Electrical Machines - I
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Lecture - 50
Parallel Operation of Transformers - III

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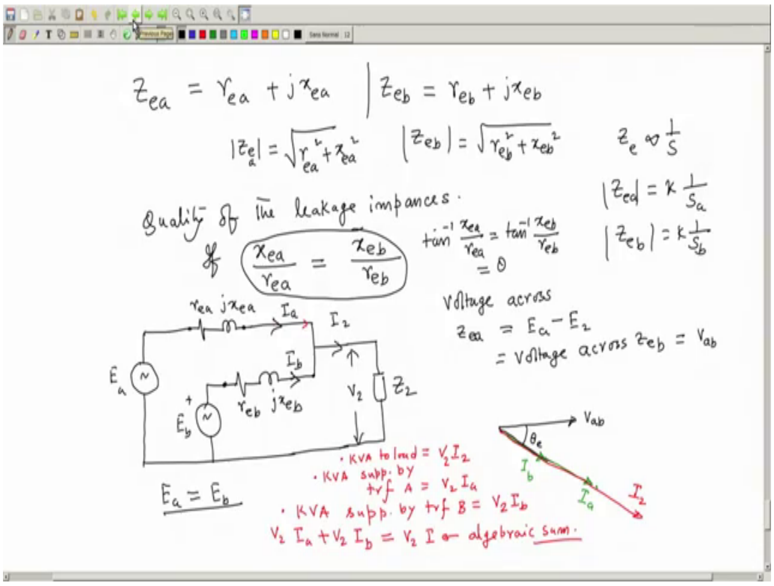

Welcome to 50th lecture on Electrical Machines – I, and we have been discussing about Parallel Operations of Transformer. So, we have seen that in our last class the impedances of leakage impedances of the transformer should be inversely proportional to the KVAs and in ohms and also of the it is always better if the qualities are also same. Then, whatever KVA is supplied by this, whatever KVA is supplied by transformer be just algebraic sum of this two will come.

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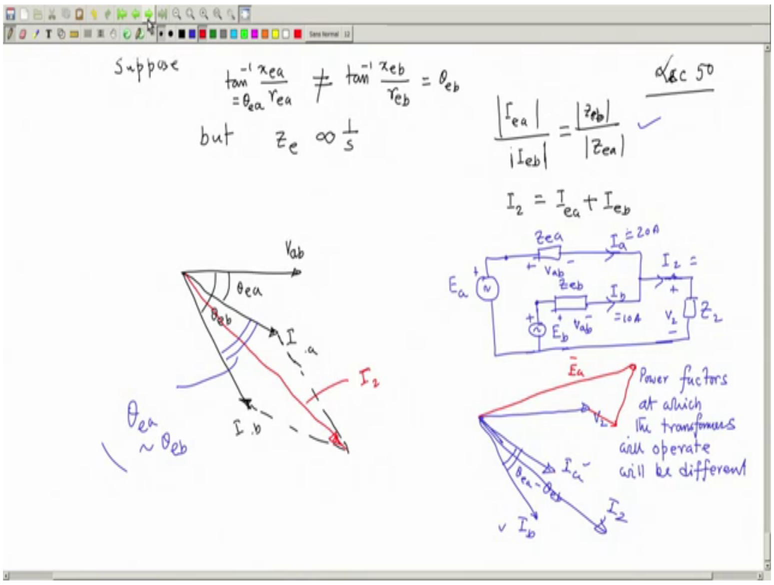

Now, what is going to happen if this condition is not fulfilled? Suppose, suppose tan inverse x ea by r ea is not equal to tan inverse x eb by r eb. Suppose, they are not equal, but impedances are inversely proportional to the KVAs, but Z e is are proportional their respected KVAs for a Z ea 1 by S a and Z eb like this. So, one thing is ensured that is the ratio of the currents will be Z I ea magnitude of I ea by magnitude of I eb this will be this will be Z eb by Z ea because KVA s are inversely proportional. So, magnitude of I ea and I eb will be in the inverse ratios, but what is the implication of this then.

