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Contributions to the diagnosis of kinematic chain components operation by analyzing the electric current and temperature of the driving engine

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Abstract

The analysis of the electric current and temperature can constitute a very valuable instrument in any monitoring program of the operating status of the kinematic chain components of an equipment and gives to maintenance department the possibility to choose the moment of an intervention; as a direct result it reduces the costs by planning the downtime period (for repairs) in favorable moments. The analysis of electric current and temperature is based on the fact that the engine can be regarded essentially as a transmitter. By installing an electric current sensor we can observe the electric current fluctuations of the engine. It is important to understand the limitations of using this type of analysis, imposed by the load conditions, when the engine is insufficiently loaded, and it is important to take all the logistic measures to obtain correct data which allow to evaluate the evolution of the engine parameters. Taking into consideration the load at which the engine is operating when the analysis of the electric current and temperature is made, we can monitor the results that appear during normal loading conditions of the equipment. Having in mind that in this case the engines can be tested remotely, from the control panel, the risk of making measurements in dangerous and inaccessible areas is eliminated right from the beginning. The results will be materialized in increased confidence in the accuracy of monitoring and will give the possibility of early recommendations for the maintenance department, leading to the amortization of the investment required to implement the research (the analysis of electric current and temperature) into an equipment.

Keywords: motor current, maintenance, transducer current, monitoring.

Introduction

The research performed till the present moment shows that up to 20% of the electric motors used in industry have various defects, such as: defects of the rotor, the rotor bars cracked or broken and the eccentricity of the rotor. A motor can also induce in the windings a current five or six times higher than the current absorbed, which can create a number of problems at startup. Nowadays there are effective techniques of maintenance to predict the critical faults of the electric machines in order to prevent their damage and the production disruption.Based on this research, this paper proposes to take over some technical data used for the maintenance of the electric motors, for analyzing the behavior of the components of a machine-tool kinematic chain.

1. Electric current analysis

The analysis of the operation of kinematic chain components by studying the parameters of the current is the part of novelty that proposes to analyze the information collected from the main driving motor of an equipment though the agency of a transducer, an acquisition board and LabVIEW software in order to determine the necessary maintenance and to make a decision without having to interrupt the production. This method is used concomitantly with the thermal analysis to confirm the diagnosis of the key machinery in the production chain. The analysis of electric current is based on the fact that the engine can be regarded as a transducer. By installing a current transducer it is possible to determine the fluctuations of electric current in the motor. In this way the equipment can be tested remotely, from the control panel, from the office or from a cell phone, eliminating the risks of performing measurements in dangerous or inaccessible areas of the production chain. A current signal generated from the electric motor is a perfect sinusoid at 50 Hz. During operation, several harmonics will be found in the signal measured, so the real signal will include several peaks, including those incurred in the line frequency and its harmonics. This is the specific spectrum of the engine. Analyzing these harmonics according to signal amplification and processing allows to identify the poor operation of the elements of a kinematic chain. The research shows that when there is a high resistance (for example: the improper operation of an element of the kinematic chain) there are changes of the electric current value. This information helps to determine the input current modulation. Knowing this information allows determining the presence and evaluating the operation level of the kinematic chain.

2. Detection of faults

When conducting research work on electric current analysis, it is necessary to observe-determine if the engine is loaded at least 65%, so that the research findings be eloquent. In order to have a determination of maximum efficiency, it is necessary to read the amperage at idle running before starting the actual analysis. The equipment proposed to be monitored are part of industrial installations and technological flows that require variable working conditions. In order to carry out conclusively this research it is necessary to choose the most appropriate moment to retrieve the information in the operation of the system-kinematic chain.
In this situation, one can determine the performances of the motors and carry out effective monitoring of their history, even when the system has variable working parameters, provided that the load is large enough. As long as the load is large enough, we can correctly assess the system condition if we have sufficient data to outline the evolution of the machinery over time. When the system is loaded below 65%, the accumulated information leads us to the decision to install other equipment with proper characteristics for production needs.
As highlighted by the research conducted so far, the demodulated current spectrum is one of the most valuable results achieved within the techniques and technologies of predictive maintenance. Modulation occurs when the signal of low frequency increases and merges with the signal of high frequency, creating another signal. Thus, the dominant peak appears at the carrier frequency and most of the spectrum information is lost because of the background noise. Demodulation is the process of

removing the spectrum carrier frequency. In this case, the carrier frequency is the fundamental frequency of the power line used, namely 50 Hz. After removing the carrier frequency, only the frequencies due to load repetitive variations remain in the demodulated spectrum. In the electric current demodulated spectrum one can identify the fault frequencies (malfunction) and establish the evolution trend of the peaks occurred at these frequencies.

