Electrical Machines - II
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Lecture – 31
Rotating Magnetic Field (Contd.) Mechanical and Electrical Speed

Welcome to the next lecture and we were discussing on the most important topic, in this AC machine course, that is the production of rotating magnetic field ok. And, in our last class I told you that there are three phases R Y B and you can connect the means star or also by delta, but star connection we have taken and if you energize the R Y B windings of the machine from a balance three phase supply, whose R Y B are connected respectably to R Y B of the machines then what happens?

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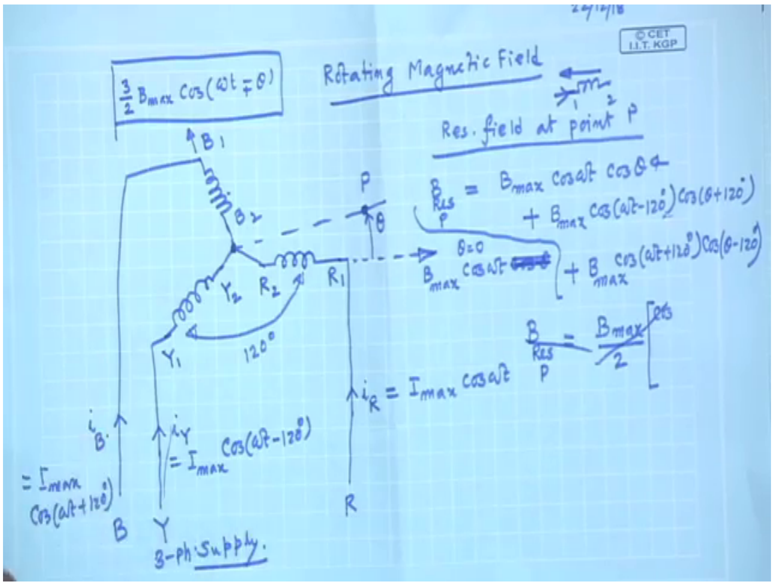

There will be a rotating magnetic field and this rotating magnetic field the resultant field, that any point was written something like this cosine omega t minus theta, it could be also plus, we will examine those things in detail. The equation cosine omega t minus theta, if you take minus sign it indicates a field moving in the forward direction of theta.

And if you take plus sign it indicates a field moving from, in the negative direction of theta. So, this is a standard equation for a travelling field, but in any case we will examine that in great detail and also we will try to show you that from another point of view, how this rotating magnetic field really moves as time passes. So, let us start. So, we are discussing actually rotating magnetic field ok, rotating magnetic field and its various aspects. So, this is the thing. So, and after doing all this windings let me draw that this is my R phase winding, which I drew vertically that they does not matter. So, suppose this is your R winding, R phase and this is your Y phase winding, Y 1 Y 2 and this is your B phase winding and I will assume that the terminal marked with 1 and 2, if current enters through 1, it will produce a field along this direction the field is produced ok.

That is if current enters through R 1 field will be produced along this. This is, and if current enters through Y1 field will be produced away from the center and so on. Now, so, this is R 1 R 2 Y 1 Y 2 and B 1 B 2 and they are separated by 120 degree angle and suppose, if there connected in star this is R 2 Y 2 B 2 shorted and this terminals, I will connected to a three phase supplying balance, three phase supply with phase sequence R Y and B this is supply, three phase supply. Now, this currents all will be time varying current i R, i Y and i B, that is the idea.

Now, first thing is suppose, I start measuring theta from the axis of R 1 R 2. I will measure the value of theta and theta measure positive is in this direction theta and suppose, at a point P, I want to find out the resultant field, because of the R phase field, Y phase field and B phase field as you can see the field that point P, the this field is B max at any instant t B max cosine omega t and cosine theta assuming that i R is equal to I max cosine omega t. Similarly, i Y is I max cosine omega t minus 120 degree and i B is I max cosine omega t plus 120 degree.

So, this three balanced currents are passed and this is theta equal to 0 axis of B phase and theta I will measure in this direction and then I want to find out the resultant field at point P. So, resultant field at point P will be the component of this field here, along this, at point P, because of these. So, it will be I think, I should not write cos theta here, it is B max cosine omega t, it is cos component.

So, it will be B max cosine omega t and then cos theta plus, because of Y phase this angle is 120 degree electrical. So, this will be B max, current is cosine omega t minus 120, but this angle you know that is cosine theta plus 120. And finally, the B axis, for B axis, it will be B max cosine of omega t plus 120 degree that will be its field along this direction and cosine of this angle, which is the difference between theta and 120 degree, I am sorry. So, this will be B resultant field at point P and this thing. So, B resultant at point P will be B max, you can take common 2 and then this, will be 2 cos A cos B. Last time similar things we did to cos A cos B. So, this can be written as cosine I think I take a new space, space will not be available. So, B resultant at point P.

