ROTOR OF A CUP MOTOR AS A HANDY TOOL FOR WINDINGS CONNECTION TESTING AT SMALL SCALE MANUFACTURE OR REPAIR SHOPS

Abstract: A new, simply method for final connection testing of repaired or small scale manufactured three phase stator windings of induction motors. The testing is carried out before final assembly of the motor (the rotor outside). Presented simply method was successfully tested at control desk of the Research and Development Centre of Electrical Machines Komel, Katowice.

DOŚWIADCZENIA Z BUDOWY I EKSPLOATAJCJI MAŁYCH PRZYDOMOWYCH ELEKTROWNI WIATROWYCH

Abstract: The sense of construction of small windmills is shown. Still increasing interest in cheap sources of energy, observed in Poland, has prompted staff of Research And Development Centre Of Electric Machines Komel to build, put in motion and test on own terrain the small and cheap windmill. This project has brought a lot of useful information concerning both the process of building of small windmills and the performance of such “power station”. The assumption was made that the windmill should be really cheap and easy to build. In given example the modernization of the 12 blade propeller windmill with belt gear is shown. After this modernization, the windmill is a three blade windmill without any gear. Such a windmill is better matched to the wind conditions observed in south Poland. In the construction of described windmill the low speed permanent magnet synchronous generator of our design is used. The energy produced by the windmill is used as a additional heat sources in buildings, so there is no need for regulation of the output voltage from generator (regarding both, rms value and the frequency). Thanks to that, the windmill is relatively cheap.

THE USE OF FIELD – CIRCUIT METHOD FOR THE CALCULATION OF PMSM PARAMETERS AT SYNCHRONOUS OPERATION

Abstract: In the paper one of the methods for calculation of lumped synchronous parameters of PMSM is described. This method, called usually the loading method, was introduced by M. A. Rahman and P. Zhou at the beginning of 90’s. The method is based on a finite element analysis of magnetic field inside the machine and simultaneous solving of PMSM equivalent circuit equations for a range of loads. Actually at the Research And Development Centre Of Electric Machines “Komel”, the software for analysis and evaluation of PMSM performance at synchronous operation is developed on the basis of described method. This software, as intended, should enable the investigation of PMSM performance for both, current and voltage source supply.
BADANIA SYMULACYJNE ZESPOŁU NAPĘDOWEGO POMP WODOCIĄGOWYCH PRZY DOŁĄCZANIU DODATKOWEGO SILNIKA

COMPUTER SIMULATIONS OF PUMPS DRIVE SYSTEM DURING ADDITIONAL INDUCTION MOTOR CONNECTING

Abstract: The problem of suitable water pump drive system selection step forward in many water pump stations. It should be a compromise among the price of drive and the best technical parameters. The most important technical parameter for water receiver is pressure. It should be constant. The paper presents results of computer simulations of pump drive system during adding the second induction motor supply from power network. There is shown the mathematical model of PWM inverter, induction motor and the characteristic of pump. The pump drive system consists of two induction motors – one supply from PWM inverter, the second from power network. The second induction motor is connected when demand for water is higher than delivery of a pump fed by the controlled motor.

A COMPUTATIONAL ANALYSIS OF DYNAMIC SUM MODEL-ROLLER TABLE OF DRIVING SYSTEM BASED ON NUMERIC METHODS FROM MATLAB/SIMULINK PACKAGE

Abstract: This article presents adaptation of mathematical model in a view of real, asymmetrical load that occurs in roller table line. Present descriptions of load torque of electromechanical systems were equivalent to the usage of load torque as their indicators to nominal torque of driving engine. The analytical description of torque, based on my analysis of load, would allow the introduction of mathematical, real course model of the load substituting those of indicators. On the basis of conducted research of simulated dynamical states by means of MATLAB/SIMULINK program, I received courses of equivalent parameters having direct influence on the complete load in a system that occurs in a single table roller, in a set of rollers or in a driving system. This article shows only selected courses of electromechanical driving system because of very extensive mathematical and IT methods necessary to conduct an anticipatory analysis.

DETERMINATION OF CORONA INCEPTION VOLTAGE OF INTERTURN INSULATION UNDER PULSE VOLTAGE

Abstract: The majority of failures of interturn insulation system of inverter-fed motors are attributed to partial discharges therefore determining of Corona Inception Voltage (CIV) is essential. However the investigation of CIV under pulse voltage leads to problems and some researchers performed the alternative of measurements using sinusoidal voltages. In this paper the simple way of determining of CIV of enamelled winding wires under high frequency pulse voltage with oscilloscope has been shown. The dependence of Corona Inception Voltage versus kind of enamel, insulation thickness, frequency of pulse voltage and temperature has been presented. It was found that mainly thickness of insulation and temperature influences on
the level of voltage at which partial discharges has begun. The obtained CIV results were verified by testing of endurance of insulation under pulse voltage.

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PROBLEMY DOBORU ALGORYTMÓW STEROWANIA UKŁADÓW NAPĘDOWYCH WSPÓŁCZESNYCH DŹWIGÓW OSOBOWYCH

THE CHOOSING OF OPTIMAL CONTROL ROUTINE FOR MODERN ELEVATOR SYSTEMS

Abstract: The following paper subject is to present controllers system for passenger and goods lifts, which has been applied in Poland till 1995. There are also shown modern control routines for group elevators systems applied by Lift Service S.A. The paper gives you an idea about new tendencies of development in the field of modern lift controlling. The paper describes basic parameters of new lift controller LS 2020 which has been developed in cooperation the Chair of Electrical Drives of Lublin University of Technology with “Lift Service S.A.”

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TŁUMIENIE OSCYLACJI STRUMIENIA MAGNETYCZNEGO I MOCY MASZYNY DWUSTRONNIE ZASILANEJ

THE FLUX AND POWER OSCILLATION DAMPING IN DOUBLY FED MACHINE

Abstract: The doubly fed machine (DFM) is useful as a generator in wind power plants and hydro-electric power stations, as well as a shaft generator on ships. However, small oscillations occur in almost each system with DFM independently of supply way if intermediate variables have been changed rapidly. The stator flux vector components form an oscillating system. Oscillations are very weak damped and may be transformed into transients of power. These ones can affect a work of other power sources and loads connected together with DFM to the same grid. The mentioned problem appeared in the literature sources several times. The effective damping methods consist in application of inverse feedbacks to correct properties of control systems with DFM. The former structure proposed by author includes the damping feedback with signals obtained from relationships of induction machine’s mathematical model. This solution cannot be applied in practice due to big distortion of signals existing in damping feedback. Asymmetries of machine and inverter as well as non-linear characteristic of machine magnetic circuit are the most probable reasons of this distortion. The oscillations may be damped in the DFM control system if the feedback contains signals obtained by filtration of DFM’s active and reactive power with the aid of band-pass filter applied for each component of the power. The structure of such system and investigation results are presented in the paper.

