DESIGN OF INSTRUMENT CURRENT TRANSFORMER

Zoltán Kocsis
Doctoral Degree Programme, FEEC BUT
E-mail: xkocsi00@stud.feec.vutbr.cz

Supervised by: Vladimír Aubrecht
E-mail: aubrecht@feec.vutbr.cz

ABSTRACT

This article outlines the both description and design of instrument current transformers. It deals with a calculation of the instrument transformer. As a result of this is a computation of electrical part of the instrument transformer CTT25 made by KPB Intra company.

1. INTRODUCTION

1.1. General overview of transformers

Transformer is a non-rotating electrical machine, which changes an applied voltage and current to other selected values. By this change the output stays unchanged (if we don't look at other selected values).

Transformer can transform a single-phase or multiphase current. With their design the transformers are relatively simple and not demanding the maintenance.

Their outputs move from the fraction of kVA to some hundreds MVA. Installed power in transformers exceeds installed power of other electrical machines in electrical distribution, because electrical energy is transformed on the way from the production to consumption many times.

In electrical practice, we don't meet only power transformers, but transformers designed for several purposes also work on the same principle.

Here belongs, for example, a transformer for measuring purposes, for communication technology, welding, testing, X-ray devices etc.

1.2. Instrument transformers

Instrument transformers are kind of general transformers. The same physical laws as for other transformers are valid for them. They are different from usage in electrical circuits.

Basically we could say, that instrument transformers transform values of current with voltage to standard values suitable for power supply of current and voltage coils of measuring or protection devices.

Further they separate circuit of medium voltage to circuit of low voltage (for example circuit of measuring devices) and retreat measuring and protection devices from the reach of effect of strong magnetic and electrical fields of current circuits and they eliminate their negative effect to proper function of these devices. They also enable easily to determine sums or differences of currents or voltage in several with one another isolated circuits. Using of instrument transformers gives also the possibility to concentrate measuring and protection devices in control rooms or centers out of distribution and to make the control and operating of a distribution point and whole network easier.

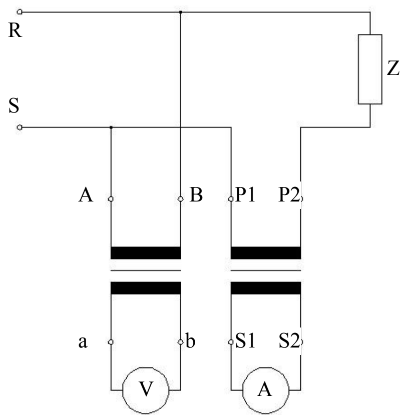

Figure 1: Connection of instrument transformers to the network.

Various devices are needed for economical and reliable operation of electrical systems and electrical devices working inside of these electrical networks. They are partly devices, by which electrical magnitudes are measured: current, voltage, output, electrical work, frequency, power factor and other. Either devices, which support safety running or restrict appropriate breakdowns and undesirable states of electrical devices to least possible rate. The first of them are generally called measuring devices, the second ones protection devices. They are often being designed so that they could collectively operate as measuring and protective devices. They have for example several secondary inputs, in which some of them have properties needed for supplying of measuring devices, the other for supplying of belaying devices or they can be used as measuring or protective.

1.3. FUNCTION OF INSTRUMENT TRANSFORMERS

They transform values of voltage and current to standard values suitable to supplying of current and voltage coils of uniformly performed systems of devices, which could be produced and designed therefore economically in restricted number of types and large series .

They isolate the circuit of high voltage from circuits of low voltage, by which the safety of maintenance and devices is ensured.

They retreat measuring and protection devices from reach of effect of strong magnetic and electrical fields of current circuits of electrical system and so they eliminate their negative effect to the right function of connected devices and accuracy of measuring.

They enable to determine easily sums or difference of currents or voltage in several each other isolated circuits.

They allow digestedly and efficiently centralize measuring and protective devices in control rooms out of distribution point and thereby contribute to easy and quick control in operating of distribution point running and whole networks.

They protect systems of measuring and protective devices by suitable design against harmful dynamic and thermal effects of overcurrent by fault condition in electrical systems.

2. ANALYSIS

For design it is necessary to know these parameters:

- rated power (load) P,
- overcurrent number n,
- accuracy class Tp,
- rated voltage of distribution system,
- rated primary current I1n,
- rated secondary current I2n.

First we will calculate primary current and secondary winding (for example number of winding, cross-section, number of layers). Further we will create magnetic circuit. Next step is the calculation of errors and the control of overcurrent number.

In the case, where there are not conditions of submission and standard IEC 60044-1 fulfilled, we have to adjust the cut section of magnetic circuit. We perform the calculation of errors for 100 % and 25 % of rated load and 10, 20, 50, 100 and 120 % of rated current. Then we could carry out the curves of errors from these values, which have to lie after proposed correction inside of allowed field of errors. Both curves of angle errors have to lie inside of allowed field of errors the given accuracy class.

I gathered results in Table 1 from my diploma work where all my calculations are presented.

