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PREDICTIVE MAINTENANCE AT ELECTRONIC EQUIPMENT - A BRIEF REVIEW

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Abstract- The purpose of this article is to present predictive maintenance, the importance of the predictive maintenance, concept, plans of maintenance and maintenance methods that are found in the literature. In the last part of the article two case studies are presented: one is the maintenance of a DC motor and another is the study on online diagnosis using artificial intelligence techniques expert system type in case of a single-phase inverter.

Keywords: Predictive Maintenance, DC Motor, Artificial Intelligence, Inverter.

I. INTRODUCTION

According to European norms of the international IEC or ISO, through the maintenance means a group of technical-economic and managerial activities aimed at ensuring maximum performance of the equipment in question.

The strategy of the predictive maintenance are based to the monitoring equipment / facility with instruments able to measurement directly assess its condition during operation, permanently or in a certain period of time. At the base of PDM is, in many cases, the prediction reliability of the equipment or its components.

The predictive maintenance is monitoring all activities and development trend analysis of characteristic parameters, properties of performance and electrical equipment for detecting degradation trends and incipient fault detection to avoid them [1]. The predictive maintenance is encountered in the specialist area and the conditions of state-based maintenance CBM (Condition Based Maintenance).

The frequency of predictive maintenance interventions depends on the type of system and how to use him. So depending on experience and knowledge gained over time and analyzing the history of defects, based on these data we can achieve a maintenance plan to include periods of intervention on the machinery here, critical components that must be replaced at a certain number of hours of operation or a certain time [2, 3].

Addressing the challenges of situations occurrence and management of a defect in an electronic system requires, as a first step, define common terms. Damage or disruption capacity of a system to provide a required function in the operating conditions specified defines a fault condition (failure). A failure is owed to the occurrence of one or more defects. Not always a defect result in failure, the system can continue to operate, but to low performances [7].

Predictive maintenance operations are very different depending on the technical and operational conditions:
- maintain the exploitation area (ventilation, dust removal);
- cleaning of filters, fans, cooling elements, cables, etc.
- poles contactor cleaning and adjustment;
- mechanical revisions and tightening the electrical connectors, terminals, etc.;
- check and adjust the essential electrical parameters;
- replacement the elements with the uncertain characteristics;
- lubricate all moving mechanisms;
- supplementing or replacing the oil.

Predictive maintenance cannot remove in totally the failure of technical equipment, but it can reduce their number through a series of well-organized operations such as:
- organizing rational revisions and maintenance with trained personnel and specialized;
- recording of defects found, repair times and costs of such repairs;
- drawing up plans maintenance (revisions) and conducting long-term studies of the correlation between the factors which determine maintenance [4].

According to recent studies, the engineering in present are looking for ways or method to achieve predictive maintenance electronic equipment without being complete stoppage of the equipment or close to it.

II. CASE STUDY WITH ON-LINE TECHNIQUE DIAGNOSIS USING ARTIFICIAL INTELLIGENCE

In this study is done on-line diagnostic system using artificial intelligence techniques expert system type in the particular case of a single-phase inverter.

A. Description of the Symptoms and Causes Defects

The purpose of creating and identifying defects tree of all possibilities of failure and remediation solutions, to be implemented in a microprocessor, code, through which it is able to detect, identify and by a solution for proper functioning problem occurred during an inverter (Figure 1).

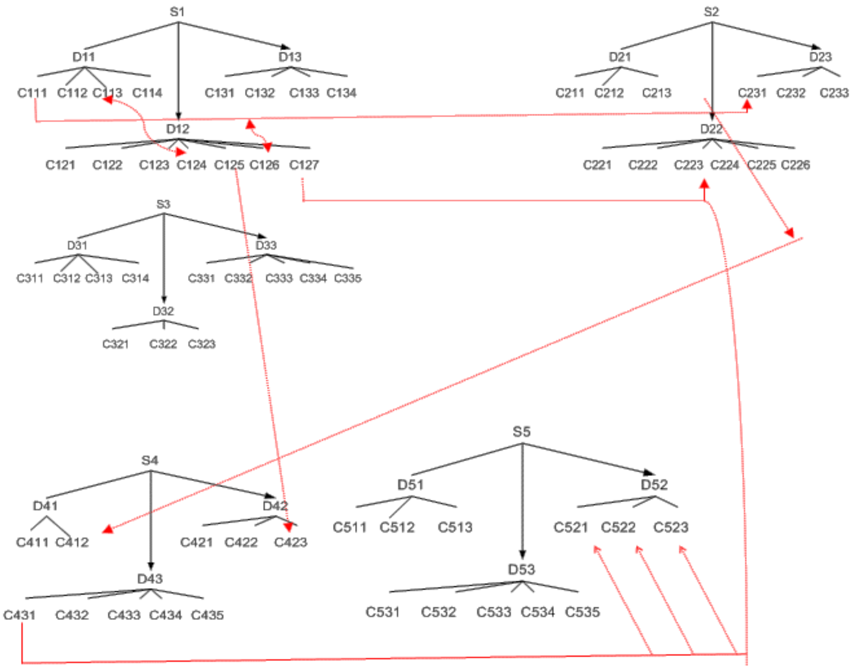

Figure 1. Diagram of defects and symptoms linked to locate the problem

Defects may occur and the causes it generates are:

B. S1 – The Inverter Does Not Work (No Voltage)

D11 – The lack of voltage at the input of inverter

• C111 – Contacts / connectors between the power source and power cable are not properly secured or are deteriorated;
• C112 – Cable (s) is not connected properly;
• C113 – Cable (cables) power shows interruptions;
• C114 – Connecting jacks are damage.

D12 – Lack of tension on one phase, at the inverter output

• C121 – One of thyristors phase without voltage has failed;
• C122 – One phase capacitors without voltage has failed;
• C123 – One of diodes phase without voltage not work;
• C124 – One of the links connecting parts damaged or destroyed inverter;
• C125 – One of the junctions which have been caught or electronic semiconductor elements was cut;
• C126 – One of the items at the inverter was not properly connected or not make contact with the conductor connection.
• C127 – The thyristor control works incorrectly;

D13 – Lack inverter output voltage (from DC)

• C131 – The thyristor control does not work;
• C132 – Inverter thyristors broke down;
• C133 – A part of the circuit was broken;
• C134 – A short circuit, which led to the burning fuse that provides protection inverter.

C. S2 – Inverter Heated Excessively

D21 – The connections between the inverter and power supply or consumer warmed excessive

• C211 – The insulation at the connecting cable was damaged;
• C212 – One of the interior of the inverter connections do not provide firm contact with plug connection (connection);
• C213 – Current flowing through the circuit in question is higher than the rated current.

D22 – The circuit of the inverter are excessively heated

• C221 – Source cooling, forced defective inverter;
• C222 – One or more elements of the inverter (thyristors, diodes) were detached from radiators;
• C223 – Thermally conductive paste between the device and radiator Heat lost properties;
• C224 – Current consumer demand is greater than the nominal current of the inverter operation;
• C225 – A short circuit in the supply line of the consumer, or the consumer in borenele mounted on the inverter;
• C226 – The command of the thyristors work incorrectly.

D23 – Local short circuits

• C231 – Contacts imperfect;
• C232 – Contacts spent;
• C233 – Submission of dust.

D. S3 – The Inverter Emits Smoke or Gas

D31 – Socket connection between the inverter and DC source omitted the smoke

• C311 – Power cable insulation was melted;

• C312 – The insulation of the cable or the jack connection are penetrated;

• C313 – Creating sparks because of imperfect contacts (between connection elements of the inverter or DC source);

• C314 – The current provided by DC source value exceeds the nominal current of the inverter.

D32 – Coupling connection between the inverter and the consumer smells of hot

• C321 – The insulation cable or plug connection to excessively hot;

• C322 – Because of imperfect contacts between the inverter and the consumer socket sparks;

• C323 – Current consumer demand is higher than the rated connection cables.

D33 – Inside the inverter smell of burning (smoke)

• C331 – The nominal current of the inverter has been exceeded;

• C332 – One of electronic parts has broken;

• C333 – A short circuit on the circuit board (inside inverter);

• C334 – The insulation of conductor connectors, the electronic parts of the inverter, has melted;

• C335 – The insulation of conductor connectors, the electronic parts of the inverter, penetrated.

E. S4 – The Inverter Control Angle Can Not Be Changed

D41 – Potentiometer for the adjustment was blocked

• C411 – The potentiometer was messed;

• C412 – The blades are worn potentiometer / desoldering.

D42 – Potentiometer adjustment does not work

• C421 – One of the potentiometer connections (with thyristor control device) was cut;

• C422 – The connection between the control knob and the device is imperfect;

• C423 – One of the cables that connect potentiometer and control device broke.

D43 – The command of the thyristors is not working

• C431 – Soft error;

• C432 – The command is not receiving power;

• C433 – The link between the order and the thyristor device was destroyed;

• C434 – The connection between the device and potentiometer command was interrupted;

• C435 – One of the electronic circuits of the control device malfunctioned.

F. S5 – The Voltage, Current or Frequency Output from the Inverter Do Not Correspond to those Imposed

D51 – The inverter does not receive the required DC input parameters

• C511 – Source DC malfunctioning;

• C512 – The cables connecting the DC source and inverter are not suitable;

• C513 – The connection between the DC source and inverter was not done properly.