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GENERATOR Z MASZYNĄ PIERŚCIENIOWĄ O BEZPOŚREDNIM STEROWANIU NAPIĘCIA WYJŚCIOWEGO

SLIP-RING INDUCTION GENERATOR WITH DIRECT OUTPUT VOLTAGE CONTROL

Abstract: The main advantage of the variable speed power generation systems with slip-ring induction generator related to cage or synchronous generator is low power and low costs of the power electronics. As the speed range is limited the power converter can be designed on few percent of the generator power, that provide lower losses and costs and higher efficiency. The Direct Voltage Control method of slip ring induction generator is presented in this paper. This method bases on stator voltage vector feedback, that permits the generator can operate as a stand-alone set e.g. in island power systems. Moreover an autonomous operation mode provide the grid connected generator is useful even after the mains outage and can supply isolated part of a grid load.
The Direct Voltage Control method uses a space vector theory. A stator voltage vector represented in the reference frame rotating with synchronous speed has fixed magnitude and position when the stator voltage amplitude, frequency and phase are fixed. To obtain the fixed values of the voltage vector amplitude and position, two voltage regulators are applied. One of them based on reference and actual stator voltage amplitude is responsible for rotor current amplitude. The second regulator based on reference and actual stator voltage angle referred to synchronous frame is responsible for rotor current frequency. Applied stator voltage control method do not use any information about the rotor speed or position, therefore it can be called sensorless. Moreover an instantaneous value of the generated stator voltage is controlled that provide not only fixed voltage frequency and amplitude but also controlled voltage phase. This is an important advantage in grid and generated voltage synchronization process.

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ASSIGN OF STATIC CHARACTERISTICS FOR SWITCHED RELUCTANCE MACHINES

Abstract: The issue assign of static characteristics of switched reluctance machines with using finite element method and experimental tests are described in the present work. Computation with using ANSYS software are made for four work out SRM constructions (12/8, 8/6, 6/4, and 4/2). Analysis of magnetic field for discusses SRM models are presented. Characteristics of electromagnetic torque, magnetic flux and inductance coil coefficients as a function current and rotor position angle are also shown. There are presented the results of experimental tests of described machines. Experimental tests are made on laboratory stand with card DS 1104. There are presented conclusion too.

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SWITCHED RELUCTANCE MOTORS DESTINED FOR APPLICATION IN HOUSEHOLD EQUIPMENT

Abstract: The issue of application Switched Reluctance Motors (SRM) in household equipment are described in the present work. Solutions of the construction of designed switched reluctance motors (12/8, 8/6, 6/4, and 4/2) are presented. Some different power converters supplying theses motors are compared. Characteristics torque-angle-current for discuss machines are presented too. Theses characteristics are prepared using finite elements method. Presented formulas make possible optimization of operating point of the machine. Results of experimental tests of the switched reluctance motors i.e. characteristics torque, efficiency and current as a function of speed motor for different control angles are presented. There are presented conclusion too.

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APPLICATION OF THERMOANALYTICAL DIAGNOSTIC METHODS IN ELECTROTECHNOLOGY

Abstract: The most sensitive parts of electrical machines – insulating systems - don’t get along without components based on organic substance. These components are usually very necessary by technical and technologic reasons. Operating effects cause specific processes in these components, which change their properties. It’s necessary to monitor concrete changes of
particular components from the aspect of equipment operation, especially in regard of reversibility and irreversibility of these processes. Irreversible processes can lead up even to destruction of materials or components. From aspect of its operating reliability, these components are key parts with their essential importance. For the monitoring of all these processes, structural analyses are (from the aspect of modern diagnostics) irreplaceable. They enable to monitor and consequently discover development of monitored properties. Generally, there is good experience with monitoring of degradation processes in materials of organic structure with a help of thermal analyses. These analyses provide us determination and monitoring of key parameters – enthalpy. This value, discoverable by Differential Thermal Analysis (DTA) is very typical for particular materials and exactly describes behaviour and application of these materials during the operation stress. The connection between the results of structural methods and classical phenomenological methods is very interesting, because structural parameters help us to complete information about monitored elements or subsystems of monitored equipment.

Václav Mentlík, Eva Kučerová, Václav Boček, Pavel Šebík, Radek Polanský
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STUDY OF HIGH-TEMPERATURE INSULATING MATERIAL PROPERTIES
BADANIA WŁAŚCIWOŚCI MATERIAŁU IZOLACYJNEGO ODPORNEGO NA WYSOKIE TEMPERATURY

Abstract: Electric rotary machines intended for working in special conditions (extremely high temperatures) – such as e.g. in drive units for positioning of fuel bars in nuclear reactor or control servomotors in aircrafts – demand particular selection of materials. Insulating system is considered to be the most sensitive part of these machines and also their biggest problem. Materials used for their construction must have special properties. Even during the full operation, they have to resist to given extreme conditions – temperatures about 300 °C and electrical stress as well as mechanical stress. Construction of these insulating systems requires new and original materials, whose character and structure would fully conform to mentioned extreme conditions. In technical use the diagnostic system has got also its special importance in detection of equipment condition, when it result from required properties and provide full and valuable information of examined object. Methods used for diagnostic system must conform by their good predictive ability, but also by their economic and material availability. The content of this contribution deals with composition and examination of diagnostic system for specific case of condition monitoring of given insulating system. Our contribution also contains study results of high-temperature insulating material properties.

