Fundamentals of Electrical Engineering
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Lecture - 62
DC Motors

So, little bit we have seen single phase transformer, then we have seen your 3 phase induction machines only in brief right. Most of the times for induction machine we have spend to make an approximate or equivalent circuit right.

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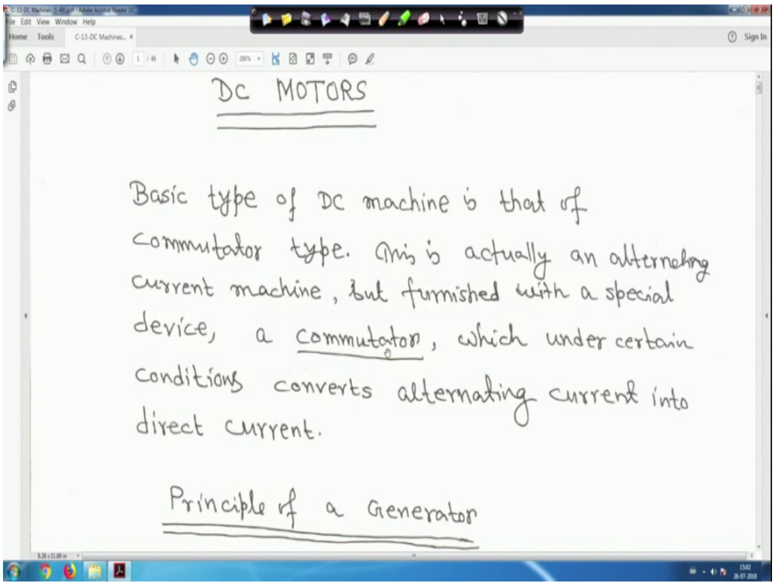

So, next this will be the last topic for this course. So, I will it will be discussed in I mean not in detail in brief at first year level some ideas we will get right. So, we start with DC motors. So, things are quite simple, things are quite simple. So, basic type of DC machine is that of commutator type, this is actually an your alternating current machine, but furnished with a special device that is called commutator which under certain conditions converts alternating current into direct current right.

Actually DC voltage or DC current means suppose it is remains constant. So, in your what you called generally the power it is AC, but we use some kind of mechanism such that it will your what you call it will be converted to DC right.

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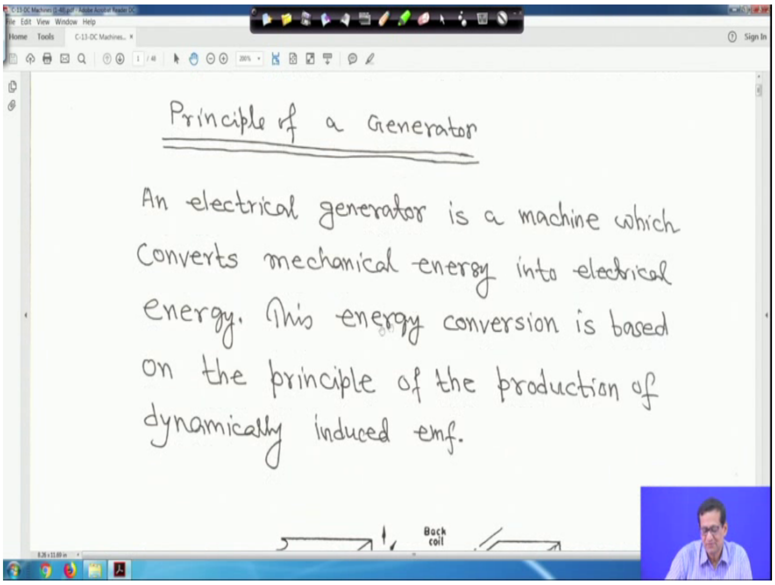

So, now we will study your DC motor, but principle of a generator very simple it is, whatever write up is there it is just I am telling.

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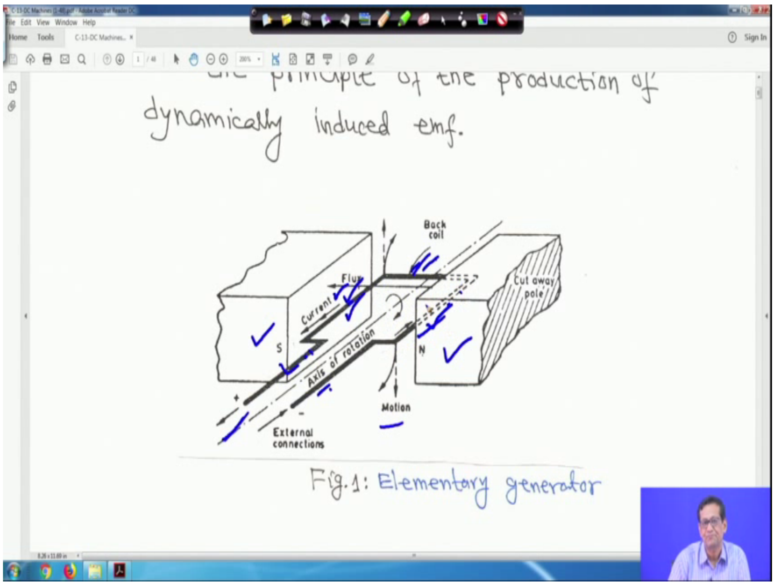

So, when you studied that your single phase AC circuits are the type we showed that how emf is generated. So, this diagram also look this is your what you call this if you look into this these two if you look into this as this is magnet, this is N magnet, N and S these two poles are there say and then suppose a coil is revolving in clockwise direction right.

This is the motion is given in clockwise direction, this is one side of the coil and this is other side of the coil only one turn it is shown. Now when the coil is in like this position right, so flux moving from N to S and it is revolving. So, at this position your what you call the flux linkages will be maximum and this is the other side of the coil the back coil and this is this thing you just out of this here what you call this pole. So, there will be assuming there will be no flux linking here and nothing will be here, and only under this condition flux linking will be maximum. If you have only one turn if you have more number of turns, so this position the flux linkage will be maximum when it is revolving.

Now when it is coming suppose, it rotates 90 degree at that time this position suppose it is moving like this. So, this position will come top and this position will come to the bottom at that time flux linkage will be 0, because this will be now at that time outside of this right. So, this why it is revolving and a voltage will be what you call an alternating voltage emf will be induced in the coil right. And this is your external connections whatever it has gone to this side.

Suppose buy some mechanism you have connected right. So, this is actually and this is the from N to S. So, that is why this is the one of the flux and this is your what you call current is given anything alternative. Only thing is that emf will induced only these two parts these two are coincides and not under the back coil not here. Because this is the main portion and this is the position right this is the position that where the maximum that these will link the maximum flux and emf will be induced maximum right. So, this is a simple thing so, this is elementary generator.

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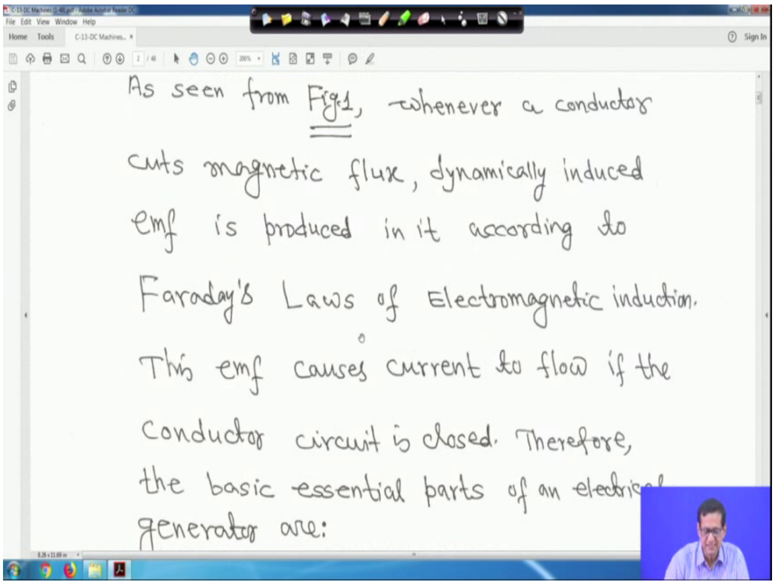

Now, this is what I say that this and this emf strictly basically Faraday’s law of electromagnetic induction right.

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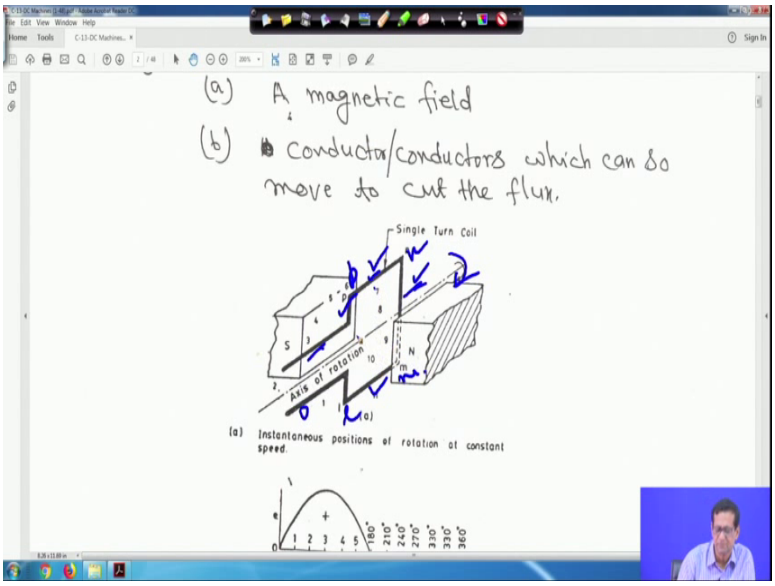

And this whatever I say question is that therefore, the basic essential parts of an electrical generator are right that in magnetic field. Now, conductor slash conductors which can also move to cut the flux right. So, in magnetic field is required and you are what you call and conductors which will also the what you call which can also.

So, move to cut the flux now this is your horizontal position in this diagram right this is another diagram for this is the position the vertical position. In this case although diagram I have taken these all these things I have taken from book right, but this is a N pole, this is N pole, this side is l, and this side is m right and this is your N and this is your P already marked here.

Now, at this position we will find so you can say it is a neutral position at that time this is called one side of the coil, this is other side of the coil, this is the back side, and this is your it is coming out. So, only voltage will be induced here and here. So, at this position say it is 0 position right. So, at this position there is no flux linkage at that particular instance it is revolving, it is revolving it is given it is revolving say by some means we are making it to rotate right. So, it is revolving, so at this position the voltage induced will be 0, because no flux linkage here and here at this position.

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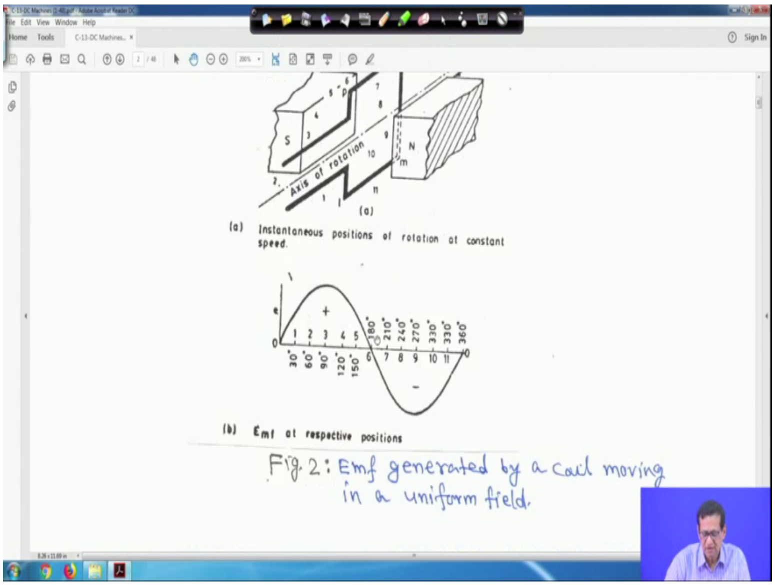

So, this; that means, let me clear it that means your this thing your this thing. So, at this 0 is not marked here. So, some it is a 0 position then 1, 2, 3 this way it has been marked in this figure. So, this way when it is revolving say 0 to your 180, when it rotates 180 degree this is the same way we have seen single phase machine that alternating emf.

So, 0 to 180 degree it will be your this plus right and next 180 to 360 it will be minus; that means, this will your what you call 0 to 360 degree it will if it complete rotates. So, this will be positive side induced and this will be the your positive voltage will induced and this side is negative right. So, this is a pure alternative when it is moving. Whenever we have given that your what you call that sinusoidal and phasor and that emf equation were the beginning of the single phase circuit the same philosophy right. So, it is evolving it is marked 1, 2, 3, 4 up to your 0, 11, and 0 it is marked just to make a 30 degree speed, but it is evolving in that your what you call here in that your what clockwise direction.

So, if it and this same way the voltage will be induced right, but if you look into that this is that instant the and this is a particular position right instantaneous position we call. When coil this l, m when will come on top, when will come, when will come on top and this P m your p, l, m this is l, m and when this p, n will come to the bottom.

So, at that time it will be like this right and again when it will go to another 180 degree then the your let me clear it. Then again it will be your what you call the same position, so this time it will be what you call your voltage will be induced as negative one same as alternative one right as it is revolving. So, and philosophy by in this in single phase AC circuit in the beginning we have seen, so this is AC.

Now our objective will be to convert this negative to DC; that means, if it if you doing like this, so all will be your what you call positive, so no question of alternating. So, then by some mechanism then we can get that your what you call DC current, instead of your the AC current, or your AC voltage we will get DC voltage and DC current. So, in that case what so, this is your what you call that alternating your emf induced right.

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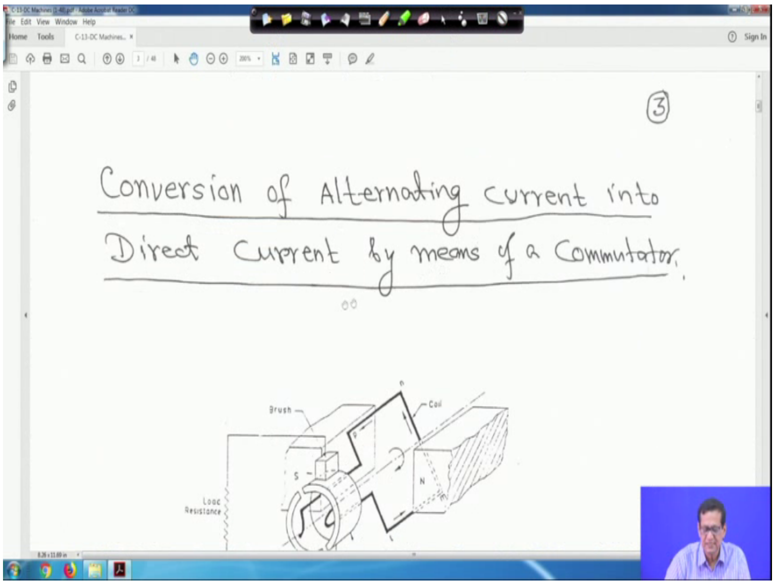

Now, next is that conversion of alternating current into direct current by means of a commutator.

