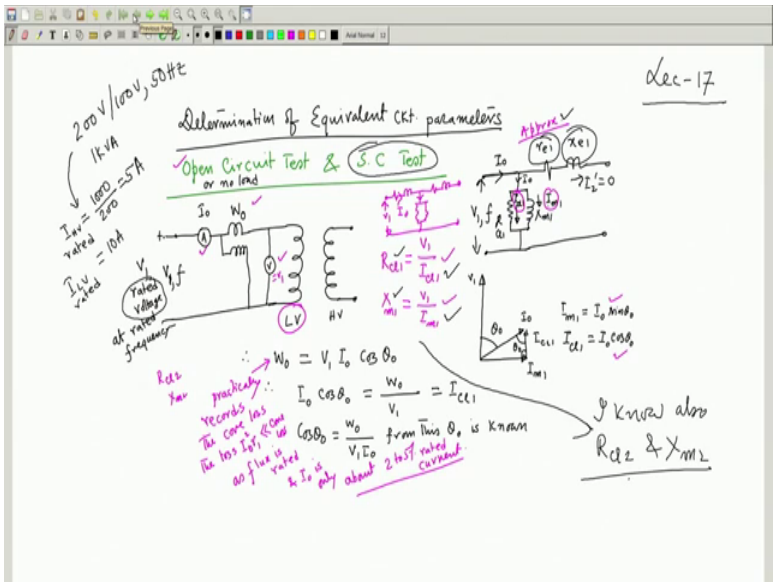
Electrical Machines - I
Prof. Tapas Kumar Bhattacharya
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 18
Choosing Sides to Carry Out O. C/S. C Test

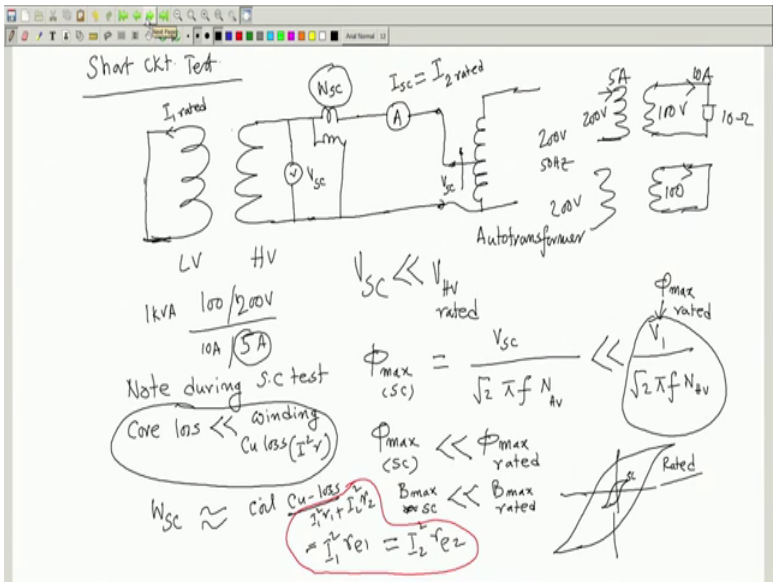
Welcome to lecture number 18 and we have been discussing about two simple tests, performing those two tests one can determine the equivalent circuit of a transformer.

(Refer Slide Time: 00:41)



