Bearing fault detection of induction motor using ANN based in LabVIEW

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Abstract The present research **on-line** diagnosis faults of squirrel cage induction motor and an early time with deferent types of faults directly, the work categories and analyzes the current waveform of 2.2kw, 300 rpm I.M.
Using Labview program this system can analyze and categorize current waveform of 2.2 kW and speed 3000 rpm. Which use fast furrier transform FFT to analysis of current waveform and Extraction the harmonics values and compare them with the information stored in the system as data base and the discovery of potentially faults through neural network used for classification purposes during the period of work directly. Two cases considered which are no load and full load case, also design indicators showing the type of the load applying on the motor. This work avoided interruption in production lines and reduce maintenance costs.

1 INTRODUCTION

The induction motors used in many industrial applications. They are simple and have a high reliability. The severity of motor fault can occur significantly grave danger to the productive activities of the plants. The diagnoses fault before it occurs may avoid sudden stops of the work and then identification times of maintenance without affecting the production lines and working hours. The faults of induction motors basic ingredients usually associated with stator, rotor and bearings. Surveys indicate that these components account for 88% of the motor faults. The disclosure of the beginning of the faults can be found from the electricity and magnetism and mechanical parts of the motor. The three major most important I.M faults problems which are containing stator winding fault , the rotor bares , faults of the magnetic circuit and faults in the mechanical system of the motor (the most popular). All these faults relate to electric, magnetic and vibration phenomena. By observing the latest stats faults in induction motors of high and low frequency note that there is a significant increase of mechanical failure in comparison with the faults of electrical circuits and magnetic [1]. It can be described as follows (as a percentage of all motor failures)

- •bearing faults: 40% or 50%,
- •stator faults: 36%,
- •rotor faults: 2.5%, or 10%,
- •Other: 14% or 20%,

The on line diagnoses faults use the motor current analyses because it very simple and its high reliability [3] [2].
Over 20 years, the last years, technology has made significant progress in creating a new virtual tool presents the user with a wide range of engineering tests compared with traditional tools.
This technique several advantages, such as, high-performance, scalability and so on. Labview program that allows flexibility in dealing with different programming languages in addition to its ability to combine and built between tools, Labview is designed to test, measure and control a variety of applications that can be created by the program, Beginning from temperature monitoring to simulate complex systems and control and taking the measurement devices readings and displayed and analysis and generate signals and dealing with all the inputs so as to allow the user to input and output signals easily and reliably [4] [5] [6]. In this research has been adopted motor current signature analyses MCSA discover faults in induction motors which are considered

2-Analysis Stator Current Waveform and Frequency Spectrum By Labview Programming:

This research involves the development of Labview modules for DAQ and analysis for AC motor test bench. The block diagram of the created virtual instrument panel analogical to the instrument panel installed with three phase squirrel cage induction motor parameters Table(1) was illustrated. In order to improve the circuit diagram transparency, some of its elements were combined into a form of subprograms containing a part of input or output elements. Configuration of the data acquisition device ports and performing the conversions required to adapt the input signal parameters to the ranges of indicators and warning lamps. For the motor test, it is to apply the proposed Labview interfaced module to motor to ensure its performances in real life motor at healthy and faulty condition. The line current, of the motor is measured by the proposed LabVIEW interfaced module, the results already are compared.

Table (1) parameters of three phase squirrel cage IM

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MOTOR TYPE	B3 90L (Electromotor company / Romania)
RATED OUTPUT POWER	2.2 kW
RATED VOLTAGE	380 V. STAR
RATED CURRENT	5 A.
RATED SPEED	2850 r.p.m. (slip = 0.05)
RATED TORQUE	7.37 N.m
STARTING CURRENT / RATED CURRENT	6.5, (I starting = 32.5 A.)
STARTING TORQUE / RATED TORQUE	2
MAXIMUM TORQUE / RATED TORQUE	2.2
POWER FACTOR	0.855
EFFECINECY	0.79
CLASS OF INSULATION	F (155 ° C max.)
CLASS OF PROTECTION	I P 54

The electrical fault in induction motor has been classified into two types stator faults and rotor faults. The stator can be typically classified as Open circuit fault, Line-to-line fault, Turn-to-turn fault, Coil-to coil fault and Line-to-ground fault as shown in the Figure 1.

