Electrical Machines – II
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Lecture – 29
Winding Table of 120° Phase Spread Coils and Group Connection

Welcome to this next lecture and we were discussing about 120 degree Phase Spread winding. So, we took a rather simple example with 2 number of poles.

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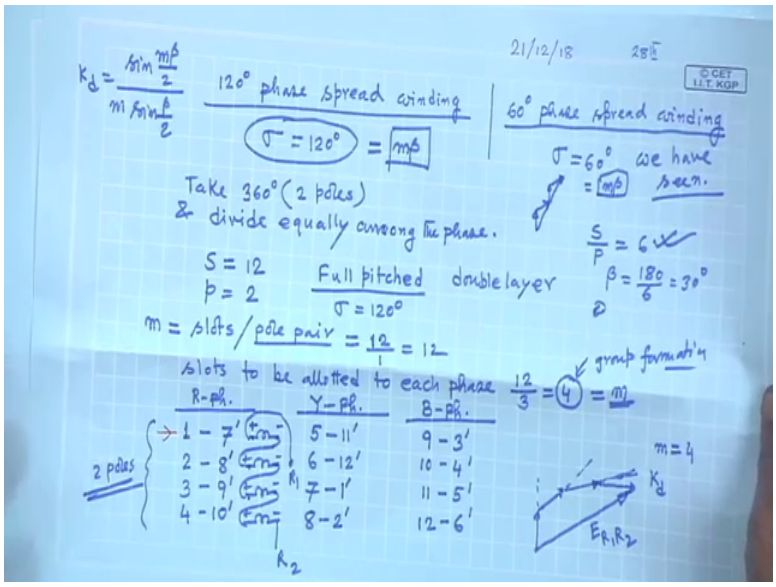

Well, if the number of poles are 4 slots are different then how to handle this? Suppose here is the example.

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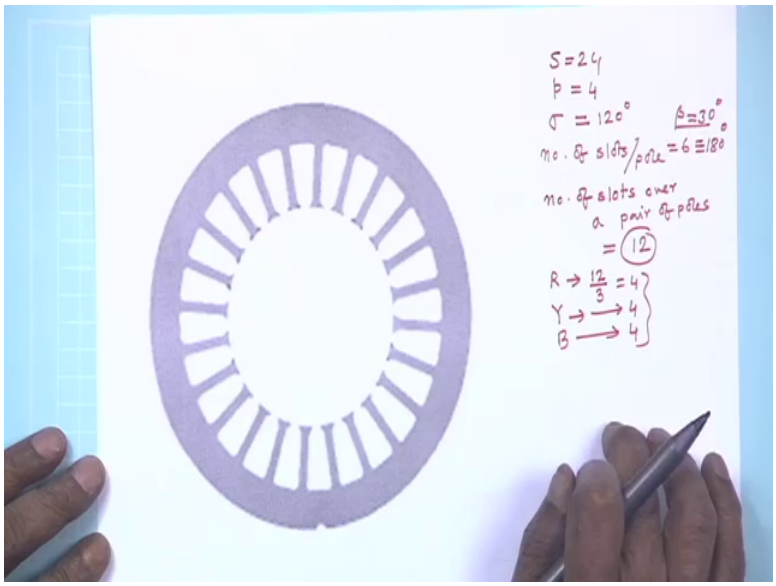

Suppose total number of slot is 24 has is shown here and number of poles is 4 ok. And I want to do a winding whose phase spread is 120 degree all electrical. Therefore, you can see the number of slots; number of slots per pole is 6 and that is equivalent to 180 degree from there you get the value of beta to be 30 degrees that is fine.

But to carry out the 120 degree phase spread winding, you should alert under a pair of pole one third of that 360 degree that is 120 degree to R phase, 120 degree to Y and 120 degree rest 120 degree to be phase. Therefore, here how many slots I should spread for R phase coil? It should be number of slots number of slots over a pair of poles over a pair of poles is 12 is not? 2 into 6 one pole.

