XVI IMEKO World Congress
Measurement - Supports Science - Improves Technology - Protects Environment ... and Provides Employment - Now and in the Future
Vienna, AUSTRIA, 2000, September 25-28

VIRTUAL INSTRUMENTS FOR ELECTRICAL MOTOR'S DIAGNOSTICS

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Abstract: The best results of electrical motor's diagnoses are obtained using the methods based on spectral analysis of vibration signals or on analysis of supplying currents (in the case of electrical driving systems). The most numerous group of driving system breakdowns is connected with the damages of roll bearings. In this case very effective diagnosing can be obtained using envelope signal processing (ESP) technique. The research stand elaborated in the Faculty of Electrical and Control Engineering (TUG) enables to make research with ESP diagnostic method used for rolling elements bearings as well as supplying current analysis. The diagnostic system is based on virtual instruments using LabVIEW of National Instruments The stand is equipped in numerous motors with determined defects as well as the motors of the same type being in good condition, computer, specialized software built on the base of LabVIEW package. The results of measurement, as panels of virtual instruments, created in LabVIEW, are shown in the paper.

Keywords: diagnostics, virtual instrument, electrical motor

1 INTRODUCTION

Diagnostics of driving systems enables to watch their condition in time of operation and to pass from scheduled maintenance to the maintenance according to the real machine condition. For this reason it is necessary to use the diagnostic methods which allow to predict condition of each machine construction and elements in situ without its disassembly and moreover during its working condition. In this case it is possible to eliminate unexpected breakdowns and usually to elongate the period between two successive maintenance.

The methods based on analysis of generalized spectra of vibration signals or envelope signal processing (ESP) are interesting [1], [2], [3]. In these methods as the source of analyzed signals are the accelerometers fixed on the housing of the investigated unit. Recording and analyzing of these signals demands utilization of specialized instruments. The analysis of harmonics and increase of their values in time enables to state the diagnosis of bearings (the most often cause of unexpected breakdowns) and to predict the moment of next examination or time of necessary maintenance.

In the last decade it could be observed the dynamic development of virtual instruments (VIs). Among the main producers of this software there are: National Instruments Corporation (LabVIEW, LabWindows for DOS and LabWindows/CVI for Windows), Hewlett Packard (HP VEE for Windows) and Kiethley Instrument (Test Point). The diagnostic system based on virtual instruments is cheaper than the systems with specialized instruments and is also more convenient in the case of its further transformation.

The stand we use for driving systems monitoring was elaborated by the group from the Electrical Measurements Department of the Faculty of Electrical and Control Engineering (TUG). This stand is based on the LabVIEW package, which enables to form instrumentation suitable to demands of each customer. Moreover using the Application Builder of the National Instruments it is possible to create VI system for the driving systems diagnosis which can be used with computers do not equipped with LabVIEW package.

This stand is equipped in numerous motors with determined bearing's defects as well as the motors of the same type being in good condition. For this reason it is possible to present the spectra of strictly specified defects and to watch the development of these spectra in time.

2 DIAGNOSTIC SYSTEM

Diagnostic system is realised using the virtual instrument (VI) basing on LabVIEW package of National Instruments [4]. The system enables to determine the electrical faults of electrical motors (induction motors) as well as for analysing the mechanical defects of these motors.

2.1 The analysis of mechanical defects

The analysis of mechanical defects is realised in two steps (Figure 1). In the first step (data collections) there is used the measuring tape recorder TR of Brüel & Kjaer connected to the accelerometer Ac fixed to the bearing housing of investigated unit. In the second step (data evaluation) the signals from the tape recorder are processed and analysed by diagnostic and conditioning VI-system which consists of the PC equipped with LabVIEW package and a/d card, display unit D and printer P.

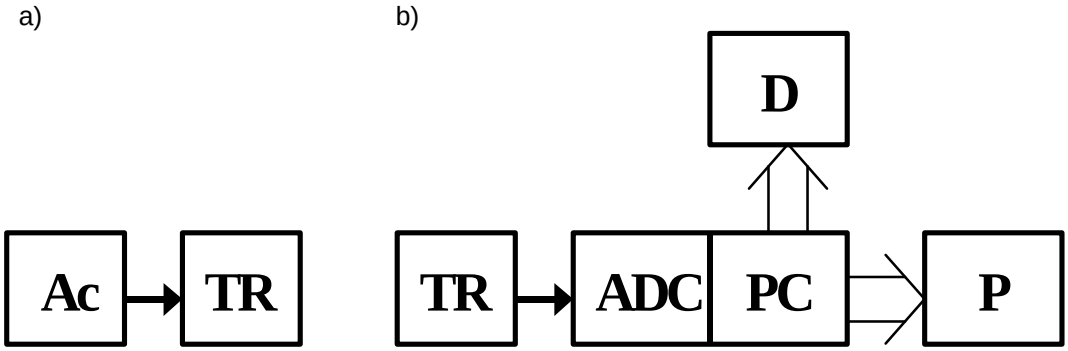

Figure 1. Bloc diagram of data collections (a) and data evaluation (b)
Ac - accelerometer, TR - magnetic tape recorder,
ADC - a/d card, PC - personal computer, D -display,
P - printers

The diagnostic VI-system processes data registered on magnetic tape for precisely determined bearings.

