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EXTRAPOLATION COMPUTATIONAL VIRTUAL SYSTEM BASED ON LABVIEW FOR SQUIRREL CAGE THREE-PHASE ASYNCHRONOUS MOTOR TESTING

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Abstract: The study of the no-load characteristics of squirrel cage three-phase asynchronous motor was made by applying balanced voltages to the stator terminals at the rated frequency with the rotor uncoupled from any mechanical load. Current, voltage and power are measured at the motor input. The losses in the no-load test are those due to core losses, winding losses and friction. The no load test of three-phase induction motor is performed on induction motor (1.1kW) when it is running without load. This test tells the magnitude of constant losses occurring in the motor. The testing was performed using a measurement acquisition software (LabVIEW) and the squirrel cage three-phase asynchronous motor will be controlled using the MHI software.

Keywords: acquisition software, real data measurement, open-circuit testing, induction motor, loss measurement.

1. INTRODUCTION

The three-phase induction motor carries a three-phase winding on its stator. The rotor is either a wound type or consists of copper bars short-circuited at each end, in which case it is known as squirrel-cage rotor [1]. The three-phase current drawn by the stator from a three-phase supply produces a magnetic field rotating at synchronous speed in the air-gap. The magnetic field cuts the rotor conductors inducing electromotive forces which circulate currents in them. The no-load test on a squirrel cage AC motor gives information with respect to exciting current and no-load losses. It is normally performed at rated frequency by applying balanced phase voltages to the stator terminals.

The three-phase induction motor behaves as a transformer whose secondary winding can rotate. The basic difference is that the load is mechanical. Besides, the

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reluctance to the magnetic field is greater on account of the presence of the air-gap across which the stator power is transferred to the rotor. The no-load current of the motor is sometimes as high as 30 % to 40 % of the full-load value [2,3].

From the diagrams, in correspondence to the current rated value, we obtain respectively: I0, iron losses Pfe, mechanical losses Pm and power factor cosϕ.

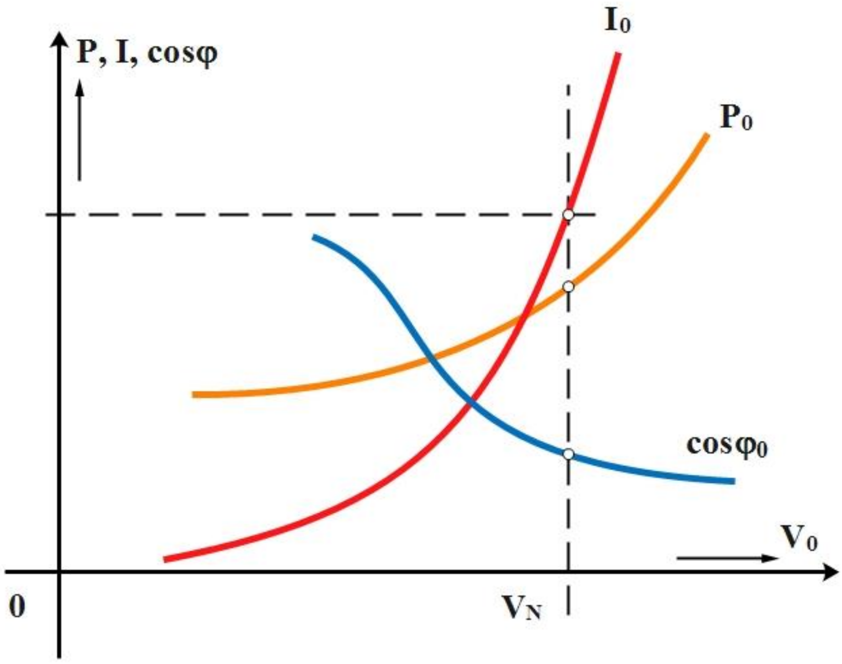

Fig. 1. The characteristic curve for the no load test of the squirrel cage AC motor

The no-load rotational losses (winding, friction, and core losses) will be seen in the no-load measurement.