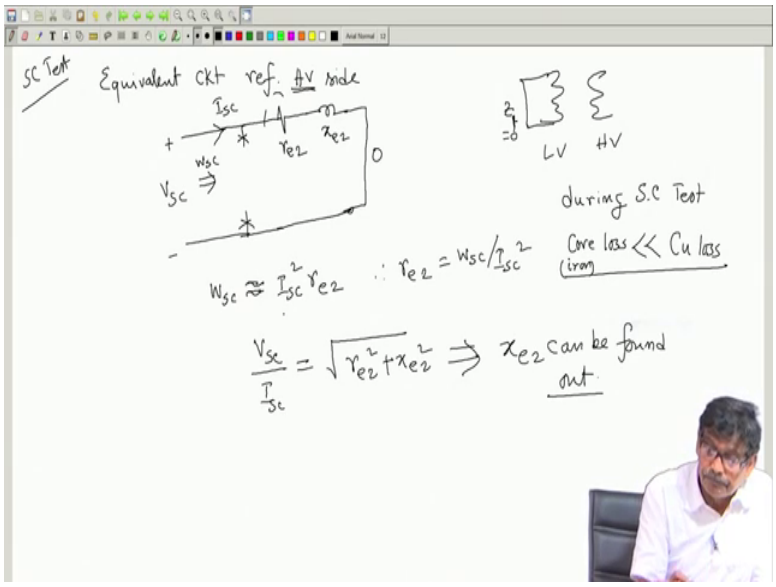
For example, you first do the open circuit test and open circuit test is carried out from the LV side and you will be if you call the LV side as 1, then you will be getting this R cl 1 and X m 1. Similarly of course, I have not told you why it should be done on from the LV side, that I will discuss today.

(Refer Slide Time: 01:11)



And, then if you carry out the short circuit test better carry it out from the HV side the reason we will discuss. But, if it is carried out from the HV side then what parameters you will get is r e 2 and x e 2 and the calculations are pretty simple.

(Refer Slide Time: 01:31)



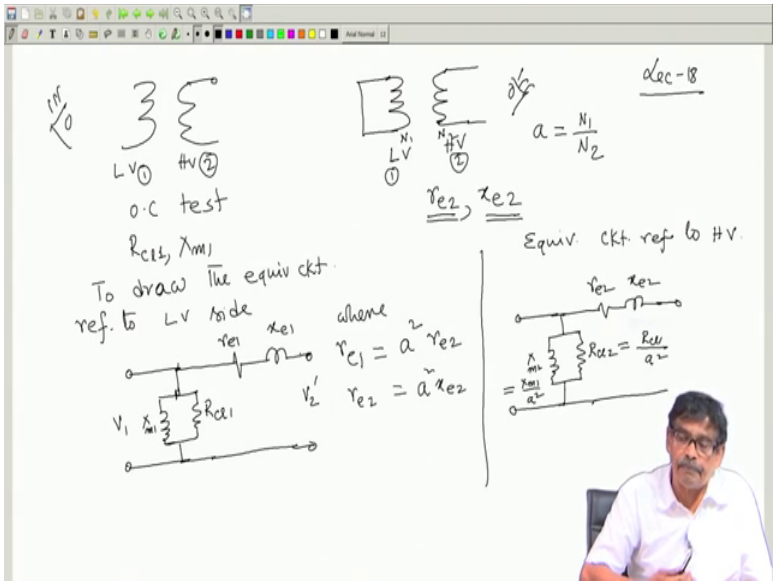
In this case the wattmeter reading, then approximately it records the copper loss, core loss can be neglected. During short circuit test some ways I right during SC test core loss it takes place no doubt is much much smaller then copper loss. Iron loss sometimes core

loss is also called iron loss whatever it is much smaller. So, that can be neglected and we say the wattmeter reads the copper loss only.

And, this saying in language in the equivalent circuit it means you can neglect this branch; both magnetizing current can be neglected as well as core loss component of current can be neglected whatever power is drawn. That wattmeter reads real power only, real power loss will take place here in r e 2 I SC square r e 2 and V SC by I SC from the j d 2 these two can be found out.

So, now we have carried out two test, but my final objective is to draw the equivalent circuit; it referred to a particular side. Referred to which side? It is my choice, the users choice he decides with respect to side 1, I want to draw the equivalent circuit. Or, somebody else would like to draw the equivalent circuit referred to the secondary side, but nonetheless whichever side you draw your end results will come same. So, you need not worry about this side ok, you choose this side with respect.

(Refer Slide Time: 03:35)



Now, after doing this test you see that I just draw here LV side, from LV side I carried out the OC test. And, whatever values you have got in the open circuit test this is the HV side; HV side was open. You got R Cl 1 the parallel branch and X m 1 this two values I got. And, while doing short circuit test which I told you for reasons not yet told that you suppose carry out the short circuit test from the HV side and during short circuit test you

keep it shorted. So, you are looking at the equivalence circuit referred to this side then you will be getting r e 2 and x e 2.