Thus the engine from which we take over the information will act as a permanently installed transducer. However we should take into account the comparison of the determined spectrum with a reference spectrum, measured when the equipment is in perfect running condition and operates at optimum parameters and also the comparison of the spectra of identical kinematic chains – equipment working in the same conditions. When registering the statistical and historical data, we have more indications on setting the alarm level for different types of equipment. In this context, the peaks occurred at low frequencies are lost in the background noise. In this case, the signal demodulation becomes very important. By eliminating the line frequency (50 Hz) from the spectrum, one can identify (presence of peaks) the frequencies characteristic to possible mechanical faults.

3. Fault monitoring system of a kinematic chain based on current footprint method

The analytical modeling of the engine before starting the monitoring is needed as a basis for the analysis conducted to highlight the effects of the faults of broken rotor bar type on engine performances. The technical environment enables the modeling and simulation in steady state conditions and in transient conditions of engine operation, without and with defects of the kinematic chain elements, by highlighting the influence of the defect on engine parameters: current, torque, rotational speed, temperature.

The engine should be checked first because the presence of the broken bars makes the value of the phase currents and of the electromagnetic torque to decrease in the same time with the increase of the broken bars number [4]. The relative variation of the current through the rotor bars highlights that a significant increase of the rotor current occurs in the bar next to the affected bar[5]. When all possible defects have been eliminated from the motor it is possible to start the monitoring of the kinematic chain. Normally, the recording is made for the 3 phases of the motor but in order to simplify implementation and to reduce the cost of development, the parameters monitoring will be made for a single phase of the electric motor (in the case of this research). Monitoring the variation of supply voltage is necessary for neglecting the possible errors occurred because of the incorrect variation thereof. The improper variation of the electric current enables the detection of malfunction of equipment kinematic chain elements as a result of the problems encountered with the electric motor.

It has been developed a system built for monitoring the operating parameters of electric motors and for highlighting a malfunction of a kinematic chain (Fig.3). The system includes a data acquisition module represented by a platform NI - DAQ, 6251 (Fig. 2), connected to a computer via USB port, an extension module that contains specific sensors for measuring the values of parameters and a LabVIEW software application for processing and representation of the information recorded by the acquisition module[1].