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THE MEASURING SYSTEMS CONSTRUCTION AND POSSIBILITIES OF THEIR SOFTWARE SOLVING

KONSTRUKCJA SYSTEMÓW POMIAROWYCH ORAZ SPOSOBY ICH REALIZACJI PROGRAMOWEJ

Abstract: The on-line monitoring is ever more frequent at diagnostics of machines, which have a strategic importance or their breakdown would means a big financial losses. The paper is focused on the theory of monitoring systems constructions. Individual steps of realization are described - the selection of methods, data acquisition, diagnosed machine and measuring system connection. The selection of watched parameters suitable for diagnostic investigation is approximated on power transformers on-line monitoring.
INFLUENCE OF SLIP-RING WAVINESS ON CURRENT DISTRIBUTION IN THE SLIDING CONTACT OF A SYNCHRONOUS MACHINE

Abstract: An investigation of the influence of slip-ring waviness on current distribution in the sliding contact with several brushes connected in parallel has been the objective of the paper. The authors have presented their own measurement results of slip-ring waviness and have made decomposition of this waviness into harmonic components. The authors’ model of the sliding contact with two mechanical degrees of freedom (published earlier) has been used for calculations. This model takes into consideration nonlinear visco-elastic interactions among the brush, the slip-ring and the brush holder. The results of calculations of radial vibrations of the brush were used to determine the resistance of the transition between the brush and the slip-ring. A nonlinear dependence of this transition resistance \( R_{sp} \) has been proposed. It is assumed that \( R_{sp} \) is a function of current flowing through the brush and of the distance between the sliding surfaces of the brush and the slip-ring. Several simplifying assumptions had to be adopted while deriving this dependence. Necessity of simplifications is a result of complexity of the problem as well as the lack of some essential parameter data in literature. On the basis of the sliding contact model with a single brush the authors have worked out an electromechanical model of the whole sliding contact of a synchronous machine with parallel brushes. This model allows for determination of current distribution in the sliding contact during transient states and for steady states. The angular speed and the excitation current can be a time dependant forcing. Simulation results of the influence of the waviness amplitude spectrum on current distribution in the sliding contact have been shown.

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THE TESTS OF INSULATION QUALITY OF THE STATOR WINDING’S ELEMENTARY SHAPED WIRES

Streszczenie: Metodyka badań izolacji elementarnych przewodów nie jest jednoznacznie określona. Polskie normy w tym zakresie są liberalne i odsyłają do norm zakładowych. Izolacja przewodów jest główną przyczyną awarii maszyn, gdyż ulegając uszkodzeniu tworzy obawy pasażeryczne w których generują się dodatkowe straty mocy, zwłaszcza w miejscu zwarcia. Temperatura lokalna, powiększająca się ze czasem eksploatacji, degraduje izolację zwojową a główną uzuwienia. W czasie wszystkich operacji technologicznych wykonania uzuwienia, od profilowania i izolowania pojedynczych drutów do montażu, zwłaszcza ostatnich cewek pętlicowych lub prętowych, należy prowadzić kontrolę jakości izolacji. W artykule zwrócono uwagę na badania izolacji metodą wyładowań niezupełnych /wnz/, która jest przydatna do oceny jakości wykonanego uzuwienia natomiast, z uwagi na zakłócenia jest mało przydatna do badań diagnostycznych maszyn w warunkach eksploatacyjnych. W badaniach diagnostycznych poleca się metodę prądu stałego.

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KWK Wujek, Katowice

ELECTRIC DRIVES OF WINDERS USED IN MINES FOR LAST 100 YEARS

Abstract: 100 years period of electric winders implementation in Silesian mines is presented in a historic depiction. The dynamic process of these arrangements construction modernisation as well as contribution of Polish scientific and technical personnel is pointed out.
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DETERMINATION OF STEADY STATE CHARACTERISTICS OF AXIALLY LAMINATED SYNCHRONOUS RELUCTANCE MOTOR USING FIELD-CIRCUIT METHOD

Abstract: The paper presents a field-circuit approach to determining the steady state performance characteristics of synchronous reluctance motor with magnetic circuit non-linearity taking into account. The method was implemented for the calculation of torque-angle characteristic and main exploitation parameters characteristics of two pole synchronous reluctance motor with axially laminated, anisotropic rotor. For a number of consecutive values of current angle and different excitation levels the direct and quadrature axis current components were calculated. On the basis of radial component of airgap flux density distributions resolved for both axes and each excitation current value, the magnetizing flux linkages in direct and quadrature axes were determined. Calculated flux linkage vs. excitation current functions were stored as a look-up tables. An iterative method of solving a set of non-linear algebraic equations was adopted, with values of flux linkages taken from a look-up table. The curves obtained on the basis of field-circuit model and measured ones were presented together for comparison. The reasons for observed discrepancy between calculated and measured curves were discussed.

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INFLUENCE OF BAR DAMAGE LEVEL ON BAR RESISTANCE OF INDUCTION MACHINE SQUIRREL-CAGE

Abstract: In calculations of failure state of induction machines damage of squirrel-cage is simulated by magnify of resistance bars or ring segments. In this paper I’m going to answer a questions: in which way resistance of bar or ring segment is changing with level of failure? What level of resistance can I use as damage of bar? Have a precision of production of squirrel-cage an effect on resistance of bars? To answer these questions I made some simulations of this problem.

Paweł Dybowski
AGH Kraków

INFLUENCE OF BAR DAMAGE LEVEL ON SYMMETRIC COMPONENTS HARMONIC SPECTRUM OF STATOR CURRENTS OF INDUCTION MOTORS

Abstract: Asymmetry of induction motor, as eccentricity or fracture of bars or end-ring segments of a cage has an effect on harmonic spectrum of stator currents. In this paper I'm going to present comparison of symmetric component harmonic spectrums of induction machines stator currents with harmonic spectrums stator currents. I'm going to answer a question: can I use symmetric component harmonic spectrums of stator currents in diagnostics of induction machines. Dynamical model of this machine calculates harmonics of stator, rotor and stator-rotor inductances accounting for only global saturation of the air-gap region. The model considered various rotational speeds of the rotor.
DIAGNOSTYKA NAPĘDÓW ELEKTRYCZNYCH W OPARCIU O STRUKTURY OBSERWATORÓW ODSPRZĘGAJĄCYCH

DIAGNOSIS OF ELECTRIC DRIVE SYSTEMS BASED ON DECOUPLED OBSERVERS

Abstract: The paper presents method of diagnosis which make possible fast and precision evaluation of technical state of electrical drive systems in a real-time mode. Inefficiencies are represented by failure signals, whose sources can be input, structure and output faults. The main accent is focused on possible application of observer procedures which can decouple fault signals during estimation of system variables. The calculated products of computed and measured variables determine diagnostic residuals which can precisely indicate a source of failure. Diagnostic observers filter unknown expected signals of selected faults and from the other hand, they taken into account an influence of these faults through implementation of controlled feedback loop.

