Electrical Machines - II
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Lecture – 09
Flux Density Distribution in Space and nature of emf (Contd.)

Welcome. Now, in our last class we analyzed a single conductor motors. Now today we just started in fact, our last class this problem.

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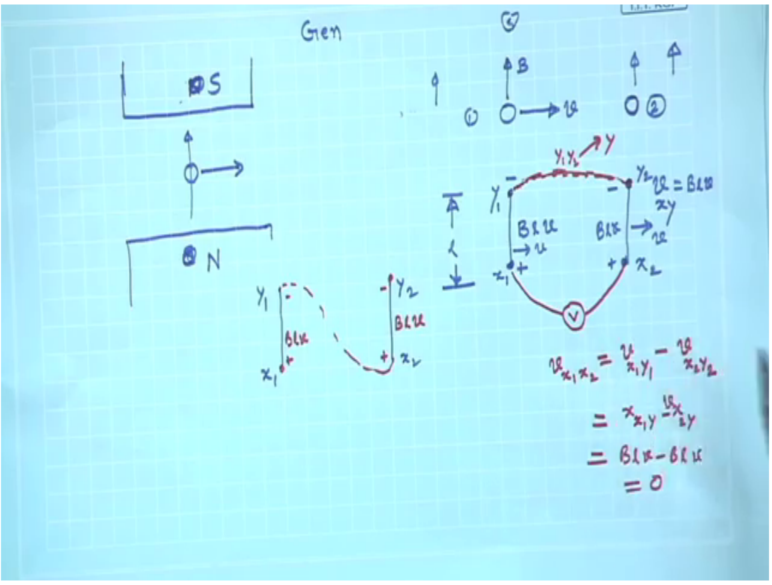

I discussed about this one that is if a conductor is moving. Then, if you have two conductors ok, if you join them by a flexible coil then really later we will call it a turn and how to get voltage here, but if you join like this you do not get a voltage and so on then I was telling you that ok.

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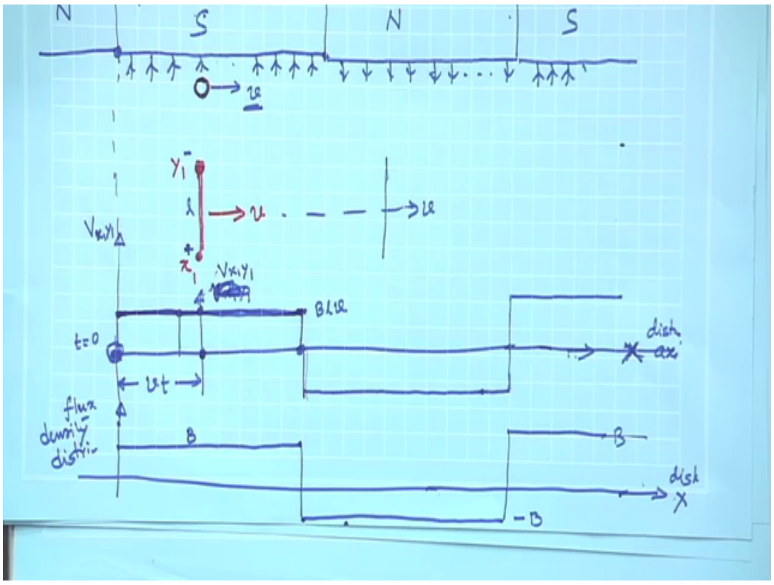

Suppose you have a certain portion of space, South Pole, North Pole South Pole; that means, lines of forces are doing like this here and suppose this field are constant value and it is doing like this and so on, and then doing like this. And it is conductor is here with its x 1 y 1 terminal, I am looking from the top. So, x 1 y 1 can be seen and then applying right hand rule I know this is plus, this is minus ok.

Now, I want to calculate the voltage between the point x 1 and y 1, I think I will use some other notation because small v is for velocity; so V x 1 y 1. So, it will act as a generator nothing is connected across it and it is moving from left to right with a constant velocity v, a single conductor. Then when it is travelling under this South Pole it will have the voltage v x 1 y 1 like this and recall that this conductor was travelling from behind and it is from this instant I have started counting my time that is t equal to 0. And since, it is moving with a velocity v at any instant its position is v t here and there I find the field is in this direction apply right hand rule gate v x 1 y 1.