Figure 1. Burg Wächter device[7] for temperature direct measurement

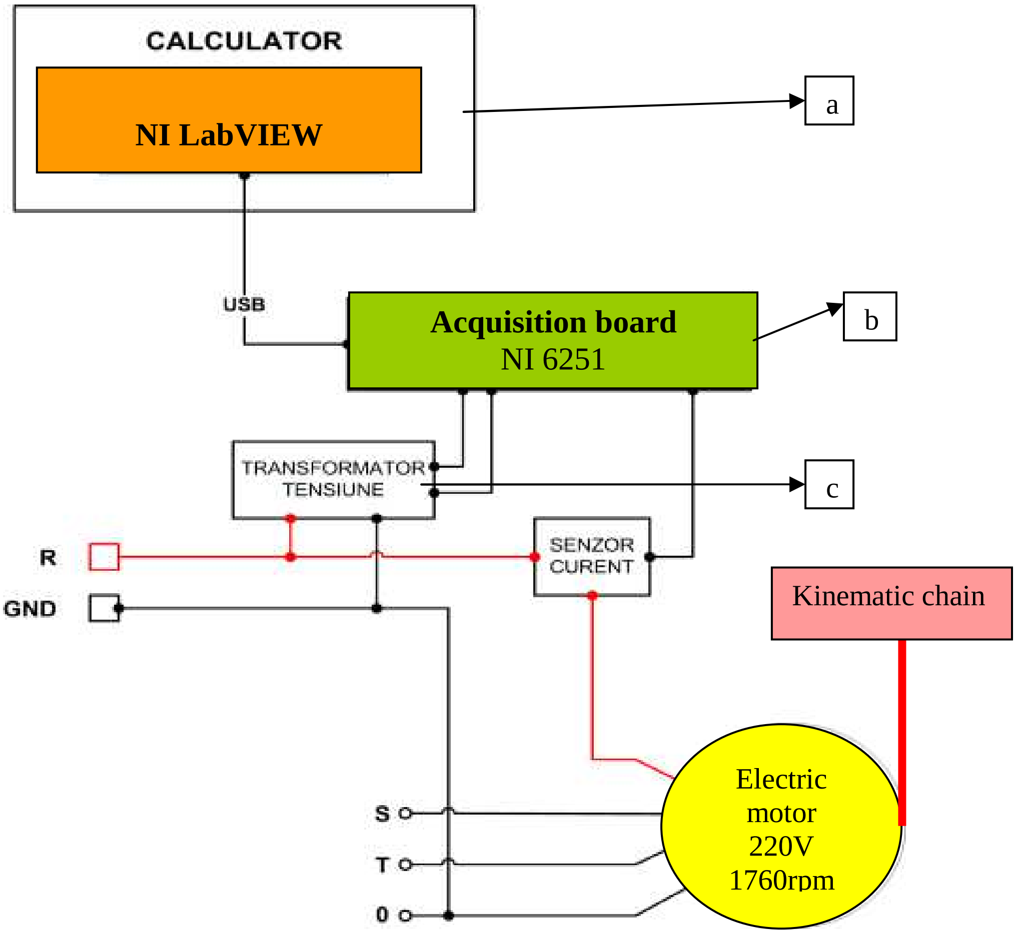

Figure 2. Monitoring system of the kinematic chain parameters

(a. LabVIEW software, b. NI 6251 acquisition board, c. Voltage transformer,)