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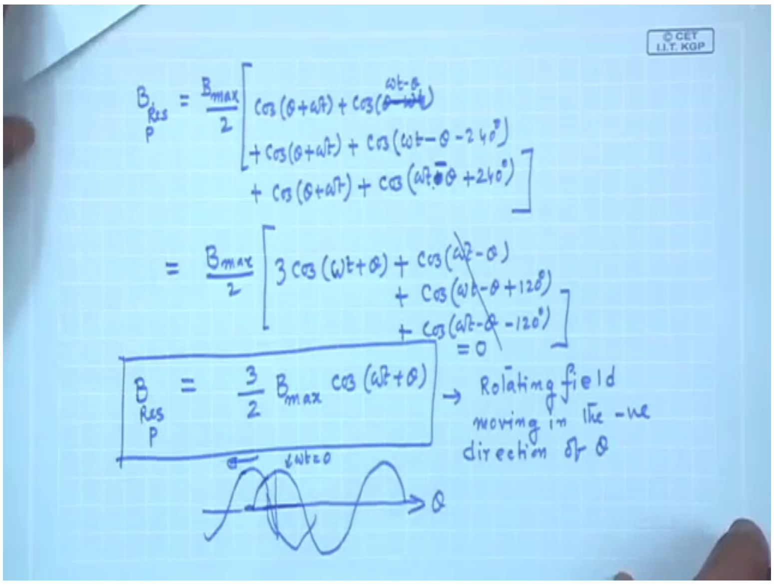

B resultant at point P will be B max by 2 and then 2 cos A cos B is cosine, A plus B plus cosine A minus B the festered this term. Similarly, the second term will give you plus cos A plus B. So, this will once again give you cosine theta plus omega t, 120 120 cancels out when you add plus cosine of A minus B.

So, that will be theta minus omega t cosine of omega t minus theta minus 240 degree. And finally, the last term you will be once again cosine theta plus omega t. This two terms if you combine and this will be plus cosine of A plus B that is omega t plus theta plus 240 degree. So, A minus B, the second term was minus 120 minus 120 minus 240 and here, it is plus 120 minus minus 120. So, that will be plus 240 and this will be the situation. So, this will be the thing, omega t minus theta minus 240. Now, this terms if you look at, this is theta minus omega t same as omega t minus theta, the festered. So, this 3 will always adopt to 0, because there phase displace by 240 degree means 120 degree. You can add 360 degree here and you can subtract 360 degree here.

So, let me write that B max by 2, this 3 of course will be 3 cosine omega t plus theta and this things will be cosine omega t minus theta plus cosine omega t minus theta. It means that it is plus 120 degree, you adjust 360 degree. Similarly, this one plus cosine omega t minus theta you subtract 360 degree, adding 360 degree does not change the value to any trigonometric functions therefore, it is omega t minus theta and this is minus 120 degree. So, it is like adding three sinusoidal or harmonically baring things with 120 degree phase displacement, with same amplitude so 1. So, this will vanish to 0 and you will be left with 3 by 2 B max cosine omega t plus theta ok.

B resultant at P now so, we get a plus sign here. What does this mean? It means it is a rotating field, but moving in the negative direction of theta ok. At theta equal to 0 it was here and it will be moving. So, it is a rotating field, moving in the negative direction of theta and it has to be, because if the rotating field is somewhere here now, after time t after certain time with respect to theta, it will be leading this voltage. So, it will move, if theta is this direction and this is your resultant field here, at omega t equal to 0, omega t equal to 0 then at omega t is certain value, it will be cosine theta plus that value, which is nothing, but a leading waveform.

So, this is theta and this waveform will then move in this direction. If theta comes out to be negative, it indicates that it is moving in the forward direction of theta. We will see this same thing in a nice, further nice way ok. This is mathematically, it is all fine. So, as time will pass, if this is the current at any time if the field, resultant field was here. See, I am now talking about resultant field at any point, at a given time it is suppose, position here.

So, what I am telling this is the direction of theta measurement, after some time that field will move like this, that is what I want to tell. Let us see it much more nicely from this diagram.

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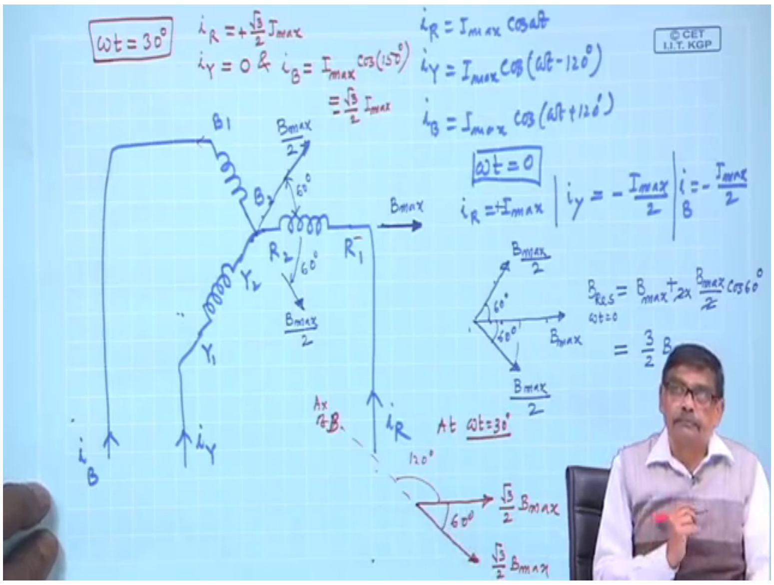

