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MEASURING STAND FOR IDENTIFICATION OF ELECTROMAGNETIC PARAMETERS OF ASYNCHRONOUS MOTORS

Summary. A measuring stand used for testing of statical and dynamical properties of asynchronous motors which make it possible to identify electromagnetic parameters of motors when having regard to the phenomenon of saturation of magnetic circuits of the machine have been described.

STANOWISKO POMIAROWE DO IDENTYFIKACJI PARAMETRÓW ELEKTROMAGNETYCZNYCH SILNIKÓW ASYNCHRONICZNYCH

Streszczenie. Przedstawiono stanowisko laboratoryjne służące do badań własności statycznych i dynamicznych silników asynchronicznych umożliwiających identyfikację parametrów elektromagnetycznych silników z uwzględnieniem zjawiska nasycania obwodów magnetycznych maszyny.

MESSTELLE ZUR IDENTIFIZIERUNG DER ELEKTROMAGNETISCHEN PARAMETER VON ASYNCHRONMOTOREN

Zusammenfassung. Man hat eine Laborstelle, die für die Prüfung der statischen und dynamischen Eigenschaften von Asynchronmotoren bestimmt ist, dargestellt. Diese Eigenschaften machen es möglich elektromagnetische Parameter von motoren unter Beachtung des Effektes der Sättigung von magnetischen Kreisen der Maschine zu identifizieren.

1.INTRODUCTION

Differential equations which form a mathematical model of an asynchronous motor and take into account the phenomenon of saturation of magnetic circuits of the machine for the main field and leakage fields[2] are those where apart from conventional parameters such as resiststance of a stator and a motor new parameters: statical inductance and differential inductance are contained and their values depend on saturated conditions of particular magnetic circuits of the machine.According to [2] these inductances are expressed by characteristics $\psi_m(I_m)$, $\psi_{s\sigma}(I_s)$, $\psi_{R\sigma}(I_R)$, see(1), which are usually approximated by means of different functions, e.g. power polynomials.

$$I_k = a_k \psi_k + b \psi_k^{n_k}, \quad k = m, s\sigma, R\sigma. \tag{1.1}$$

In consequence, the identification of electromagnetic parametrs of mathematical models of asynchronous motors covering the phenomenon of saturation consists in determining the vector of parameters **P** as factors of corresponding magnetization characteristic are incorporated.

$$\mathbf{P} = \left[R_1, R_2, a_m, b_m, n_m, a_{s\sigma}, b_{s\sigma}, n_{s\sigma}, a_{R\sigma}, b_{R\sigma}, n_{R\sigma}.\right] \tag{1.2}$$

It is possible to perform the estimation of the vector **P** of parameters when taking measurements of the motor within the demain of time of frequency (start-up of the motors) and within the demain of requency (steady state of the motor at varying motor slip) and minimizing the mean square error between measurement quantities (current , electromagnetic moment) and quantities calculated from the mathematical model.

When making measurement it is necessary to take care about proper saturated conditions of magnetic circuits being analyzed so that the obtained parameters might represent correctly various operating conditions of the machine: normal states and emergancy states.

A special measuring stand has been constructed in order to test different methods for determining of electromagnetic parameters of induction motors. The stand has been described thereinafter

2.TECHNICAL DESRIPTION OF THE MEASURING STAND

The laboratory stand, the sketch of which is shown in fig. 1, is composed of a motor under testing **1** connected by means of couplings **2** to a moment transducer **3** and to an inertial mass system **4** being joined with a rate generator **5**.

The inertial mass system is formed by a set of disks with the known moment of inetiall joined with a shaft of the system by means of rigiol couplings.

Operation of the moment transducer is based on measuring of relative strains of the transducer shaft when appying electric strains wire strain ganges stuck to a side surface of the shaft necking.

A stabilized feeder designed to supply strain ganges as well as the first stage of the output signal amplifier of strain ganges connected in a full system of the Wheatstone bridge are situated on a rotating part of the moment transducer.

A selection of siutable coupling is a problem of great importance for the system of the measuring shaft composed of a shaft of the motor under testing, of the moment transducer and a shaft of the mechanism of notating masses. They must provide for the accuracy of the torgue of the mtor being transmitted onto the moment transducer and onto the inercial mass system. It is not possible to apply flexilbe s which dampen amplitudes of quick-changing values of the motor torgue occuring during the motor start-up. The application of rigid couplings guarantees the accurancy of the torgue being transmitter but with the out-of-line arrangement of connected shafts extra bending moments take place.In the practice when making measurements couplings of the Hooke's type without angle plays are used.

Measuring signals (of voltage, currents, torgue and rotational speed) taken from corresponding sensing element are transfered via optoisolating amplifiers to a card of analog-

to-digital converters LAB-PC of the National Instrument Compagny (12-bit converter, maximum sampling frequency of 64 kHz) situsted in a microcomputer of the PC-486 type.