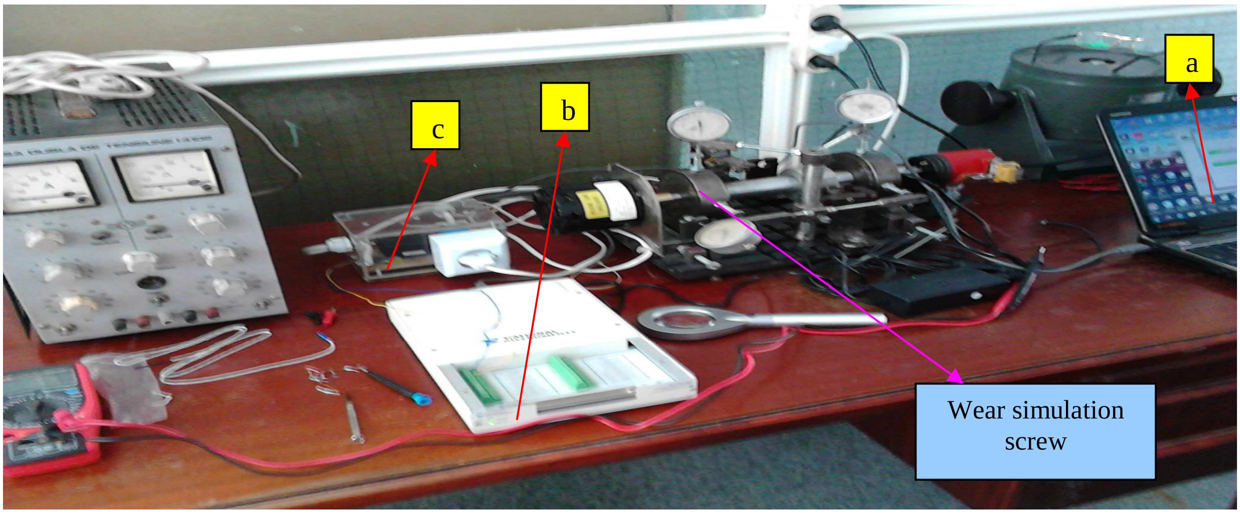

Figure 3. Experimental stand for kinematic chain monitoring

LabVIEW software application will perform the necessary processing of the electric current parameters for proper viewing of these ones and will allow their storage for subsequent viewings in the form of electronic files.
The LabVIEW software installed in the data acquisition module allows to record information regarding input voltage and the current used during the operation of the motor to be tested [1].
The monitoring system enables both the storage of the information recorded by the acquisition module and the viewing of the recorded information in graphical form. The graphical representation allows us to determine any malfunction of kinematic chain elements by detecting the points of sinusoidal signals alteration, representative for the input voltage and of the current used during the running of the equipment.
Information referring to the date and time of the test, the name of the test performed and a minimum description shall be saved for each test performed on the equipment.
While conducting the test, the power supply of the electric motor can be turned on or off and also the monitoring process can be started or stopped. The acquisition board records information specific to testing only during the period when the monitoring system is turned on. During the test carrying out, the recorded information can be viewed in graphical form (Fig. 4).

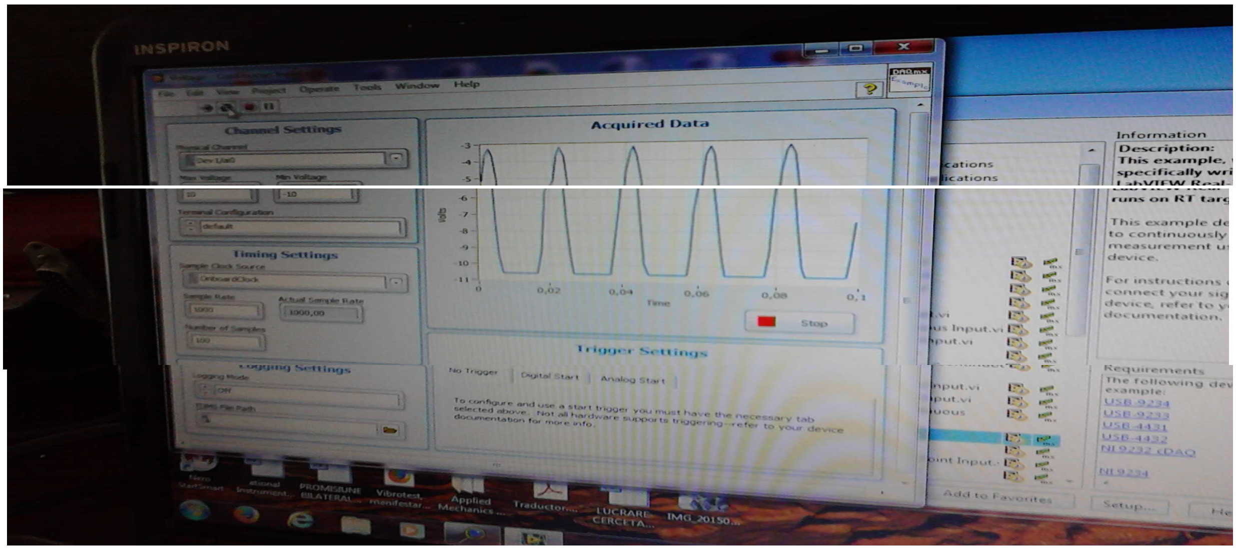

Figure 4. Monitoring of electric signal

The specific information of the tests performed can be viewed in the same way. A proper diagnosis, applied to any type of kinematic chain, requires a good theoretical foundation. By using simulation instruments, one can outline the effects caused by faults on the performances of the electric motor and can establish diagnosis indicators to identify and locate the defects occurred in the kinematic chain elements [2].
The analysis based on numerical methods enables the observation of changes in electric and temperature parameters (with device, Fig.1) as a result of the wear/failure process, without the need of shutdown or experimentation in laboratories. The main idea is to understand the electric, thermal and mechanical behavior of the electric motor transmitted by the elements of a kinematic chain in good condition or under wear [3].