The main data of numerous bearings are stored in bearing directory. Taking into account the value of rotational frequency f_r at the time when the signals from an accelerometer were registered the main defects frequencies of tested bearing can be determined.

Afterwards it is possible to start the diagnostic process using VI system. The window presented in the figure 2. shows the values of depth modulation coefficient (DMC) for particular bearing defect frequency specified its fault i.e.:

- revolution around outer race
- non-uniform radial tension of the bearing.
- wear of outer race
- cavities on outer race
- wear of inner race
- cavities on inner race
- wear of cage and rolling elements

If the value of depth modulation coefficient exceeds specified values the colour signal lamp is glimmering in the field of particular defect. The green light if weak defect is detected and the red one for sever defect. The diagnosis is performed for the earlier chosen value of rotational frequency . The diagnostic system specifies also existing in the analysed spectrum frequencies which were bounded with strictly determined faults.

2.2 The analysis of electrical defects

For analysis the electrical defects we use the same stand. For his case laboratory stand was equipped with another sensors - current transducers type LEM mounted on supply lines of motor

Among numerous diagnostic methods of electrical motors, like analysis of direct or envelope vibration spectra, temperature measurements, especially interesting is the method based on the measurements and analysis of motor's supply voltages and currents curves. The analysis of their

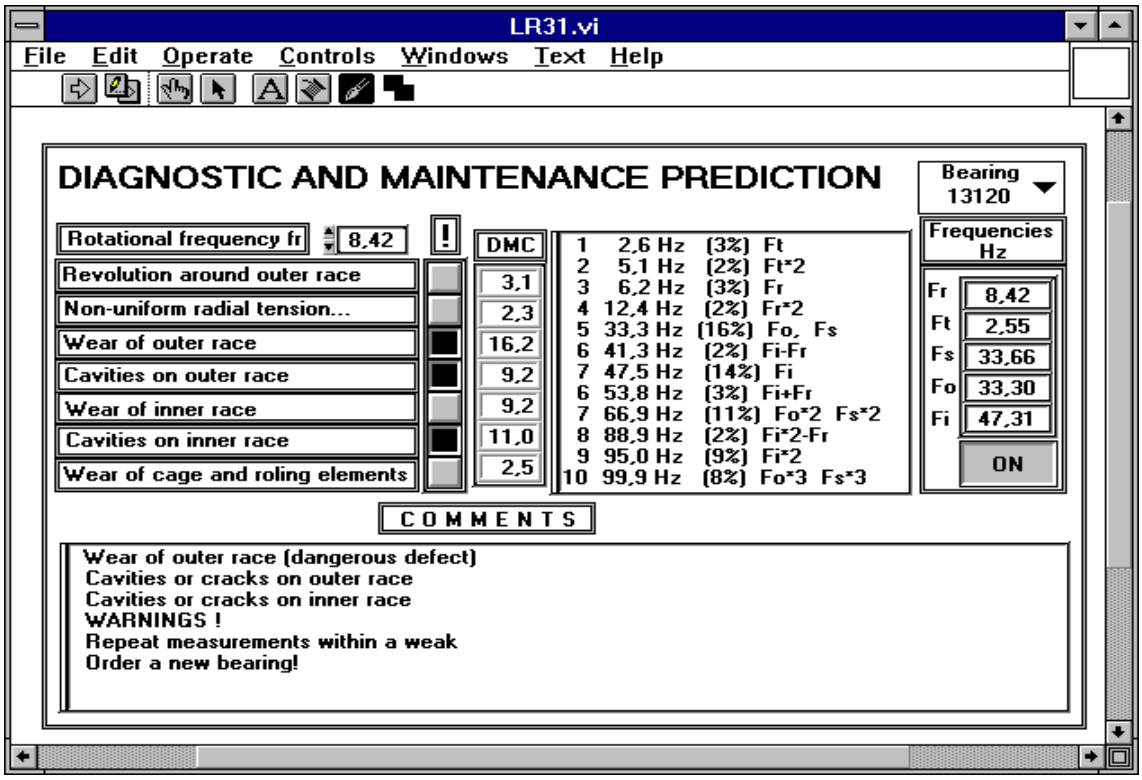

Figure. 2 Diagnosis and maintenance prediction for rolling elements bearings

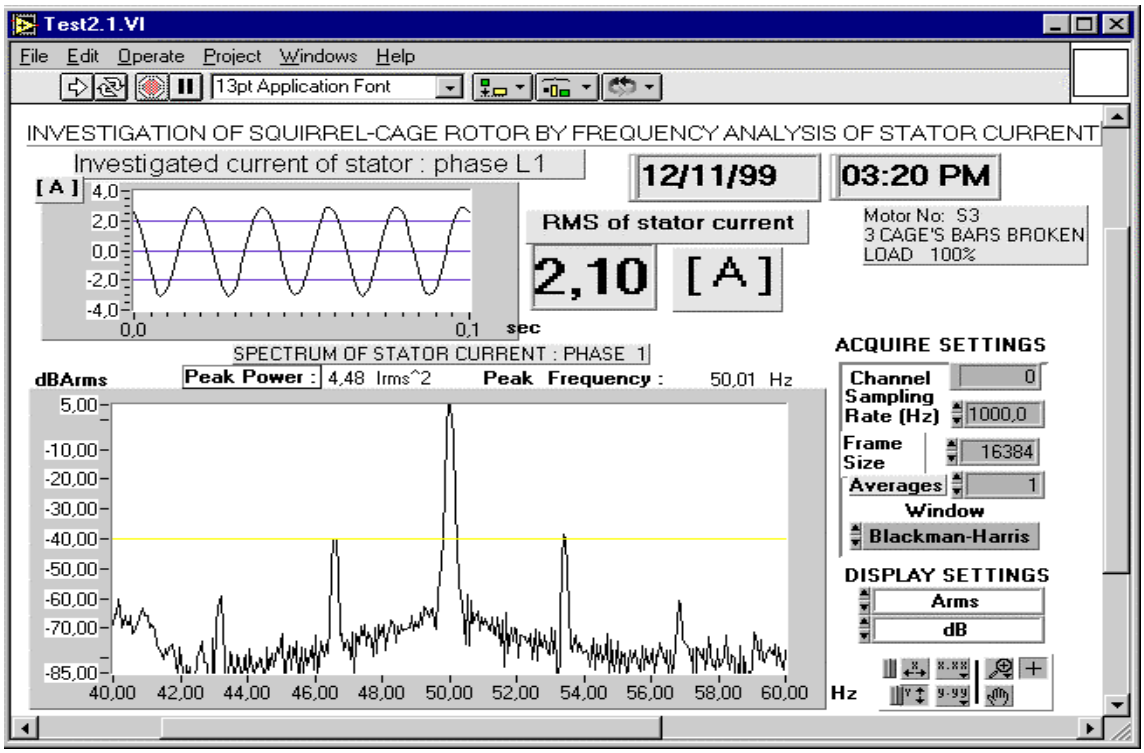

Figure 3 An example of measurement's results of electrical faults.

harmonics and their phase shifts enables the diagnostic of the different types of faults. In comparison with the other known methods the presented one has several advantages. The measuring sensors (current and supply voltage transducers) can be mounted in the certain distance from tested motor and moreover the measuring signals are not disturbed by the work of other machines.

