



VEBKO ONLINE HELP

CT Excitation Test, Part 4

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1 Imported Content

Saturation Point and Frequency Variation

As mentioned earlier, the core losses include eddy current and hysteresis and its model is as you can see here:

$$P_f = K_e (V^2)$$

$$P_h = K_h \cdot V_x / f^{1-x} \Rightarrow P_h = K_h \cdot f^{1-x} \cdot V_x^2$$

$$P_c = P_e + P_h = K_e (V^2) + K_h \cdot f^{1-x} \cdot V_x^2$$

By using this relation, we can obtain the Foucault and hysteresis resistance models which Foucault resistance model is linear and independent from the voltage while hysteresis resistance model is non-linear and dependent on the voltage.

$$R_e = 1/K_e$$

$$R_h = 1 / (K_h \cdot f^{1-x})$$

If voltage is fed from the secondary side, since R_{ct} and the current drawn from the source is clear, the voltage of the parallel branch is calculated using:

$$E = V_{terminal} - R_{CT} \cdot I$$

After calculating E, the core losses are calculated using:

$$P_c = E \cdot I \cdot \cos(\phi)$$

By having the core losses value and its extended formula

$$P_c = K_e (V^2) + K_h \cdot f^{1-x} \cdot V_x^2$$

It is possible to calculate K_e , K_h and X by solving the three equations in the three variables system. To solve these equations, it is possible to apply three different voltages. But if the frequency is the same, its determinant turns zero and no answer can be obtained for the variables. Therefore, it is better to apply one of the voltages with a different frequency.

In the first step of solving these equations with V_1 and f_1 as voltage and frequency, K_e and $(K_h \cdot f_1^{1-x})$ parameters can be obtained using a two equations in the two variables system.

$$P_{c1} = K_e (V_{12}) + K_h * f^{1-x} * V_{12}^2$$

$$P_{c2} = K_e (V_{22}) + K_h * f^{1-x} * V_{22}^2$$

Now, if one of the voltages is applied along with f_2 as the frequency, "x" is obtained and by substituting it in $K_h * (f^{1-x})$, K_h obtained achieved as well. By specifying these parameters, the resistance of Foucault and Hysteresis obtained.

$$P_{c2} = K_e (V_2^2) + K_h * f_1^{1-x} * V_2^2$$

$$P_{c3} = K_e (V_2^2) + K_h * f_2^{1-x} * V_2^2$$

Due to voltage application limit for CTs with a very high saturation point, it is possible to find the saturation point in the nominal frequency by decreasing the voltage and frequency with the same proportion. Because the relation of the according flux is V/f .

But does not changing the frequency change the CT system? To explain this subject, we need to examine those components of the CT that are affected if the frequency and voltage are changed. According to previous analyses, R_{ct} is dependent on the material of the wire and Reddy to the material of the coil. In X_m branch, due to the proportional change of V and f and the stability of the flux, this branch remains unchanged as well. Therefore, the only parameter affected by the voltage and frequency is hysteresis resistance which was obtained.

$$R_h = 1 / (K_h * f^{1-x} * V^2)$$

Now suppose that to obtain the saturation point, the fed voltage and frequency are split in two. Is it possible to obtain the saturation point in the nominal frequency by multiplying the voltage and current by two? This will be clarified later.

Suppose that the CT knee point is obtained by decreasing the frequency to 25 Hz with 500 volts of voltage and 15 milliamps of current. The voltage of the parallel branch is obtained using:

$$E_{Exc} = V_{terminal} - R_{ct} I_{Exc}$$

Since now we have K_e , K_h and x , by dividing E_{Exc} by R_{eddy} and R_h , I_a and I_h currents are calculated. By subtracting these two from I_{Exc} , the self-inductor current is obtained. According to this relation,

$$\Phi = L * I$$

when the flux is fixed, the self-inductor current is fixed as well. Therefore, by doubling the voltage of the parallel branch, this current remains fixed. After doubling the voltage and frequency, as it is

shown in this formula.