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NAPĘD ODWRACALNY W ELEKTROWNII SZCZYTOWO-POMPOWEJ

INVERSE DRIVE WITH DOUBLE-FED MACHINE FOR PEAK PUMPED-STORAGE POWER STATION

Abstract: This paper presents possibility to use AC machine in the inverse drive with double-fed machine for peak pumped-storage power station. AC machine which works as double-fed machine (DFM) can works in the generator and motor range. The paper describes above ranges work of drive in peak pumped-storage station. In the paper include equation slip-ring induction motor using in DFM drive with vector control system. This control system enables independent control of active and reactive power of drive. This kind of control – independent control of generator power, permits to fast regulate of power in dynamic and static time. This type of generator in peak pumped-storage stations are practically useful in generators big and very big power (more 150–200 MW).

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WPŁYW UKSZTAŁTOWANIA ŚLADÓW OBRÓBKI ELEMENTU STAŁOWEGO NA WŁAŚCIWOŚCI TRIBOLOGICZNE MATERIAŁÓW POLIMEROWYCH W OKRESIE DOCIERANIA

THE INFLUENCE OF THE MASCHINING TRACK DIRECTION OF THE STEEL ELEMENT SURFACE ON THE POLYMERS TRYBOLOGY PROPERTIES DURING A RUNNING-IN PROCESS

Abstract: Dynamic development of polymeric production in last few years, makes application of this materials in machine construction very common. Very good trybology properties of polymeric materials, cause that they are very often apply as an sliding elements, specialy in the sliding bearings. The essentiial advantages these polymers are suppression of tremblings, considerable durability in corrosive and special (aggressive environment, lack of lubrication etc.) conditions. The main requirements of the slide polymeric bearings, are good stability of position of bearing elements. The bearings should be characterized stable work parameters after a running-in process. The most often apply sliding couples in sliding bearings construction including shaft and bush is coupple metal – polymer. In coupples metal – polymer, the bush is usually made from polymer. This paper shows results of tribological investigation of influence the machining track direction in the steel element surface on the selected polymers tribology properties during a running-in process sliding couple. In addition analysis of investigation results prove that the circuital direction track of the mashining on the toe surface ist most advantageous.
GENERATOR SHEETS DESIGNED FOR WORK IN MOTORS IN LIQUID NATURAL GASES

Abstract: The squirrel-cage asynchronous motors working in liquid natural gasses place the particular requirements concerned both active materials and insulation, fastening, electrical connections etc. Generator sheets, used in magnetic core of motor, their insulation and way of packeting are only few essential elements which have the influence on parameters and durability of the motors working in range of temperatures -160°C - -196°C. In the paper, works concern testing and selection of generator sheets for realization of motor working in liquid natural gasses with temperature -161°C are presented. Apart from this, the results of tests conducted in liquid nitrogen environment and room temperature are included. To choose the optimal kind and thickness of electrical sheet, the behavior of electrical sheets with different thickness and kind of insulation were examined. The magnetic parameters of the tested electrical sheets, such as: magnetic induction, total energy loss with division on hysteresis and eddy current loss were determined. On the grounds of the obtained results and analysis of literature the kind and thickness of electrical sheet used in construction of magnetic core of motors working in liquid gasses was chosen.

RESEARCH OF SAFETY OF ELEKTRICAL AGRICULTURAL, FORESTRY AND GARDEN MACHINES AND EQUIPMENT

Abstract: Many machines used in agriculture, gardening and forestry is powered from electroenergetic lines at voltage 230V~/50Hz or 400V~/50Hz. Their construction, magnitude and power means are diverse – occur compound objects (drying room, technological lines to processing of the grain) and simple (comminutors, conveyors, wooddraws, lawnmowers, hotmates and so on). Safety testing operating of the machines executed after 1 may 2004 year are testing of compatibility type with requirements directive 73/23/EEC (called lowvoltaged LVD) and standards harmonized with that directive. Repeatedly, depending kind of hazards occur while operation of the object overlap need additionally investigation compatibility with another appropriate directives (for example: machinery directive 98/37/WE, electromagnetic compatibility 89/336/EEC, noised 2000/14/EC) and harmonized standards. Signed laboratory testings are part of ruling in Poland European system account the compatibility.

Theme safety eksploataion electric machines in agriculture is most important inview of operation environment (condition of electric instalation, unprofessional users, adverse and variable donditions) and often meet defects in construction and building. Because of this unfortunatelly circumstances we to deal with large amount of industrial accidents. In these article author limited to topics electric hazards. Article introduce basic laws and normalization executed actions, used testing procedures and experiences on this area.

PIONIER – POLSKI INTERNET OPTYCZNY

Abstract: The Programme called “Polish Optical Internet PIONIER“, planned for the period 2001-2005, is aimed as further infrastructure development for polish scientific and academic institutes. It constitutes the continuation of the Committee for Scientific Research previous programme (1993-1999), the aim of which was the scientific infrastructure construction. The
The results of these projects are as follows: establishment of 5 High Performance Computing (HPC) centres and 21 academic metropolitan networks as well, and development of data bases and software. Also, an intelligent optical network - the Polish Optical Network - was developed, of following properties: multichannel (the DWDM technics), bandwidth nx (10,40,...) Gb/sec and IP protocol. The network is now of length 3000 km, and further 2000 km will be constructed in the year 2005. As the result, the uniform interurban fiber optics network has been constructed. This network can be the development base for private networks of ATM standard, for SDH channels, for special applications optical lambdas and grids. The network will serve the science, education, national health service and administration, applying equal and independent rules.