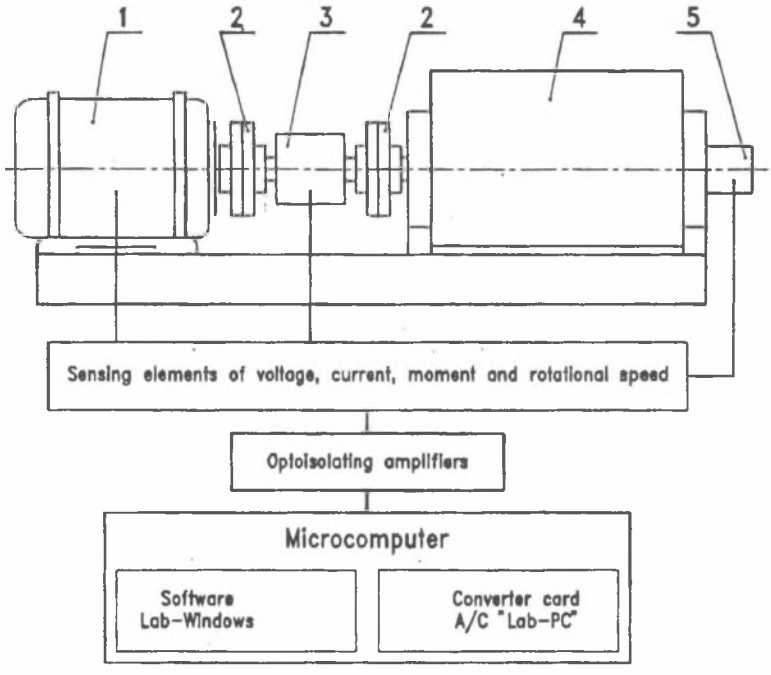

Fig.1. Sketch of the measuring stand
Rys. 1. Szkic stanowiska pomiarowego

Acquisition, analysis and visualization of results of the measurements are carried out on the basis of the LAB-WINDOWS program ver.2.2.

The measurement of a torgue is taken in a section plane A-A (fig.2). On the left side of the section plane masses(of the motor rotor, coupling and a partion of masses of the moment transducer) with the moment of inertia J_1 are rotating and on the right sode there are rotating masses (a portion of massesof the moment transducer, the right -hand a shaft of the inertial mass system) having the moment of inertia J_2.

Equations of the moment equilibrium take a from:

— for the left side of the section plane

$$M_e = M_{J1} - M_{s1} - M_p = 0 \tag{2.1a}$$

— for the right side of the section plane

$$M_p - M_{J2} - M_{s2} = 0 \tag{2.1b}$$

where:

M_e - electromagnetic moment of the motor being tested

M_{st1} - moment of mechanical losses in the motor

M_{st2} - moment of mechanical losses in the system of rotatung masses

M_{J1} - accelerating moment of masses with the moment of inertia

M_{J2} - accelerating moment of masses with the moment of inertia

M_p - moment measured in the section plane

A torque of the motor being tested is determined from the relationship

$$M_e = \frac{J_1 + J_2}{J_2} M_p \pm M_{st1} - \frac{J_1}{J_2} M_{st2}, \tag{2.2}$$

where plus sign "+" be used at the motor start-up and minus sign "-"to be used in case of counter-current braking.

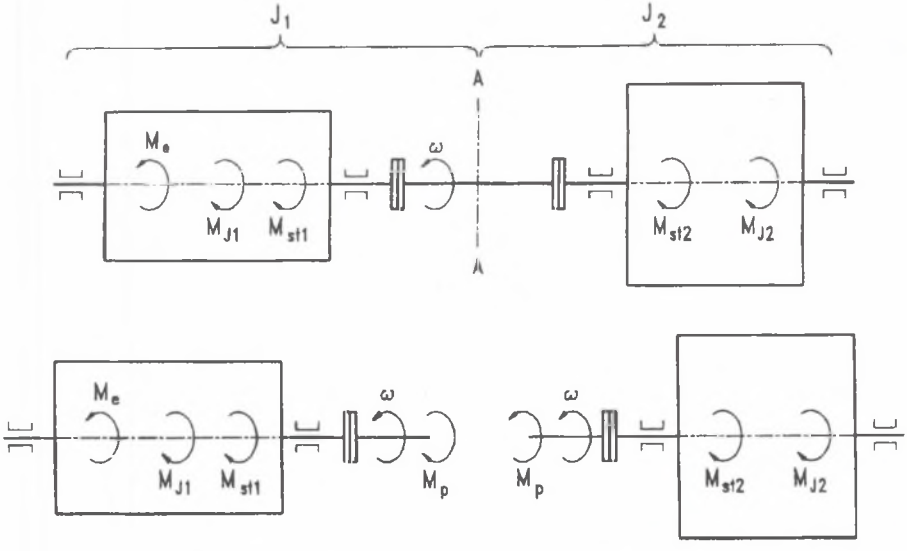

Fig. 2. Distribution of torque moments of the measuring shaft
Rys. 2. Rozkład momentów skręcających wał pomiarowy

3. DESCRIPTION OF THE LAB-WINDOWS ENVIRONMENT AND EXAMPLES OF RESULTS OF THE MEASUREMENTS

A special program based on the LAB-WINDOWS software environment has been developed for acquisition and analysis of measuring signals.