Therefore, to draw now I want to draw the equivalent circuit; to draw the equivalent circuit referred to and suppose LV side I am calling it side 1, HV side calling it side 2; so, this is 1, this is 2. So, to draw the equivalent circuit it refer to, LV side it should be drawn like this now V 1 rated voltage you will apply and approximately equivalent circuit I am telling this is R Cl 1 and this is X m 1 parallel. And these values are already known so, I will put these values and then I have to that series impedance which I know it must be r e 1 and x e 1.

But, from short circuit test I have got r e 2 and x e 2. So, do not put r e 2 x e 2 here then that will be a blunder. So now, you have a duty to change these r e 2 to r e 1 and x e 2 to x e 1 and that can be easily done since r e 2 and x e 2 is known. So, a turns ratio from the rating of the transformer I know it is N 1 by N 2; r e 2 with respect to side 2 it is known. Therefore, this r e 1 should be so, r e 1; where r e 1 should be equal to a square into r e 2, where a is this turns ratio N 1 by N 2. And, r e 2 is equal to a square into x e 2 this you have to do then put it here.

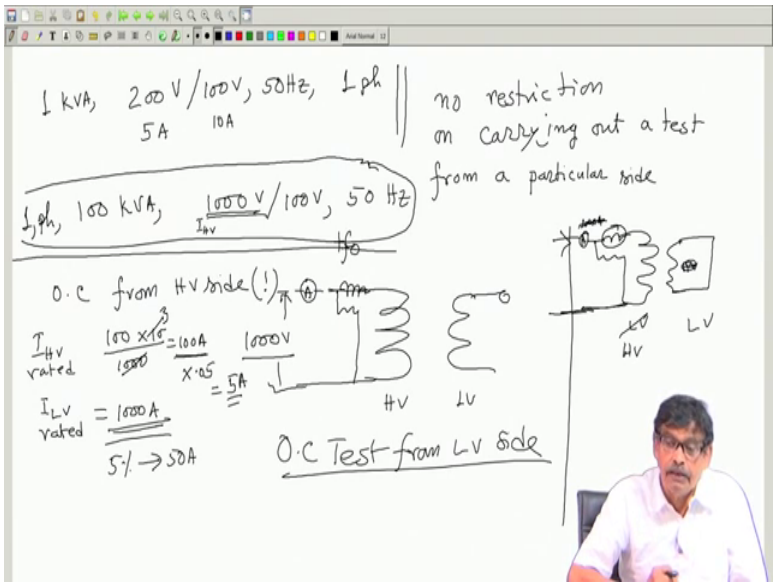
So, these values should be transformed correctly, then write it here this is the equivalent circuit. What should I write, should I write V 2 here? No, I should write V 2 dashed and so on. Then wherever this circuit is now connected I can replace that transformer by this equivalent circuit and calculate all the things needed. Similarly, this test although has been done from LV side and HV side to draw the equivalent circuit. So, once you know this then you know equivalent circuit refer to HV side will simply be this one.

Structure remains same here with respect to HV side they you should right here r e 2 x e 2 do not disturb them, because that is with respect to HV side those parameters unknown. But, the only thing then do not right here R Cl 1, you should write R cl 2 and X m. And what is R Cl 2? It should be R Cl 1 by a square and X m 2 as X m 1 by a square. Therefore, you can do the test either from LV side or HV side then you can of course, draw the equivalent circuit refer to any side you like. But, you should be careful about these two points.

Now, I will tell you why people say that generally you carry out the LV test from the short circuit test from the LV side and open circuit tests from the LV side and short

circuit test from the HV side. The reason is rather more practical than ah saying that it cannot be done I mean. For example, in this transformer the rating of the transformer I chose to clarify some of the points.

(Refer Slide Time: 10:07)



Suppose the rating of the transformer is our this transformer 200 volt stroke 100 volt, 50 Hertz, single phase and kVA rating is suppose 1 kVA. And, as I told you the rated current of this side is 5 ampere and this side is 10 ampere. And, these numbers you can easily calculate straight away; once a problem is given be ready with these numbers what are the rated currents of these two sides. Now, for this transformer of this kind of rating there is really no restriction because, in the laboratory these voltages are low voltages and available in the lab.