So, out of this 12 R phase I will allot 12 by 3 4 slots, Y phase I will alert 4 slots and B phase, I will allot 4 slots that is the idea ok. And this 12 slots will make 2 poles you know 12 slots will make 2 poles so that is the idea. Now how to do the winding forget about this filling up this void spaces in these slots that we can always do provided I have a correct winding table. Then the rest of the work of filling of the windings here is easier task provided you have make made a winding table which is corrected. So, in this case what I will do is this winding table while making I will do it in this fashion this data I keep.

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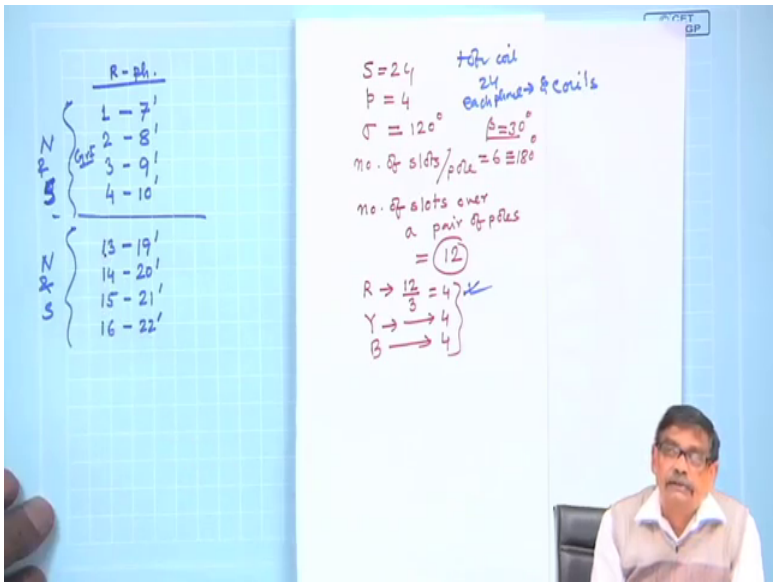

So, for R phase I start from slot number 1 first coil. So, and at a how many coils are there? Total coils are 24, do not forget that and each phase must have 8 coils is not these are known [FL]. So, 1 1 2 and coil span is 6 therefore, it will be 1 7 dashed 2 8 dashed 3 9 dashed, I do not stop here I will give 4 in sub session and 4 10 dashed.

And when I have done this that is I have made a distributed distribution of the group I; coils belonging to R phase. And when we have moved this much I have moved by 2 poles and only 4 coils have been covered where will be the other 4 coils of R phase? Because each phase has 8 coils where from should I start? Should it be 1 plus 6 7? No one pole pair is over; so the this is one north and south; it is a 4 pole machine and next pole pair will be here north and south that is all.

Therefore, the start of the this is group I; phase group I of R phase, this point is important. So, it should start from 1 plus 12 13 once again from these things 13 plus 6 19 dashed 14 20 dashed 15 21 dashed and 16 22 dashed. And then all 8 coils are over for R phase I am repeating see that number 4 I have got over this is the this length covers you know a pole pair and this length covered another pole pair.

So, in this pole pair first 4 coils, this number 4 I have got from this. So, 1 7 dashed 2 8 dashed, 3 9 dashed, 4 10 dashed and then next pole pair starts once again starts with north therefore, 1 plus 6 plus 6 that is 13 19 dashed, 14 20 dashed like that.

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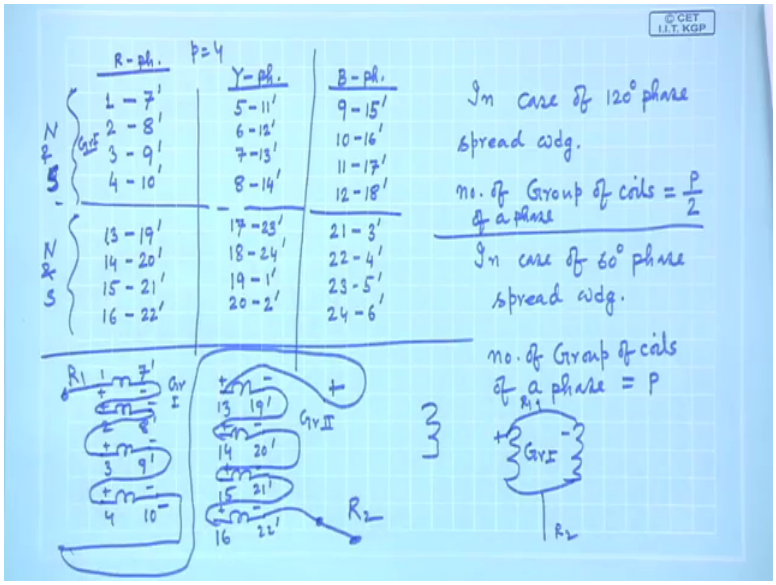