D52 – The thyristor control works incorrectly

• C521 – Soft error;

• C522 – One of the thyristors connections is imperfect;

• C523 – One of ties with potentiometer control device or digital-to-analog converter (if any) was made poor.

D53 – The inverter operates correctly but does not point mounted provides the desired parameters

• C531 – The inverter is not shielded;

• C532 – There is a disturbing source in area;

• C533 – Electromagnetic pollution in the work area exceeds the limits specified by the inverter manufacturer;

• C534 – Screen protection (electromagnetic) at the inverter is damaged or destroyed local;

• C535 – The cables pass near the inverter crossed by intense currents or high voltages.

G. S6 – The Inverter Disrupt Network Operation other Consumers in the Connected and/or in the Room Was Fitted

D61 – The coefficient of total distortion (THD) exceeds normal values

• C611 – Reactive power compensation circuit has failed;

• C612 – Links / Connections between reactive power compensation device and inverter and / or network were damaged / destroyed;

• C613 – The device for the command was damaged;

• C614 – Electromagnetic protective screen degradation or destruction of its local.

D62 – The degree of electromagnetic pollution emitted by the inverter exceeds the permissible values

• C621 – Screen protection inverter deteriorated or partially destroyed;

• C622 – The insulation cable for the connections is degraded.

H. S7 – The Switch Inverter (Reverse Ignition)

D71 – The thyristors is not switch cyclically

• C711 – The valve has been in conduction time to regain command properties;

• C712 – Overloading or ordering thyristor command angles too high (close to 180);

• C713 – Decrease or disappearance AC voltage network.

D72 – Short circuit (inverter system operates rectifier)

• C721 – AC voltage network no longer supply voltage decreases the switch but gather it.

I. S8 – Overvoltages Exceeding the Maximum Allowable

D81 – Repetitive overvoltages

• C811 – Current variation di/dt in inductance L;

D82 – Random overvoltages

• C821 – Lightning, switching tasks in parallel on the same parallel distribution system.

III. CASE STUDY FOR MAINTENANCE OF A CURRENT ELECTRIC MOTOR

In this case a diagnosis of a DC motor with permanent magnets remotely using a microcontroller connected to a series of sensors are on the motor. Sensors which gives the required parameters are to find a fault situation. Based on information from the sensors we know what to do to fix it. With the microcontroller can record data both off - line and on - line. The parameter monitored and the tools with which we can determine are presents in continuation.

Monitoring temperature: is done with thermocouples, temperature resistant, FIRB sensors based on optical, infrared thermography or thermal modeling. By monitoring temperatures can diagnose faults such as overloads, hot spots, aging insulation and in some cases can cause their remaining life time.

Partial discharge monitoring: to monitor these parameters are used acoustic sensors, RF detection, cord Rogowski. For monitoring these values we can see if the wires or insulation of high voltage coils [5].

Noise and vibration monitoring: is the most common method of diagnosis and is performed using vibration sensors or by measuring vibration amplitudes. By measuring these characteristics fastening systems can detect weakening its parts overload or poor contact.

Monitoring speed and torque: these measurements can be made using two different sensors, one inductive encoder to determine the speed and torque. With this sensor we can realize if a gear or motor bearings are stuck. Monitoring the absence of voltage at the motor terminals work: monitoring of this parameter we need a transducer that gives us information on voltage level. Once all these monitored parameters realize Table 1 with possible defects and methods of investigation.

Table 1. The monitored parameters with possible defects and methods of investigation

Defect	Investigation
The lack of voltage at the motor terminals	Reading a specialized voltage transducer that gives us information on the voltage level.
Interrupting winding rotor	Reading a specialized current transducer gives us information on the current level.
Mechanical defects gearing system	Reading speed sensor; Read couple sensor;

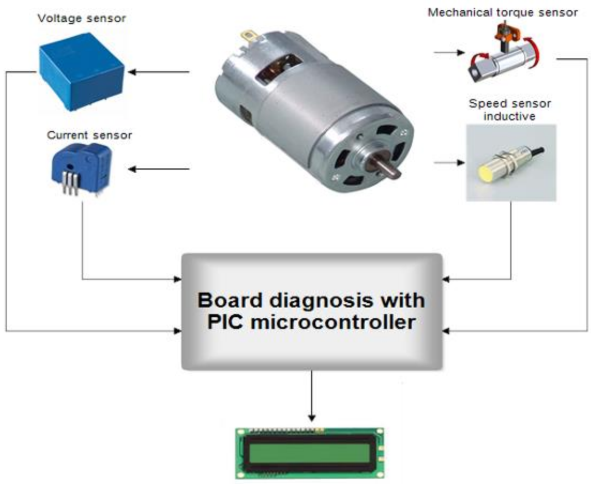

Figure 2. Block diagram of the engine diagnostic system continuous current with permanent magnets

For hardware implementation, as shown in Figure 2 can use the following elements:

To measure current and voltage transducers we used two products, the LEM Company. These sensors are based on Hall Effect [6]. Also to measure speed used a specialized sensor produced by the IFM Company. The sensor has ability to detect metals without touching them.