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APPLICATION OF ROTOR POSITION SENSORS IN PM BLDC MOTOR SPEED CONTROL CIRCUIT

Abstract: The basic structure of electric drive control system contains current control circuit (inner loop) and speed control circuit (outer loop). Two criteria are used in setting current and speed controllers: symmetry and absolute value. In application, the goal is to limit the quantity of extra parts used with PM BLDC motors, which are usually small power motors. The simplification of the drive structure may be achieved, for instance, by eliminating tachogenerator and using rotor position sensor for calculating motor rotational speed. The rotor position signals are then converted into signals corresponding to motor’s actual speed. The time interval between two rotor characteristic positions is inversely proportional to motor’s rotational speed. The measurement delay changes with motor speed and the typical controller settings criteria cannot be applied, since they are based on assuming that time delay is constant. The paper presents a novel method of selecting speed controller with parameters changing with rotational speed. The controller design is shown. Proposed control system structure and method of selecting controller’s settings ensure that the drive attains properties similar to those of a drive using speed controller system with symmetry criterion used. The theoretical considerations have been verified with help of computer model and laboratory tests.

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SIMULATION AND LABORATORY TESTS OF A PM BLDC MOTOR WITH ROTOR POSITION SENSOR IN VELOCITY CONTROL CIRCUIT

Abstract: In the paper the control system for permanent magnet brushless DC motor is considered. The simulation research results as well as the results of the experiment result carried out using the control system are presented. There were the following conditions of the experiment: speed measurement was performed with the position sensor, the frequency of position sensor signals were proportional to motor velocity. Due to the measurement delay time variability and dependence on the rotational speed of the motor, adaptation regulator was used as a part of the control system. The algorithm of the adaptation regulator setting parameters selection is referred in [3]. As a results of simulation and experiment test, the authors shown waveforms of speed and torque of PM BLDC motor. The laboratory test was performed on laboratory stand for evaluation of drives with PM BLDC motor properties. The laboratory stand was designed for rapid prototyping of BLDC motor control systems. The DS 1104 controller board was used as the main controller of BLDC motor.
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SILNIKI BLDC – KLASYCZNE METODY STEROWANIA
BLDC DRIVES – THE CLASSICAL CONTROL STRATEGIES

Abstract: The definition of BLDC motor classical control method, terminology and classification of the classical control strategies are described in the paper. The proposed classification based on electronic commutator transistors switching sequences. Equivalent circuit diagrams in steady state for each strategy are shown. Based on those diagrams derived formulas to calculate current increasing and falling times for unipolar and bipolar strategies. Those times show the differences in transistors switching frequencies. The advantages and disadvantages of all presented control strategies are indicated too.

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DWUBIEGOWY SILNIK SYNCHRONICZNY W UJĘCIU POLOWO-OBWODOWYM W RÓŻNYCH STANACH PRACY
TWO SPEED SYNCHRONOUS MOTOR IN FIELD-CIRCUIT FORMULATION IN DIFFERENT STATES OF WORK

Abstract: The work presented calculation results of a two-speed synchronous, silent–pole, high power motor. The calculations based on the examined two dimensional, field-circuit model for the large power motor, type GAe 1510/12p were done. Using the prepared model, calculations of static (no load, load) characteristic as well as dynamic (start up to no load) were compiled. A comparison between the calculated and measured results of physical quantities for load, in these synchronous motor with changing pole number of magnetic field, was presented. The following physical quantities were calculated: the armature and field winding current, electromagnetic torque, flux density and electromagnetic forces for different value of filed current, for both rotating speed. The satisfactory convergence between the results of calculations and measurements allows the authors to claim, that the examined model of the motor is correct. It may be therefore accepted, that the described model is useful in evaluation of events occurring in different states of motor operation.

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DIAGNOSTYKA MASZYN INDUKCYJNYCH KLATKOWYCH Z WYKORZYSTANIEM CEWEK ROGOWSKIEGO
DIAGNOSTICS OF SQUIRREL CAGE INDUCTION MACHINES IN SUPPORT ABOUT ROGOWSKI COIL

Abstract: The article presents the possibility an application of Rogowski coils to diagnostics exploational the squirrel-cage induction of motors. It the examples - possibilities of uses were introduced was to detecting in drive the alignment errors (parallel offset), the damage the squirrel-cage as well as airgap eccentricity. The metrological values of coils act it fully useful to diagnostics of motors. The presented in article results of measurements concern coils "own" construction.
OPENING SLOT DEPTH AND ELECTROMAGNETIC FORCES ACTING ON MAGNETIC WEDGE CLOSING STATOR SLOT

Abstract: In sustained use of high-voltage electric motors, when magnetic wedges are used to close the slots, loosening and slipping out of the wedges can be observed. This can lead to destruction of the motor as a result of seizure of the rotor and deformations of stator windings caused by dynamic action of current in absence of rigid closing of slots. In the course of inspection of dismounted wedges, one can observe evident losses of wedge material, in the pack part, as well as absence of wedges in some of radial ventilation channels. This is an effect of forces acting on magnetic material in electromagnetic field. The analysis of forces acting on the magnetic wedge was conducted by means of a model being a representation of a fragment of the motor’s circuit. As a subject of analysis, the area being a cross section in plane transversal to motor’s axis and covering stator slot and rotor slot together with neighboring teeth has been adopted. The performed calculations proved that in the model, relative position of slots with respects to each other results in changes of both value and direction of the resulting force reduced to the geometric centre of the wedge. The opening slot depth value influence on the value of this forces. In this article there are shown the calculate resultates this dependence.

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MODEL MATEMATYCZNY DO BADAŃ CIEPLNYCH DWUBIEGOWYCH SILNIKÓW GÓRNICZYCH
MATHEMATICAL MODEL FOR THERMAL INVESTIGATIONS OF TWO-SPEED MINE MOTORS

Abstract: The paper presents a thermal model of two-speed induction motors with water-cooled frames. This model is made basing on the method of finite differences with the use of interpretation of the heat conduction equations in the form of thermal-electrical networks. It enables calculating temperature distributions in all constructional elements of induction motor and in the stream of water flowing in the frame as well as in the streams of air flowing in ventilation ducts of the rotor core and the frame. Basing on the model, a computer program that can be used for computer aided design is developed. Exemplary thermal calculations are carried out for the two-speed induction motor of 85/250 kW. The results obtained from simulations are compared with those from thermal measurements.