We have seen already that the voltage across this impedances are same and that voltage denoted it by V ab. So, let us draw this once again this phasor diagram. Suppose, this is V ab which I have already defined which will be small I am drawing it very large [laugher] just to understand. So, this is this one. Now, I am telling this two angles are not same ok. So, you draw I ea, I am sorry you draw I b eb this lengths are decided by this ratios for a given load current I ea, I eb.

Therefore, this is the suppose this angle I say it is theta ea and this angle I say it is theta eb. So, that the this angle is theta ea and this angle is theta eb, is it not? This way it will lag. Earlier this two angles were same I ea and I eb were in phase. Now, where is your I 2? I 2 is equal to I ea plus I eb phasor sum. So, add them vectorially. Add this two and you will say your load current the this is your I 2 now, is not? This will be the I 2.

Now, I redraw this circuit to avoid any confusion that is over to your planning this is my circuit, this is your Z ea, this is your Z eb. Sorry, this is your Z eb this two are parallel this is your I 2, this is your I a, this is your I b and here is your secondary load Z 2 this is the thing same thing. Here only that source will be there e b. So, e b e b. So, this is E b, this is E a and so on. This is the thing. So, your I 2 is equal to I ea plus I eb I ea why I ea I have written I a transformer a I was not writing this. So, I a plus I b.

Now, in numbers for the given example I have telling if you are the this what you will see is this you will see that this I 2 will be suppose 30 ampere suppose the output load current is 30 ampere, then the other two transformer this current will be shared as 20 ampere and 30 ampere; 20 and 10 ampere which one was Z ea was 20.

Student: Sir, 20.

[FL] 4 KVA. 4 KVA so, this is this is suppose 30 ampere. You imagine ammeters are connected here. It will read 30, it will read 20 ampere, it will read 10 ampere because of what because of the fact this thing.

Student: I 2 will be less than sum of all.

Student: I 2 will be less magnitude of I 2 will be less than I ea plus I eb because they are not (Refer Time: 07:45).

It will be less than, is it?

Student: I 2 will be less than yeah.

I 2. So, you see that when it will carry correct when it will carry 20 ampere and when it will carry 10 ampere these two sum of this two currents cannot be 30 ampere. It will be less than this. In other words what I am telling that this two transformer will be operating at different power factors. For example, so far as this transformer is concerned V 2 it is contributing I a at this much angle it will because V I I to this V ab which is this voltage here if you add say I want to get what is E a. E a, E b are same.

So, it will be like this V ab; V ab is which these two points are at same potential we have seen. So, potential of this point will be this voltage this I have assumed it to be V ab, this is also V ab. Now, E a I want to get. So, you see that I a and I b they will be displaced and this angle will be the difference between theta ea and theta eb, that is understood. Now, I want to get this voltage is V 2 V 2. Suppose from V 2 I want to get E a.

So, I will now start from V 2 I will draw V 2 first, but if you start drawing from V 2 that this transformer the angle between this two is theta ea difference theta eb, is not that will be the angle I a and I b angle will be that one. So, suppose this angle this current is I a and the other transformer current is I b, such that this angle is this one, are you getting? theta ea minus theta eb.

Therefore, you can easily see the power factor at which this transformer and this transformer is operating is at different values. So, power factors at which the transformers will operate will be different and your total load current will be in between here I I 2 therefore, to get the E a back or E b back you have to add I will just indicate here V 2 plus I r ea I Z ea axis like that and you will get E a. Same thing you will get if you add to V 2 I b r eb plus I b Z eb, got the point?

Therefore, we find that since the vectors sum of I a and I b will be less than the sum of this two currents when they are co-phasal therefore KVA handled will be slightly less. Therefore, to I mean summarize this what I will say that to operate a two transformers in parallel successfully voltage ratio should be same, leakage impedance should be inversely proportional to their KVAs and try to also see that the qualities of the leakage impedances are same that is the best thing ok.