Given that the rotor current is negligible under no-load conditions, the rotor copper losses are also negligible. Thus, the input power measured in the no-load test is equal to the stator copper losses plus the rotational losses.

The Pm + Pfe = f (V0) curve is nearly a parabola, presented in figure 3, shifted with respect to the X-axis by a Pm quantity. Following the variations of V0, in fact, the mechanical losses do not change, because they are related to the speed that remains sensibly constant.

On the other hand, the iron losses do change (because, changing the voltage means to change nearly by the same amount the magnetic flux that is generated) and, as between iron losses and induction there is a square proportionality, the graph that shows them will have a parabolic behavior.

The separation between Pm and Pfe is, therefore, possible through a graphical way, when the cross point between the curve and the Y-axis has been determined. That point cannot be experimentally measured because, with too reduced supply voltages, the asynchronous motor will tend to stop.

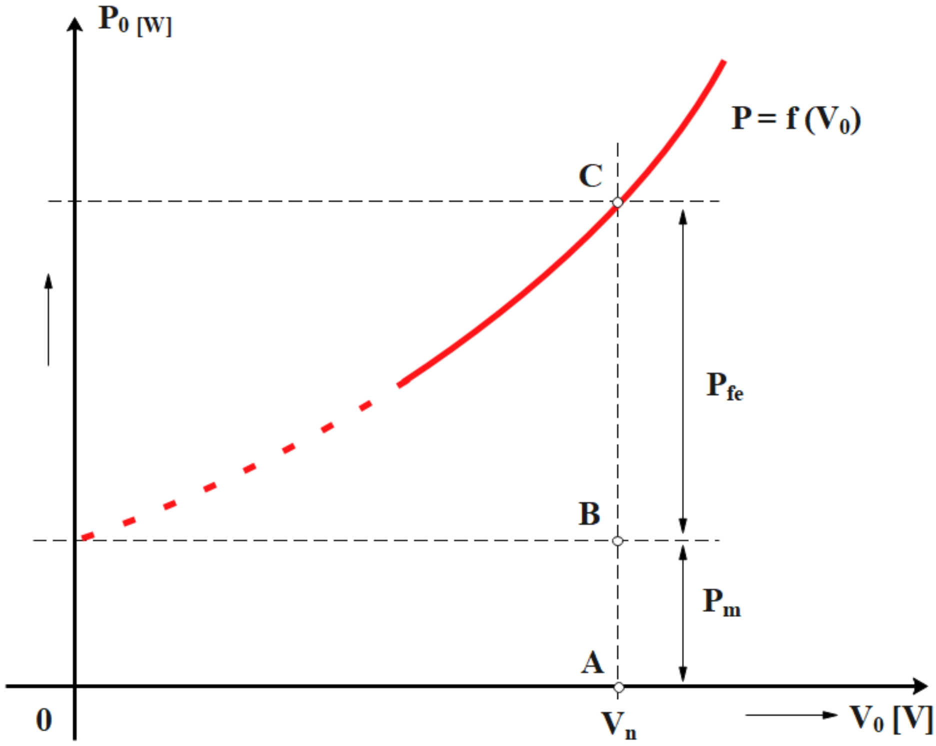

Fig. 2. Characteristic curve for determining the mechanical losses and the iron losses of the squirrel cage AC motor

The cross-point, therefore, has to be determined by graphical extrapolation on the amount of the curve that has been measured: to reduce the difficulty of this operation, it can be useful the fact that in the cross-point the curve is tangent to the X-axis.