Commonly used methods for diagnosis of motors has not such advantages . The most typical faults, possible for detection by described method, are: demages of stator and rotor windings, misalingnment of shafts.

We hope, that faults of bearings (the most often cause of unexpected breakdowns) will be also possible to detect by this method.

The investigations were performed in a several steps. The first step it was the testing of the transducers. The transducers were tested both on the laboratory stand and in the field condition - on working machine. The results of LEM transducer's testing showed, that they completely fulfil our demands. From the next step of investigations we expect an answer, how sensitive is this method for different type of motors' faults, and how reliable are diagnoses, obtained by this method in the presence of disturbances of different type. For this aim first we tested the motors completely new, without any faults, with different load : from 0 to 100 % of rated power. Afterwards a few defined faults were introduced into the motors. An example of measurement's result is shown in the Figure 3. This figure present motor with 100% load and broken 3 cage's bars.

3 CONCLUSIONS

The introduced fault changes the spectrum's curve in evident way. This changes are not visible, if load in under 20% of nominal power - the current is too small.

The broken bars result in arriving spectrum's components with frequency:

$$f_X = f_r + s*f_r$$

where: f_r - rotational frequency of rotor

s - slip of rotor

The next step of develop the software will be creating the expert system, which should give an answer - what type of fault has the motor, how deep is this fault and prognose how long it is possible to use machine before its maintenance.

Under design we have the system, which will use different input signals (vibration, input voltage and current), for achieving more precise and reliable diagnoses, as a result of widen range of data. The increase of the range of data sources will extend the diagnostic possibilities of the system.

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