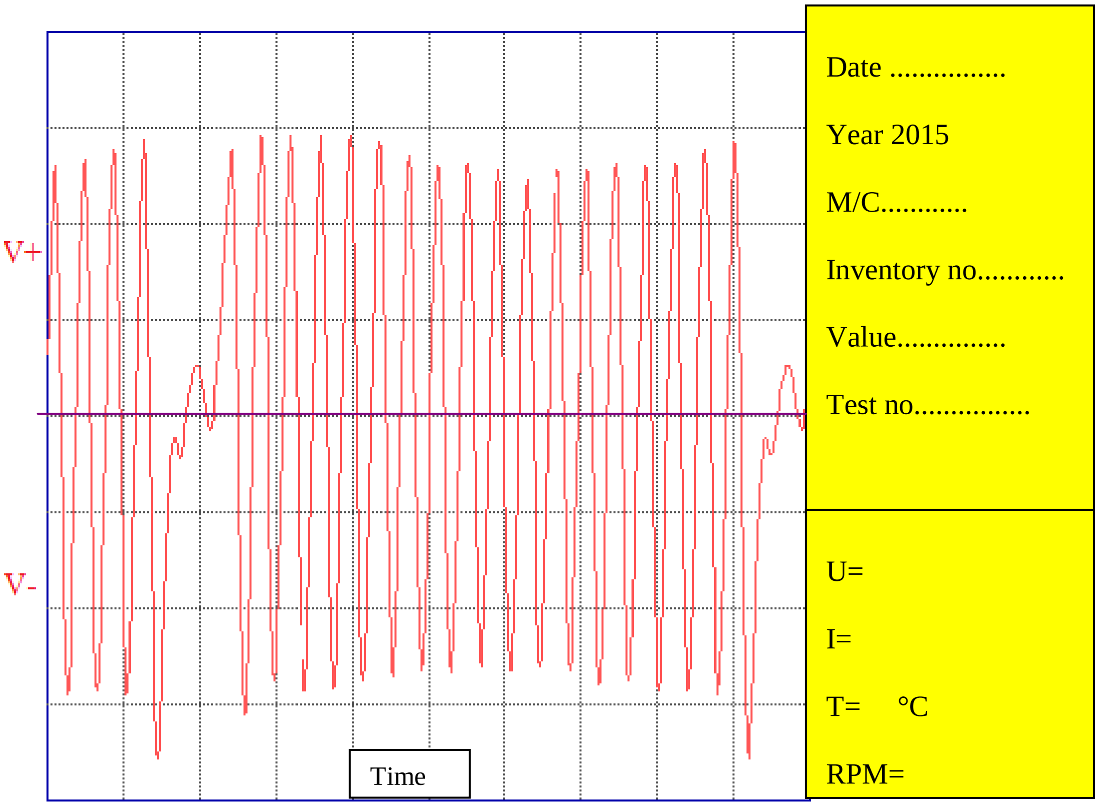

Figure 5. Variation over time of the signal recorded at a normally operating kinematic chain

The curves obtained have been analyzed and compared to the calibration curves of the device.
The shape of the curves obtained indicates:
- a constant amplitude of the displayed signal, corresponding to the type of sample –kinematic chain without defect;
- increase of signal amplitude accompanied by a deformation that corresponds to a worn out element in the kinematic chain.