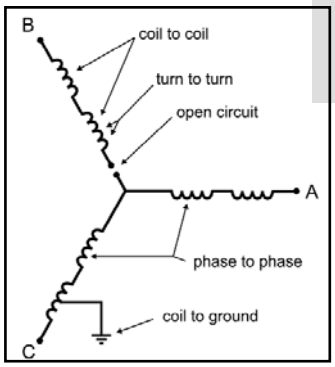

Fig. 1 The stator fault in induction motor

In this paper the stator turn to turn fault is only taken into account.

A stator turn to turn fault ac machine cause a large circulating current to flow and subsequently generates excessive heat in the shorted turns is considered as a first type of fault in the given induction motor[5, 6].

The inter-turn short circuit of the stator winding is the starting point of winding faults such as turn loss of phase windings, The short-circuit current flows in the inter-turn short circuit windings. This initiates a negative MMF, which reduces the net MMF of the motor phase. Therefore, the waveform of air-gap flux, which is changed by the distortion of the net MMF, induces harmonic frequencies in a stator-winding current as:

$$t_{stator} = \{\frac{n}{p}(1-s) \pm k\} t_1 \quad \dots (1)$$

Where p is the number of pole pairs, n = 1, 2, 3,…
And k = 1, 3, 5, . . ., respectively

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With sinusoidal mmf the frequency of the slot harmonic component for the stator current can be expressed as:

$$t_{stator} = \{z_2(1-s)\frac{n}{p} \pm t_1\} \quad \dots (2)$$

z being the rotor slot number.

To take stator mmf time harmonic into account, f_1 must be multiplied by h, the harmonic number of the stator mmf time harmonics (h = 1, 3, 5, 7.).

The slot harmonic frequency for the stator current will come out as

$$t_h = \{z_2(1-s)\frac{n}{p} \pm ht_1\} \quad \dots (3)$$

Fault diagnostic techniques are gaining importance in industry because of the need to increase reliability and to decrease the possibility of production loss due to machine breakdown. [7].

4-Procedure of fault diagnosis

The way of the approved methods in the diagnosis of faults have been dealing with analyses current waveform of IM directly and continuously, where designed monitoring system for current waveforms using LabVIEW program that through the signal converter from analogue to digital and vice versa to take the current waveforms analyzed and classified through neural networks to identify the type of the existing faults. The faults studied in this research are stator, rotor, bearings as well as the natural state or healthy motor. The internal faults of the motor are processed directly through the analysis of current waveforms.

1- Current waveforms are taken through three current transformer connecting to the feeding lines as show in figure1. The transformer type is considered to read current waveforms and show the largest number of present harmonics, because the basis way of diagnosis faults is to analyze this harmonics.

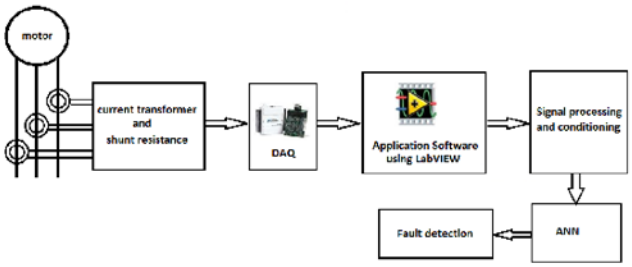


Fig.1 block diagram of fault diagnoses of I.M using Labview

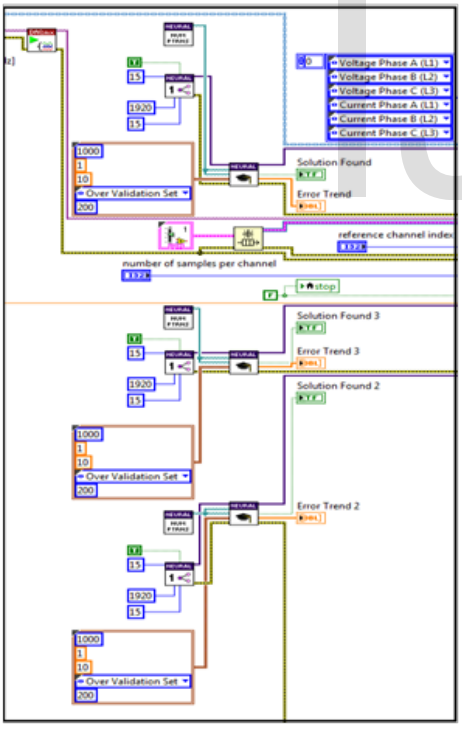
2- Voltage transformers of 220 to 3 volts are used to match the input of Data Acquisition Device (DAQ) which deals with voltages ranging from +10 to -10 volts

3- To read the voltage waveforms of the three phases allows the user to find out if the voltages applied on the machine without decrease.