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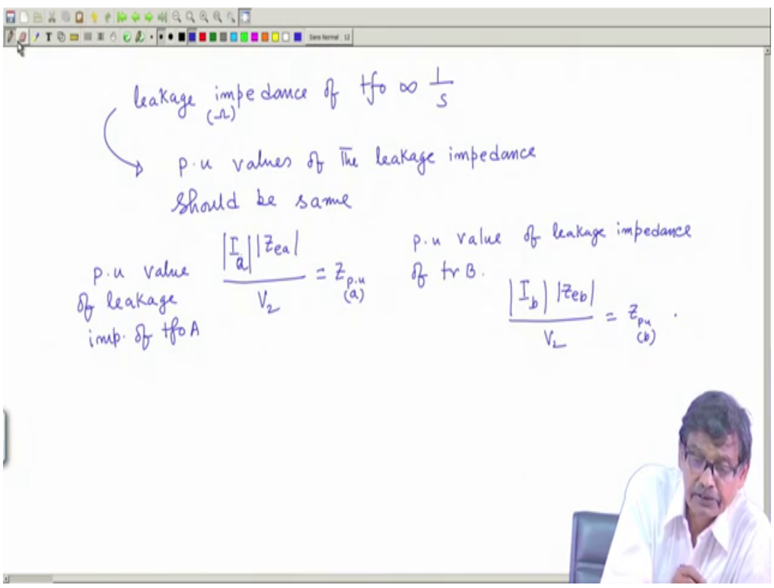

So, one important thing sometimes people say that leakage impedance that is what we have seen leakage impedance of the transformers of the transformers should be proportional to their KVAs 1 by S ok; leakage impedance in ohms. The same statement is told in this way that per unit values of the leakage impedance should be same. This is one and the same thing because you know per unit values of impedance for transformer a it will be I a rated current into magnitude of Z ea with respective the rated voltage of that side.

We are talking about the other side this is the per unit value of leakage impedance of transformer A this is the thing, all referred to the secondary side. Similarly, per unit value of leakage impedance of transformer B will be its rated current magnitude of the rated current how much is dropped in that with respect to the rated voltage I b Z eb by same voltage V 2 this is called Z per unit transformer A and this is Z eb per unit Z ea per unit Z per unit A transformer Z per unit B transformer Z per unit transformer B, are not this two are same?

What is I a into Z ea? Voltage across Z ea and voltage across Z eb that is this no point in redrawing.; voltage across Z ea and voltage across Z eb in volts they are same; this voltage minus this voltage is this voltage in case E a equal to E b therefore, and what is the per unit leakage impedance? Per unit leakage impedance physically it means that when rated current flows through the transformer there will be some voltage drop magnitude of that voltage drop expressed as the rated value of the voltage of the transformer of that side. And, per unit values are same with respective to secondary or primary for a given transformer.

Now, since I a Z ea is equal to I b Z eb here all the parameters are with respect to the secondary side, they are same. Therefore, instead of telling that ohmic value is inversely proportional to the respected KVAs you simply say per unit impedance of transformer A and per unit impedance of transformer B, they are same that is all. So, we have gone through. Now, the last thing I will tell about the parallel operation of transformer is what happens if it is a three-phase transformer because after all in our power system it is all three-phase transformer.