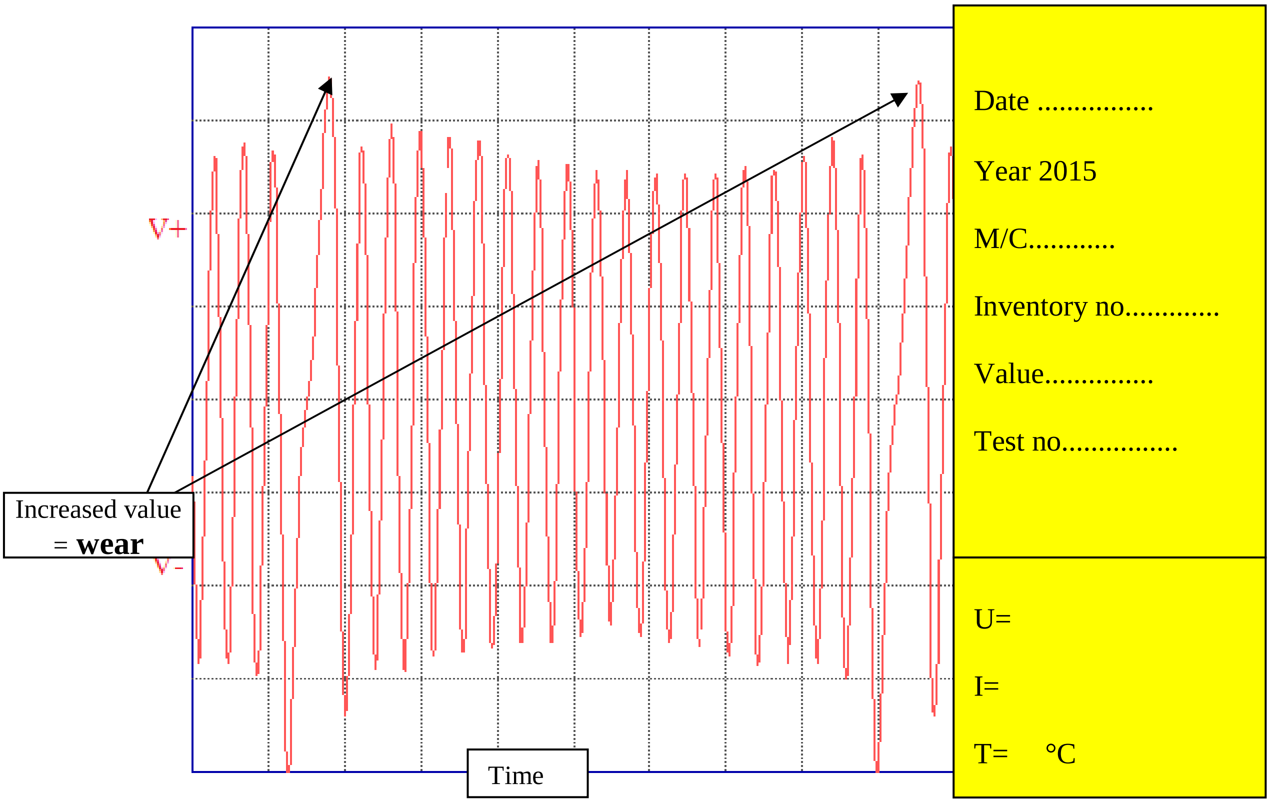

Figure 5. Variation over time of the signal recorded at kinematic chain with abnormal operation (screw displacement by 1.5 mm for wear simulation)

Table 1. Voltage during normal operation and wear simulation with screw displacement by 1.5 mm

No.	U /V/normal	U/V/1.5mm	Time/min	N1 RPM	N2 RPM	T1 °C	T2 °C
1	5	5.9	1	1760	1720	24	25
2	4.9	5.85	2	1758	1718	24.5	28.3
3	4.95	6	3	1768	1718	24.5	29.2
4	4.98	5.97	4	1757	1719	24.7	30.6

The parameters of the electric motors (rated current and power consumption) can be indicators of wear of kinematic chain elements when the motor is running normally (Fig.5). Following the tests, one can notice that the rated current and the voltage increase in the same time with the wear of the elements of a kinematic chain (simulated by the displacement of the screw by 1.5 mm); also, the motor power and rotational speed decrease and the temperature of the bearing increases [6].Using this information we can maintain the performances of the electric motor within the acceptable limits imposed by standards; the determination of the kinematic chain elements wear and of the failure rate can be achieved by identifying the sources and the causes produced by each element of this one.

5. Conclusions

In conclusion, the analysis of electric current is a research paper that provides an efficient way for a program to monitor the equipment operating status. However the research also highlights the limits of using this type of analysis, imposed by the load conditions, when the motor is insufficiently loaded; it is necessary to take all technical measures required for obtaining repeatable data, allowing the evaluation over time of the behavior of equipment kinematic line. Considering the load at which the engine operates, while making the research on the electric current analysis we can also check the results that we anticipated by using this method. The outcomes of this research lead to higher levels of confidence in the accuracy of the decision to be made and transmitted in due time to the maintenance team, enabling finally the possibility of amortization of the current analysis implementation in the shortest period.

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