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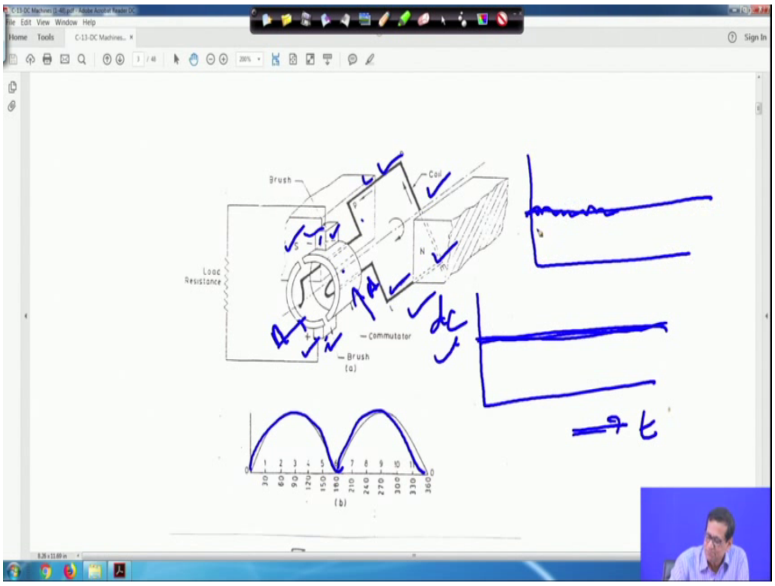

Generally that commutator actually in a your what you call in a DC machine you have several commutator segments right.

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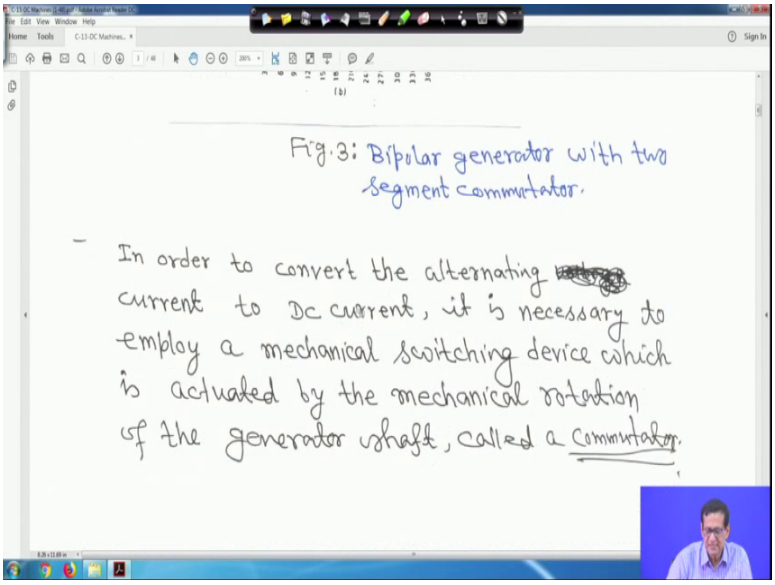

So, basically in order to before going to that figure in order to convert the alternating current to DC current, it is necessary to employ mechanical switching device which is actuated by the mechanical rotation of the generator shaft, called a commutator. So, in this case what will happen that this is your some instant this is some instance this is the position of the coil, this is your N p, and this is your l N this is the back side of the coil. And here suppose this point is A this segment, this segment is B these two are the commutator segments. This commutator segment actually they are insulated from themselves right and their they actually that shaft is there.

If you look you will call it if you see the laboratory the opened your open DC machine then you can have a better look. And this coil this is beyond suppose this is a brush generally made of carbon this is the minus side and this is the plus side this is the N pole, and this is the S pole right and in that case suppose it is rotating in this way the clockwise direction. So, in that way this one side of the coil right one coil that is first end with a segment of the commutator a, and other side and it is a plus.

Another side of the commutator connected to segment side b right. So, in that case when it is revolving suppose the way we saw alternating thing the mechanism is such that when it is revolving right. So, up to your first 180 degree the voltage will be like this. After that what will happen? This is down, this coil side is connected to a because next cycle it will go to the negative side automatically it will change its position and go to the negative you are what you call negative side of this these two are called your what you call that you are that DC machine brush right.

And in that case what will happen? The here this coil position from plus when it will go to the negative voltage induced automatically it will be connected to the negative side by this mechanism. So, this is actually show only two commutator segments and DC machine you can 1000 commutator segment. If you look into this that all commutator segments are insulated right. So, in the in that case what will happen? As the next half cycle next half cycle when negative voltage will be induced automatically this coil side will be shifted to the negative your negative your negative side right.

So, in that case reverse will happen for other coil side also so; that means your voltage will be always you always your positive. So, this is actually mechanism for your DC machine DC machine actually generates alternating voltage, or current right. But due to this commuator and this mechanism actually this your polarity this minus and plus sign will remain as it is right only at a your at the particular instant or you can say that when it is sub causes the neutral zone right.

So, at that time what will happen that when negative voltage will be induced. So, this coil automatically connected to the here automatically move to the other one and reverse will happen for the other coil side, so such that voltage will remain positive. So, for DC thing whatever we know suppose this is our time, suppose this is your what you call the your and this is your my DC voltage, this is my DC voltage whenever we draw it is like this constant right.

Because with because with time DC voltage is constant, but in a DC machine you have several segments you cannot unless and until you see in your exact your what you call that figure right. Then this is actually apparently it will be apparently looks like a DC, you are straight line, but basically it will have a I am drawing it here. It will have the very small ripple, the you know very small ripple like this. I mean very I mean it is positive side all the ripples will be positive side I mean just hold on. If I make it here as you have here it is only two segments, but you have more number of segments. So, this all the things will be positive side, it will be like this, it will be like this, it will be like this very small you cannot make out from your eye just looking into this.

Because it is DC but it is not exactly as a straight line. Because so many segments are there so many such half cycles are there, so there, but it is DC, but it is DC right. So, this is actually what you call this mechanism. That means, every half cycle I mean when it is going to the negative that one side of the coil automatically connected to the your what you call nik's brush right negative side such that your what you call that you are voltage always will remain your in the positive, so DC.

Since the current will be DC, and that is the sum load resistance is connected here right. So; that means, your power generator the power will flow like this. So, this is just for the sake of explanation I have taken this diagram from a book right. And but in the in the actual DC machine you have you have several segment of the commutators. They are basically you are insulated from each other, so this is whatever you have.

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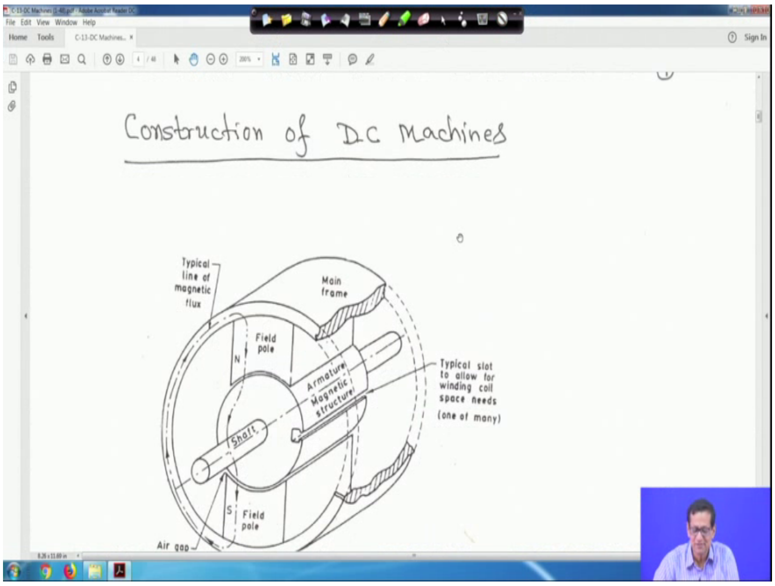

So, all these here now construction of DC machine just I will tell you what exactly this things. This diagram I have taken from a figure right taken from a book right.

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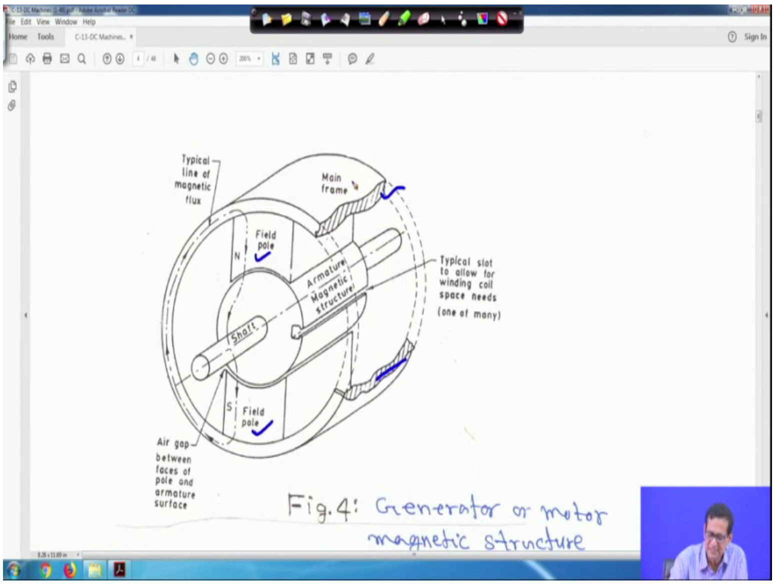

So, in this case if you look into this that just for your general knowledge. So, this is the typical line of magnetic flux, this is a shaft, this is the armature and this is a magnetic structure. And this is the mainframe it is cut actually it is cut right, and this is a typical slot to allow winding coil space need right one of many.

There may be many slots are there and this is your N pole. These are your and this is your S pole that a field right and this is the flux path is shown. And this is the air gap between phases of phases of pole and armature surface this is air gap is marked right. So, this is generator, or motor where your what you call magnetic structure and this is the shaft, this is I have taken from a book just for the sake of your to completeness of this brief discussion right and this is the main frame.

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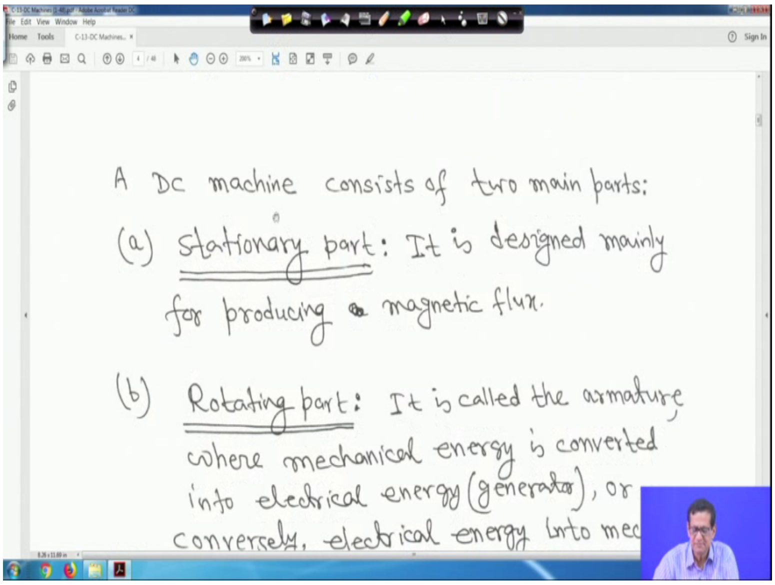

Next is so DC machine consists of two main parts, stationary part it is designed mainly for producing magnetic flux right.

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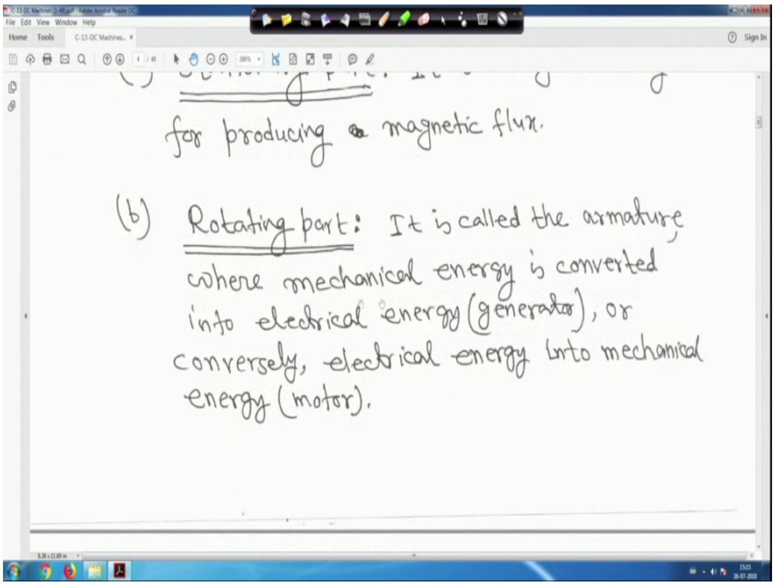

And rotating part it is called the armature right, where mechanical energy is converted into electrical energy for generator or conversely electrical energy into mechanical energy for motor. This thing you should keep it in your mind right.

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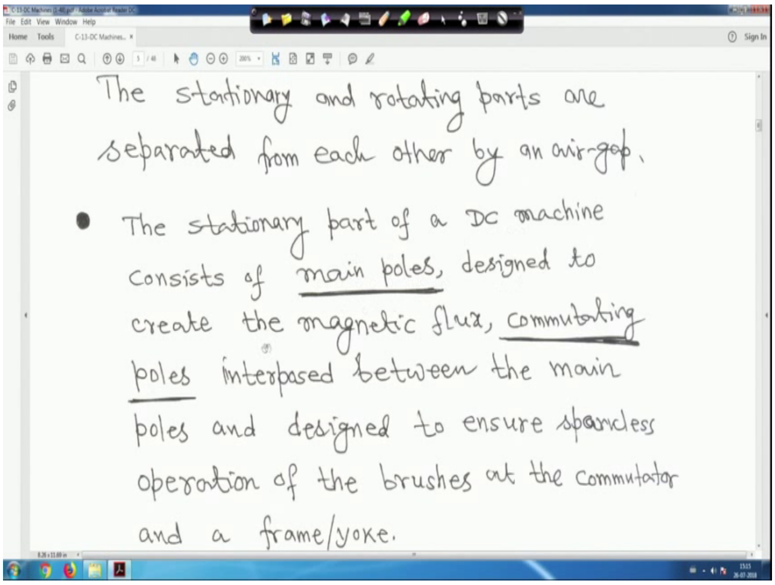

Now, the stationary and rotating parts are separated from each other by an air gap just I show in the diagram right. The stationary part of a DC machine consists of main poles, designed to create the magnetic flux, commutating poles inter interposed between the main poles and your designed to your sparkles operation of the brushes at the commutator and a frame or yoke. This inter pole you are what you call about this commutating poles other things you will not study for this course you will study in your second year or third year electrical machine course. Just for the sake of completeness all this things are noted down right.