Similarly, Y phase; Y phase beginning will be 120 degree apart, that has not changed that has to be complied with always. So, 1 plus 4 that is 5 and then 11 dashed and once you get these then 4 coils under this pair of poles.

So, 5, 6, 12 dashed 7 13 dashed and 8 14 dashed and then this thing what I am telling after 2 poles that is you add 12 to 5 to get 17. And then plus 6 the coil spans 17 6 23 dashed 18 24 dashed 19 25 dashed so 1 dashed 20 2 dashed 1, 2, 3, 4, 5, 6, 7, 8 all 8 coils are over. And then B phase 5 plus 4 9 120 degree apart 9 16, 6 you add 15 dashed 10; 16 dashed 11 17 dashed and 12 18 dashed.

Then next group of B phase will start from by adding 12 to 9 6 6 after 2 pole apart. Therefore, 9 plus 12, 21 21 and then 6 27 dashed 27 dashed means 3 dashed. Then 22 4 dashed 23 5 dashed and 24 6 dashed and you will see all the coil sides will be in place, if you want to carry on this winding. You can now go to that slots arrangements and find it out, but here one thing I want I have not kept enough space.

But the thing is if I draw the coils like this is 1 7 dashed, this 1 I am reproducing in terms of coil, which is much easier to apprehend 3 9 dashed for R phased I am showing and 4 10 dashed. And potential of 1 with respect to 7 dashed plus minus; this will be plus minus and this will be plus minus this will be plus minus. And you connect this in series to get the first group of R phase. Second group of R phase will be 13 19 dashed quickly

let me do 14 20 dashed, 15 21 dashed and 16 22 dashed. Here what should be the polarity?

One again same because this 13 and 1 are similarly placed at a given instant of time. So, this is plus minus, plus minus, plus minus, plus minus and you connect them in series get the group terminals here. Therefore, in this case you have to ultimately connect these 2 groups in series it will be just like minus to be connected to plus so, you can proceed to connect in that way.

So, this is plus minus plus minus plus minus plus minus. So, this is plus so minus then go there plus and these 2 will be the terminals of R 1 and R 2 and similarly for Y 1 and Y 2 you can do. Therefore, I have taken a slightly involved 120 degree phase spread winding because 2 polarity is too simpler thing. So, that you do not be under the impression it cannot be done for higher poles or higher number of slots and so on.

So, we find there will be 2 groups of R phase Y phase similarly it can be drawn which I am not doing I leave it to you. Therefore, in case the conclusion is in case of 120 degree phase spread winding, number of group of coils will be equal to number of pair of poles P by 2. See in this case number of poles were 4 so 4 by 2 to 2 groups; I group, II group this is one thing.

And in case of this we have seen earlier 60 degree phase spread winding. Number of group of coils, number of group of coils of a particular phase of a phase is equal to number of poles straight 4 pole 60 degree phase spread winding; if you look back, you will find for R phase there are 4 groups one under north, one under south, one under north, one under south. But in this case the very distribution takes place based on under a pair of poles. So, over a pair of pole you have 120 degree allotted to R phase in immediate succession next 120 degrees.

Therefore, as many pair of poles will be there so many groups will be there understood? Therefore, if it is a 6 pole machine you will soon discover there will be 3 groups. Only interesting thing is the polarity of the voltages here it goes fine because 1 starts under North Pole, 13 also starts under North Pole. Therefore, there they will be of like polarities and therefore, they can be straightaway connected in series.

