So, these are slip rings which will be moving along with the rotor, but it always touches this point no matter where it is. So, depending upon this R Y B this terminals and it is this terminals which are available rotor terminals, understood. So, rotor windings are just like stator 3 phase balanced winding may be with different number of turns that is different issue, but it is and its terminals are available through slip ring and brush and then when the question of coming external resistance connection comes in, connect it, because we have learnt, this is one of the very nice point about slip ring induction motor is that you can a vary this starting torque.

And even you can create that T e max, which the motor is capable of developing at some slip otherwise to appear that T e max at s equal to 1 by appropriately connecting, this r 2 external. So, this is the slip ring induction motor stator and rotor R Y B, whatever way you call it R Y B terminals. This is the slip ring type induction motor. Now, this rotor terminals to one can have, if one says that each phase of this windings has got two terminals in very some special machines, this 3, that is 2 terminals.

Suppose, you say that I want to get access to both R 1 R 2; I mean separately Y 1 Y 2 and B 1 and B 2. All the 6 terminals suppose, I want to have access to it then what is the problem? Problem is then you have to use 6 slip rings and 6 brushes. So, it is really not done like that as I you will never see a 3 phase induction motor with 6 terminals coming out from the rotor for R 1 R 2 Y 1 Y 2 and B 1 B 2, because then your length of the machine, shaft length will increase, because 6 slip rings, 6 brushes.

While slip ring and brush arrangement is a very nice one, but this is also one of the things maintenance people will not lie in, because this brush is to be replaced for regular maintenance, brush will were out, because of this friction between these copper ring and the brush. So, maintenance problem, I mean you have to regularly maintain the 3 phase induction motor, which is slip ring type otherwise performance of the machine will not be there ok. So, this is called slip ring induction motor. What is the other kind of induction motor; is the cage induction motor, cage induction motor.

I will just tell this much in a cage induction motor, in the rotor you do not make a 3 phase balanced winding, the way we do it for the stator ok. What will be there, it will be represented like this there will be conductors in slots and this conductors will be shorted. And, we will continue with this in the next class that is also very important.

Thank you.