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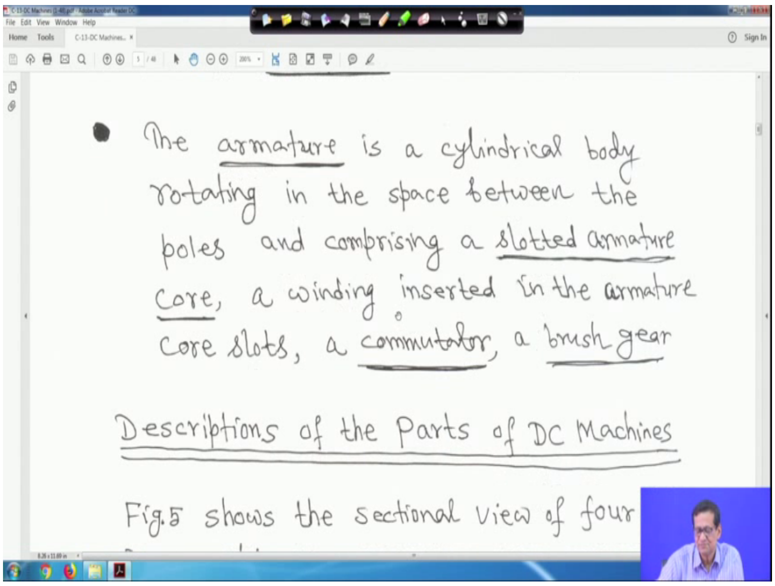

The armature is a cylindrical body rotating in the space between the poles and comprising a slotted armature core. A winding inserted in the armature core slots a commutator a brush gear most all this thing perhaps you will study in your machine design course also if it is there.

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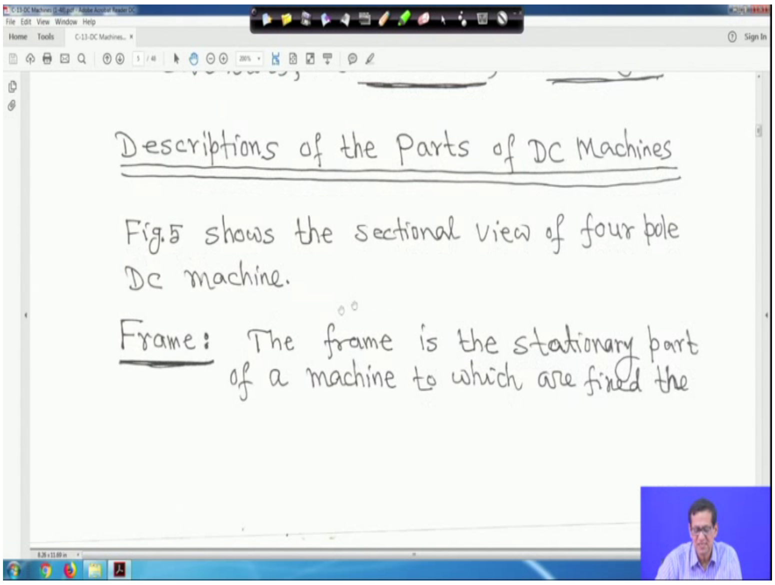

So description of the parts of a DC machine, so figure 5 actually shows the sectional view of four pole DC machine, first one is the frame I will show you in the diagram. The frame is the stationary part of a machine to which are fixed the your what you call this Just see this diagram.

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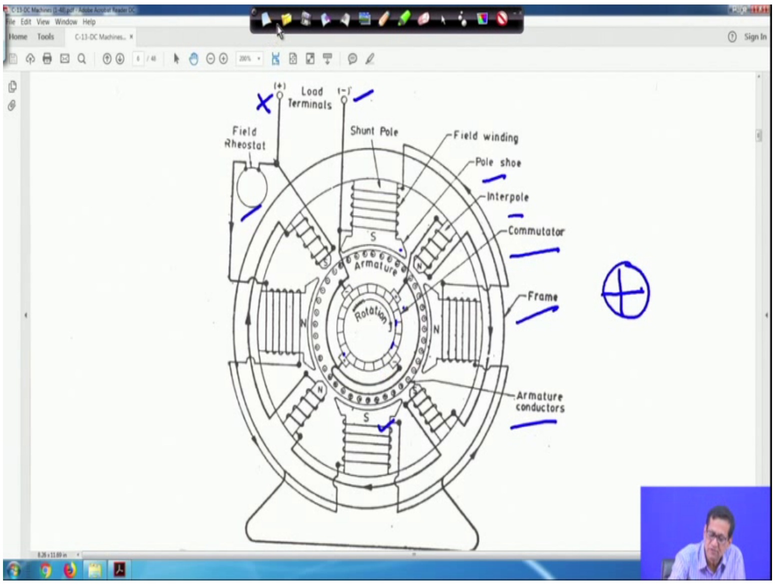

This is actually this is your rotation direction of the rotation, this is the brush bar, this is the armature. Wherever you see the current this conductor are there. Here it is basically actually here we need later this is the just hold on. This is actually conductor if it is a plus; that means, we will see that current entering into the page right.

And if you use current entering into the page then the thumb will be what you call the direction of the current and this fingers, the curling fingers will be the direction of the flux right. So, similarly this side it is it this side it is plus right, this side it is plus under S pole this is also plus dot plus dot everything is there right. So that means, plus means current entering into the you are what you call into the plane right. And dot means it is leaving the plane; that means, if it dot means current coming out.

So, this is the reaction of the current and this will be the finger your curling this will be the direction of the flux right. And this is this is your inter poles are there we will not discuss much these are the two terminal this is plus just hold on, this is your this is your this is your plus and this is minus. And this is the field rheostat field resistance this way it has been symbolized and this is the field winding it is given right and this is pole shoe here, this is inter-pole. We will not discuss about the function why inter-pole is for this course inter-pole is there. Then this is commutator this is so many commutator segment as I mean in the diagram it is few you will have many right.

And this is your frame and this is your armature conductors right. So, this is a schematic diagram which I have taken from a book right. So, and if you look into that it is 4 pole machines right, so you will see the 4 your brushes 1, 2, 3, 4 plus minus plus minus right.

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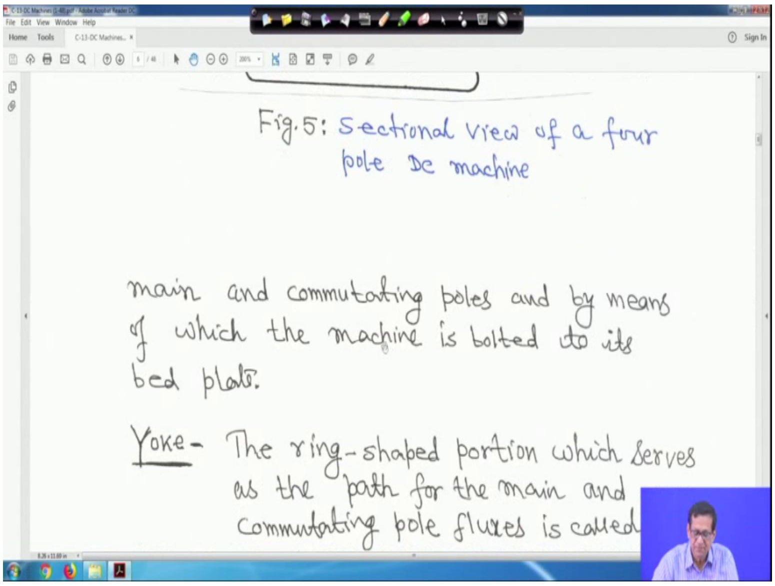

So, this is the your what you call that your are fix the your what you call the main and commutating poles. And by means of which the machine is bolted to its your bed plate the yoke.

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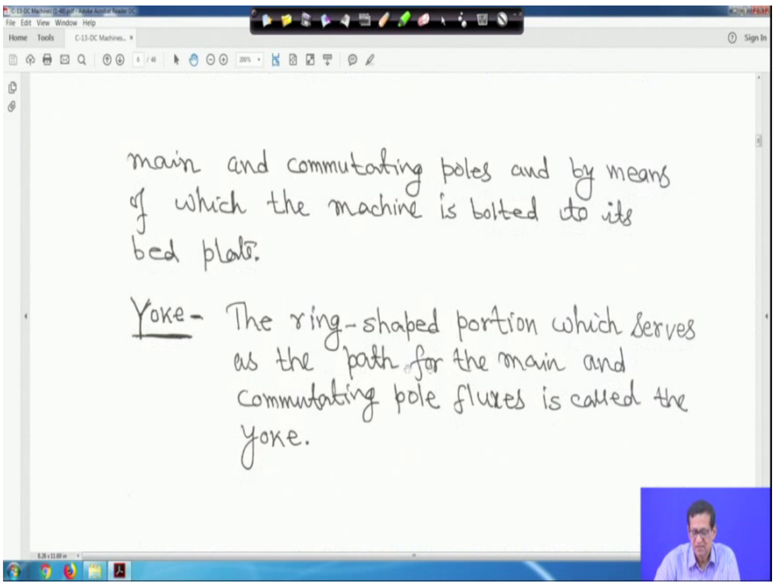

The ring shaped portion which serves as the path of the main and the commutating pole your commutating pole fluxes is called the yoke right. So, here your if you if you look into that that this is your what you call this is your inter-pole is there, commutator is there, this is the frame and this is the shunt pole load terminals, field rheostat, field winding right. And this is the direction, this is the armature, armature is marked here this is the armature right.

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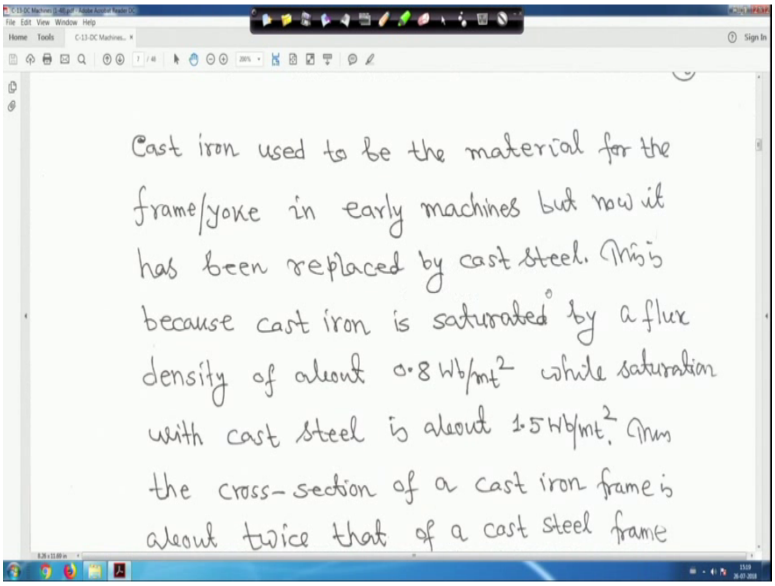

Next is your what you call and you are the cast iron used to be the material for the frame or yoke in the early machines. But now it has been replaced by your cast steel this is because the cast iron is saturated by flux density of about 0.8 Weber per meter square. While saturation with cast steel you are about 1.5 Weber per meter square. Thus the cast thus the cross section of a cast iron frame is about twice that of a cast steel frame for the same value of magnetic flux right.

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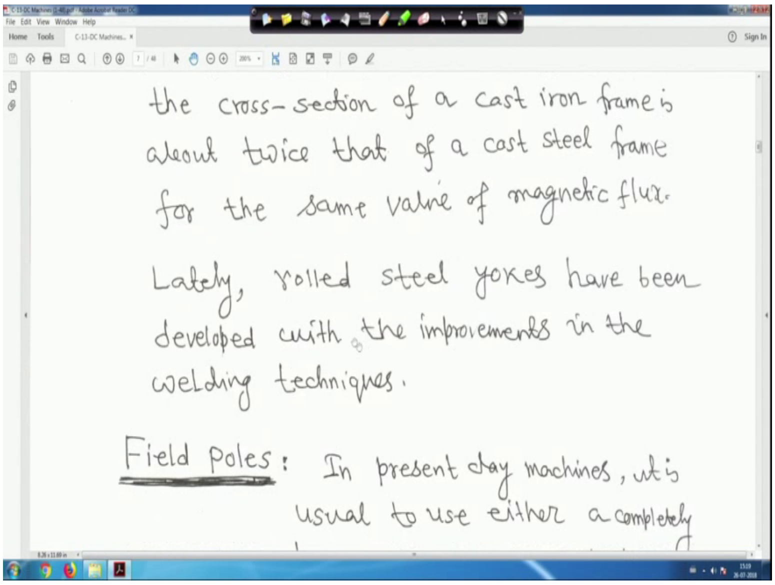

So, lately rolled steel yokes have been developed with the your improvements in the welding techniques.

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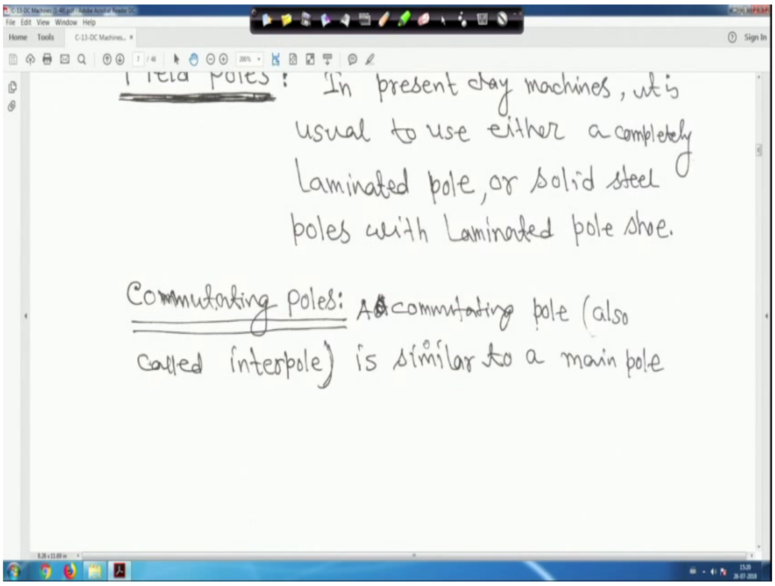

Now next is field poles, in present day machines it is usual to use either a completely laminated pole, or solid steel poles with laminated polls shoe right. Then commutative poles commutating poles also called inter pole is similar to a main pole.