$I_{h} = 2 E_{Exc} / (K_h * f^{1-x} * V_h^{x-2}) = 2 E_{Exc} * (K_h * 50^{1-x} * 2 E_{Exc}^{x-2})$

$I_h = 2 E_{Exc} / (K_h * f^{1-x} * V_h^{x-2}) = 2 E_{Exc} * (K_h * 50^{1-x} * 2 E_{Exc}^{x-2})$

$I_e = 2 E_{Exc} * K_e$

The Foucault and hysteresis currents are calculated and added by self-inductor current to achieve I_{Exc} using this relation. Then, the voltage of the parallel branch which is $25 E_{Exc}$ is added to $R_{ct} * I_{Exc}$ and the terminal voltage is obtained.

As you know, the maximum output voltage of a device in one-phase mode is “450” volts. Usually, to avoid damaging the measuring equipment, measuring CTs go to saturation in low voltages. But the saturation voltage of some protection CTs such as “TPX”, “TPY” and “TPZ” is too high and usually this saturation point voltage is beyond the ability of the device. To test these CTs, it is possible to increase the voltage until the CT goes to saturation but some scientific references suggest that high voltages must not be fed into CTs because high voltages can damage the insulation resistance of the equipment. Another method for excitation test in CTs with too high saturation voltage is to decrease the frequency. This method is also mentioned in the standard CT excitation test, which can be performed with an “AMT105” device.

As you saw, the knee point of a 5P10 protection CT in 50 Hz frequency was measured to be about 159 volts. If you wish to specify the value of the final voltage and injected frequency manually, you need to uncheck “Calc. from Test Object” option and fill “Frequency” and “V end” fields. For example, “25 Hz” and “186 volts” are entered as frequency and final voltage respectively which means “372 volts” in “50 Hz” frequency. Note that by changing the voltage, it is so much probable that the wirings change as well. In this method, “Demagnetize” option is checked by default so that the magnetic residue is removed and the aforementioned calculations are done.

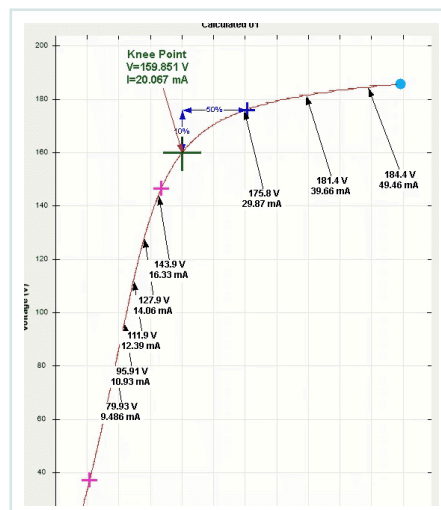


Figure 1

State Settings

☐ Rdc

☒ Demagnetize

Time: 10.00 s

% of Vend 50.00 %

☐ Calc. From TestObject

Frequency 25.00 Hz

V end 300.0 V 150.0 V

Excitation Time Test: 30.00 s

Choose Current Measurement Mode:

☒ Low Current I exc < 500mA

☐ High Current 500mA < I exc < 800mA

☐ Don't change hardware settings

Figure 2

After adjusting this settings and specifying the test time, click on "Init Test" to initiate the test. As you can see in the "Signal View", by decreasing the frequency and equating, the knee point is almost equal with what was measured in 50 Hz frequency. Therefore, in cases where the CT saturation point voltage is beyond the limit of the device, by decreasing the frequency, you can measure the knee point and its saturation.

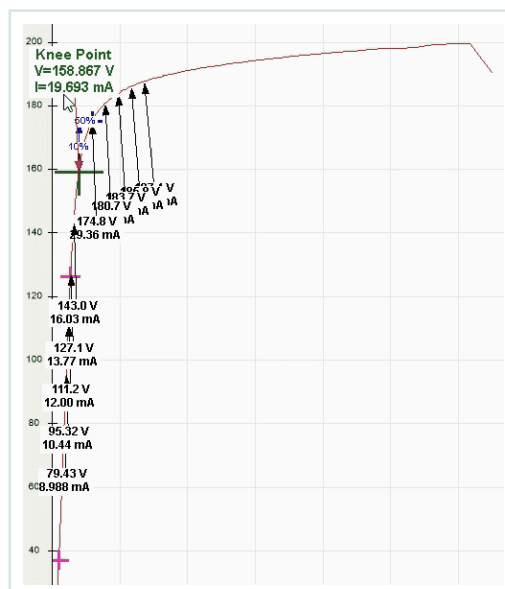


Figure 3

[jg1]CT_Excitation_Test_Part4