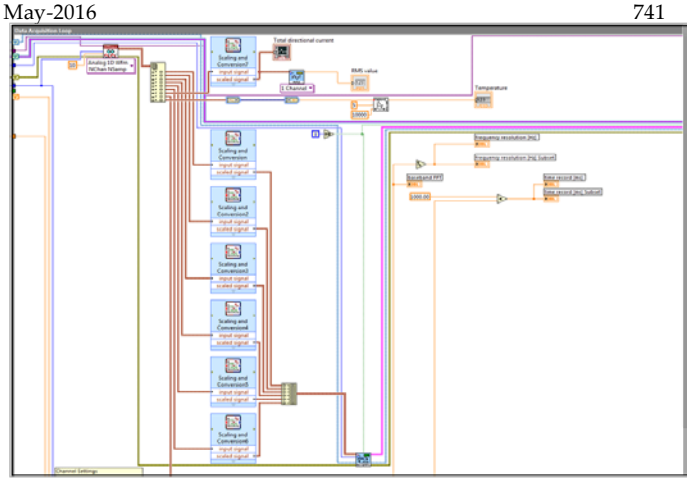
4- The current transformers measure the leakage current of the motor in order to determine if there is a short circuit with the outer body or iron core of the motor.
5- The stator windings faults centered on the internal turns short circuited with different ratios and these ratios are calculated by knowing the number of turns per phase and the number of turns per phase group. This allows the system to determine the bearings faults
6- Using the MCSA and Fast Fourier Transform (FFT) analysis to find out the harmonics of each case. The decision of fault type can obtained depending on these values.

5-Simulation model of fault diagnosis

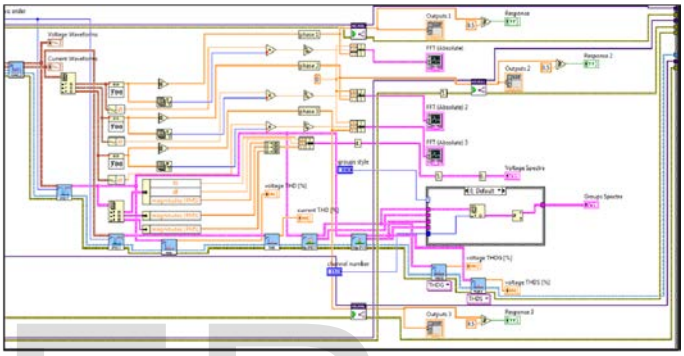
A PC based DAQ system is plugged in for the combination of the computer with the signal from IM, which shows the real time characteristic of the experimental IM during its operation. Beside give the graphical views to the user and direct processing and comparing with data base LabVIEW also give good analysis capabilities about the measurements on the IM for the proposed system. The block diagrams of signal analyses, data processing, neural network and fault detection are shown in figure (2)



(a) Block diagram of ANN classification



(B) Data input and monitoring



C) Analysis of current waveform by FFT and saving values of harmonic.

Figure (2) Block diagram of LabVIEW fault diagnosis system

6-Results and discussion

The faulty motor tested with bearing fault type and the healthy case. The output current spectrum or signature of the motor with each of, , bearing damage, and healthy are presented.

A it can be seen from the figures 3, 4, 5, 6,7 respectively showed the amplitude and waveform graph of the stator current and current spectrum frequency at no-load And the fault detection and foundation by using ANN tool in LabVIEW program.