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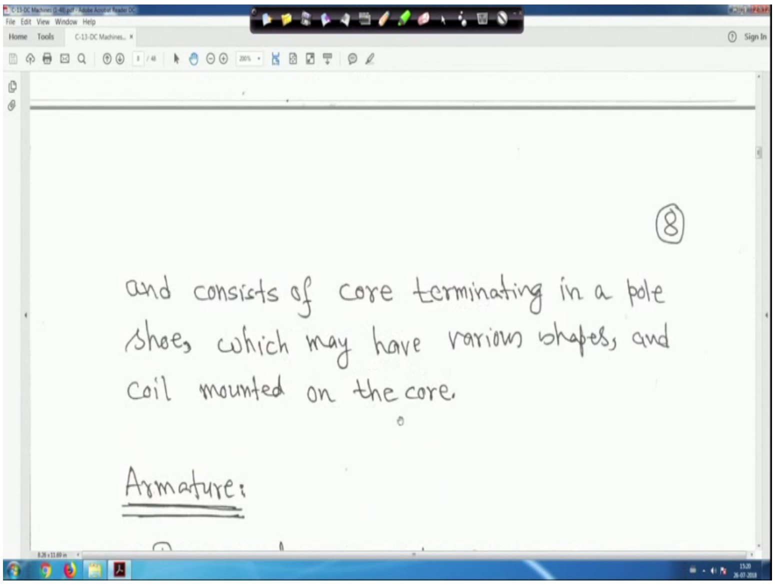

And consist of core terminating in a pole shoe which may have various shapes and coil mounted on the core. So, function of this your inter pole called commutating pole etcetera I am not discussing here, because this first year level just some ideas right.

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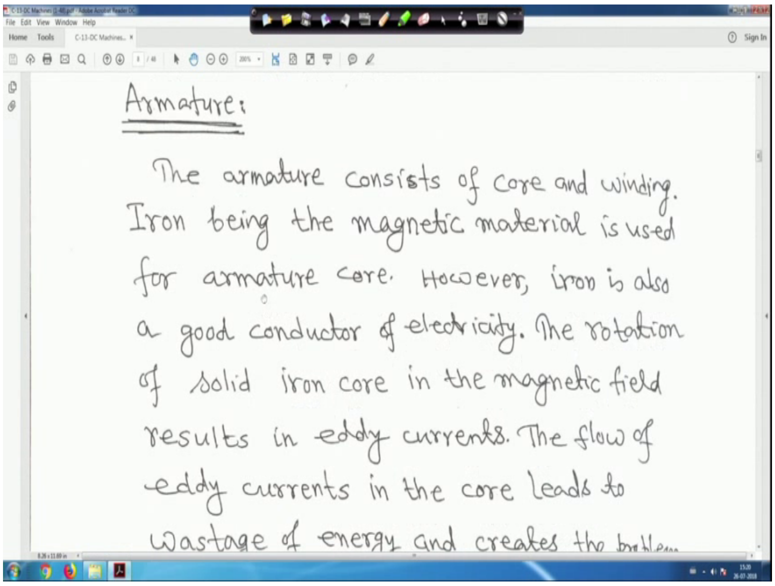

So, next is the armature, the armature consists of core and winding. Iron being the magnetic material is used for armature core. However, iron is also a good conductor of electricity. The rotation of a solid iron core in the magnetic field results in eddy current right. The flow of eddy currents in the core leads to wastage of energy and creates the your problem of heat dissipation right. To reduce the your eddy currents the core is made of thin laminations this is same everywhere, if you see all the machines you will find like this right.

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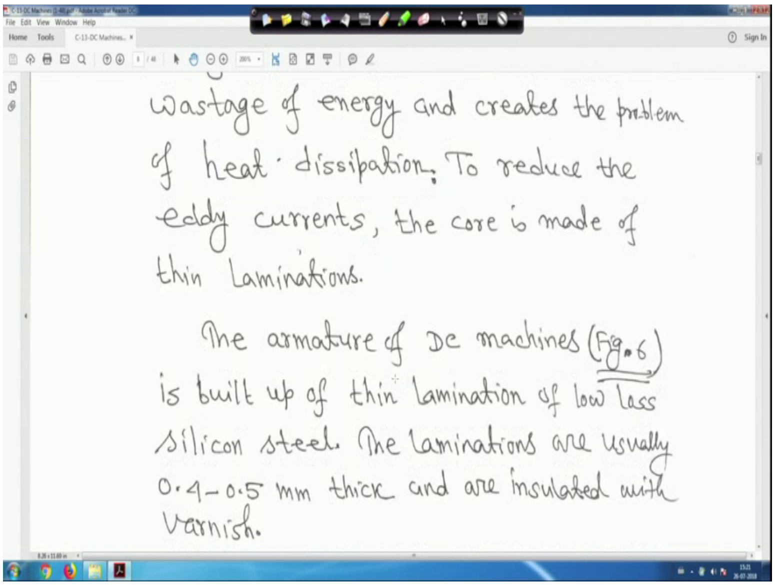

So, just I have written for this thing the armature of DC machines is build up of thin lamination of low loss silicon steel. The laminations are usually 0.4 to 0.5 millimetre thick and are insulated with varnish right.

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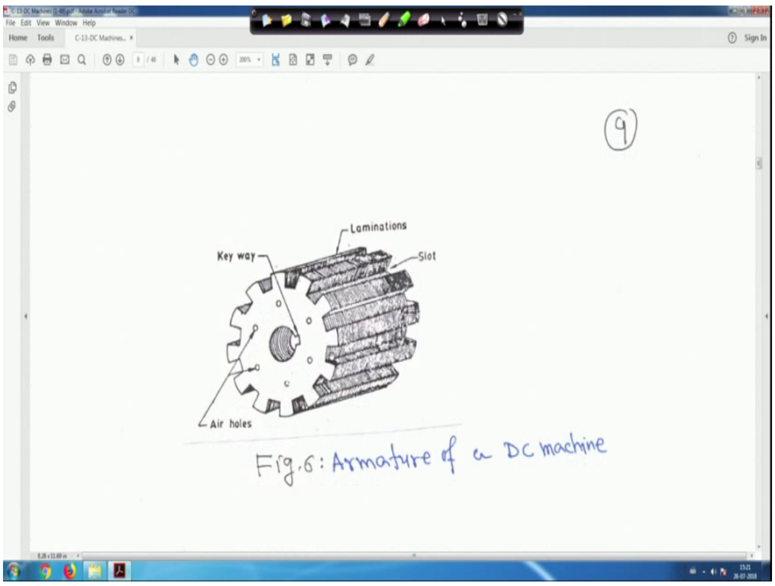

So, this is actually that your armature of a DC machine. These are the laminations and these are the slots right. So, so where that you are conductors are placed right. So, this is the key way and this is lamination, this is I have taken from a book, and this is the air holes right.

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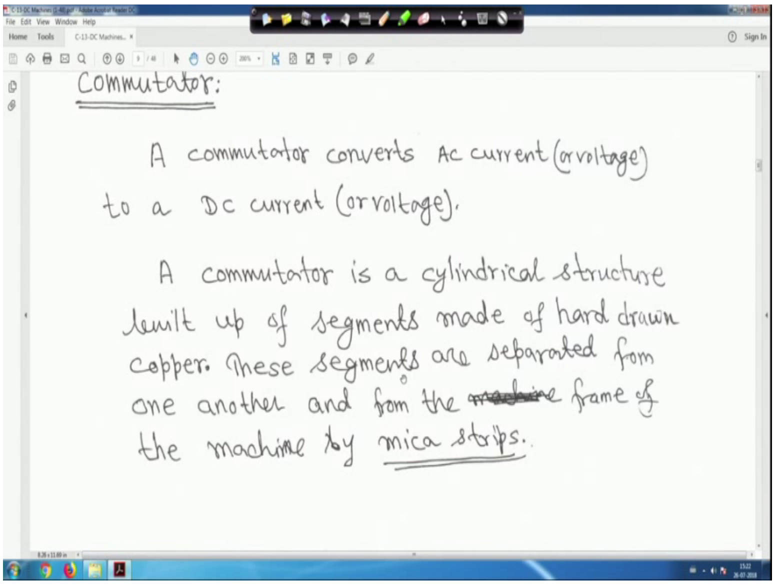

And then commutator converts AC current or voltage to a DC current right sorry. Here actually you know it will be your convert AC, AC current voltage to DC current or voltage this right. A commutator is a cylindrical structure built up of segments made up of hard drawn copper. These segments are separated from one another and from the frame of the machine by mica strip right.

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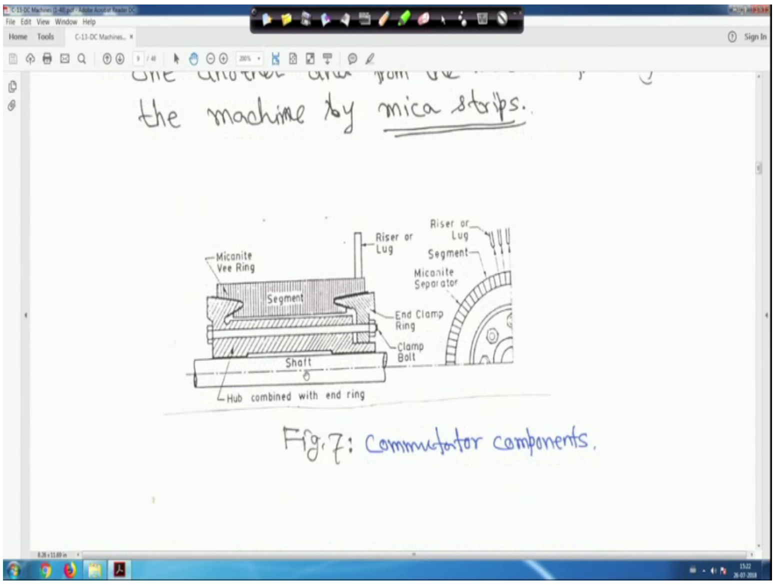

So, this is actually your what you call some kind of diagram this is the commutator segment. This is micanite your vee ring, and this is riser from this commutator where the windings are connected through this riser or lug right. You I suggest you see in your college that open DC machine, DC motor or DC generator.

And this is that commutator segment right and this is called riser or lug and this is a segment and they are all insulated separated from each other by mica say. And this is end clamp ring and this is clamp bolt, this is just to give your then this is a shaft just to give one ideas about this commutator right. So, this is commutator component.

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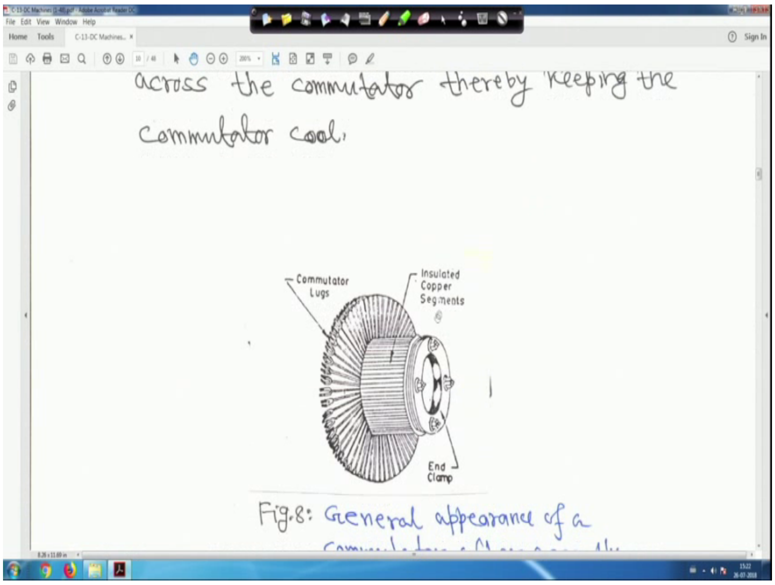

So, another thing is here if you look into the insulated copper segment this is all insulated your copper segment. This is your what you call commutator right. And this is your commutator lugs from here where it is connected to the winding, and this is your end clamp. And this is all this is very thin you will find and separated by mica if you looking on a open DC machine.

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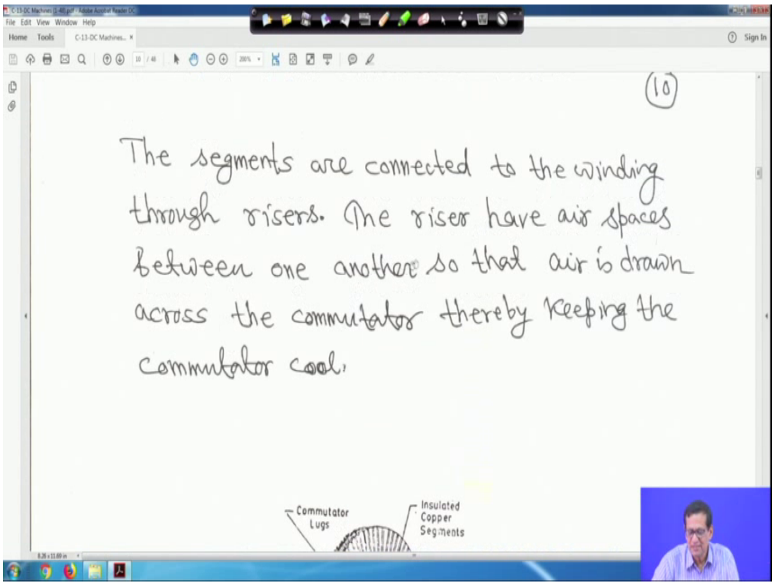

And therefore, all these things are your what you call detailable here. So, I am not going to repeat right, so this is your what you call is some kind of your idea you have.

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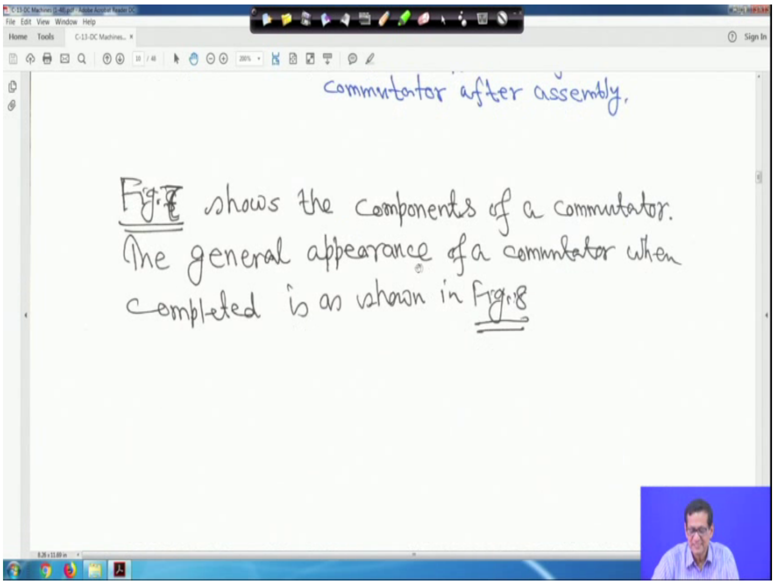

Now, so all these things I showed you and I told you right. So, figure 7 actually components of a commutators is a general appearance of a commutator when completed it is showing here right this figure.