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SYSTEM AKWIZYCJI SYGNAŁÓW DIAGNOSTYCZNYCH DLA OCENY STANU SILNIKA INDUKCYJNEGO KLATKOWEGO
ACQUISITION SYSTEM OF DIAGNOSTIC SIGNALS FOR STATE ESTIMATION CAGE INDUCTION MOTOR

Abstract: This paper presents a procedure of acquisition of diagnostic signals, needed for a comprehensive diagnostics of squirrel cage motors. The is data obtained from a Data Acquisition Card (DAQ), measuring transducers and a database. The
procedure allows the measurements of the required quantities and data transfer to the server via the LAN Network or the Internet. Basic diagnostic signals required to evaluate the condition of the squirrel cage motor are three phase currents and phase voltages feeding the stator of the machine, measured at the same instant. The system delivers data needed to the comprehensive diagnostic of the squirrel cage motors, especially the ones used to detect faults which are difficult to recognize without simultaneous measurements of motor currents and control of a stator voltage symmetry. Simultaneous measurement of the three currents and the three voltages is necessary for the diagnostic methods, based on the analysis of the specific features of the motor currents component’s spectrum described by the authors. This paper contains examples of the diagnostic signal analysis collected and stored with the use of the developed data acquisition system.

Abstract: This paper presents a diagnostic conclusion block, based on a fuzzy logic approach. It proposes implementation of a decision making, algorithm based diagnostic system, in order to achieve an uninterrupted work cycle of the squirrel cage motor drives. The diagnostic conclusion interface has been designed on the basis of the diagnostic data, obtained from the analysis of the phase currents spectra and symmetrical components of the currents spectra. Indicators for the diagnostic evaluation have been selected on the basis of the solutions of the mathematical model of the motor, which takes into consideration the eccentricity of the rotor. The principle of work of the diagnostic conclusion block designed to evaluate the state of the rotor has been presented for a selected motor. Artificial intelligence, including fuzzy logic, applied in the conclusion systems increases the system’s ability to derive characteristic relationships and correlations, which are not recognizable by traditional diagnostic methods, thus giving a higher possibility of forming a correct diagnosis. This is especially important in situations, when the correct interpretation of the measurement data and the diagnostic indicators requires knowledge, coming from the engineering experience.

Abstract: The fault detection and diagnosis in drive systems has practical great significance. Modern non-invasive diagnostics of induction cage motors usually bases on Fourier spectra of stator currents. Creation of individual diagnostic system for one specific motor is very expensive. This problem can be transfer to specialized Diagnostic Center. The aim of this center is to provide detection and diagnosis damage in motors as such outsourcing service. For realization diagnostic applications, Diagnostic Center provide for a specialized data-base. Information can be analyzed in this center by expert systems and faults can be detected before they lead to a partial or total failure of the machine. It requires of installation suitable equipments for remount control measurements and data acquisition in industrial plant. That system offers advantages like: reduction of costs measure and data collection, immediate data delivery and independence from distance to measured object. In this paper, we propose a distributed tele-measuring system supporting Diagnostic Center. As for data transmission, Internet and industrial Ethernet net is used as inexpensive link.
Abstract: The paper presents a model for simulating the influence of a voltage phase shift on the emf and dynamic states of an induction motor. The model was employed to simulation investigation of both the balanced and unbalanced voltage dip and the voltage phase shift in the subsequent voltage recovery and the voltage phase shift without voltage dip. The observation of the emf provides information about the influence of the field suppression rate on the dynamic performance of a motor after the voltage recovery. The influence of the voltage phase shift on the motor operation was analysed for various values of the moment of inertia and the motors loads. The equations describing the electromechanical conversion in an induction motor are based on the Hamilton’s principle of least action and Euler-Lagrange equations. Equations of the induction motor dynamics are written for the sinusoidal, three-phase stator supply voltage, in the stator-fixed coordinates for the space vectors components (a,b) of voltages $U$, currents $i$ and the electromotive force $E$. The simulation was carried out using the Matlab package.

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Abstract: High power induction motors produce high starting currents and high voltage drops on the supply system. Especially difficult problems are when high inertia load is driven by the motors and when the short circuit power of the supply system is low, Then the starting time is very long and sometimes not possible. Application of the power electronic converter significantly reduces starting current which is fully controllable according references. Paper presents results of calculations of the starting processes for directly connected motor and a case of the power electronic converter.

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Abstract: In this paper structure and main characteristics of DC brushless motor driver of the air-condition machine have been presented. The DC brushless motor with permanent magnets supplied by three-phase voltage converter has been used. This paper contains description of developed and manufactured motor and its converter as well as chosen examination results of the driver. Developed motor is characterized by very cogging torque and the converter contains very few elements and is of small dimensions.
COMPARISON OF THE PROPERTIES OF THE AC MOTOR TORQUE AND FLUX VECTORIAL CONTROL METHODS (THE DTC AND FOC)

Abstract: Field oriented control (FOC) and direct torque control (DTC) are becoming the industrial standards for induction motors torque control. Direct torque control method proposed by Takahasi and Noguchi in 1985 in spite of its disadvantages (flux vector hexagonal in shape and distorted current for small motor speed) is competitive to the flux oriented methods of control (FOC). FOC and DTC method comparative analysis are performed to show the basic distinctness of the both. This paper is aimed to give a contribution for a detailed comparison between two control techniques, emphasizing advantages and disadvantages. The analyze performed in this article shows the likeness of the both methods in scope of scheme and properties. The comparison of the FOC method with linear PI controller, nonlinear delta-modulation controller or look up table method and standard DTC method were carry out. The performance of the two basic control schemes is evaluated in terms of torque and current ripple, and transient response to step variations of the torque command. The analysis has been carried out on the basis of the results obtained by laboratory investigation.

OPTIMAL OPERATION OF INDUCTION MOTORS AT VARIED VOLTAGE OF THE FEEDING SOURCE

Abstract: Most of induction motors operate at a load that is considerably lower than the rated load. It brings about a change in such energy indicators as power factor and efficiency that decide over electrical energy consumption. Economic efficiency of a drive system operation depends on those indicators and therefore optimum conditions for the motor operation should be created. If the motor load is lower than the rated load, voltage should be reduced or frequency should be changed to such a value that can ensure maximum values of the energy indicators. Possibilities of energy-saving operation of an induction motor with the regulation of voltage and feeding voltage frequency have been considered. Rules for the enhancement of such energy indicators as current input to the motor, power factor, and efficiency have been given. It is advantageous to feed a motor with voltage and feeding-voltage frequency that vary depending on the load degree as then energy consumption gets reduced. At the rated load a motor has to be fed with rated voltage and rated frequency but with decreasing load the voltage should be adequately reduced and the frequency adequately adjusted. Minimal feeding-voltage values are required at the open-circuit operation. Additionally, algorithms of voltage regulation that can ensure maintaining energy indicators at an adequate preset level have been presented. The indicators have been enhanced and electrical energy savings for various algorithms of voltage and frequency adjustment have been calculated.