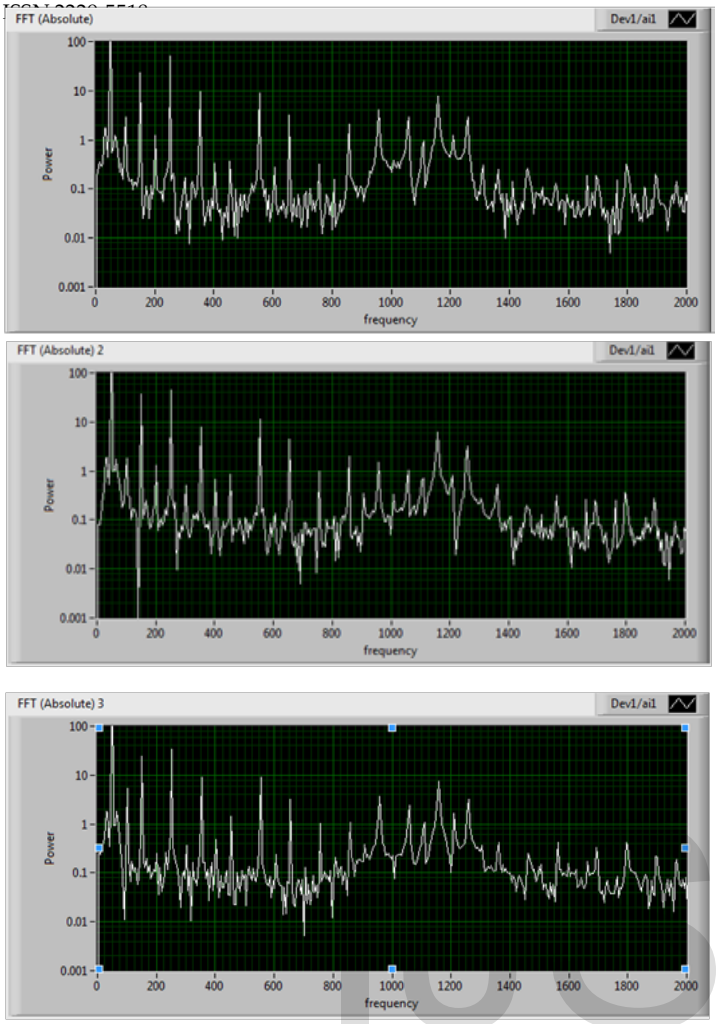


Fig.3 Stator current spectrum in healthy state motor without load

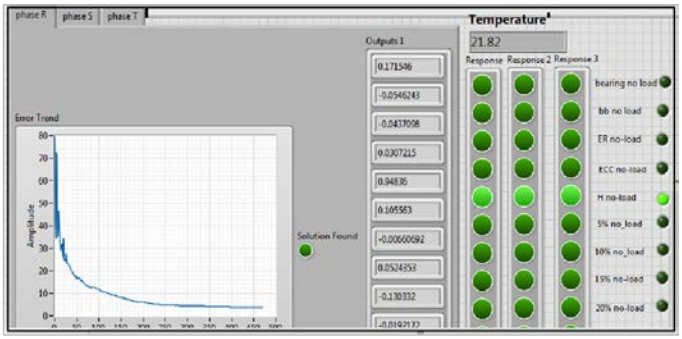


Fig.4 case detection and classification of healthy machine

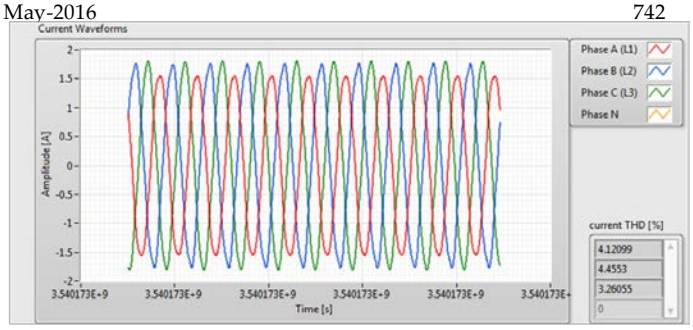


Fig.5 current waveform of bearing fault machine at no load case

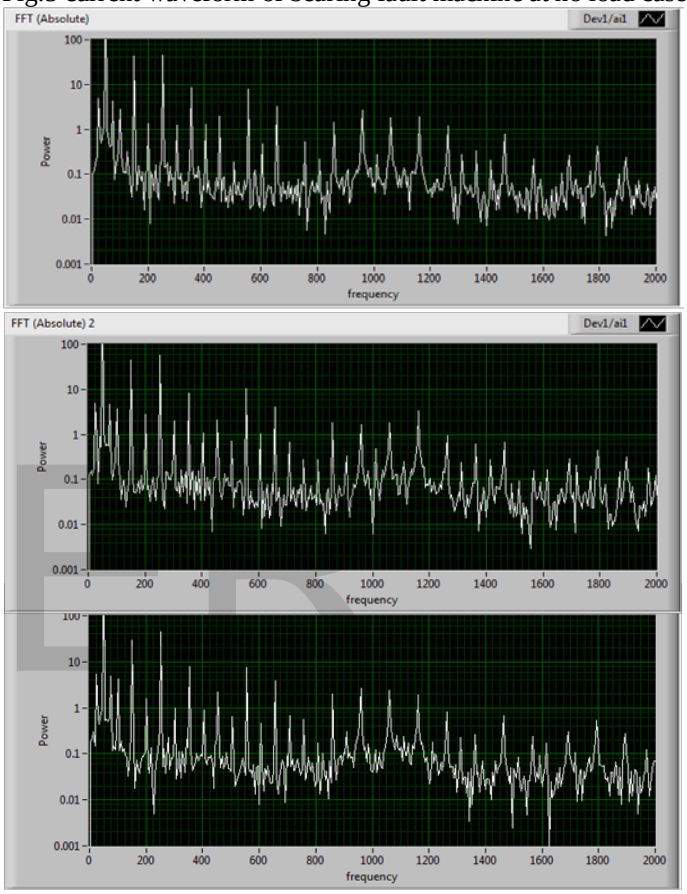


Fig.6 Stator currents spectrums in bearing fault motor without load

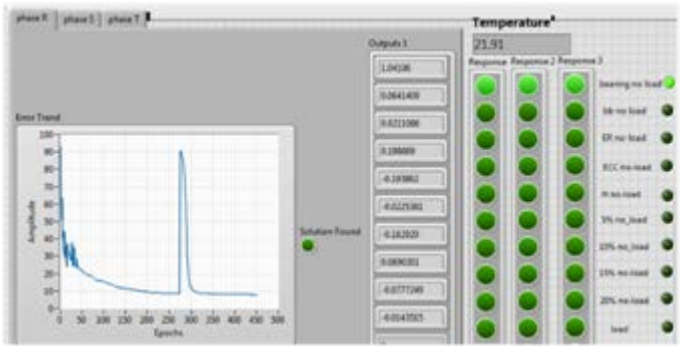


Fig.7 case detection of bearing fault machine at no load

7- Conclusions

This paper deals with the problems related to the bearing fault and healthy case of 3 phase induction motor. The line current are captured from the data acquisition and are passed through some signal processing tools and data reduction tool i.e. FFT. The processed data has undergone the DWT for the extraction of the fault feature of the motor compared to the healthy condition of the motor. ANN with five processing element are useful for the classification of the faults that has been extracted from the feature of the DWT. Proposed methodology is being useful in detecting the fault even though there is five percent turns or more of the stator short circuit. This method can be useful for the preventive measure for the restriction of the inter turn short circuit fault in 3 phase induction motor**.**

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REFERENCES