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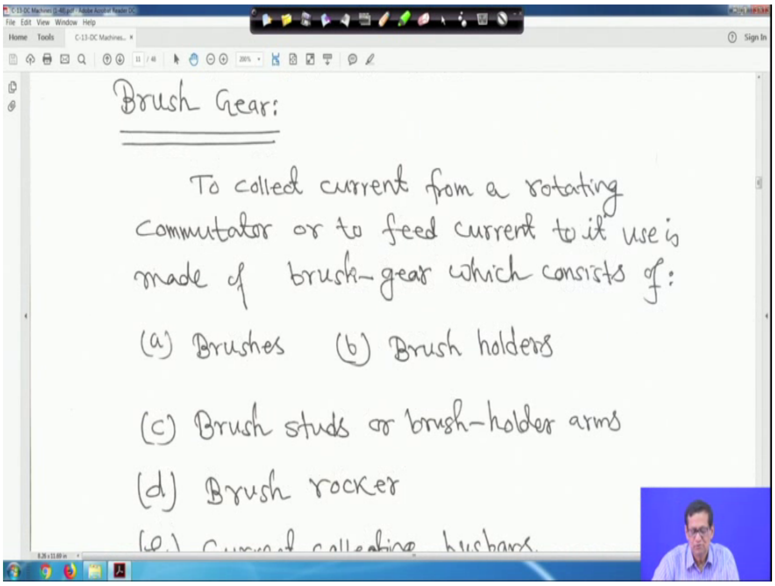

Next is brush gear to collect current from a rotating commutator your commutator, or to feed current to it use is a made of brush gear which consists of brushes, brush holders, brush studs, or glass holder arms, brush rocker, current collecting, brush bars right.

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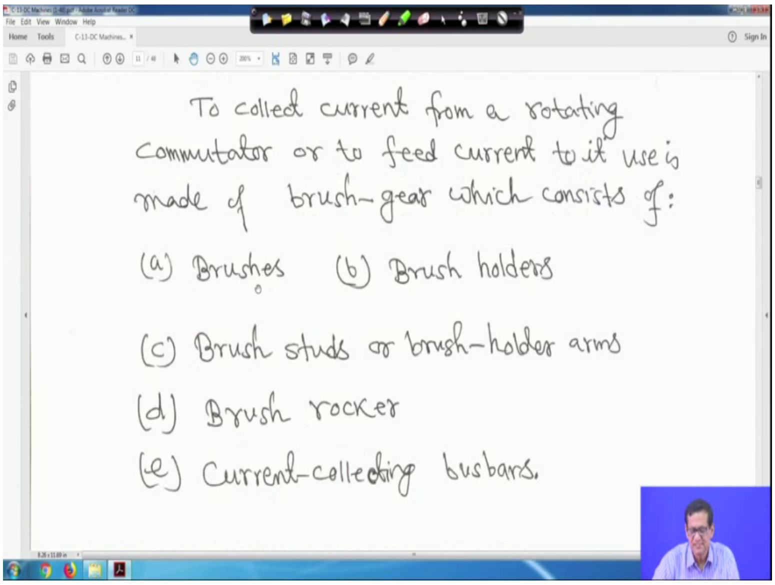

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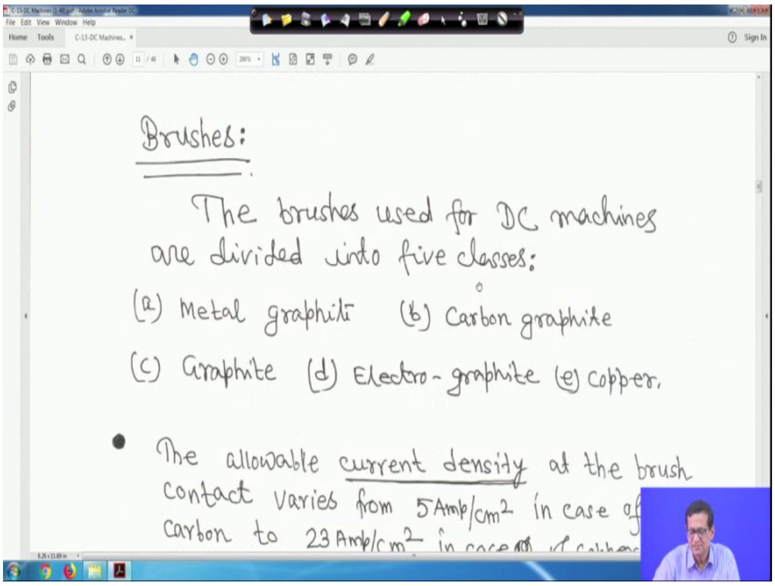

So, the brushes the brushes used for DC machines are divided into 5 classes; metal, metal graphite, carbon graphite, graphite, electro graphite, and copper right.

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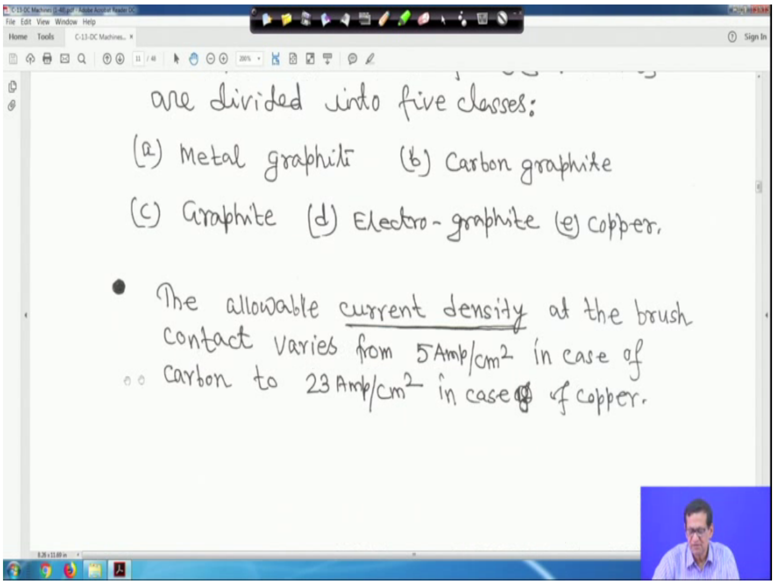

So, the allowable current density at the brush contact varies from 5 ampere per centimetre square in case of carbon to 23 ampere per centimetre square in case of copper.

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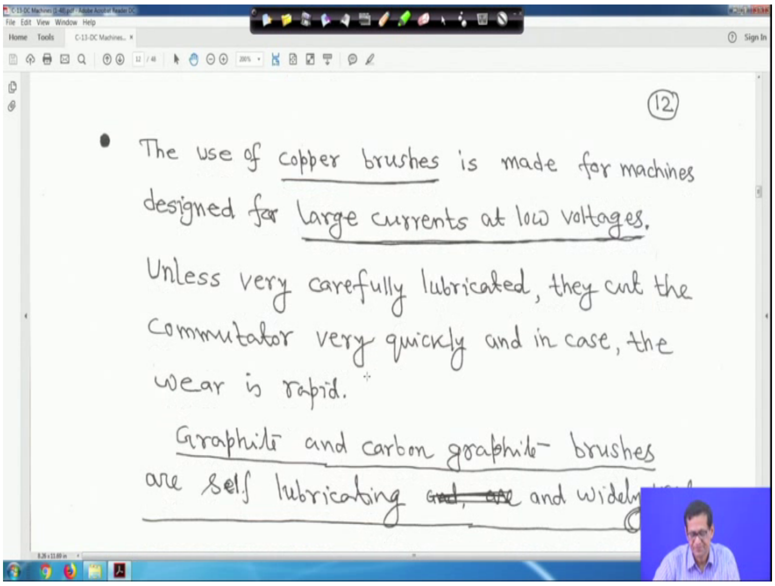

So, the use of copper brush is made up for machines designed for large currents at low voltages right. Unless very carefully lubricated they cut the commutator very quickly and in case, the wear is rapid right.

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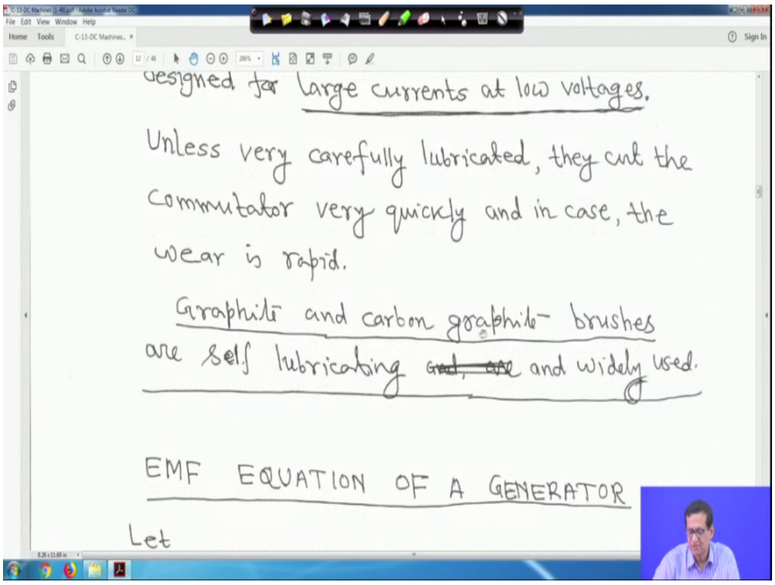

Therefore graphite and carbon graphite brushes are self lubricating and widely used. In your college also in the lab if you see this brushes are made of you will find it is a carbon graphite brushes right. So, next is these are all some brief discussion of the DC machine.

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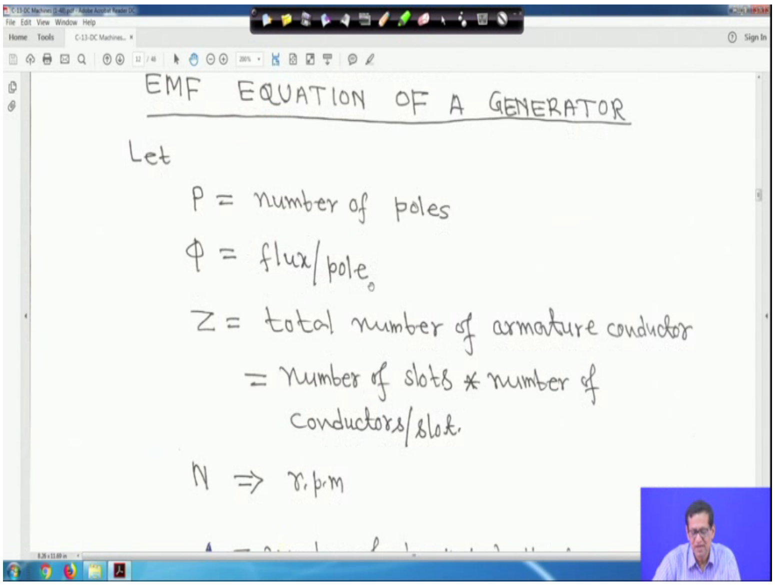

Next is emf equation of a generator, so from that we will move to motor. So, let P is the number of poles, and phi is equal to flux per pole, Z is equal to total number armature conductors. So, number of slots is equal to into number of conductors per slot that is the total number of conductor right. And N that speed is given is rpm revolution per minute.

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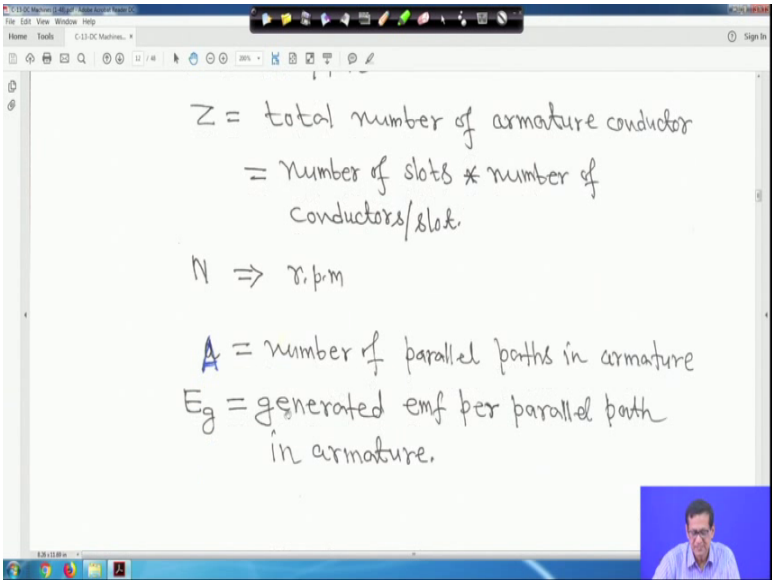

And a number of parallel paths in armature E g generated emf per parallel path in armature. Basically DC machines are of two type; one is lap connected, another is om. In lap connected number of path is equal to number of poles, A is equal to P, where is this one this capital A is equal to P and way of connection it will be A is equal to 2. But these are given the scope for this course, but we learn in electrical machines or in machine design right. But here for the sake of completeness we have to choose to we have to consider it for numerical also. For lab connection A will be P; and for om A will be is equal to 2 always right.

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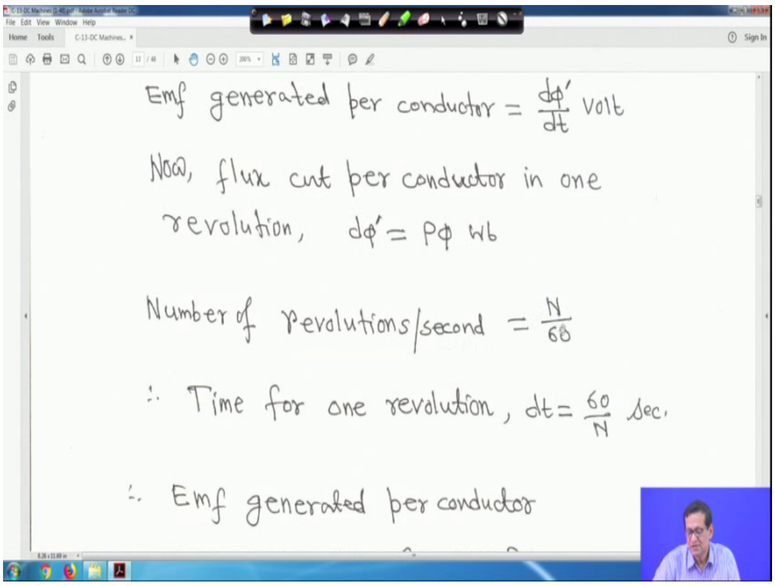

Now, suppose emf generated per conductor will be say d phi dash by dt volt right. Now flux cut per your conductor in one revolution will be d phi dash will be P into phi right, because phi is flux per pole, so d phi dash will be P into phi Weber right. So, number of revolutions per second because we have taken speed rpm revolution per minute. If it is revolution per second it will be N by 60 then. Now time for one revolution d t will be just reciprocal of this d t will be 60 upon N second right. Therefore, emf generated per conductor this is your d phi dash by d t.