So, so one should not make a issue or insist that for this transformer you carry out the test from OC test from the LV side and SC test from the HV side. Reason is simple these two voltages are available in the lab, we can always get these two voltages of 50 Hertz using a transformer, auto transformer always you can connect to get these voltages. Similarly, these current values are also reasonable values 5 ampere, 10 ampere is no large values at all no issues. You can have Watt meters of this ranges. Therefore, if you carry out the open circuit test from the HV side, you can do it what is wrong.

So, for this kind of transformer of this kind of rating no restriction on carrying out a test from a particular side. Remember let us come to the circuit diagram of open circuit test,

it need some telling open circuit test. Suppose the rating of the transformer is this it is written there fine. Now, if I carried out the test open circuit test for this transformer from the high voltage side, I have to apply rated voltage 200 volts 50 Hertz is available, I will apply that. Rated current of the HV side is 5 ampere only is not, HV side is 5 ampere.

So, is no load current will be small ok, but meters are available to record that, similarly wattmeter with rating 200 volt and that current rating estimated current is 2 to 5 percent. I can easily carry out the test either from this side or then that side; no problem at all in the laboratory because all the ranges of the meters are available and so on and no safety issues also is not. Now, similarly during short circuit test, if you had carried out the short circuit test energizing from the LV side, keeping the HV side shorted also for this transformer no issue. Because, rated current is only 5 ampere and 10 ampere; LV side you can do you will.

So, all the voltages and currents to be measured, power to be measured or all those meters are available and there is nothing wrong in that. But, you imagine suppose I say you that I have to test a transformer, I asked you to find out the rating of a transformer whose rating is 100 kVA. I am just taking some 100 kVA, then say 1000 volt stroke 100 volt, 50 Hertz transformer single phase. This is the transformer whose parameters I want to find out. Suppose, somebody says that I will carry out the open circuit test, he suppose thinks that open circuit test from the HV side, OC from HV side suppose somebody decides.

Can I not do it? Open circuit test demands that whichever side you energize you have to apply rated voltage because, you have to create rated flux. So, all the core loss should take place therefore, suppose somebody this is the HV side and LV side he keeps open circuit. So, he has to apply 1000 volt here and he has to connect an ammeter and then wattmeter and they voltmeter. First thing is to carry out the open circuit test from the HV side in the laboratory you then require a 1000 volt, 1000 volt is not easily available.

Although perhaps 200 volt is available, connect another transformer get 1000 volt that is also not a big issue. But, the point is whoever will be doing this experiment his safety will be in question or the heat a table of this equipments we have kept, you will switch on 1000 volt supply, 1000 volt supply is dangerous in the laboratory. You cannot work unless it is a high voltage laboratories specially designed therefore, immediately you see

to apply rated voltage I come and say you do not do this a that will be a big safety issue cannot apply. So, open circuit test carrying out from HV side that is why people in general say carry out the open circuit test from the LV side understood.

So, 1000 volt you cannot apply. Similarly, also you see then he will require a pressure coil whose rating is 1000 volt current coil rating of course, will not be a big problem. Because what is the rated current? As I told you given a rating of the transformer of this kind, what is rated current of the side I HV rated is how much? 100 kVA divided by I HV rated is how much? It is 100 into 10 to the power 3 volt ampere divided by 1000 is not so, 100 ampere. What will be I LV rated? I LV rated will be how much? LV side rated current will be higher. What is the turns ratio? 10 so, 10 times higher 1000 ampere getting.

Now therefore, you see I am doing the test; trying to doing the tests from the HV side then I see I HV rated is this one. What will be the order of no load current? About say 5 percent. So, 5 percent of 100 ampere into 0.5 is how much? 5 ampere therefore, the current drawn will be less, that ammeter I can have. Similarly, current coil of the wattmeter will not be an issue from the HV side, but the voltage is high which is dangerous for the personnel will be carrying out the test. So, this should not be carried out from the HV side.