		Border according standard		Error for 100% load	Error for 25% load
	In [%]	+	-		
Before correction	10	1.00	-1.00	-1.596	-0.493
	20	0.75	-0.75	-1.215	-0.405
	50	0.60	-0.60	-0.902	-0.324
	100	0.50	-0.50	-0.736	-0.243
	120	0.50	-0.50	-0.697	-0.230
After correction	10	1.00	-1.00	-0.896	0.207
	20	0.75	-0.75	-0.515	0.295
	50	0.60	-0.60	-0.202	0.376
	100	0.50	-0.50	-0.036	0.457
	120	0.50	-0.50	0.003	0.470

Table 1: Results of calculation

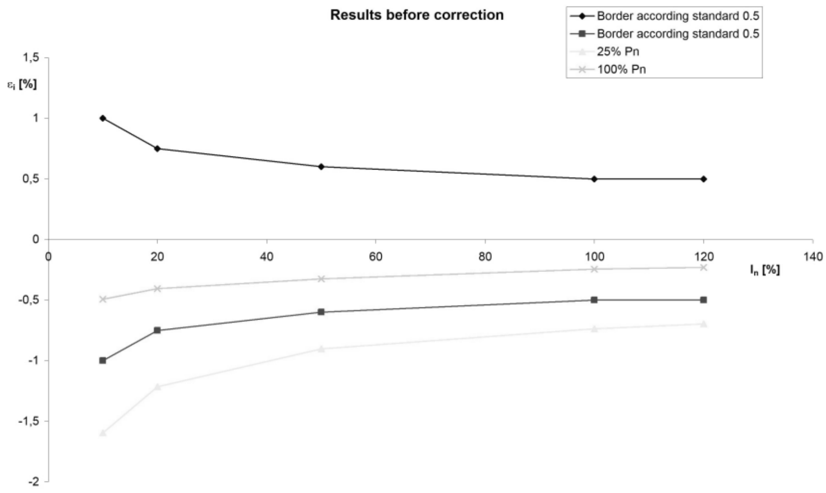

Figure 2: Result according of calculation without correction

2.1. CONSTRUCTION OF INCOMPLETE (FRACTIONAL) TURN

Within this way the correction is solved that last turn doesn't encircled whole the cross-section of magnetic circuit, but only its part (for example: 1/3, 1/2, 2/3). Whole magnetic flux doesn't come through the last turn, but only through its part. Generated voltage is lower in this turn than in other turns. This method of correction of errors is relatively widely extended. Its disadvantage is, that the turn has to be inserted into the core already by the production (winding). It is not possible to realize this correction after winding of secondary winding.

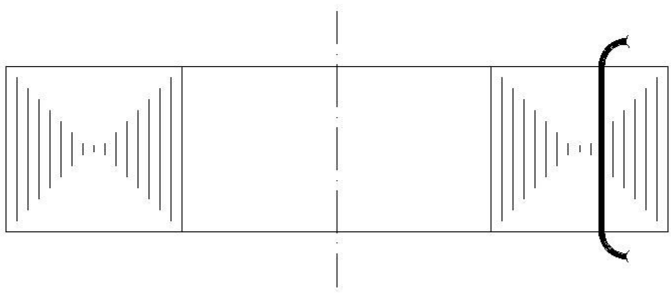

Figure 3: Exemplary image of implementation incomplete turn

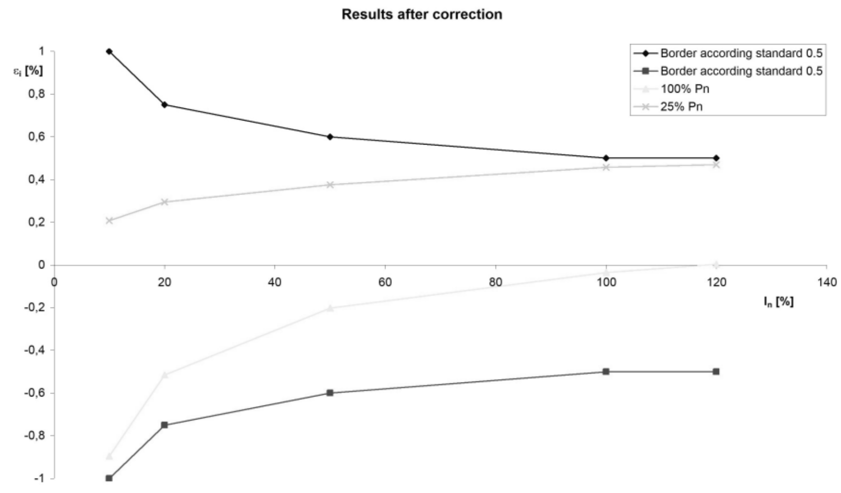

Figure 4: Result according of calculation after correction

I have verified the result using calculation program MTP. Both results are equal.

3. CONCLUSION

I enriched my experience at branch of instrument transformers within elaboration of article. Thanks to KPB Intra company, I could work on design of current instrument transformer. Company has provided me with not only an excellent background, possibility of self-education but I have also obtained wider outlook in a sphere of power engineering. For all this time I have gathered much rich experience and knowledge, both in branch of technology, and in company management. Within calculations I got much new knowledge and many new things from branch of instrument transformers. I could calculate many parameters by the help of calculation program of KPB Intra company - results were comparable. Then I have adjusted an error acquired by the result by implementation of incomplete turn - last turn will be only one-third. Results obtained by this way correspond with a required accuracy class.

REFERENCES

[1.] Ing. Josef Král, Ing. Jaromír Vaněk, Electromagnetical devices, Editing centre VUT Brno, Brno, 1984

[2.] Zoltán Kocsis, Graduation theses , VUT Brno, Brno, 2006