So, in this axis I am plotting v x 1 y 1 and it is a positive number and it will be a positive number all along this distance till you reach this point of demarcation. In the next stretch suppose it is another equal length North Pole, but the conductor is nonetheless moving here also, with same velocity. What thing has reversed is the direction of v therefore, v x 1 y 1 will still be there its magnitude will be b l v, but it will be negative like this of same strength and it will continue like this is not and it goes like this, the amplitude is B l v, B is constant l is constant, v is constant. So, this is the voltage which one will expect across this coil side, I will not say coil side across the straight conductor of finite length l and potential between of x 1 with respect to y 1, it will be some times plus sometimes minus.

Now, another interesting thing is this is what? This is distance mainly distance, but anyway if b is constant it can be also thought of time. So, far as the conductor movement is concerned. Now, another thing I can plot here and for the first time I will use this term that is called flux density distribution, along distance x and suppose I say that when the flux lines are entering here I will call it give it a plus name. So, this is B and here it will be minus B then, B minus B, B. And once again after equal length of travel it will reverse. So, in space the flux density is distributed in this nice rectangular manner, suppose then I can say that across the conductor the voltage will be also rectangular and it will alternate. See the most important thing of this drawing etcetera I conclude that the nature of the voltage across a conductor is same as the nature of the flux density distribution along this space. For example if you have understood me right here.

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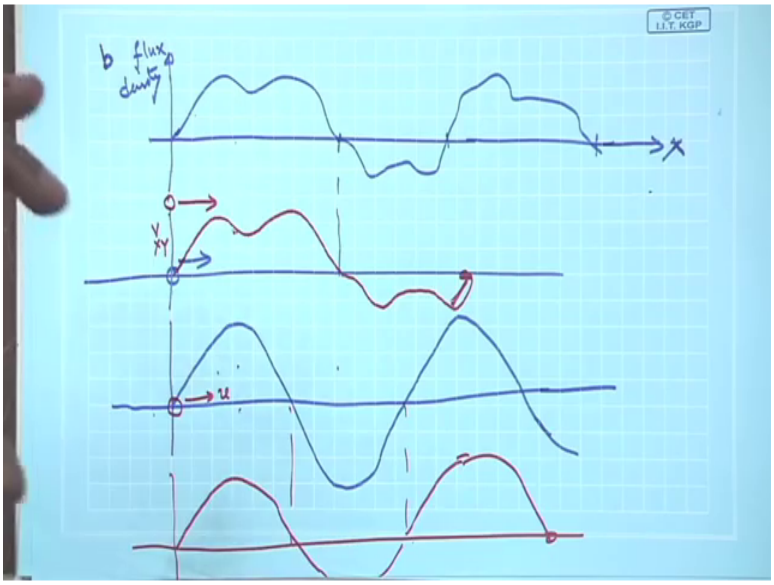

If somebody says I have a flux density distribution which is quite arbitrary like this, I mean how one will get it that is besides the point the, but the point to be understood is this is flux density along space, suppose it is distributed along x axis in this way and beneath it I am moving a conductor in this way. So, if this is the b distribution, b which I will write now small b because I find it is not constant at all the points, but it is repeating at some way. So, some equation will describe this b, but I am sure about one thing that is the emf; emf generated across the two ends of this conductor will be of same shape. Are you getting me? Because B l v l and B are constant; so, the way b varies your emf generator generated across the two conductors end that too will vary in the same way. Therefore, emf generated if you have a special description of b along space axis and through that axis if sub conductor is moving the emf generated v xy will be identical in shape as that of b B l v, l v are constant. So, that is the idea.

Therefore of course, no one is going to make such a big distribution perhaps one popular b distribution will be we will see later in detail a sinusoidal b distribution. Suppose somebody has and you are moving a conductor under this with a velocity v then the emf generated will be also sinusoidal. I mean, if you want to generate a sinusoidal voltage that is what our generator is doing in power stations then I will after knowing all these things I will demand that the b distribution in whatever machine that conductor is moving must be sinusoidal sinusoidally distributed in space and that and that only will ensure that sinusoidal voltage of a particular frequency is generated. So, so nature of b decides whatever for example, if the big distribution is rectangular you are getting here also AC voltage because supply voltage generated voltage is alternating it polarities. But it is not a sinusoid voltage square wave voltage why it is square wave because b distribution was square wave I have assumed. So, if b distribution is sinusoidal then the induced voltage to across the conductor two ends will be also sinusoidal, that is the thing ok. Now, if that be the case let us do another interesting thing.

