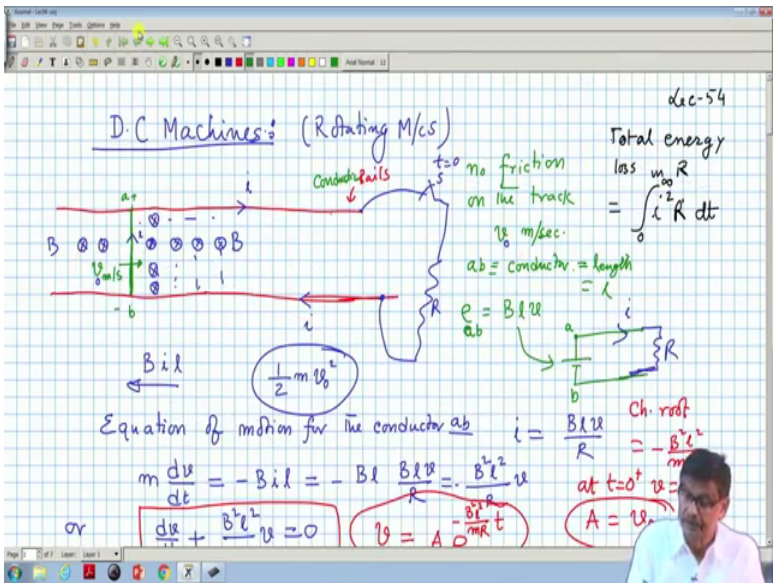
Electrical Machines - I
Prof. Tapas Kumar Bhattacharya
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 56
Homopolar D.C Generator

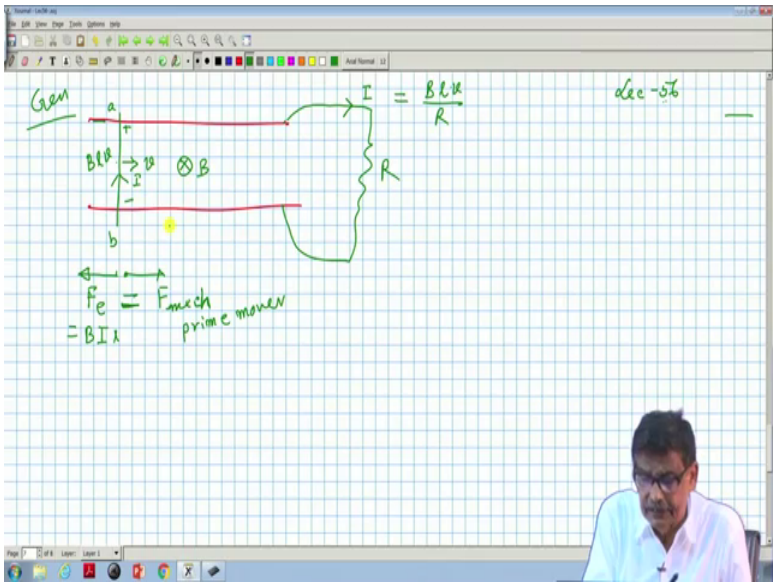
So, I was telling about very simple DC machines and a simple generator and motor consisting of a single conductor and placed under a magnetic field. If you excite it with an external voltage it will act as motor and if you give a movement it may act as generator. Only thing about the motor I have completed for the generator I will not tell much except this information I must tell, you recall that in case of Generator mode also.

(Refer Slide Time: 01:03)



In generator mode here also I assumed one thing there is no friction like that and only thing it is in fact, a no generator at all somehow you have dumped some kinetic energy to the conductor initially it was running with velocity v naught and the moment you try to draw power out of this generator the power will be delivered to be load, but not for so long, voltage will collapse gradually to 0, current will collapse. So, long kinetic energy will be present in the conductor that will be there, but what I am telling is that, this I will tell in a nutshell now in case of see generator just to have for completeness sec on discussion on this topic I will say that ok.

(Refer Slide Time: 02:09)



Suppose you have a generator on this railway track as we have drawn earlier and very quickly I can write down the results this is my a b conductor generator mode generator and it is running initially with velocity. And suppose I say like this it is running with velocity v at constant speed and then I say that the generator is supplying a resistance like this and your b is in this direction. So, polarity of the voltage induced will be Blv is it not.

Now, suppose I say that this generator is found to deliver a constant current of value I and the conductor was found to run with a constant velocity v. You get me that is the conductor is of length l moving it was found at one time that moving from left to right with velocity v and we know voltage will be Blv and it is delivering a constant current which has to be equal to Blv by R.