At the rated voltage Un it is possible to obtain:

AB = mechanical losses Pm (W)

BC = iron losses Pfe (W)

2. CONCEPTUAL NO-LOAD OPERATION

Figure 3 shows the circuit diagram for measuring the electrical parameters needed for drawing the characteristic curves for no-load operation using a delta configuration of the stator windings. Figure 4 is used to perform the test using star configuration of the stator windings. This test describes the operating conditions in the magnetic circuit of the motor, and it is important because it makes available several elements that are useful both for the drawing of the circular diagram (I0 and cosϕ0) and for the calculation of the conventional efficiency (Pm and Pfe). It consists in supplying the asynchronous motor with its nominal voltage, leaving the rotor free to rotate without any resistant torque [4].

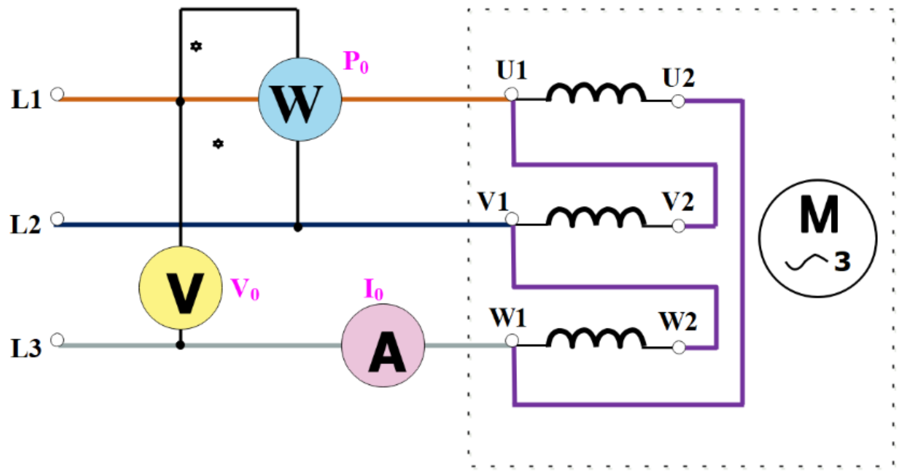

Fig. 3. Circuit diagram for the no load test of the squirrel cage AC motor (delta)

The set up for no load test of squirrel cage three-phase asynchronous motor is shown in the figures 3 and 4. The machine is started in the usual way and runs unloaded from normal voltage mains. On the mains side suitable instruments are connected between supply mains and motor terminals to measure power, line current and line voltage.

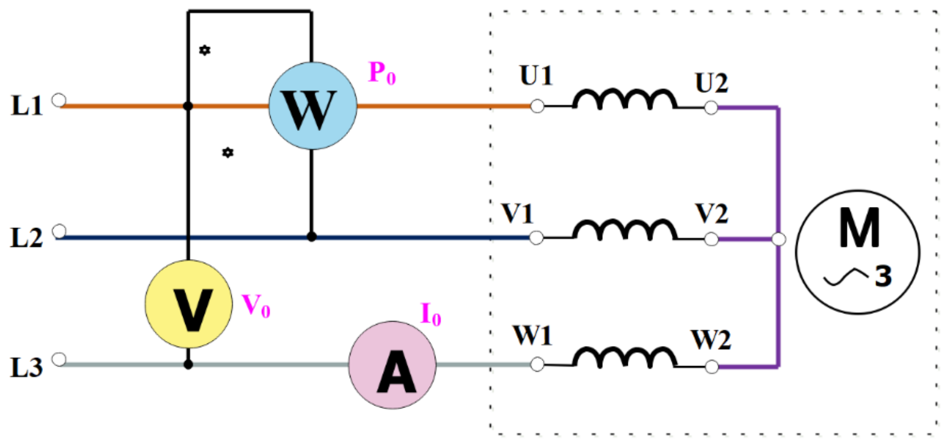

Fig. 4. Circuit diagram for the no load test of the squirrel cage AC motor (star)

The no-load electrical parameters can be measured using the ammeter A and the voltmeter V. In this schematic diagram, the AC stator configuration is presented. The electrical power has been measured with a three-phase wattmeter. As the asynchronous motor is, due to its construction and operating conditions, a symmetrical machine under every load condition, in figure 3 only one wattmeter, voltmeter and ammeter are indicated.