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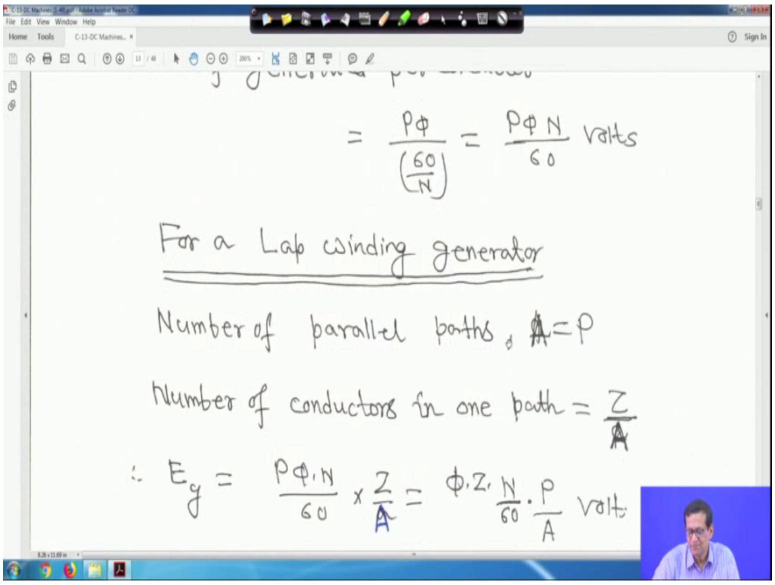

So, it will be d phi dash is P P phi and dt will be 60 upon N that is P phi N upon 60 volts right, straight forward. Now for a lap winding generator I told you number of parallel paths will be A is equal to P. And so number of conductors in one part will be Z upon A right because a you have A number of parallel path so Z upon A. Therefore, voltage induced will be P into phi into N upon 60; that means, this much into your Z upon, so that is equal to phi Z N by 60 into P by A volt right.

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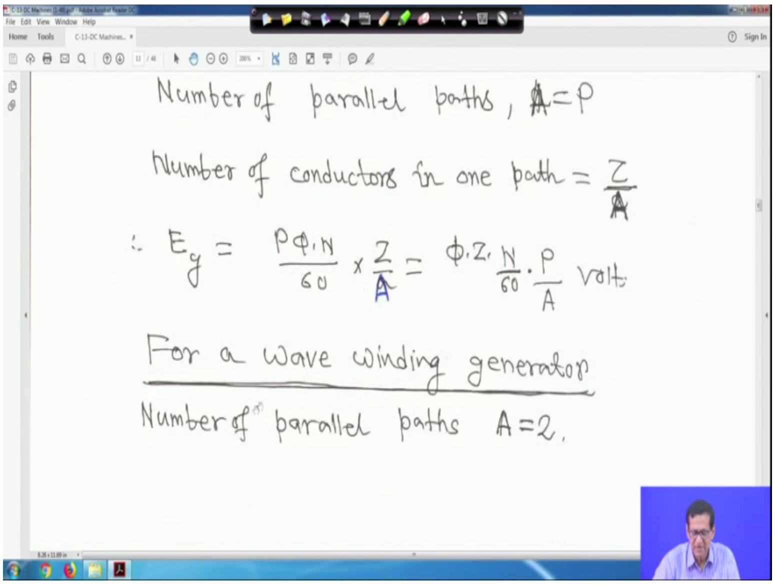

Now, for a wave winding actually number of parallel path is always 2, A is equal to 2. So if you put here A is equal to 2 right.

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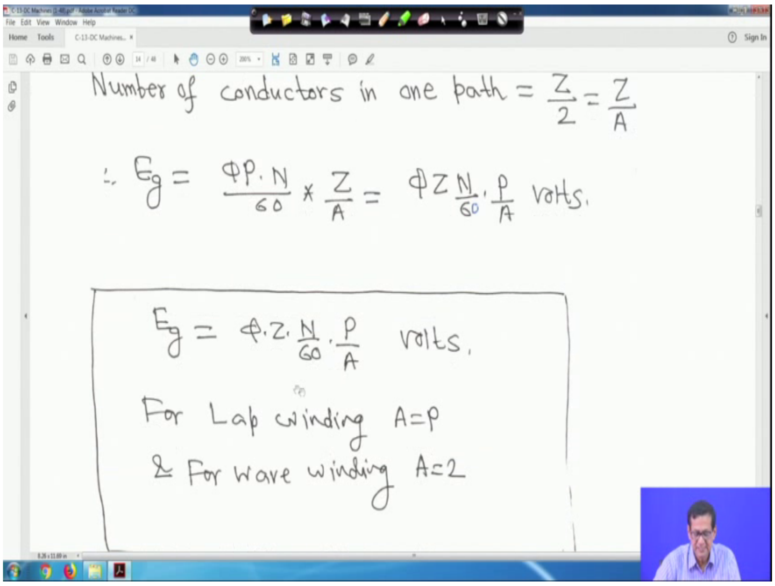

Then that mean number of conductors in one path Z by 2 is equal to Z by A right. So, I mean it is for wave connection. So, it will be Z by 2 right Z by N; A is equal to 2. So, this is easy to remember again it is phi Z N by 60 into P by A right. So, for lap connection A is equal to P, and for wave connection A is equal to 2 right. So, therefore, E g is equal to phi Z N by 60 into P A volts, for lap winding A is equal to P and for wave winding A is equal to 2 right. This thing for numerical part you have to keep it in your mind.

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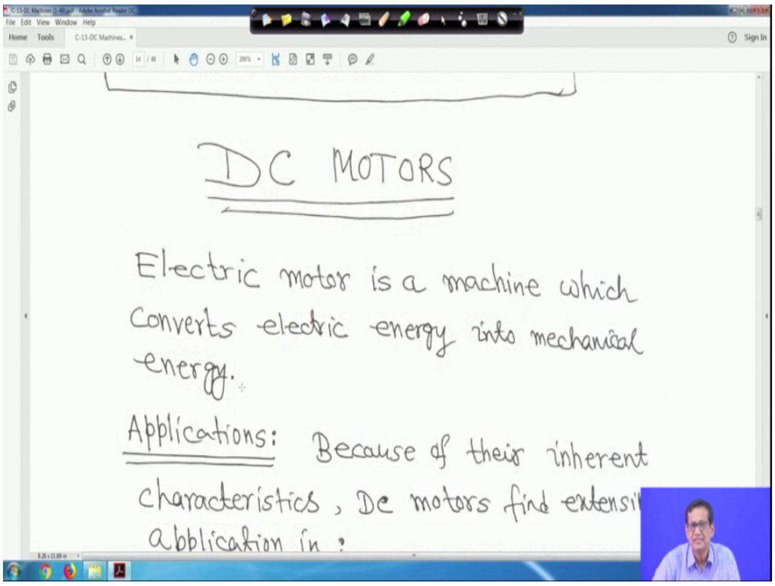

Next is DC motors philosophy is same. So, electric motor is a machine which converts electrical energy into mechanical energy, this is DC motor.

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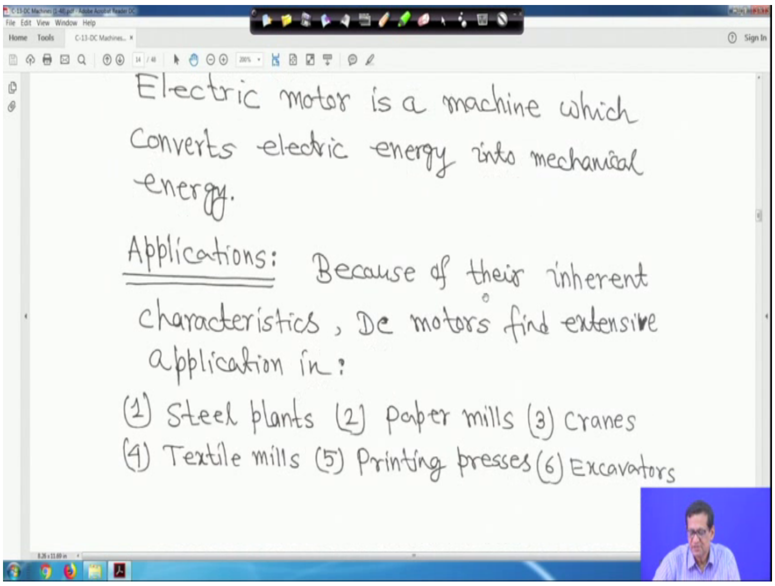

Because of the inherent characteristics DC motors find extensive application in steel plant, paper mills, cranes, textile mills, printing presses, and excavators right

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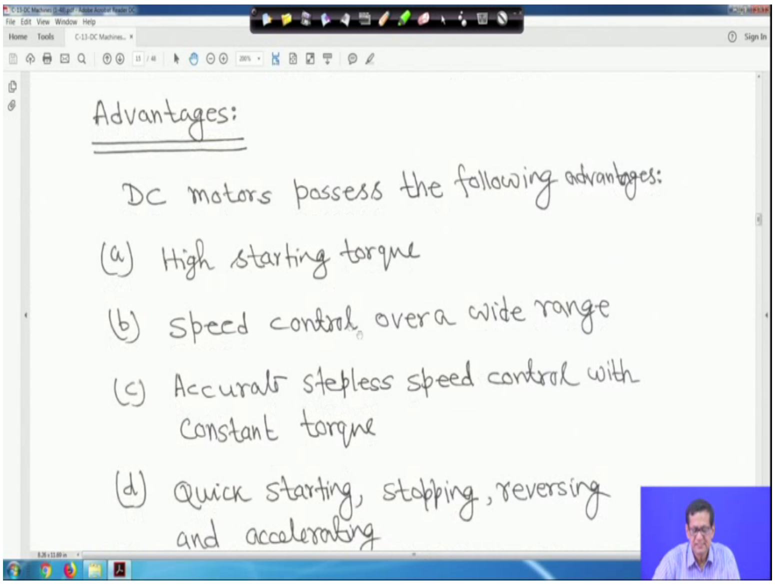

And advantages DC motors possess the following advantages; high starting torque, speed control over a wide range, accurate stepless speed control with constant torque, quick starting, stopping reversing and accelerating. These are the advantages for DC motor.

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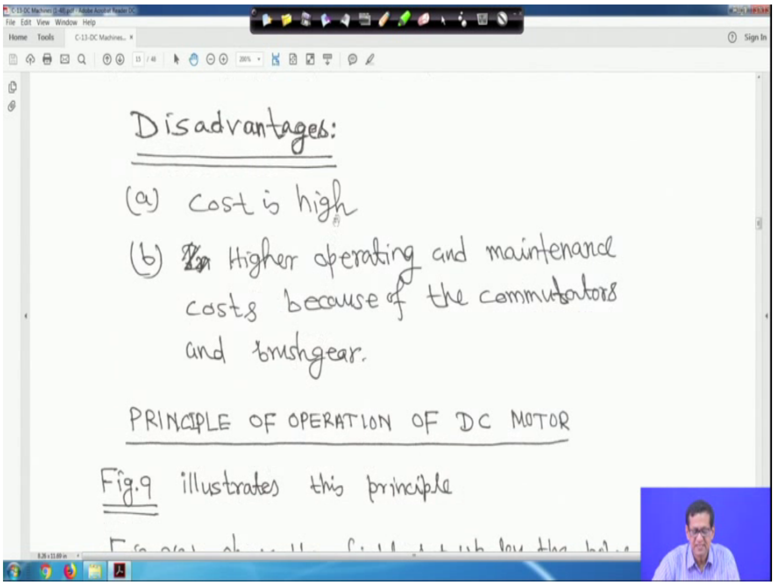

Disadvantages; cost is high, higher operating and maintenance costs because of the commutator and your brush gear right.

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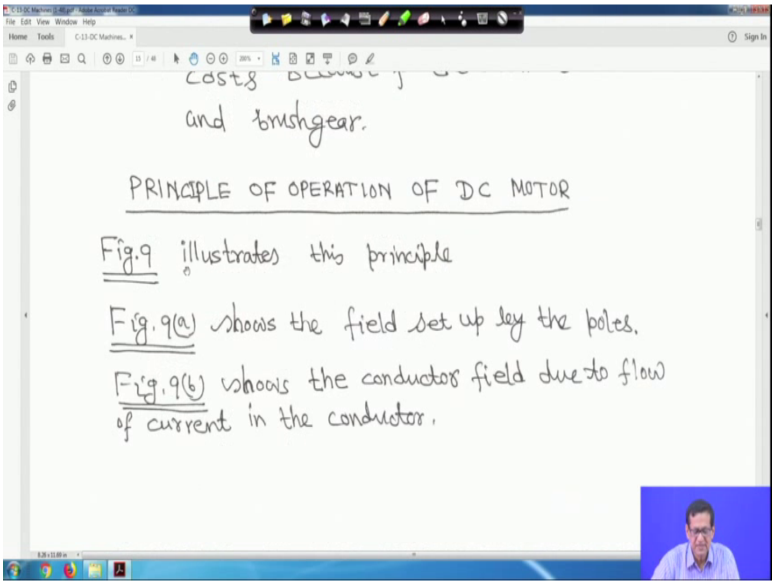

Now principle operation of DC motor. So, figure I will come, so figure 9 in general illustrates the principle next I will show. Figure 9 a shows the field set up by the poles, and figure 9 b shows the conductor field due to flow of current in the conductor.

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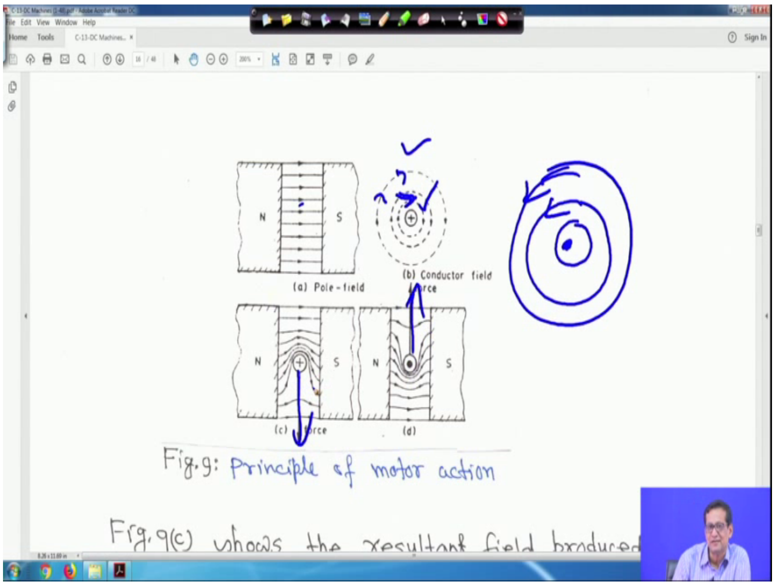

Now, this is actually figure. Now here before anything we do we have to understand little bit. Now, here when this is my N and S poles and thing is the your what you call this is the flux line is shown here right. And second thing is that second thing is this is the plus;

that means, conductor actually we that is this is the conductor and plus means the current is entering into the plane.