[1] Kanika Gupta1 , Arunpreet Kaur2 1 "A Review on Fault Diagnosis of Induction Motor using Artificial Neural Networks"2Department of Electrical Engineering, Baddi University, Himachal Pradesh, India (Book style with paper title and editor)

[2] Mariana Iorgulescu, Robert Beloiu ,Mihai Octavian Popescu, "Rotor bars diagnosis in single phase induction motors based on the vibration and current spectrum analysis", International Conference on Optimization of Electrical and Electronic Equipment, OPTIM 2010. H. Poor, "A Hypertext History of Multiuser Dimensions," *MUD History,* http://www.ccs.neu.edu/home/pb/mud-history.html. 1986. (URL link *include year)

[3] Alberto Bellini, Fabio Immovilli, Riccardo Rubini, "Diagnosis of bearing faults in induction machines by vibration or current signals: a critical comparison", IEEE , 2008.

[4] Gao Bingkun,Li Yanjia,Song Zhaoyun,Xu Mingzi, "Vibration Testing and Analysis of Motor Based on Virtual Instrument", 33rd Int. Spring Seminar on Electronics Technology, IEEE 2008, pp.216-219.

[5] Ioan Liţă, Daniel Alexandru Vişan, and Ion Bogdan Cioc, "Virtual Instrumentation Application for Vibration Analysis in Electrical Equipments Testing", 33rd Int. Spring Seminar on Electronics Technology,2010.

[6] D. Ganeshkumar and K. Krishnaswamy, "Intelligent bearing tester using LabVIEW", Jl. of Instrum. Soc. of India ,vol. 39, 2009, pp.18-22.

[7] Arkan,M., Unsworth, P.E. (1999)"Stator fault diagnosis in induction motors using power decomposition", IEEE Industry Applications Society Conference, pp. 1908- 1912.