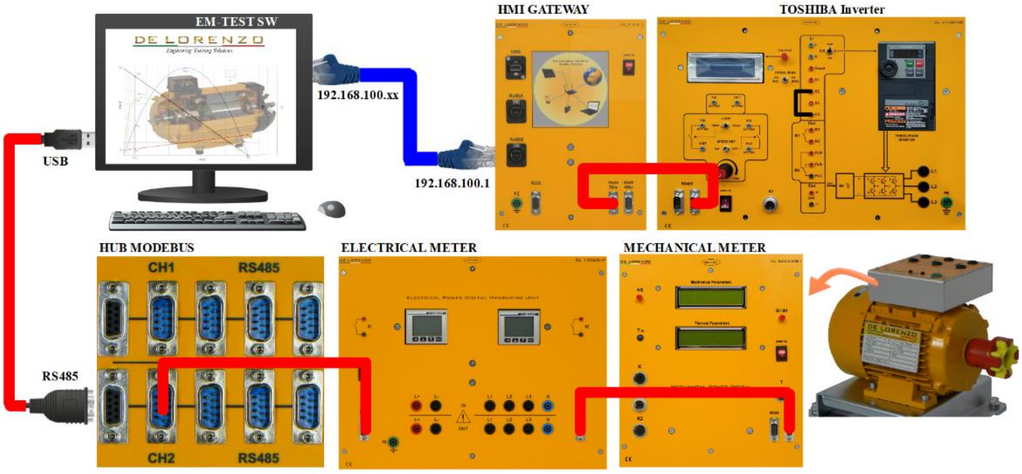

Fig. 5. MODBUS communication diagram for dynamic analysis

3. DINAMIC NO-LOAD TEST OF SQUIRREL CAGE THREE-PHASE ASYNCHRONOUS MOTOR

Figure 6 shows the measurement and control interface. Using the HMI software START the power supply to power the induction motor. By gradually increasing the voltage until the voltage reach 1.1*Un. The machine is started in the usual way and runs unloaded from normal voltage mains. On the mains side suitable instruments are connected between supply mains and motor terminals to measure power, line current and line voltage.

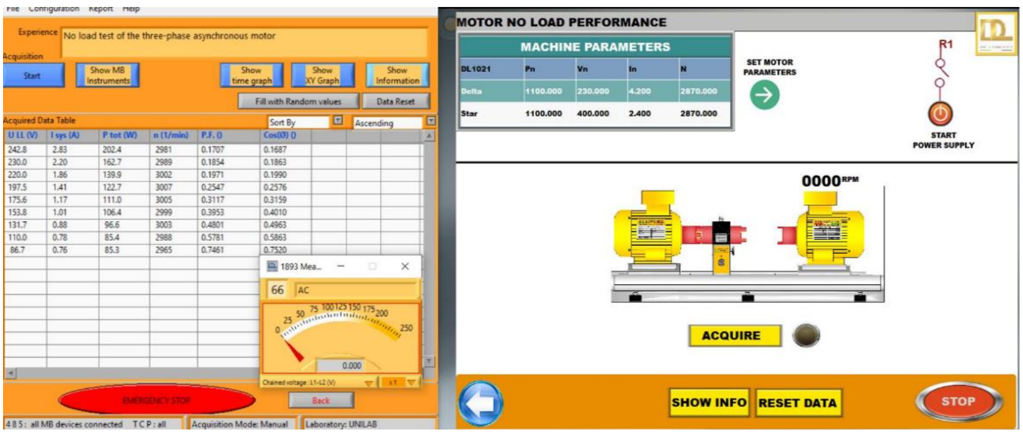

Fig. 6. Dynamic analysis using HMI control and LabVIEW

Figure 7,8 shows the curve that is used to determine the values Pm and Pfe using the extrapolation method, when the motor stator is in delta.