However, in case of 60 degree phase spread winding you should be careful while connecting several groups in series. One point I would like to tell be it 120 degree phase spread winding. Generally group terminals are available you connect them in series sometimes the group connections in the winding itself will be connected inside.

And you will be machine will give out these 2 terminals phase terminals, ultimate phase terminals. But in any case what I want to tell you is that when the group terminals are available it is sometimes available the reason I will tell you later the connection among the groups should be carefully done.

And I will ask you questions later suppose somebody makes a mistake in that group connection what could be the effect of that? Those are very interesting things after machine has been owned groups are available they have to be connected in series. Also it is to be noted these groups may be also connected in parallel, it does not matter these groups say group I R phase this these two terminals and these two terminals they are identical all the voltages are. They could be connected in parallel and brought out for this is done for low voltage high current machines the outer current.

So, if the groups a group I and group II may be connected in parallel why not? And say this is your R 1 this is your R 2 parallel connection requires that voltages at all times must be same and connected like terminals. But do not connect plus with minus and minus with plus; then there will be internal short circuit of those 2 group voltages.

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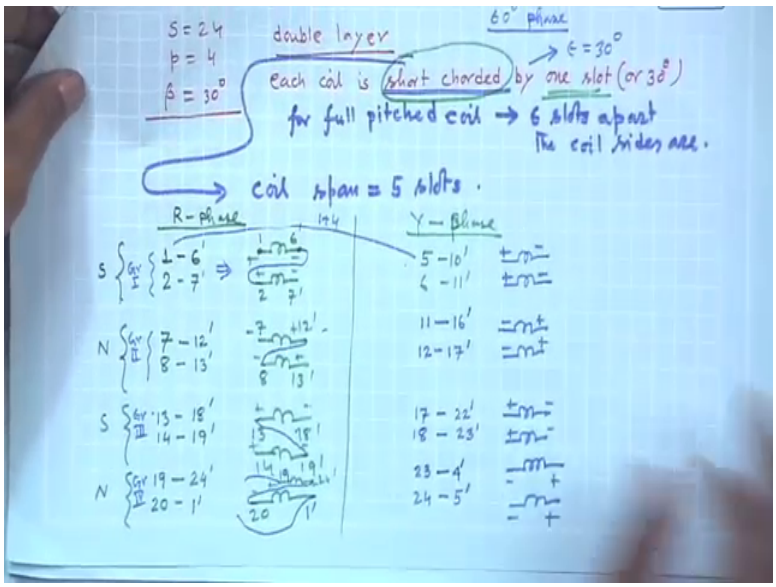

Similarly, a 4 pole machine I mean 60 degree phase spread coil for example, here there are 4 groups 1, 2, 3, 4 they can be connected in series and also all these 4's can be connected in parallels or 2 2 you take connect them in series and then the combination in parallel , but in that case you have to be only careful about the polarities.

So, generally for high voltage machines the coils will be connected in series so that it gives you appropriate voltage. Of course, no one stops you if you connect the coils in parallel and then specify the voltage. So, this I will not tell see winding is a very big thing there are other types of winding fractional pitch winding this that we will not go, but I have considered the winding to be one of the most important thing one must understand before he learns about how a rotating magnetic field will be produced by stationary poly phase balanced winding. That is the reason I went rather deeply into this.

And here about the windings I will not make further comments; whenever I say it is a balanced 3 phase winding, I know what it is what does it mean. And when the carry current will be discussed right now I mean there is now no stopping after I have gone through this few lectures about the windings. I think you will be placed in a better position to understand what exactly is going on when a balanced 3 phase distributed winding will be excited by balanced 3 phase current [FL].

So, the introduction to that will be in this way. Let us now try to understand that you have suppose the if some current is passed in a balanced 3 phase winding; then there are 3 phases R phase carries current it produces its own magnetic field. Then Y phase 2 will carry current produce magnetic field also B phase produces magnetic field of its own depending upon its current. If the winding is balanced externally I will show it like this.