See suppose, this is your R phase coil, this is your Y phase coil, this is your B phase coil. So, R 1 R 2 Y 1 Y 2 and B 1 B 2 and this 3 I have connected in star and the same diagram. And I have assume that i R is equal to I max cosine omega t, these are the current i Y is equal to I max cosine omega t minus 120 degree phase sequence is R Y B and i B is equal to I max cosine omega t plus 120 degree and what are these? These are the instantaneous value of the current i R, i Y and i B. Now, what I will do is this suppose, I want to see what happens at omega t equal to 0 and I will find out the resultant field for that instant, so ok. So, if omega t equal to 0 under this condition i R is equal to I max, i Y will be I max cosine minus 120 degree and that will be minus i max by 2 and i B also minus I max by 2.

That is you simply put omega t equal to 0, in this current expressions you get that and then sketch take a snapshot at omega t equal to 0 and figure out what are the field produced by R Y and B phase. R phase will always produce field along X axis Y phase this way B phase this way since i R is I max and I told you if for maximum current the field produced here is B max. So, R phase will produce a maximum field their and i R is a positive number. It is really entering and if current enters through R 1 field is away that is what I have assume.

So, it is like this, but look at the currents of Y phase and B phase, Y phase and B phase currents are negative; that means, i B is negative means currents is coming out from these. Therefore, magnetic field produced by B 2 B 1 will be here and for Y it will be there, along the axis of Y, but the current is negative; that means, current is leaving Y 1. So, the direction of the field will reverse. So, these are the three fields and what will be the strength of this, this field? For I max it is B max; therefore, it will be B max by 2 and this will be also B max by 2. So, the resultant and these angles are 60 degree. Mind you, this is all the electrical thing we are doing over a pair of poles.

So, this is B max and 60 degree, because of Y phase, it is B max by 2 and for B phase, it is B max by 2. Therefore, what will be the resultant field? The vertical component you have to add this three vectors. So, vertical component will cancel out, so B resultant at omega t equal to 0 is nothing, but B max plus B max by 2 cos 60 degree is not this angle is 60 degree. So, B max by 2 plus B max cos 60 degree, what is cos 60 degree? Cos 60 degree is half. So, did I do any mistake here?

So, this value is B max by 2, this is B max by 2 and then 2 into this, because the projection of this here and projection of this, these plus this projection, this projection. So, this will be then this 2 cancels and you will be left with 3 by 2 by B max and that is a expected; the resultant field, no matter at what time you are calculating, it must become 3 by 2 B max that is what we have found out earlier. 3 by 2 B max is the amplitude of the rotating field. Therefore, it will be 3 by 2 B max.

Now, let us considered on the same diagram, another instant. For example so, resultant field at omega t equal to 0 is horizontal of amplitude 3 by 2 B max, effects of that instantaneous current at omega t equal to 0 B C. Considered another instant I will do this on this same paper so that you can understand. Suppose, omega t is equal to 30 degree, time passes such that omega t becomes 30 degree. So, if omega t becomes 30 degree then the value of i R, first we calculate from this i max cos 30 degree; cos 30 degree is root 3 by 2.

So, it will be root 3 by 2 i max, i Y, it will be if you substitute 30 degree here it will be cosine 90 degree ok, cosine minus 90 degree. So, i Y will be 0 at that time and i B will be I max cosine of 150 degree. What is this value; minus. So, this also you know the instantaneous sum of the currents, at any instant is 0. So, if this is root 3 by 2 i max, i Y is 0 i B has to be minus this one anyway this is the thing; now, this currents.

Now, current in R phase is root 3 by 2 I max, plus it is. Therefore, R phase at omega t is equal to 30 degree, time passes B R phase field will be horizontal and away from the center, because current is really positive and entering through R 1 and its value is root 3 by 2 I max. So, this this strength of this field will be root 3 by 2 into B max, because you have already assumed for I max current B max is produced. So, this will be the R phase field, y phase there is no field because i Y is 0 no field along this line.

But B phase will produce a field ok, because B phase is carrying a current of minus root 3 by 2 into I max, but should I draw the field this way? No, because the current is i B is negative means current is leaving B. It is flowing exactly at omega t equal to 30 degree. This is the exact direction of the current and exact direction of the current defines in which direction you should plot the field, is not if current reverses then the pole produced will be reverse.

Therefore, the axis of Y is like this 120, but field produced by the Y at, this is 120 degree mind you, this is axis of Y. So, this field will be like this, at omega t equal to 30 degree. So, this is R phase Y phase nothing is there, Y phase nothing is there and B phase, it is B phase sorry B phase axis, B phase will have 120 and this field is negative of that. So, root 3 by 2 B max I have shown the correct direction that us why positive sign. So, we will continue with this.

Thank you.