But, from the LV side if you do what during open circuit test, how much voltage you need to apply? 100 volt only, very safe available voltage in the lab. What will be the pressure coil of the wattmeter? 100 volt. What will be the order of the no load current? 1000 into 0.5 say 5 percent of this one, how much it is? 50 is not for this particular transformer; so, 5 percent of this is 50 ampere ok, 50 ampere large current voltage is not high. So, I can use CT PT or ammeters of measuring a 50 ampere is available do not worry, even if it is not available I can use CT to scale down the current, pressure coil no issue.

Therefore, it is this thing you do LV side so, for large transformer with ratio of turns ratio are very large then really it becomes an issue high voltage. So, carry out so, OC test from LV side always LV side. Now what about SC test? Short circuit test people say carry on carry out from the HV side. Why? Because, during short circuit test you know you will be suppose somebody says, no I will carry out the short circuit test from the LV side. If

you want to carry out the short circuit test from the LV side, what are the things you require? What are the meters you require LV side suppose? You require ammeter, you require wattmeter and a voltmeter. Suppose from the LV side, how much voltage you will be needing? What is the LV side? 100 volt very little voltage is needed that is not a big issue with an auto transformer not 100 volt you apply and HV side is shorted, is not HV side is shorted.

But, what is the rated current? Rated current is 1000 ampere. So, you have to measure that current 1000 ampere, range ammeter may not be so easily available or of course, you can use CT PT and voltage rating is small. Similarly, the current coil of the wattmeter should be of the rating of the same in the laboratory such a wattmeter may not be available. Therefore, all these point to the fact, but if this was HV side and this was LV side you see high voltage side what is the rating 1000 volt. But, do not require 1000 volt to carry out SC test only little voltage maybe 10 percent of that which will circulate the rated current.

So, 100 volt 100 50 volt etcetera and the current will be also small rated current is only 100 ampere. So, these are the issues why people say carry out for transformer with large transformer high kVA rating large voltage ratings, if voltages ratios are one side is kVA another side is volt. For example distribution transformer 6.6 kVA of course, those are three phase transformer, but 6.6 kVA and 440 volt. This is the kind of transformation ratios, in that case to carry out the open circuit test you carry it out from the LV side. And, similarly to carry out the h short circuit test carry it out from the HV side.

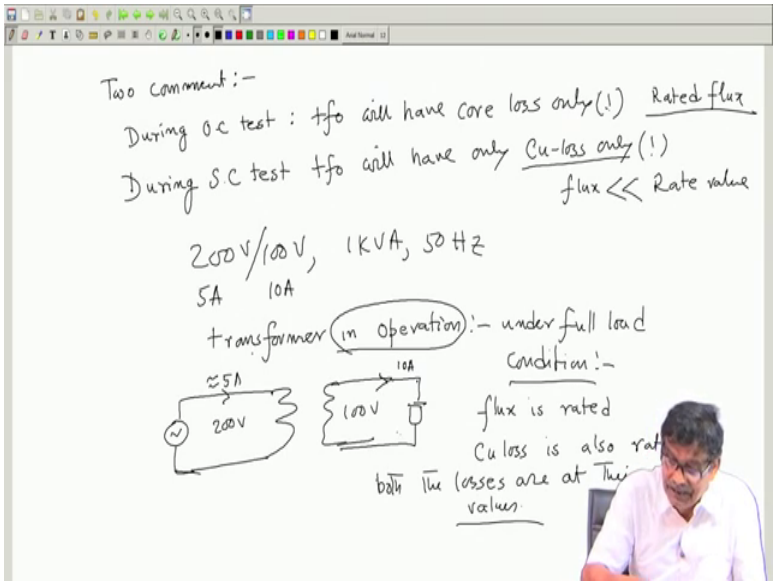
And, in generally this is the statement of course, since it is expected you will carry out the test from two different sides. Therefore, at the end after getting the parameters parallel branch parameters referred to the LV side and equivalents series impedance parameters which you will get from the short circuit test carried out from the HV side.