The LAB-WINDOWS ver.2.2 program running under control of the operating system DOS is a program of open structure i.e. on the basis of its standard functions and program libraries

it is possible to form processing programs applicable for the aquisition, analysis and presentation of the measurements taken by means of A/C converters and through a wide range of versatible measuring instruments which are in communication with a computer througt the interface RS 232c or SPIB .The program is adapted for the cooperation with two pragram languages: Cand Quick Basic.

With the aid of the above software onown program has been developed. This is used:

— for aiding the measurements of steady-state characteristics of the motor (non-load, short-circuit condition, loading) madeby analog instruments,

— for acquisition, analysis and presentation of the measurements of dynamical states of the motor under application of A/C converters.

A measuring panel being incorporated in the program under developed and applicable for presentation and pre-handling of results of the measurements (results of the measurements are displayed on proper screens) is shown in fig. 3 and the recorded time course of current and rotational speed of the asynchronous motor during its start-up is represented by fig. 4.

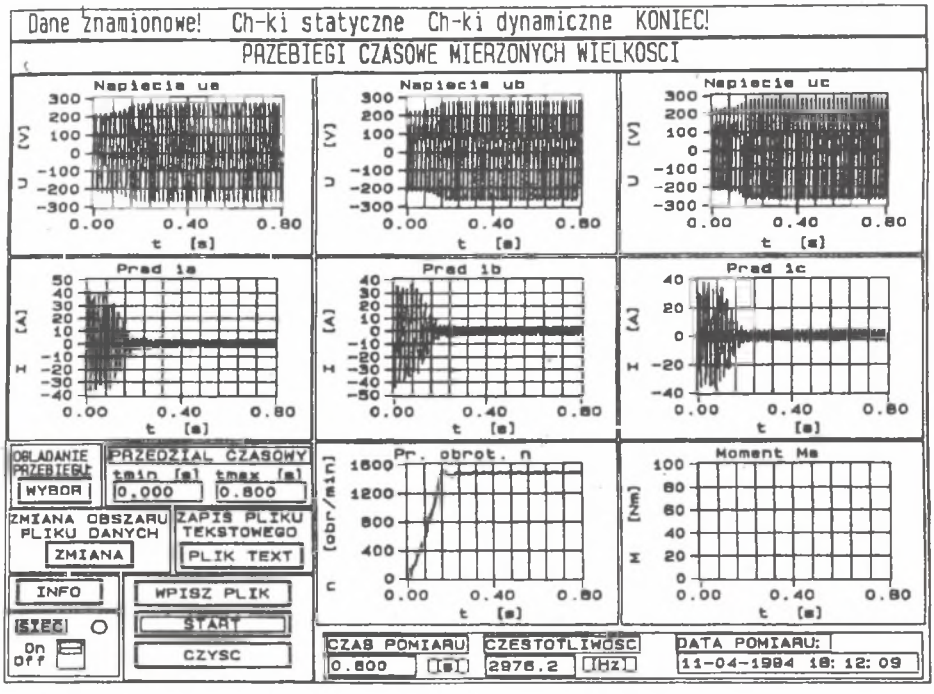

Fig.3. Panel for presentation and pre-handling of results of the measurements
Rys. 3. Panel do prezentacji i wstępnej obróbki wyników pomiarów

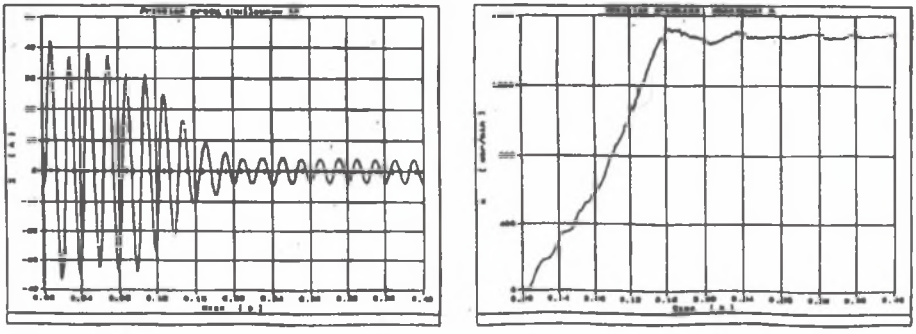

Fig.4. Ware of stater current and rotational speed of the asynchronous motor
Rys. 4. Przebiegi czasowe prądu i prędkości obrotowej silnika asynchronicznego

The constructed laboratory stand along with the computer acquisition and analysis of measuring signals makes it possible to cary out tests of statical and dynamical peopertiesof asynchronous motors. Results of the performed tests will be used for estimation of electromagnetic parameters of motors with special consideration being given to paramaters related to the phenomenon of saturation of magnetic circuits of the motor.

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