SYNTHESIS OF SIGNIFICANT METHODS FOR SCALAR CONTROL OF INDUCTION MOTORS

Abstract: Presently, motors that are installed in electrical drives require adjustment of speed or position or the both values simultaneously. It concerns not only simple drives of open-circuit speed control but also complex elevator drives and servov-
drives that find ever-wider application. DC motors that initially dominated in the industry applications presently get replaced by AC motors as due to a huge development in the domains of power electronics and microprocessor technology the AC motor control is as simple and inexpensive as it is in the case of DC motors.

The paper determines necessary conditions for a drive system that concern asynchronous motor control and follow from the need to ensure adequate torque overload capacity and a slip value. The requirements can be realized in drive systems by controlling amplitude and frequency of the feeding voltage.

The following mathematical models of an asynchronous machine have been described: phase model, vector model and a model expressed in relative units. The models are considered as an introduction to further considerations on the control of asynchronous motors. Significant scalar control techniques for controlling speed and torque in such motors have been presented. A set of methods for the motor flux stabilization as well as a control with the rotor slip stabilization have been discussed.

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ZASTOSOWANIE ESTYMATORA REZYSTANCJI UZWOJENIA STOJANU I WIRNIKA SILNIKA INDUKCYJNEGO

APPLICATION OF OBSERVER FOR RESISTANCE CHANGES OF INDUCTION MOTOR STATOR AND ROTOR

Abstract: In the paper the application of the thermal equivalent diagram method to identification of stator and squirrel cage windings resistance thermal increases in the induction motor. Basing on stator and rotor windings resistance thermal increase, to obtain the change of induction motor rotor speed, caused by increase of windings temperature in the load and overload state. Induction motor thermal model is presented, applied to identification of squirrel cage and stator windings resistance changes in transient states. In fig. 4 and fig.5 was presented comparison of stator windings and squirrel cage temperature, from simulation and measurement. Comparison of induction motor windings average temperature was performed, the temperatures was obtained from laboratory measurements, and from computer simulation in transient state, performed with use of thermal equivalent diagrams the method. The method takes into consideration not only changes of the squirrel cage and winding of the stator temperatures caused by the passage of current in a rotor but also the influence of other losses generated in magnetic circuits and created by bearing friction. Thermal equivalent diagram which was applied to identification of windings temperature, can bee also applied to temperature monitoring in another elements of induction motor e.g. stator and rotor magnetic circuits, shields bearings. The thermal monitoring can take place in thermal transient state and with some modifications in steady state. The system takes into consideration the influence of the majority of the losses in a machine on the squirrel cage temperature. Identification is carried out owing to easily measurable quantities such as current and voltage of a stator. Values of these resistances will by used to improve precision of real time rotor speed calculation. The results presented in fig.8 show improvement in rotor speed calculations.

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ANALIZA NIELINIOWYCH METOD STEROWANIA PRZEKSZTAŁTNIKIEM SIECIOWYM AC/DC

ANALYSIS OF NONLINEAR CONTROL STRATEGIES FOR AC/DC LINE-SIDE CONVERTER

Abstract: The paper presents a comparative study of nonlinear control techniques for AC/DC line-side converter. Virtual Flux Based Direct Power Control for AC/DC converter has been modified by adding nonlinear DC-link controllers. In particular, design methods of robust control has been presented and used to design robust controllers: sliding-mode controller, fuzzy-logic controller and sliding-mode fuzzy controller. The sliding-mode method uses the concept of a sliding line which divides the state space into two semi-planes and defines the distance to the sliding line. Since the system trajectory reaches the sliding line, it cannot leave it. This is achieved despite parameters fluctuation and disturbances, being the main characteristic of robustness. Fuzzy logic controllers are designed by using the phase plane determined by error $e$ and change of error $\dot{e}$. The phase plane is next parted into two semi-planes by means of sliding line. This makes diagonal form of fuzzy logic control similar to sliding-mode with boundary layers. The goal of the control systems presented in the paper is to
maintain the output dc-link voltage at the required level, while line currents should be ideally sinusoidal and in phase with respective phase voltages to satisfy the unity power factor (UPF) condition.

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PRZEKSZTAŁTNIKI ENERGOELEKTRONICZNE AC/DC/AC I AC/AC - UKŁADY TOPOLOGICZNE I STEROWANIE

AC/DC/AC AND AC/AC CONVERTERS - TOPOLOGICAL CIRCUITS AND CONTROL

Abstract: Most variable-speed drive systems use an AC/DC/AC or AC/AC power conversion procedure. Currently, standard adjustable speed drives consist of a diode rectifier and a PWM voltage source inverter. Another alternative is controlled rectifier and a current source inverter. Today, due to the increased use of power electronics appliances and converters, the quality of power in the majority of the ac supply systems is reducing. Nonlinear currents drawn from the utility grid by those equipments imply mains voltage distortion and other problems resulting in harmonic pollution and electromagnetic interference implications. The paper presents a survey the most popular traditional and modern topologies of power electronics systems of converters used for adjustable speed AC motors. The topologies of front end rectifiers and motor inverters are presented. The special attention is paid for double-sided converters, multilevel converters, cascaded converters and dual inverter fed open-end stator winding of induction motor. The topologies of recently developed AC/AC and AC/DC/AC matrix converters are also discussed. The control systems and performance of presented converters is described.

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ANALIZA MATEMATYCZNA WYNIKÓW ISKRZENIA MASZYN KOMUTATOROWYCH PRĄDU STAŁEGO

MATHEMATICAL ANALYSIS OF SPARKING RESULTS IN DIRECT-CURRENT COMMUTATING MACHINES

Abstract: The paper presents mathematical apparatus in the form of indicators that makes possible to describe sparking processes forming at the moving contact of brush bridges with commutator bars at the 'oncoming' and 'leaving' sides in direct-current commutating machines. The formulated mathematical dependences make possible to observe and analyze sparking distribution of each single commutator bar in the course of a whole measuring cycle or during an arbitrarily selected revolution or a few successive revolutions of the commutator within the measuring cycle. Boundary values of the proposed sparking indicators have also been given.