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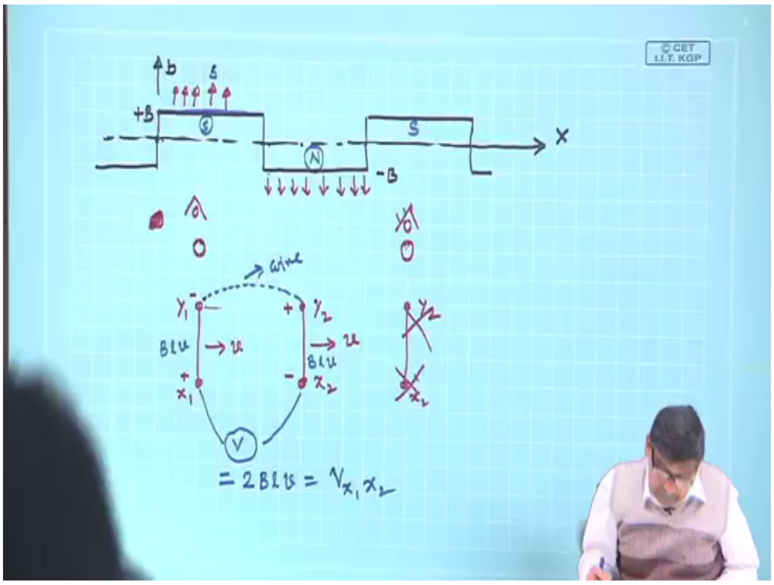

I was telling that suppose you have a b distribution like this suppose, suppose rectangular 1, 2, 3, 4, 5 here also 1, 2, 3, 4, 5 and then it repeats suppose. This is your axis space axis say x axis and this is b this y axis is small b, why small b because at different points b is a function of time here it is minus b suppose this is plus b and this is minus b, it is not constant all along x up to this to this it is constant this to this constant, but of opposite value; suppose b distribution is like this. Now suppose you have got two conductors and I will assume the conductor is here and one two and another conductor separate these two conductors have got their own identities separate conductors. This conductor it looks like this if you look from the top and this conductor looks like this if you look from the top and let this be called x 1 y 1 and let this be called x 2 y 2.

Now, as I told you if you put the conductors in this way and both of them are moving with velocity v and if you join y 1 and y 2 voltage will be 0, because it is plus b this is also plus b voltage will be 0. So, but if I put the conductor here the second conductor here this is suppose y 2 x 2 and both of them are moving with velocity v then this plus means lines of forces are like this as I told you. So, applying right hand rule you get this is plus this is minus and for this zone it is lines of forces are like this. Therefore, polarity of the induced voltage will simply reverse B l v is the voltage. So, this will become plus and this will become minus.

So, if you now join these two points y 1 and y 2, then the voltage voltmeter suppose you connect this voltage will be B l v this voltage is also b l v with this polarity will be twice B l v and this is the potential of x 1 with respect to x 2 understood. So, if this is suppose I say some one pole north or south this way it is going. So, it is heading for a South Pole. So, if you call this is south, this is north, this is south, then the induced voltage will be you will be getting if you connect these two coils in series by wire conducting wire then across x 1 x 2 you will get 2 b l v, why, because this amplitude is same over this zone capital B and over this also minus capital B and so on.

Another way of looking at this thing is that I will is better go to another page and tell you.

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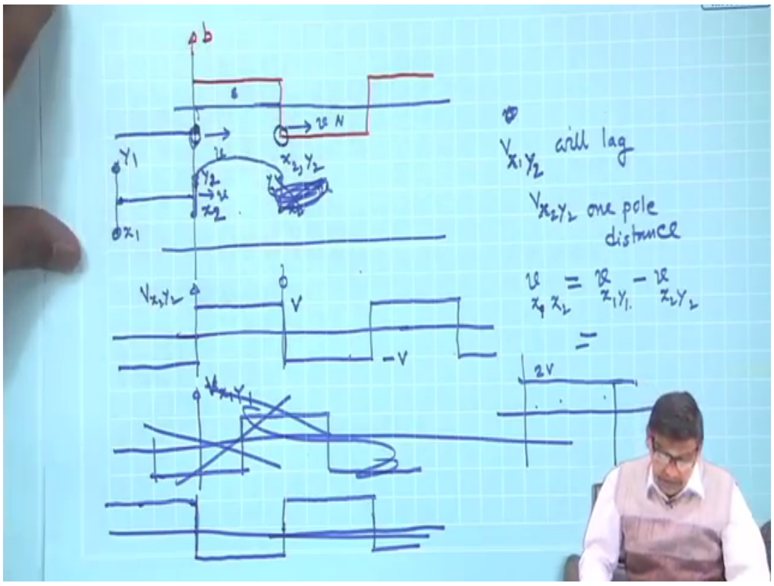