It was found it is sustained, now the then I will such a situation is present that it is moving with a constant velocity and this one, is it possible? I will say yes it is possible, because this conductor is carrying a current I therefore, this conductor experiences and opposite electromagnetic force Fe whose value is BIl it has to be because if it is delivering a current I. Then I will demand that oh it is running at a constant velocity; that means, some external agency must have applied a force to the right mechanical force, matching this electromagnetic force that is why it is running at constant velocity v and current is Blv everything is in place.

In other words what I am telling is for a generator to continuously supply power in this case it will not happen the velocity will come to 0. So, long there is an external fellow providing you this mechanical force which is equal to this electromagnetic force developed by the machine which is from right to left that is why that engine comes in to run a generator you require some mechanical assistance whatever power you deliver to the load will come from the mechanical system or prime mover in case of rotating machine it is called a prime mover. So, what is that prime mover? Maybe it is a diesel engine sort of thing which will give you this mechanical force got the point.

Therefore this is the called the prime mover must prime mover which drives the generator. So, to make a generator run you must have some mechanical some external agency which will provide these much needed mechanical force to match the electromagnetic force and make the generator run at constant speed. If any offset between these 2 happens then also I know because this is the net force acting is F mechanical. So, F mechanical must act along the direction of the velocity, if f mechanical is greater than F electromagnetic it will accelerate. If F mechanical is less than F electromagnetic it will decelerate if these 2 are same it will run at a constant velocity.

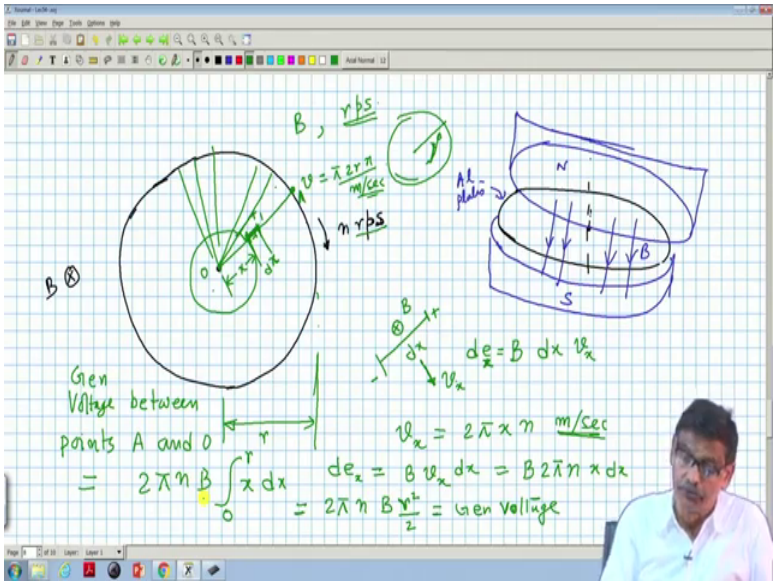
Anyway where this is in short the basic idea of a very simple DC generator which of course, one will not manufacture because it is so, non ideal in the sense that very impractical long infinite long rails what for, but this problem we have tackled to bring out several interesting points that in a generator and motor take place ok. It gives you an idea in a moving system 2 forces will act on the moving conductor; one is the electromagnetic force, another is the mechanical force. In case of motoring mode electromagnetic force will decides the direction of motion and in case of motoring mode it is the prime mover in which direction it is driving the generator this one that will decides the direction of motion and so on.

And will come to these points several times when we start a real practical generator. So, go through this exercise and the as I told you can once again start if you say mechanical force I have set then how the final operating point will be reached and so on we will discuss about it. Now, I will talk about another interesting generator of this kind. Now, in this type of generator as you can see this conductor is it moves from left to right and lines of forces are into the papers. Conductors never see a reversal of field that is it is always a we will see north to south north through south lines of forces it will cut and

give you force ok. Let us see another generator another's generator to make things clear, DC can be generated because that was so impractical.

Now, I will tell you about a very practical simple DC generator which is rotating type let us see how it will look like very interesting. Suppose you have an aluminum disk we will be discussing another simple type of DC machine which is more practical, I mean there is no doubt about it and this structure or the constructional feature of this machine is you take a aluminum disc here like this.

(Refer Slide Time: 10:21)



Aluminum disc and a circular aluminum disc and it has got a spindle about which it can be rotated vertical axis along this line that is there. Now, on the top you keep a north pole suppose this is a north pole above it ok.

This blue colored thing is a North Pole and below you keep a South Pole all along the covering the area of this aluminum disc so, this is South Pole. So, there will be lines of forces crossing this aluminum disc like this way this will be the direction of B. The black one is the aluminum plate; aluminum plates ok and this aluminum disc can be rotated about a vertical axis.

