Experiment 323

The initial magnetization curve and the hysteresis loop of the iron core of a transformer

Authors: M. Domagala, J. Tosiek

1 Theory

1. A magnetic induction, a magnetic field strength, a magnetic flux, magnetization intensity, Ampère's law [1], [2].
2. Properties of a magnetic field [1], [2].
3. Magnetic properties of materials. The hysteresis loop. [2].
4. An alternating current, instantaneous value and root-mean-square current and voltage [1], [2].
5. Faraday's law of induction [1].
6. Transformers [1].

2 Preliminary tasks

1. Study theory indicated above and read carefully a description of this experiment.
2. Using the Ampère law find the maximal value of the magnetic field strength inside the primary winding of the transformer. Assume that the primary winding of the transformer is of the infinite length.
   Remember! The Ampère law determines the magnetic field strength. In ferromagnetics there is no linear relation between the magnetic field strength $\vec{H}$ and the magnetic induction $\vec{B}$.
3. Applying the Faraday law of induction calculate the maximal value of the magnetic induction inside the iron core of the secondary winding of the transformer. Assume that the magnetic induction at the cross-section of the core is homogeneous.
4. Propose a data table and a list of quantities which values have to be verified at the laboratory.
5. Prove that at the oscilloscope screen an image of the hysteresis loop is generated [3].

3 Measurements

3.1 The initial magnetization curve

1. Build the electric circuit sketched below. Check that the initial value of the voltage of the power supply is 0 V. Set the maximal measuring capacities of the ammeter and of the voltmeter. Check that the iron core of the transformer does not vibrate.

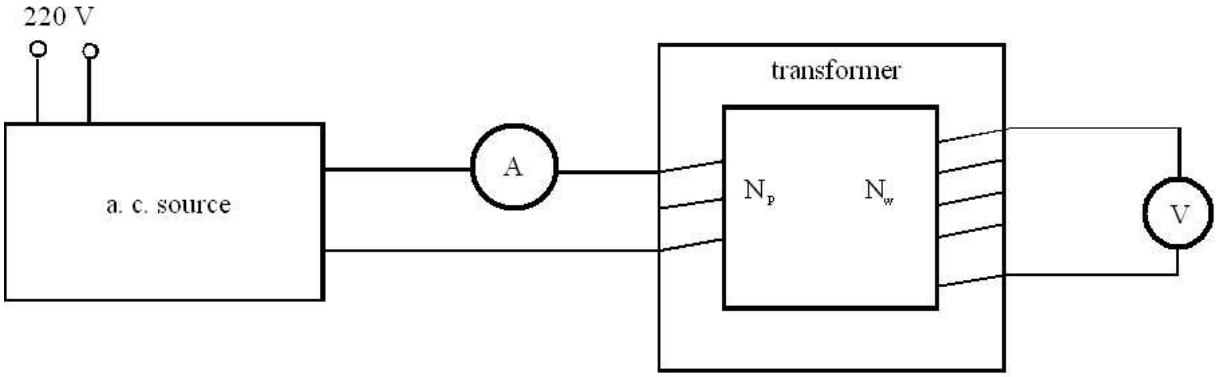

Figure 1: A scheme of the system

2. Ask the supervisor for checking your electric circuit.
   Warning! Do not touch live cables.

3. Increase gradually the setting of the power supply control and investigate the relation between the current in the primary winding of the transformer and the induced voltage in the secondary winding. If necessary, change measuring capacities of the ammeter and of the voltmeter.

4. Turn off the a. c. source and disconnect the electric circuit.

3.2 The hysteresis loop of the iron core of the transformer

1. Arrange the electric circuit as at the fig. 2.
   The zero lead of the X input is also the zero lead of the oscilloscope.

2. Ask the supervisor for checking your electric circuit.

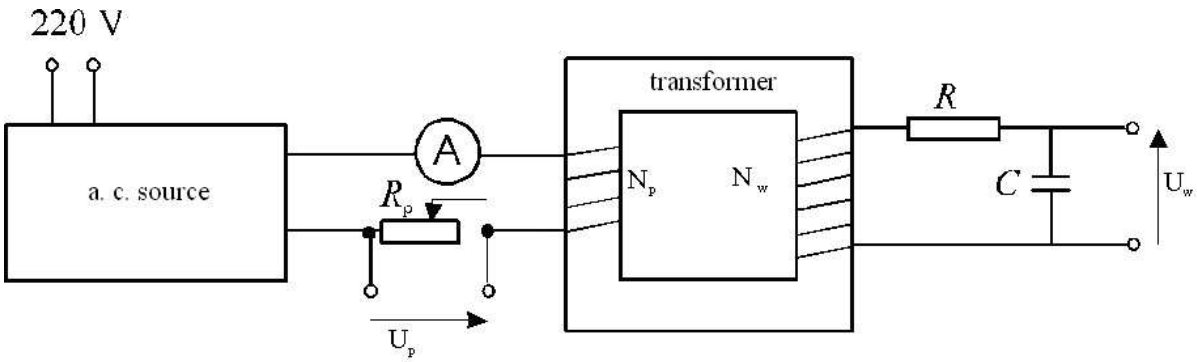

Figure 2: The experimental arrangement

3. Adjust the oscilloscope's settings (X and Y amplifications) to obtain the hysteresis loop on the screen.

4. Copy the hysteresis curves for some different values of the primary current. Put these curves together in the same system of coordinates.

5. Turn off the a. c. source and disconnect the electric circuit.

6. Dismount the transformer. Measure its cross-section and the length of the primary winding coil.

4 Analysis of results

1. An introduction of the report should comprise short description of the phenomenon of magnetization. Present proofs of formulas defining the magnetic field strength inside the primary winding and the maximal value of the magnetic induction inside the iron core of the secondary winding of the transformer. Moreover, explain why in the second part of the experiment the hysteresis loop is generated.

2. Add the data table. Remember to present results in SI or SI derived units.

3. Draw a graph presenting the the initial magnetization curve. Remember about error bars.

4. Add the hysteresis curves observed in the second part of the experiment.

5. Discuss your results, add some comments and conclusions.

References

[1] D. Halliday, R. Resnick, J. Walker *Fundamentals of Physics Extended*, Wiley John & Sons 2007.

[2] H. D. Young, R. A. Freedman, *University Physics with Modern Physics*, Addison - Wesley Publishing Company 2000.

[3] B. Zoltowski, *Experiments in physics*, available at the web page http://www.if.p.lodz.pl/bogdan.zoltowski/