Now, these are simple exercises, but very it conveys many thing for example. If I say your b distribution I will draw in a this way I will draw, suppose your b distribution is 1, 2, 3, 4; 1, 2, 3, 4. Suppose this is your b distribution and I am talking about two conductors separated by a constant distance and moving. Suppose I say for conductor 1, conductor 1 is suppose it is here moving with a velocity v. And there is another conductor which is here which is also moving with velocity v suppose it you consider this conductor what will be the voltage across this conductor and its terminals are x 2 y 2 what will be the induced voltage x 2 y 2 you recall it is like this x 2 y 2 plan view similarly this conductor is y 1 x 1 this is the another conductor and both of them are moving with this velocity.

So, you move it so that separation between them is constant. Now the induced voltage polarity for the second conductor if I sketch this is are you getting what I am skating v x 2 y 2, I am sketching it will be same as b, it is moving like this. So, its induced voltage pattern will be like this it is not, the conductor is here right now it is moving, but the induced voltage pattern whatever has happened to this second conductor if this is the induced voltage pattern.

The first conductor is behind you and e 2 is going to gate same experience of b as first conductor date, but after this much of distance. Whatever this conductor is feeling here South Pole or North Pole whatever it is if you call this South Pole it is North Pole when it is entering North Pole it will have induced voltage like that, but if the first conductor is behind it by 1 pole apart it is going to experience the same voltage waveform.

But after this much of distance because both the observers if I am sitting on this conductor. And if he you are sitting on this conductor whatever I will experience in terms of change of b as I proceed from left to right, you will also experience the same changes, but only after a constant distance of this much, after a distance of this much. When I am experienced started experiencing a North Pole you have started experiencing a South Pole. Therefore, the induced voltage in terms of distances potential of V x 1 y 1, V x 1 y 1 will lag V x 2 y 2 by this by one pole by one pole distance [FL]. So, this was V x 2 y 2.

So, if I want to sketch what will be V x 1 y 1? I will say this waveform same waveform, but it will lag by an angle of 1 pi or should I draw this is V x 2 x 2 this will lag by 90 degree, you know it. So now, let me do it like this let me call this is V x 2 y 2 and this is I mean here is x 1 y 1 I mean you know whichever way you like you do no problem, suppose I cut it like this and here it is like this. So, this is V x 2 y 2 and this is the voltage waveform if you are claiming for V x 2 y 2, the same voltage waveform for V x 1 y 1 will be shifted by one pole, p 2 1 2 3 4, is it? No, it is something is wrong.

So, V x 1 x 2 will be x 1 y 2 will lag this one by 180 degree o. So, V x 1 x 2 will be this 1, 2, 3, 4 and this is 1, 2, 3, 4 (Refer Time: 23:41). I am sorry, this way it will lag. Therefore, I can draw separately the voltage waveforms of this conductor and this conductor. And if you have connected them at the back like this then you take the difference of these two waveforms to get the so t v x 1 x 2. If you join them it will be v as I wrote it earlier y 1 minus v x 2 y 2, y 1 y 2 are at same potential. So, this will be the difference of this two. So, it will become then if this is V and this is minus V it will become then twice V and minus twice V, maybe I have made it a slightly clumsy. So, it will be just like this.