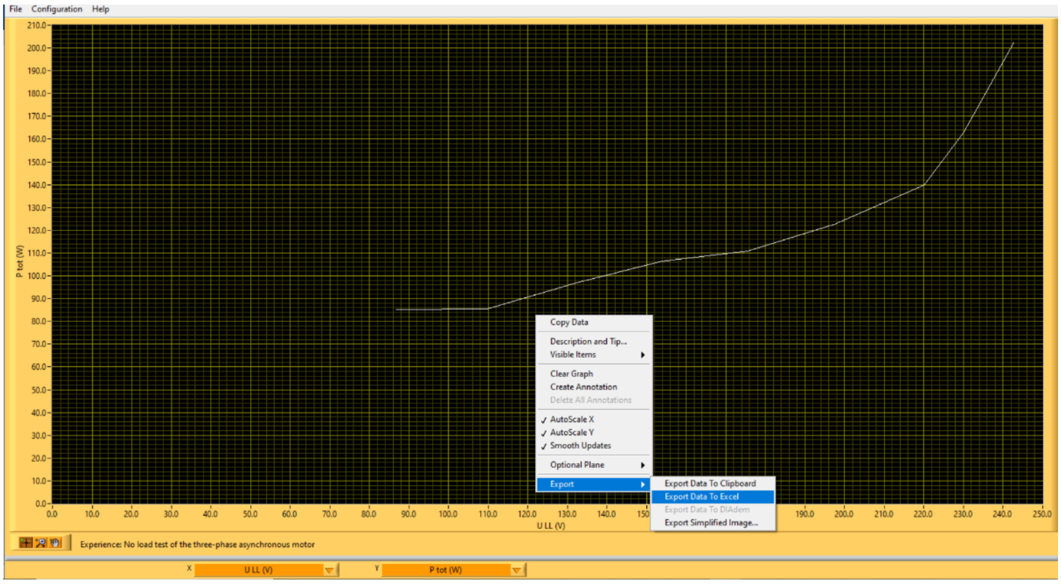

Fig.7. Squirrel cage AC motor no-load power measurement (delta)

Since the motor is not loaded so input power absorbed by the motor is providing losses only. Losses are occurring in iron core of the stator as well as the rotor which are called core losses. A small amount of copper loss is also occurring in stator winding. This can be neglected since the stator current is very small.

The point where it intersects, is the zero applied voltage. When applied voltage is zero the core losses and stator copper losses are zero.

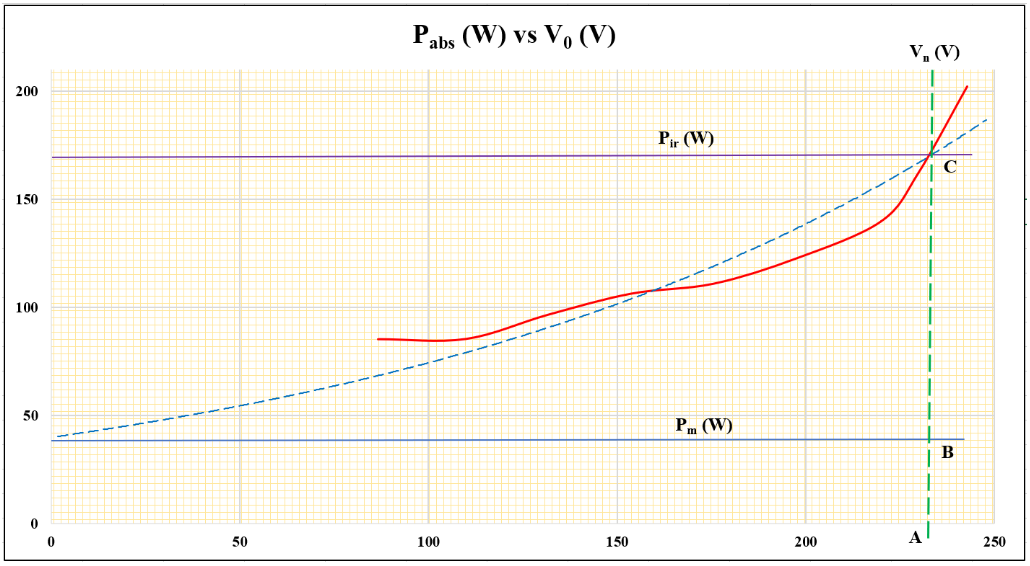

Fig. 8. DELTA configuration: The experimental characteristic curve for extrapolation of the Pm + Pfe