So, if the current is entering into the plane that this is the direction of the current thumb looked at by thumb. And if you curl the finger like this will be the direction of the flux that is why flux direction if you see here all this things are clockwise all this things are clockwise. The plus one you just make this your thumb is right hand rule you put and you are the thumb is your what you call the direction of the current.

Because it is going into the paper right or in to the plane and this is the direction of the flux. And similarly if you take a if you take a you are what you call suppose a dot suppose, this is the conductor suppose dot. Then current actually what will happen? Current actually leaving the plane, or leaving the plate, so move it upward. So, in that case the direction of the flux will be anticlockwise, direction of the flux will be anticlockwise say this one, say this one just opposite to this, just opposite to this just you will use the thumb rule. So that means, that means whenever this the when you are bringing this conductor say bringing this it is given N S, N S like this.

Whenever bringing this conductor here, then what is happening? The flux this is your N to S it is going and this upper side if you see this is your this is clockwise. So that means, this if you if you this is clockwise. So, this upper side it is actually additive, and the lower side it is subtractive. Similarly here the lower side is additive, because it is anticlockwise and upper side is subtractive. Then we force actually acting downwards here and here it here it is upward right. So, here it is upward, so that that is the first thing this thing you have to understand before that mechanism of rotation.

So that means you are because here it is if you look into that this is a direction and if you put here this is also direction. So, both the flux will be same direction this one and this one. So, finality it is additive that is why it is you are what you call force is acting downwards, and just opposite here the force is acting you are what you call upwards right. So, that means, when conductors are placed carrying current and placed in the magnetic field this is your that is the plus and this is the dot I told you how it is right. So, all these things actually whatever I said all these things are written here so, not for not further I am explaining this right.

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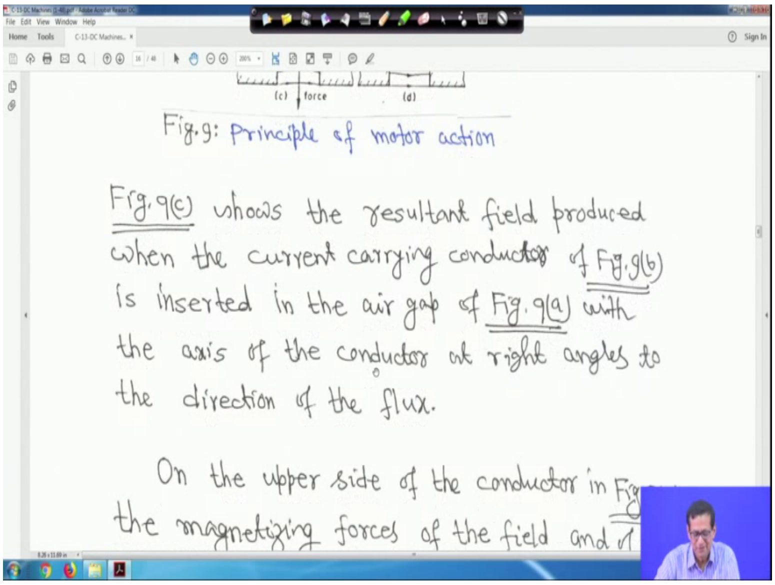

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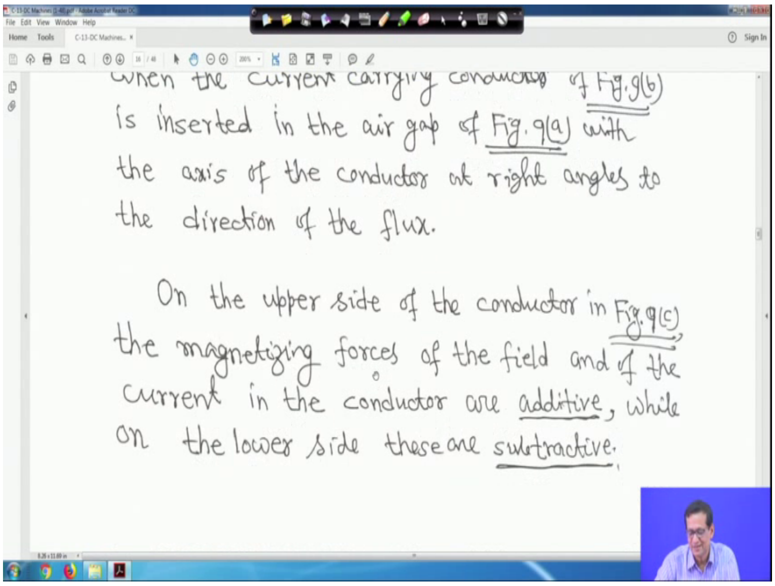

So, that is it is written additive and subtractive everything is written here.

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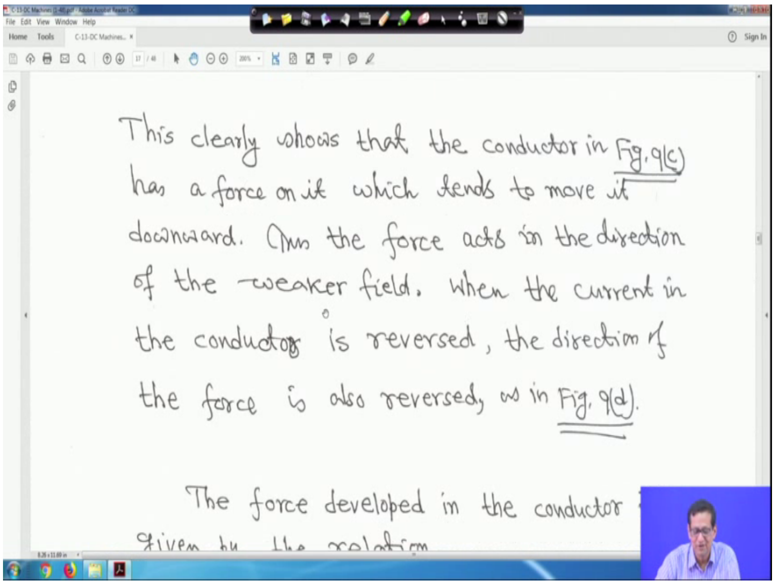

Now, this clearly shows that conductor in figure has a force on it which tends to move in downward. And this and thus the force acts in the direction of the weaker field right whatever I showed in the diagram. When the current in the conductor is reversed that is the second diagram right the force is also reverse and it is your what you call force is acting on the downwards that is weaker field this side and here also right.

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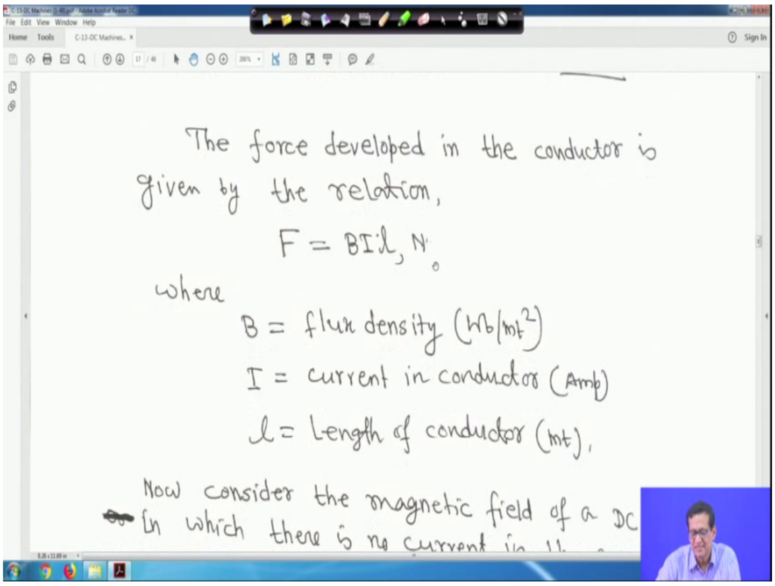

So, now generally the force developed in the conductor is given by that F is equal to B I l Newton, N right, N here it is given Newton. So, B is the flux density Weber per metre square, and I is the current in conductors say ampere, and l is the length of the conductor in metre.

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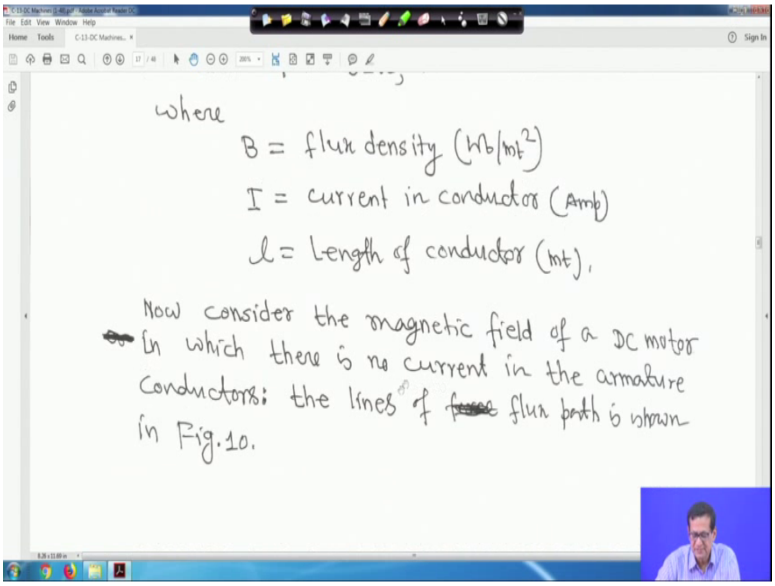

Now, consider the magnetic field of a DC motor you know there is no current in the armature conductors the lines of flux path is shown in figure 10.

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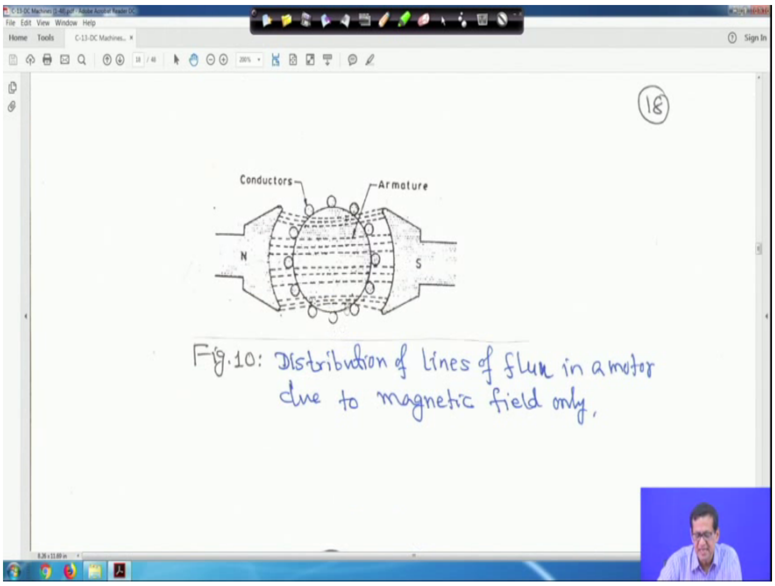

So, just if you see the diagram here that these are the conductors placed and assuming the conductor is not carrying any currents. So, this is the flux path for N to S right this is conductors, and this is your armature. So, distribution of line of flux in a motor due to magnetic field only right, but conductors carrying no current.

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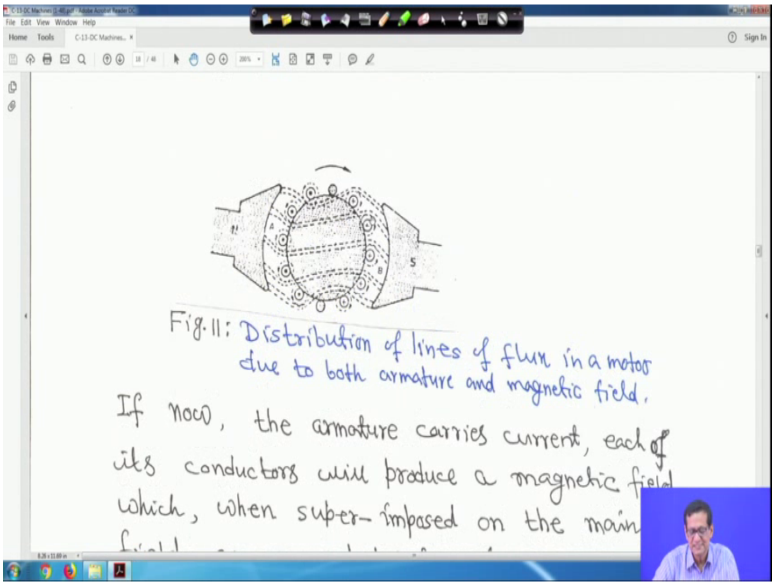

So, if it is so let now let us see that conductor is carrying current, this side is plus. Look at the look at the my cursor this side is a plus, this side is your what you call dot. So, if you look into this and just your what you call that follow you apply the same your right hand see if you apply that your right hand rule right, then you can easily find out that the you are what you call the direction of the flux right.

So, in this case it is N to S naturally upper part this is the plus plus can carry on as per our convention current entering into the plane. So, this side will be your what you call this side will be your additive right. So, and force will be acting down ward and this side your what you call lower portion will be additive force will act upwards.

So, the here every where downward everywhere it is upward. So, from intuition you can say that will start rotating in your what you call in that clockwise direction right. So, this is your just you just same philosophy that is why previous slide I showed the diagram. This diagram I have taken from a book right.

So, if so now, if the armature carries current each of the conductors will produce a magnetic field which when superimposed on the main field causes a distribution of magnet magnetic lines of flux as shown in your figure one. So, this is the thing I told you basic philosophy is like this.

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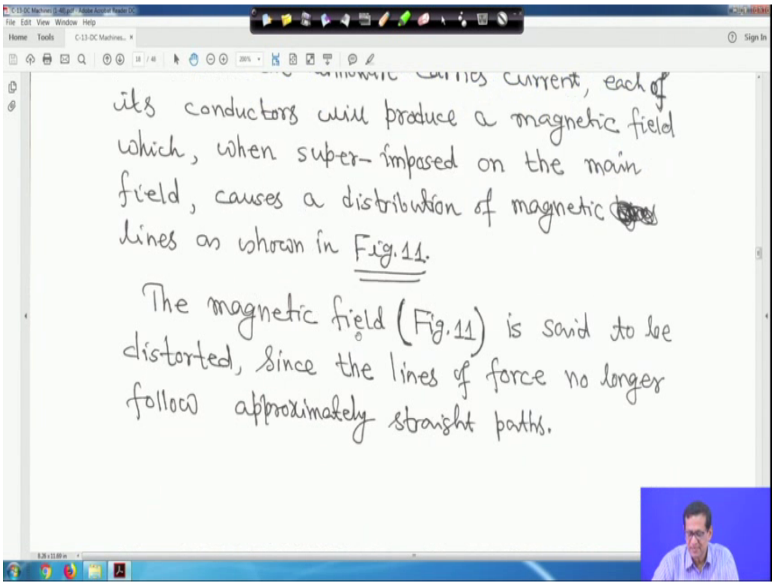

So, the magnetic field that is your in figure 11 is said to be distorted since the lines of force no longer follow approximately straight paths, because this is distorted, because it is not following any straight line path right.