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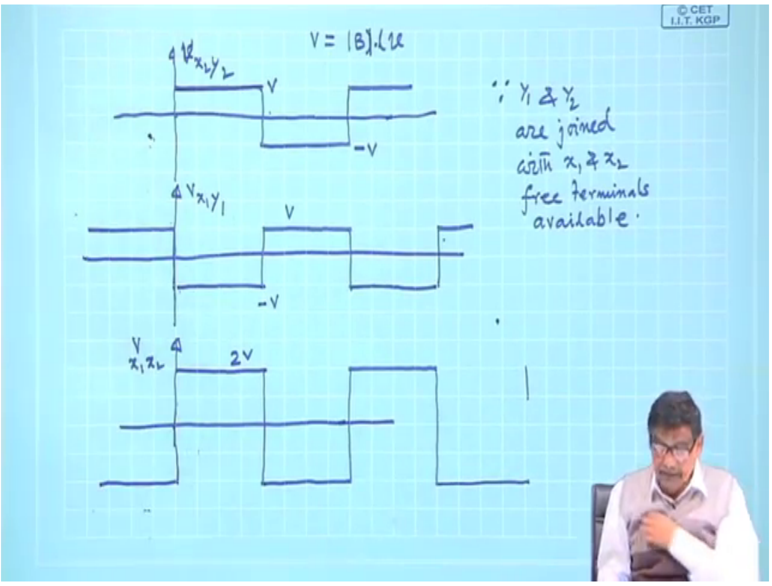

Let me draw it nicely here. So, suppose this is time and this is 1, 2, 3, 4 suppose if you have drawn for one of the conductors 3, 4 and that conductor is x 2 y 3. If you say that this is the V x 2 y 2 then V x 1 y 1 will be lagging this by 1 pole 1 pole apart and that that will be like this. Just in phase opposition it will be, suppose this maximum this level of voltage is V and then this must be minus V, because b after all V, what is V? V is magnitude of B into l into v. So, v minus v and this will be minus v v. Therefore, what I am telling is since y 1 and y 2 are joined with x 1 and x 2 free terminals available then I will say that V x 1 x 2 will be this waveform minus this waveform. So, if you do that it will be 2 V, it will be 1, 2, 3, 4 minus 2 v and so on, It will continue doing like this.

Therefore if you have to make a coil and to get twice the voltage you have to ensure one thing; whatever is your b distribution, if you place one coil under the centre of that b distribution, suppose South Pole then the other another single conductor must be placed under the centre of the North Pole and both of them you allow to run at the same velocities. And if these two conductors are joined at the back then you have formed really a coil and you will get twice the voltage of each of the conductors. So, I am repeating, suppose you have a b distribution, symmetric b distribution of say like this sine wave suppose b is like this.

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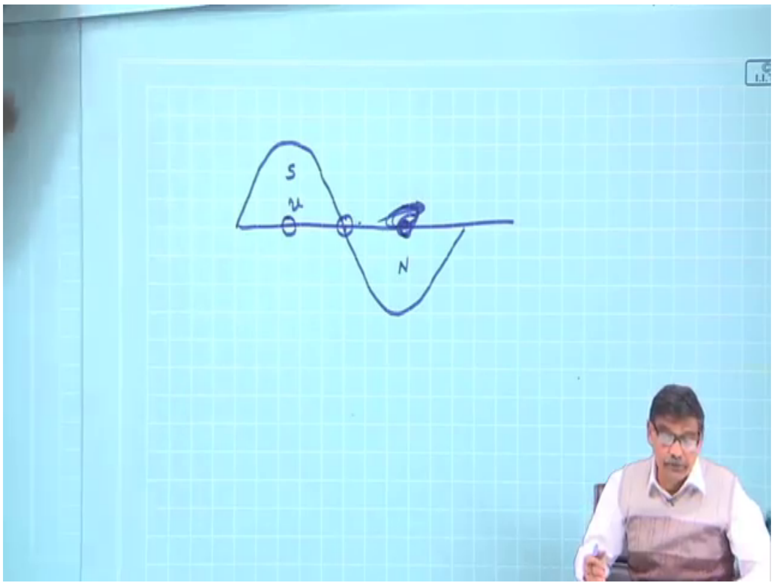

So, if you place one conductor here, the other conductor must be placed at the centre of the; if it is South Pole at the centre of the North Pole and both of them are moving with velocity v. So, whenever this conductor experiences a South Pole of certain amplitude, some certain strain its counterpart the other conductor will experience the same strength of pole, but of opposite polarity. And that will ensure twice of the voltage all the time. If you like you can place one conductor here and another conductor there suppose you place it, but when it is having maximum voltage this fellow will be having zero voltage.

Anyway, think about it, we will continue with. This is the most in important and interesting part, we are gradually moving towards rotating machine ideas. And in the next class we will further discuss about this problem and bring out rotating machine concepts that is the winding basics.

Thank you.