Figure 9,10 shows the curve that is used to determine the values Pm and Pfe using the extrapolation method, when the motor stator is in star [5]. To obtain the characteristic curves of the AC motor tested under no-load conditions was selected on the horizontal axis the no-load voltage and on the vertical axis the active power.

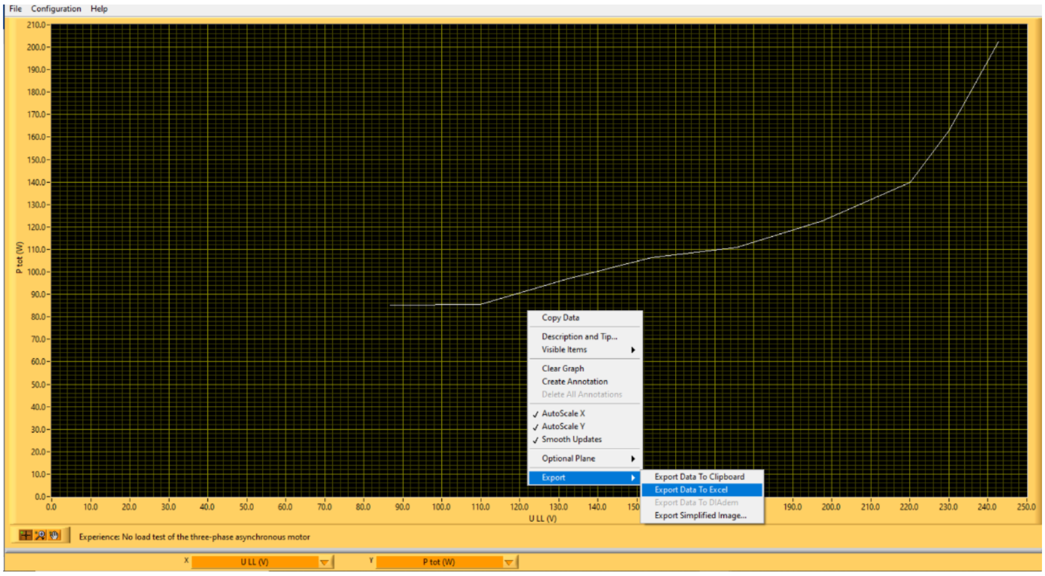

Fig.9. Squirrel cage AC motor no-load power measurement (star)