To measure the torque sensor type encoder used a 6058 model RV manufacturer IFM. Incremental rotary transducers give a precise number determined rotation per pulse [6].

As seen in the flowchart software (Figure 3), the microcontroller receives information from each sensor, analyzes them and we displays the readings. If one of the defects appears on the display will show the type of defect and corresponding value read from the sensor defect.

Also microcontroller circuit can be attached to a module for connecting / disconnecting the engine supply, but is remaining the fault message on the display.

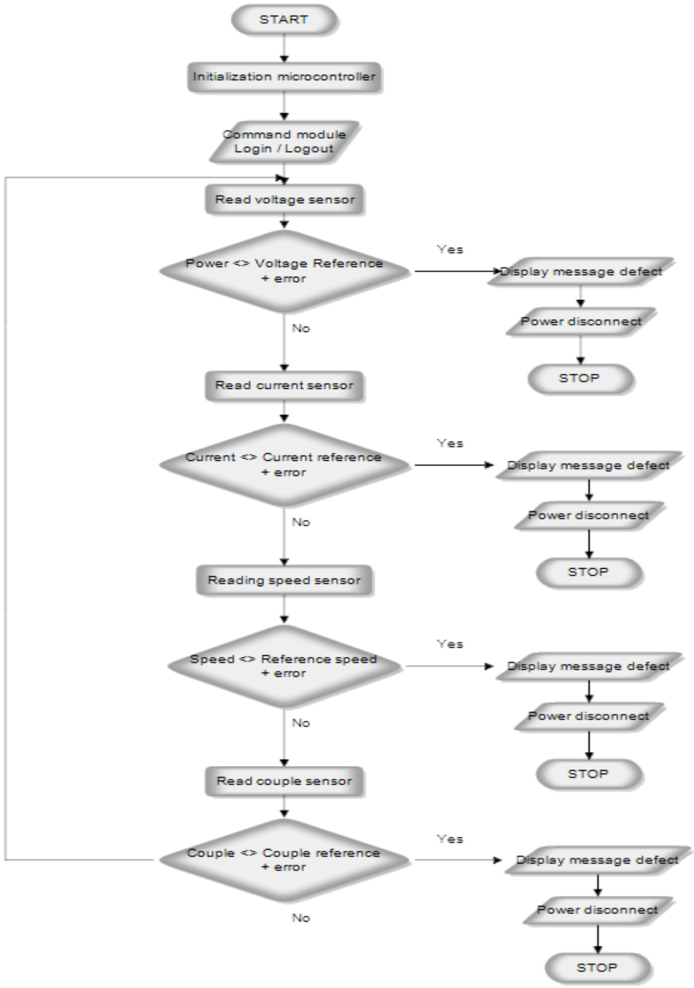

Figure 3. Organizational engine maintenance software for continuous current

IV. CONCLUSION

With predictive maintenance we can eliminate a large number of problems. Problems caused by loss of production, costs and sometimes even problems with staff. Given the continued growth of the complexity of equipment and facilities, PDM implementation becomes more necessary and more advantageous the higher the price monitoring systems is decreasing while the cost of equipment increases.

Predictive maintenance of electronic equipment is very important because we can improve efficiency, life of the equipment is longer. This article presents two case studies of predictive maintenance:

1. On-line diagnosis using artificial intelligence techniques with expert system type in case of a single-phase inverter;
2. Maintenance of the current motor with permanent magnets.

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BIOGRAPHIES

George Robert Sisman was born in Calarasi, Romania on February 3, 1989. He received the B.Sc. in the field of Telecommunications Network and Software and the M.Sc. in the field of Electronic Systems for Managing Industrial Processes from University of Pitesti, Pitesti, Romania. His past experience is as Automation Engineer and currently is working as a Telecommunications Engineer.

Mihai Oproescu was born in Romania on September 2, 1974. He completed his studies in the University of Pitesti, Pitesti, Romania (1998-2011) which received B.Sc. and Ph.D. degrees in Electrical Engineering Science with particular emphasis in "Modeling and optimizing of power flows on inverter systems powered by fuel cells". He participated in 9 national scientific research projects, 1 project as a manager, in 2 projects as economic responsibility, and the other as a member of the implementation team. Over the last 8 years, he has published over 70 papers which focused on renewable energy. His scientific objectives and appropriate goals of education curriculum are in different levels of higher education in electronics, communications and computers sustained at Faculty of Electronics, Communications and Computer Science, University of Pitesti. He is a member of the scientific committees of ECAI Conferences and ICTPE Conference, Program Chair of ECAI Conference and member of scientific board for 4 journals.