Now, in a simpler diagram I will put it like this that you have this disc of certain radius and this aluminum plate I now draw on the plane of this page. So, your axis of rotation will be here this is the axis of rotation and above this aluminum plate there is the North

Pole, below this there is a South Pole lines of forces will be into the paper all over this I am not making it clumsier by putting so many cross here.

And if this is a rotated suppose in this direction with some rpm say n rps, so many rotations per second I am rotating it. Then final result I am telling then if you connect a voltmeter between this centre point and this ream of this aluminum disc that is the periphery, if you connect a voltmeter you will find there is voltage generator and that will be DC voltage. So, on the top there is a north pole here and below this aluminum plate there is a south pole. So, magnetic field will be B and things. Now, why it happens, how do I get the voltage?

So, for that what I am telling, you consider any line radial line here it consists of infinite radial lines like this one of them you choose and then what I am telling you and suppose the radius of this aluminum disc is r ok. So, it will be this one and what you do now at a distance this let this point B O this spindle point at a distance x here, you consider a small element vanishingly small element dx here this we concentrate on this element. And this I am drawing it in a here the dx element in a larger scale dx is small mind you. Now, this since it is moving like this therefore, it will be it is tangential velocity will be along this line it will be moving suppose that tangential velocity is v x and this length is dx and there is a magnetic field B into the paper that this elemental length is c.

Therefore why not there will be induced voltage because there is a magnetic field, there is a small element dx having a velocity meter per second v x, v x can be related to this end and radius we will do that, but this is the thing and how much will be the voltage? Voltage will be B length that is dx into v x and what will be the polarity of the voltage B right hand rule you apply B v and this will be the polarity of the voltage. So, this side of this element will become plus and this side will become minus. So, we expect a voltage is induced this one with this side plus, this side minus.

Now, the question is why I have considered an element dx? Because of the fact if you consider this whole length you do not know what is the velocity ok. B is perpendicular length of the conductor is perpendicular to B, but you cannot assign a constant tangential velocity to this whole segment is not because tangential velocity is a function of radius.

So, that is why I have considered a small element only anyway if you divide this in small small small things elements then all the emfs will add up and finally, give you a voltage

between this point and that point some substantial voltage if all the small elementary lengths they become seat of emf with this polarity only they will become and if you add them up you will get a substantial voltage. So, magnitude of the voltage is this one. Now, the question is they you have considered a single line there are I mean infinite number of lines like that is not if you draw close by this line many lines are there many lines ok.

And they are touching each other this line you will find another line close by touching each other, then each one of them this segments has become plus minus not doubt then will they not will not there be a problem this conductors are in contact with the next conductors no insulation between no there will be no problem. Because if you considered a radius here if you consider a radius all the points in this circle considered they will be at equipotential. Therefore, there is no current in this theta direction or there is no voltage induced in this direction why because tangential velocity suppose somebody says no I will consider the element like this here.

I will consider the elements like that at a given are this element then tangential velocity and the length of the element are in the same direction they must be mutually perpendicular Blv business so anyway so, they that will be equipotential. So, no matter you consider just one element. So, all these elements are in parallel that is what I am telling. So, finally, a finite voltage will be available between this point and this point and we would like to and that voltage will be DC only because B is constant, velocity you are running it at a constant velocity n therefore, n rps and so on.

So, and we found that the elemental voltage for a single element is if I say this is de x in this element what is the voltage Blv. Now, what is the known input? Known input is this one B is known and n rps is known ok. Now, rotation per second is same at this point, at this point rotation is same, but the distance traverse meter per second velocity will change as you move from origin to this way. How they are related? v is equal to what omega are, see for example, here what will be the velocity, velocity will be tangential velocity at any point here is equal to pi dm it is not in once again this point moves how much meters to pi r and in once again n rps it is rotating n times. So, therefore so much of meter per second will be the velocity.

Therefore tangential velocity v x of this element should be 2 pi into the radius here x x into n, because rotation per second are same for all these. So, this is v x mind you this is

rotation per second yes. So, this is meter per second it will become therefore, the elemental voltage has become de x has become equal to B v x l here and Blv that is fine that is and this is equal to put this value of v x here it will B b dx is this is dx and this will be twice pi n x dx is not. So, this will be e x, then what will be the total voltage between point O and say point A potential and what is the polarity this side plus minus?

So, potential voltage generated voltage between points between points A and O will be then 2 pi n B these are constant and you have to integrate it x dx is not, from 0 to r where r is the radius no resistance nothing like that. So, it is a simple integration it will be equal to 2 pi n B r square by 2. This is the final thing is equal to the generated voltage, we will continue with this in the next lecture ok. So, you will get a DC between the center and the parameter and this A point there these are all equipotential point. So, whether this point or that point you I will tell you about how to collect this voltage and use it for practical purposes.

Thank you.