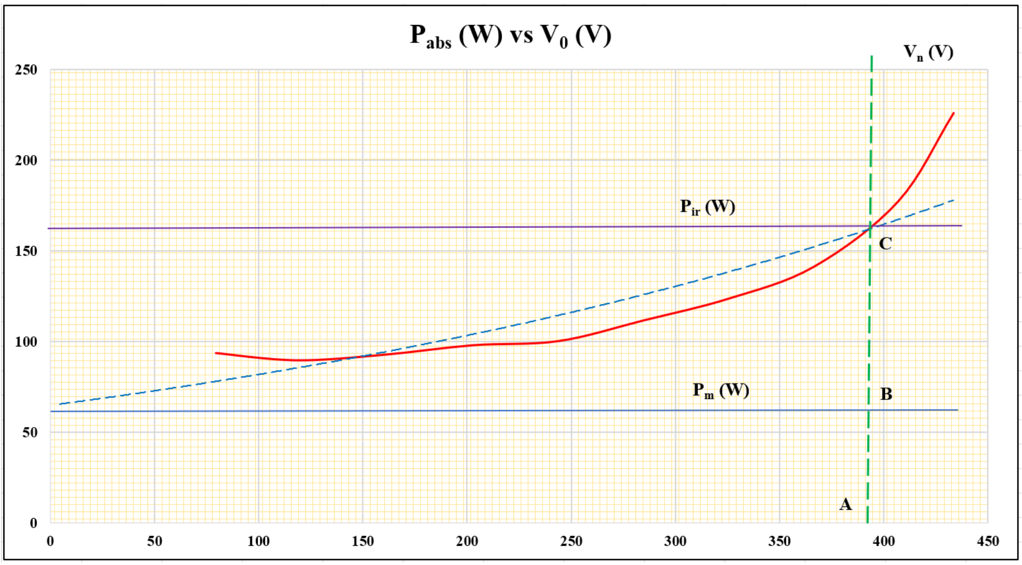

Fig. 10. STAR configuration: The experimental characteristic curve for extrapolation of the Pm + Pfe

Successful design of electrical machines hinges on a knowledge of the likely temperature rise within the machine. The ability to predict an accurate temperature distribution, in turn, requires a knowledge of the iron loss distribution, thermal characteristics of the materials, and the cooling conditions. Other methods are proposed to evaluate accurately the iron loss density distribution in the stator of an induction motor by measurement of temperature gradients in the machine [6,7].

4. CONCLUSIONS

The no-load test of the induction motor calculates the rotational (these losses are such power loss which occurs due to friction and windage) losses of motor and deliver knowledge about the magnetization current of the motor. By performing specifically tests the losses in an AC can be identified and these losses are converted into heat that raises the temperature of the machine and lowers its efficiency. Determination of the conventional efficiency can be done by indirect tests using the classical calculation method or by using a software approach.

Using an HMI, the motor was controlled and supplied up to the rated voltage and the active power was measured for different values of the input voltage.

REFERENCES

[1]. Jimoh F., Pokxijadoft, *Stray losses in induction machines*, Part I and IL IEEE Trans. PAS, Vol. 104, No. 6, 1985.

[2]. Pană L., Grabara J., Păsculescu D., Păsculescu V. M., Moraru R. I., *Optimal quality management algorithm for assesing the usage capacity level of mining tranformers*, Polish Journal of Management Studies, Vol.18, No.2, pag.233-245, 2018.

[3]. Utu I., Păsculescu D., *Power quality study in order to comply with European Norms*, Supplement of Quality-Access to Success, Vol. 18, S1, January, pp. 366-371, 2017.

[4]. Dobra R., Buica G., Pasculescu D., Leba M., *Safety Management Diagnostic Method Regarding Work Cost Accidents from Electrical Power Installations*", RECENT ADVANCES in INDUSTRIAL and MANUFACTURING TECHNOLOGIES, Proceedings of the 1st International Conference on Industrial and Manufacturing Technologies (INMAT '13), Vouliagmeni, Athens, Greece, May 14-16, ISSN: 2227-4596, ISBN: 978-1-61804- 186-9, pag. 58-63, 2013.

[5]. Niculescu T., Păsculescu D., *Use of numerical simulation to study capacitive loads which is connecting to an AC power source*, 15th International Multidisciplinary Scientific GeoConference SGEM 2015, Conference Proceedings, ISBN 978-619-7105-34-6 / ISSN 1314-2704, June 18-24, Book2 Vol. 1, pp. 391-398, 2015.

[6]. Betz R. E., et al. *Control of synchronous reluctance machines*, IEEE Transactions on Industry Applications 29.6, 1110-1122, 1993.

[7]. Kytomski R., Arkkio A., Niemenmaa A., Sountausta A., *Validity of conventional and modem methods of no load loss calculation in asynchronous machines-statistic approach*, Record of EMD-97, IEE Conf. Publ. No. 444, pp. 185-189, 1997.