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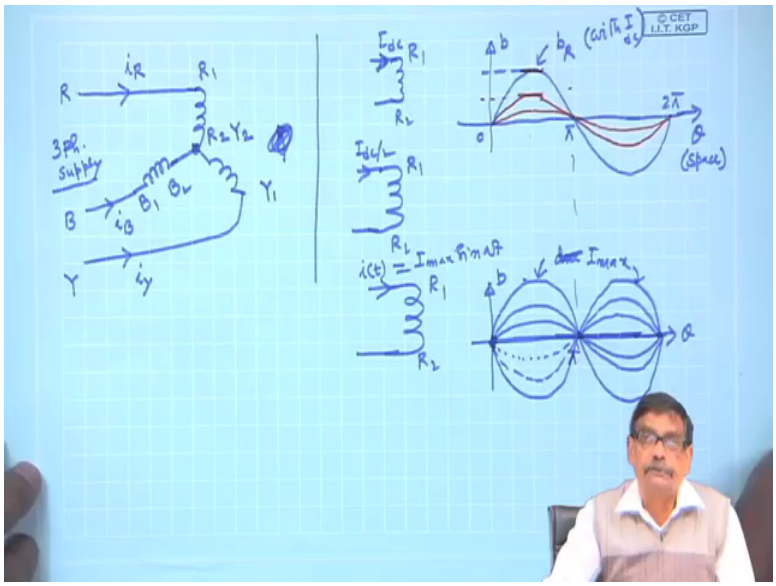

Suppose R 1, R 2 is the R phase 2 terminals these 2 terminals I am talking about after group connection inside the machine which are available to me. Similarly suppose Y 1, Y 2 is Y phase and B 1, B 2 this is how I will now represent the coil and suppose they are connected in star R 2, Y 2, B 2 R short circuited ok.

And what I am telling is this these 3 windings and this winding is suppose I mean carry current like this. Now, if you have a 3 phase supply; please do not miss any point when I am telling this is very important. If you have a balanced 3 phase supply; it is a balanced 3 phase it could be stator rotor winding let us assume stator houses this balanced 3 phase winding.

And I will connect it to a 3 phase supply you know I will connect it. And suppose the supply phase sequence is also like this R this is Y and this is B R Y B is the supply terminals. And since these windings are balanced; so they will take balanced 3 phase current. This is i R, i B and i Y balanced 3 phase sinusoidal current they will take because it is a balanced load connected across a 3 phase supply therefore, each coil is carrying time varying current ok.

Now when they carry steady state current we know what is the consequence. For example, if you pass a DC current to any of the coil say R 1, R 2 individually suppose I have passed some DC current of constant value I; what it will do? It will do it will make a space distribution of B ok space distribution of B will be there.

And if you consider only the fundamental component, it will have a peak value of this B. So, this is theta space angle I am passing a constant current only energize the R phase; drawing a constant DC current and it will generate a flux density distribution across the air gap of the machine and this is b R, this is 0 this is all electrical ok, this is pi, this is 2 pi.

And there will be some maximum value at associated with this current. What do you think if I say that I will energize the same coil with DC current, but I dc by 2 hop I have made the current out. What will be the flux density distribution? So, this is with I dc, if you make the current up and if you assume linearity the maximum value of the current depends upon number of turns and the magnitude of the current here.

So, it will then become hop; the same pattern, but only thing its big value if it was b max earlier, it will become b max by 2; make it one third, it will become one third and so on. Therefore, I know the effect of on b distribution as you change the magnitude of this current. Therefore, if I now say that this coil R 1, R 2 is carrying a time varying current i t; which is of the form I max, sin omega t, then the MMF distribution this is space magnitude space.

Now, the current magnitude is changing on its own, I do not have to change connect another DC source, pass the I dc by 2. It is own its own it is changing, when it will be 0, this B distribution there will be no bit distribution this will be this axis only that curve. When current becomes 1 ampere it will have some bit distribution like this, current increases it will be like this current becomes I max plus I max.

So, this is due to for I max this B distribution. And I also notice this current will become negative sometimes, then the polarity of the B will be also negative depending upon the magnitude of the current getting? So, this will be the kind of wave or MMF distribution, flux density distribution along the air gap of the machine. We will continue with this.

Thank you.