Then you stop you think a bit before drawing the equivalent circuit referred to a particular side, you have to do a little bit of transformation either that parameter or this parameter depending upon from which side you want to draw the equivalent circuit of a transformer.

So, there are a lot of examples, consult any machine book I have not yet told any machine books names yet. I will tell you will somewhat later, I will insists that first go

through the lectures and whatever study materials I gave you go through that then I will give you names of some books. There are so, many books good books are there, open the chapter equivalence circuit see the data of open circuit test and short circuit tests, on your own try to find out the equivalent circuit parameters. Only one comments about these two testing, see two comments.

(Refer Slide Time: 26:31)



Two or one anyway let us see whether two comments can be made, what I am telling note that during open circuit test no matter from which side you do theoretically transformer will have core loss only practically, core loss only is not. Because, copper loss is neglected only little current is drawn and during short circuit test transformer will have only copper loss only. I have put this symbol to indicate that little bit of core loss copper loss will be there, here also core loss will be there. Why?

Because, during open circuit test rated flux, rated flux means rated flux density; rated flux density means core loss will be at its rated value. And, we will have only copper loss during short circuit test because flux is much much smaller than rated value. Why? Because, you require very little voltage to carry out short circuit test and it is copper loss only.

Therefore, if you take a transformer and while carrying out this two test we find this is the situation. But, certainly you have purchased a transformer for example, the same old

good old transformer I am always referring for easy calculation 1 kVA etcetera, rated current is 5 ampere, rated current is 10 ampere, 50 Hertz etcetera is there.

Now, you have purchased a transformer you do the open circuit short circuit test, but you will be putting this to use. So, that transformer is fully loaded, it should operator under full load condition. For example, you would like to see transformer this transformer in operation, what will be the situation? In operation situation will be you apply 200 volt here, approximately you will get 100 volt there and you will connect an impedance air. So, that you have purchased 1 kVA transformer, you would always like to see the transformer operates under full load condition. So, you must apply rated voltage, get almost rated voltage on the secondary side.

Voltage across this terminal maybe a little less that is we will see that, but what I am telling for normal operation I would like to see this side carries 10 ampere current. This side carries current 5 ampere and you will be happy because based on that only you have purchased a transformer. You have not purchased a transform to carry out open circuit and short circuit test and that is there to find out the parameters. But, you have purchased these transformer you know you have to supply a load at 100 volt 10 ampere current. So, this transformer should be put to use under this condition, applied voltages are on this side, that side, rated voltage and windings are also rated current.

Then only you are really utilizing the transformer properly, these the transformer in operation you would like to have this situation prevailing. You have spent so, much money to install this transformer to supply the load. Certainly not you have connected a transformer and supplying a load which is 2 ampere secondary, what is the plan then why you purchased a transformer of secondary current rating 10 ampere. So, this will be the situation. We would like to see this thing happens you will be happy, oh transformer is now fully utilized.

And, it is called rated condition windings are carrying rated current and also. So, in this case transformer in operation under full load condition, under full load condition I will be very happy. So, the flux is rated as well as copper loss is also rated because, windings are carrying rated current is not. Both these losses unlike open circuit and short circuit test during open circuit test only core loss rated value. During short circuit test only

copper loss at rated value, but when the transformer will be in operation both these losses will be at its rated values you must understand this.

So, both the losses are at the rated values. So, if I ask you a simple question that open circuit tests there is power loss temperature will rise. There will be some temperature raises in open circuit test, there will be some temperature rise during short circuit test you measured them ok. This is the maybe 30 degrees, the temperature some number I am just telling. Here it is suppose 35 degree copper loss, but when the transformer will be operating at rated voltages and also windings are carrying rated current, that is what I would like to happen.

I would like to see this thing happens, then only I will be satisfying myself I purchased a transformer of this rating whose windings can carry rated current 10 ampere 5 ampere, voltages can have 200 100 volt under this condition; only I would like to see the transformer is operating. But, when the transformer will be operating under this condition both these losses will be present and temperature arise will be much higher than this; under these two conditions. Anyway this you would just note, we will refer to this information later in the next class.

Thank you.