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WPŁYW POŁĄCZENIA SPAWANEGO POMIĘDZY BLACHAMI WIRNIKA SILNIKA Z PRZEŁĄCZANĄ RELUKTANCJĄ NA JEGO SPRAWNOŚĆ

INFLUENCE OF ROTOR WELDED JOINT ON ELECTRICAL MACHINE EFFICIENCY IN SWITCHED RELUCTANCE MOTOR

Abstract: In the paper the welded joint influence on the switched reluctance motor efficiency has been presented. Due to the fact that there are no windings in a rotor of the SR motor it is difficult to join the rotor sheets. Welding is one of the methods of connecting the parts of rotor. It is very strong joint and this is helpful especially for a high speed rotor. In the article the simulation of SR motor model and the diagram of flux dependency on the rotor angle rotation have been shown. All the calculations were performed at the FEMM V3.1 Open Source version program [ 1 ].
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**KONCEPCJA REDUKCJI PRZEMIENNYCH MOMENTÓW PASOŻYTNICZYCH W SILNIKU INDUKCYJNYM KLATKOWYM POPRZEZ PODZIAŁ WRNIKA NA WZAJEMNIE SKRĘCONE PODPAKIETY**

**CONCEPTION OF DECREASING OF PARASITIC SYNCHRONOUS TORQUES IN SQUIRREL-CAGE INDUCTION MOTOR BY DIVIDING THE ROTOR INTO MUTUALLY BRAIDED SUBROTORS**

**Abstract:** This article presents a new conception for decreasing of parasitic synchronous torques in squirrel-cage induction motor. It is based on well-known method of dividing the rotor into two equal subrotors, mutually braded for specially chosen angle. This method allows for reducing amplitudes of synchronous torques for one chosen synchronic speed. Author suggest to divide the rotor into 2^n equal subrotors also mutually braded. In this way it is possible to reduce parasitic synchronous torques connected with n synchronic speeds. Paper presents principles of operation of rotor divided into subrotors and basics of poliharmonic mathematical model (containing simplifying assumptions). Some simulation results are shown to prove the correctness of the model and the method of reducing the synchronous parasitic torques. Also some measuring results, taken in the laboratory for motor with rotor divided into two braded subrotors are presented.

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**SPRZĘŻONE POLE MAGNETO–TERMICZNE SILNIKA INDUKCYJNEGO Z USZKODZONĄ KLATKĄ WRNIKA**

**COUPLING MAGNETO-THERMAL FIELD OF INDUCTION MOTOR WITH BROKEN ROTOR BARS**

**Abstract:** The work presented calculation results of a small power (1.5 kW) squirrel cage motor warm-up. Computation was realized with normal load. There is two models: one with non-damaged rotor and second one with three broken rotor bars. Calculation of coupling transient magneto-thermal field was realized with two-dimensional field-circuit motor model. There is a linear temperature characteristic of aluminum resistivity in squirrel cage, and a linear temperature characteristic of a thermal parameters in squirrel cage and core. Heating characteristic of motor with non-damaged rotor and another one with three broken rotor bars was compared. Heat distribution in rotor was investigated in both situation, in thermal transient state and after its in steady state. Investigations were operated for non-damaged and damaged rotors.

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**PEWNE SZCZEGÓLNE SPOSOBY WYBORU OPTYMALNYCH POD WZGLĘDEM TECHNICZNYM I EKONOMICZNYM UKŁADÓW ELEKTROMASZYNOWYCH**

**CERTAIN PECULIAR METHODS OF THE CHOICE OF AN ELECTROMECHANICAL SYSTEMS OPTIMUM FROM BOTH THE TECHNOLOGICAL AND ECONOMICAL ASPECT**

**Abstract:** The report presents the procedures of the choice of an electromechanical systems optimum based on its econominal mathematical. First procedure presents the relation between joint outlays which are to be destined for a given systems variant and outlays both for its purchase and its operation costs. It is variant choice in the case when outlay category is substituted for another. In other words this economical and mathematical model relates the joint outlays with the type and power of electric
driving motor, the characteristic of the working machine driven by this motor, the characteristic of the working machine
driven by this motor, the time of operation, etc...
The report present also criterions for choosing a systems variant by means of the point method. This point method of
assessing electromechanical drive systems properties allows us to include both of the measurable and nonmeasurable features
of the systems investigated into one joint calculus
The possibility to describe different values of the intensity of properties of systems did draw the author attention to minimax
method based upon Wald’s matrix. This method consist in finding the maximum and minimum value of function of many
variables in a certain set of events (searching of the saddle point).
In some case the determination of the optimum variant is possible by means mathematical regret minimax method.
Mathematical regret method propose the choice of such a possible action that the level of regret for not choosing a best
variant should be the smallest. The auxiliary methods can be used simultaneously with other ways of choosing.

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MOŻLIWOŚĆ ZASTOSOWANIA ZMIENNYCH LINGWISTYCZNYCH W
DIAGNOSTYCE UKŁADÓW ELEKTROMASZYNOWYCH

THE POSSIBILITY OF APPLICATION OF LINGUISTIC VARIABLES
TO DIAGNOSTIC OF ELECTROMECHANICAL SYSTEMS

Abstract: To assess an diagnostic system for electromechanical system and choose its best variant requires formulate of
criterion determination. This process consists of formulating the criterion function and then finding critical variable values.
Technological, economical and, sometimes, praxeologic criterions are presents in this report.
Basing on the consideration should be applied when data used for calculation are multivalent (fuzzy) nature. The idea of
linguistic variables is identified with the idea of linguistic terms. This means:
- an appropriate of number of linguistic variables shall be determined,
- a value of the membership function is subordinated to each linguistic variable.
The set of linguistic variables describing the diagnostic state of electromechanical systems is admitted depending of the origin
if its components: good – medium – bad.
The upper number of linguistic variables should be suggested. In practice distinct limits exist. These limits may be set by the
perceptive capacity of person responsible for the assessment of system. This number of linguistic variables applied in the
diagnostic of a elektromechanical system is determined at three (good – medium – bad), maximum at five (good – mediocre –
medium – weak – bad). The thus suggested number of linguistic variables may be applied rather easily for arriving at
multivalent logics. However, the rules of bivalent logics impell the choice of only two state: good – bad.