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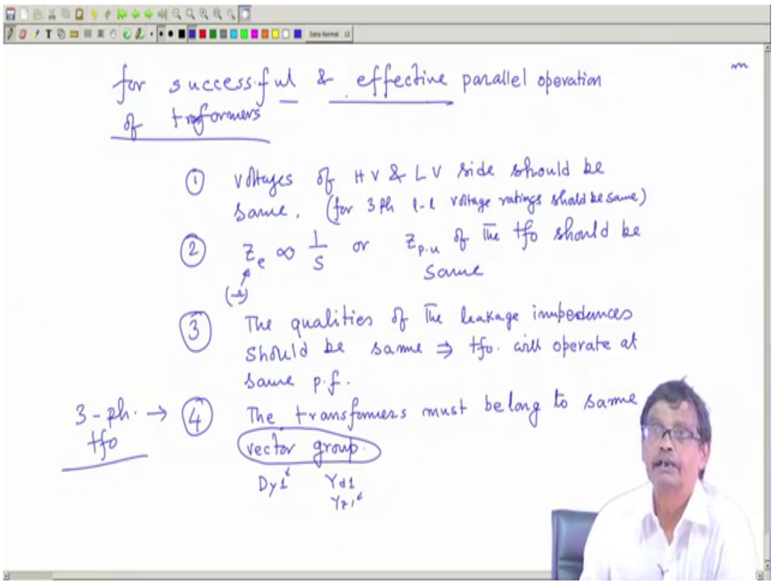

So, I write down this conditions once again. So, I write down for successful so, for successful and effective parallel operation of transformers we list voltage ratios. Voltages not voltage ratios voltages of HV, LV side should be same HV and LV side from transformers various transformers. Voltages of HV LV side should be same or very close to each other will same that is all. Let us not complicate the issue. This is the thing.

Second thing is leakage impedances. I write I am writing in short leakage impedance Z e should be inversely proportional to their KVAs this is in ohms or same thing is Z p u's per unit of the transformers should be same. When this condition is satisfied what is guaranteed? The current divisions of the transformers will be in the ratio of these two currents fine.

Then, the third condition is which is desirable condition that ok, the qualities of the transformers qualities of the equivalent of the leakage impedances the leakage impedances should be should be same. This will ensure transformers will operate at same power factor transformer will operate at same power factor.

Now, number 4 and of course, this I have not listed with due regard to polarities you have to connect otherwise what. 4 – fourth is for three-phase transformer only thing is we will say that line voltages other things are there these are line voltages because after all voltage of HV side LV side same because line voltage three-phase transformer that is how it is specified. We must write that the transformers must belong to must belong to same vector group.

What is the vector group? Plus 30 degree or 11 or 1 which means that are you getting the line to line voltage rating should be same. Here I have written simply voltages of HV LV side should be same for three-phase line to line voltages should be same, voltage ratings should be same, got the point? Line to line voltage ratings are same and then I am telling the transformer must belong to same vector group that is plus 30 degree or minus 30 degree and so on.

This tells me suppose you have a transformer D y 1, the other transformer need not be D y 1, but it must be Y d 1 that is what I mean same vector group parallel operation means line to line voltages are same and they must belong to same vector group. Of course, I have see primary you have applied a voltage, it is getting shifted both phase and line to line voltage get shifted by some angle of 30 degree or so. But, primaries will be connected in parallel, secondaries will be connected in parallel and they must be shifted by same angle then only the voltages magnitudes of course, will same and then parallel link can be done successfully.

So, this is the thing we must add. Of course D y 1 can be parallel with D y 1 no question, but I should not demand that one transformer is D y 1 another transformer should be also D y 1. No, it could be Y z 1 also, it can be parallel with clear that is they must belong to same vector group that is this numbers should be same apart from the fact that the line to line voltages have same and then for better load sharing this things are valid that is the impedances should be inversely per phase impedances should be inversely proportional to their KVA ratings and per unit impedance should be same of both the transformer ok.

So, this is a in short or whatever you call it not so short, but I hope I have been able to give you some idea of how transformers can be operated in parallel, what is the need of making transformers operating in parallel, and most importantly you must have appreciated this conditions why they are to be fulfilled in order that successful and effective parallel operation can be implemented ok. So, we will continue with some more topics on transformer before starting DC machines.

Thank you.