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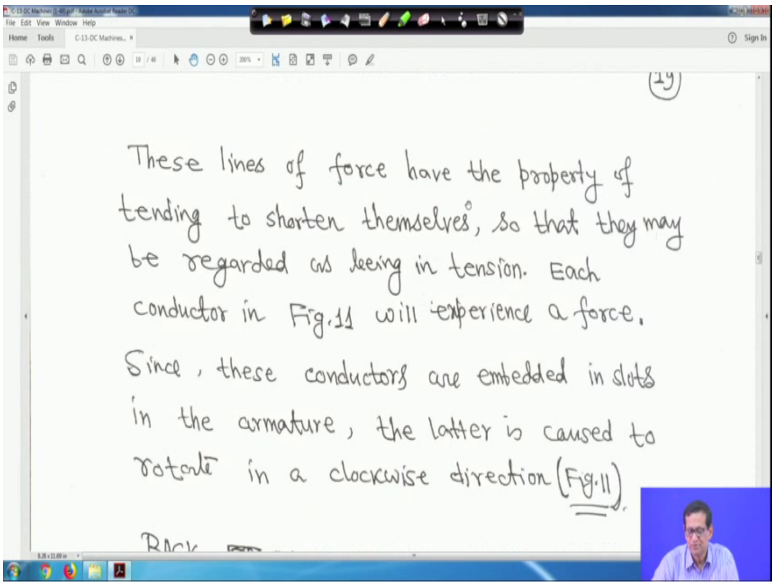

So, this line of force have the property of tending to shorten themselves a shorten themselves right, so that they may be regarded as being in tension. Each conductor in figure 11 will experience a force I told you how it will experience. Since these conductors are embedded in slots in the armature, the latter is caused to rotate in a clockwise direction whatever I told you right. So, it will rotate in the clockwise direction and this conductors are placed in a slots.

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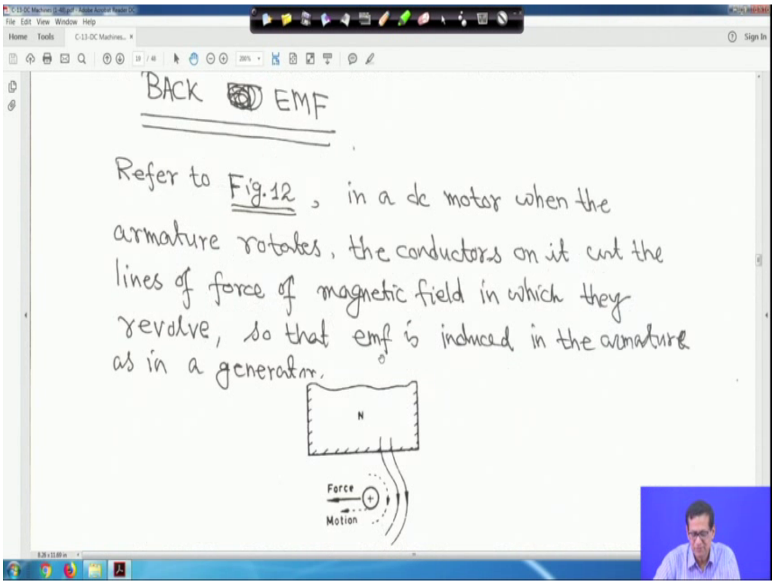

Next is that back emf of a motor generally referred to figure 12.

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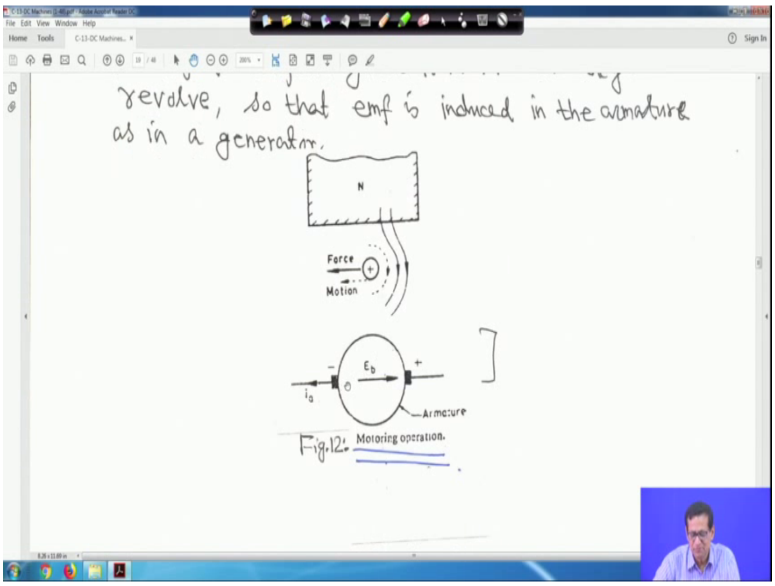

Now, this is a motor right and this is suppose you take the your plus that conductor right and current is entering into the plane. So, if it is entering the plane then here it will be what you call if you look into this is your again the same philosophy this is the plus current is entering into the plane. So, move it like this thumb is the direction of the current, then you just grasp that your what you call the finger 1, this is the direction of the flux that is why this is shown here, that is why this is shown here right, and this N to S that flux line will be N to S.

So, naturally your what you call this is the force is acting your what you call this from stronger magnetic field to the weaker one. So, this is the direction of the force and naturally this is the direction of the motion right. So, in a DC motor when the armature rotates the conductors on it you are what you call cut the lines of force just hold on, cut the line, cut the lines of force of magnetic field in which they revolve right. So, that emf is induced in the armature as in a generator right.

So, this is the motor in operation and this is the armature. So, this is the same philosophy and this is only N pole is shown here. And this is your what you call we have to think about the back emf right.

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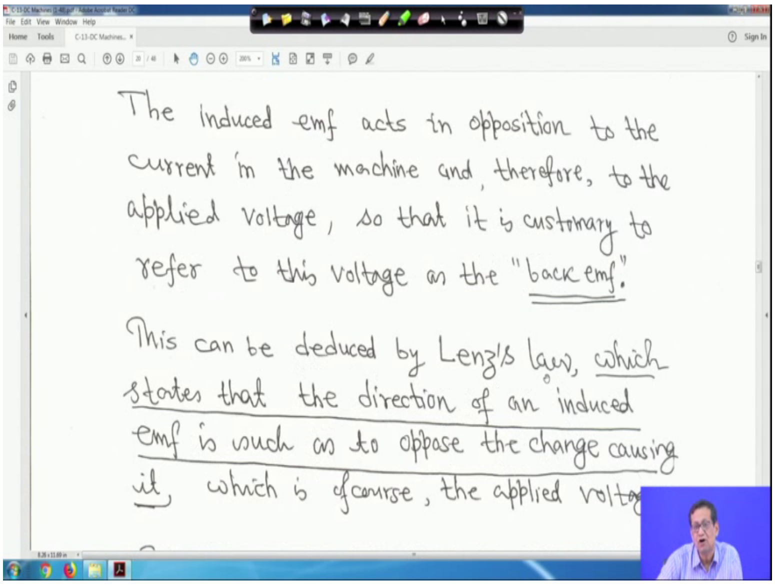

So, in that case what will happen the induced emf acts in opposition to the current in the machine and therefore, to the applied voltage. So, that it is customary to refer to this voltage as the back emf. Now as per the your what you call for your transformer we have seen that this can be deduced by Lenz's law which states that the direction of an induced emf is such as to oppose the change causing it which is of course, the applied voltage right.

So, that means, that is that means, if you look into that this is the plus direction and this is the minus, and this is my back emf E b right. If you look into that that i a actually current your what you call instead of you are going into the my your negative polarity that current actually leaving from this one for the motor.

It is just a schematic diagram, but when you are connecting supply voltage we will see that right. So, that is your what you call the meaning here. This can be deduced by Lenz's law which states that the direction of an induced emf such as to oppose the change causing it which is of course, the applied voltage right. So, that is why the magnitude of back emf can be calculated by using formula for the induced emf generator.

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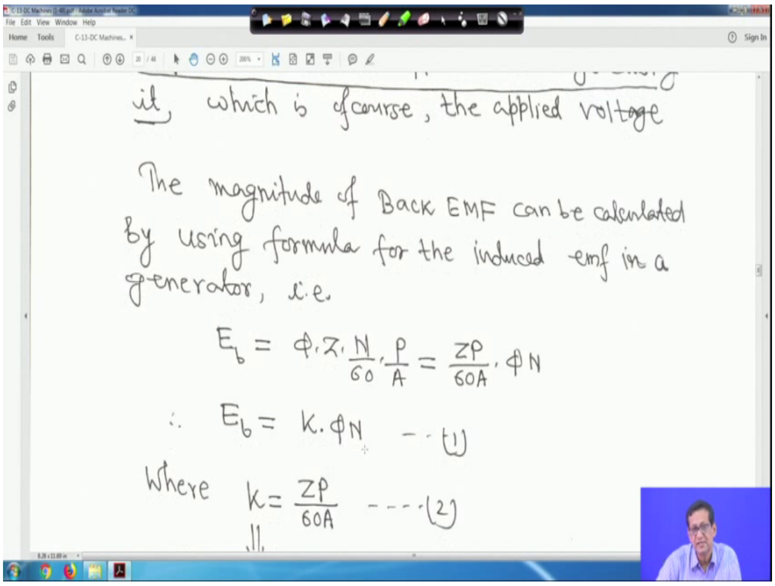

Same formula back emf will be same formula E b is equal to phi Z N by 60 into P by A; that means, Z P upon 60 A phi into N. So, Z P upon 60 A is a constant right. So, E b can be written as k into phi N per motor back emf.

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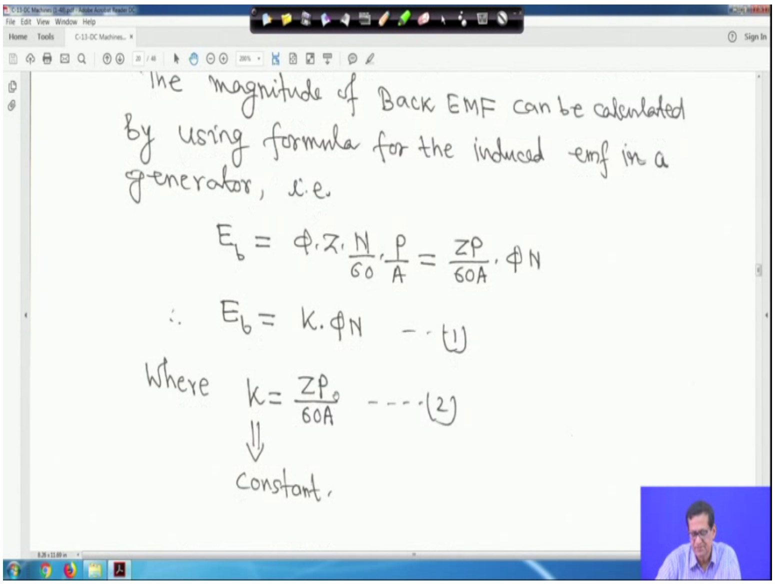

Therefore k is equal to Z P upon 60 A, because Z is a constant, P is a constant, A is a constant. And so therefore, it is a constant right. So, this is actually your what you call back emf. When you will take numericals at the time you will find things are much easier right.

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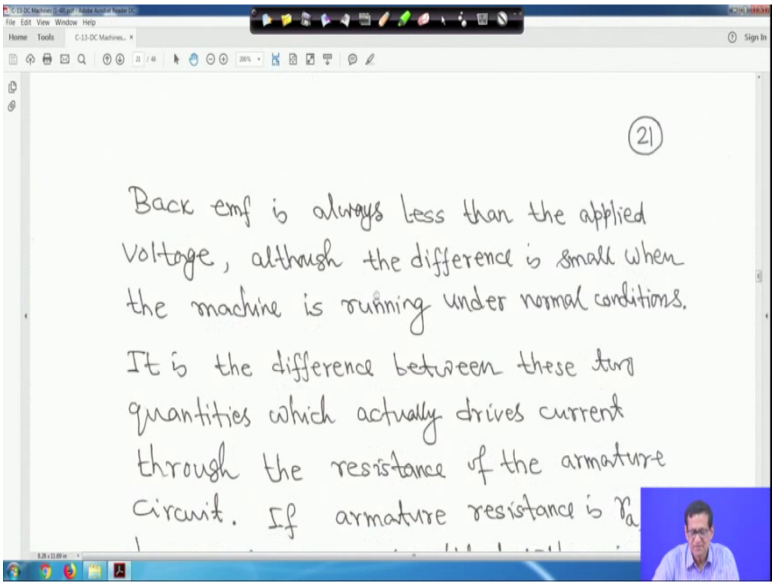

So, in this case you therefore, back emf is always less than the applied voltage, so although the difference is very small when the machine is running under normal conditions. So, it is the difference between these two head quantities which actually drives current through the resistance of the armature circuit we will see later. If the armature of if the resistance of the armature you what if the armature resistance is r a, back emf is E b, applied voltage is V right.

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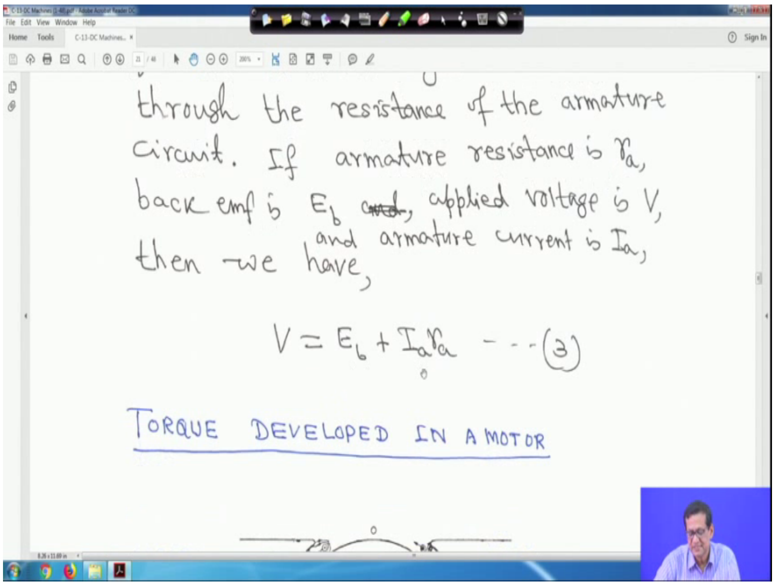

Then we have this equation, V is equal to E b plus I a, r a we will see this, we will see this later, we will see this later right.

Thank you very much, we will be back again.