Research Article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Diagnosis of Squirrel Cage Induction Motors by Spectrum Analysis of the Current and Magnetic Field of Dispersion

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ABSTRACT

This article presents the results obtained with a test bench dedicated to the diagnosis of the squirrel cage induction motors and installed within Laboratory of Technology of the University Félix Houphouët-Boigny in Abidjan (Ivory Coast). We present two methods dedicated to the detection of broken rotor bars of the induction motors. These methods are based on the spectral analysis of the signals: the MCSA (Motor Current Analysis Signature) and a method by analysis of the magnetic field. These two methods are then compared.

KEYWORDS: Squirrel cage induction motors, diagnosis, MCSA, magnetic field, spectral analysis, broken rotor bars.

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INTRODUCTION

The squirrel cage induction motors are mainly used in industries because of their robustness. However, they are not safe from certain defects. When these failures are detected as soon as possible, that makes it possible to avoid more disastrous consequences. In the increasingly effective search for methods, we undertook a comparative study of two methods of diagnosis.

Let us present these two methods of diagnosis based on two different signals. First called MCSA (Motor Current Analysis Signature) is most widespread; it uses the spectrum of the stator current. The second is pressed on the spectrum of the flow of the stray magnetic field also called radiated field.

Our study relates to defects of the rotor types, more particularly the defects of broken bars which account for approximately 10% of the failures of the electric motors[1]. Two cases are analyzed: an operational machine with healthy rotor, and a machine with a rotor having one broken bar.

MATERIALS AND METHODS

Test bench

The machine on which we worked is a three-phase asynchronous squirrel-cage motor of power 1.5 kW and nominal speed 1410 rpm. Our engine is a standard engine without particular modification before its purchase to enable us to approach the reality of the existing engines in industry. The asynchronous motor is coupled mechanically with a machine with current continues functioning out of generator. This one supplies a battery of resistances, thus playing the role of a variable resistive load in order to vary the resistive torque and thus the current of engine supply of test.

Figure1.The squirrel cage induction motors

Acquisition of the data

For the acquisition of the data, we provided ourselves with a sensor of the wound type connected to an oscilloscope. It enables us to record the data collected on key USB. Software MATLAB enables us to treat the data and to emphasize the spectrum of the phase of the signal. The figure below presents the sensor as well as oscilloscope used during our work.

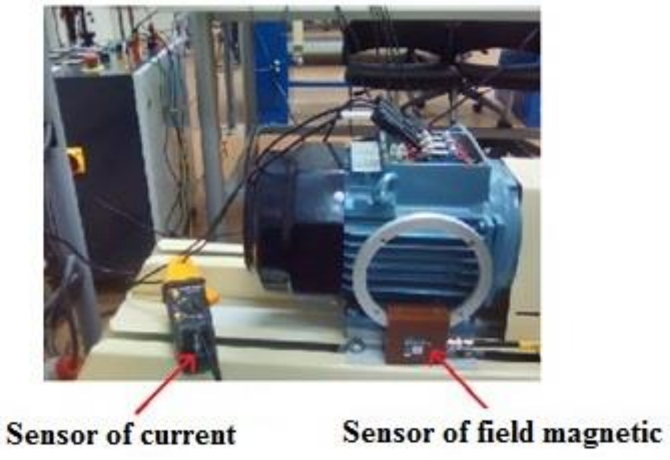
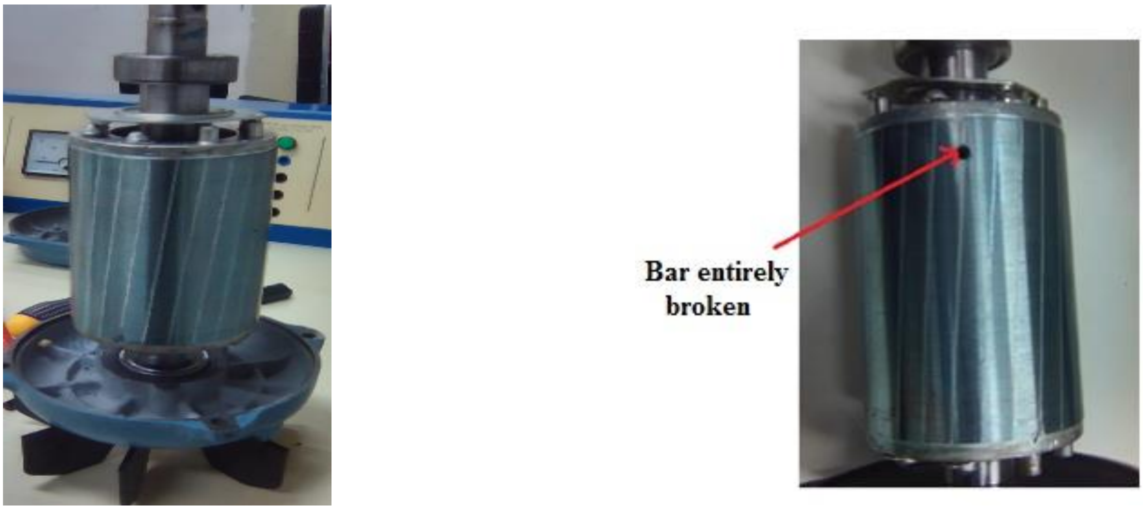


Figure2. Presentation of the sensors

Creation of defects

To create the defect of broken bar, we perforated one of the rotor bars[2, 3]. The power supply of the machine is done by direct connection on the three-phase network. A case of resistance makes it possible to vary the load. The figures below present two rotors: one healthy and the other with a defect of broken bar.



(a) Healthy rotor (without defect) ***(b) Rotor at fault with a broken bar***

Figure 3. Healthy rotor and rotor with defect

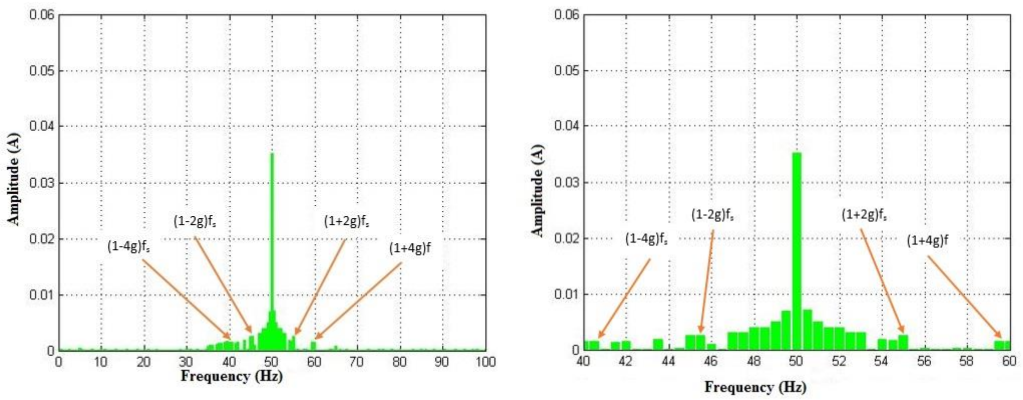
RESULTS AND DISCUSSION

Spectral analysis of the current

Healthy rotor

The spectrum of the stator current watches the fundamental component with 50Hz. The machine is operational but it appears weak components at the characteristic frequencies $(1\text{-}2g)f_S$ and $(1+2g)f_S$ [3-6]. These components are not easily distinguishable even with a zoom.

With f_S is the fundamental frequency and g is a slip.

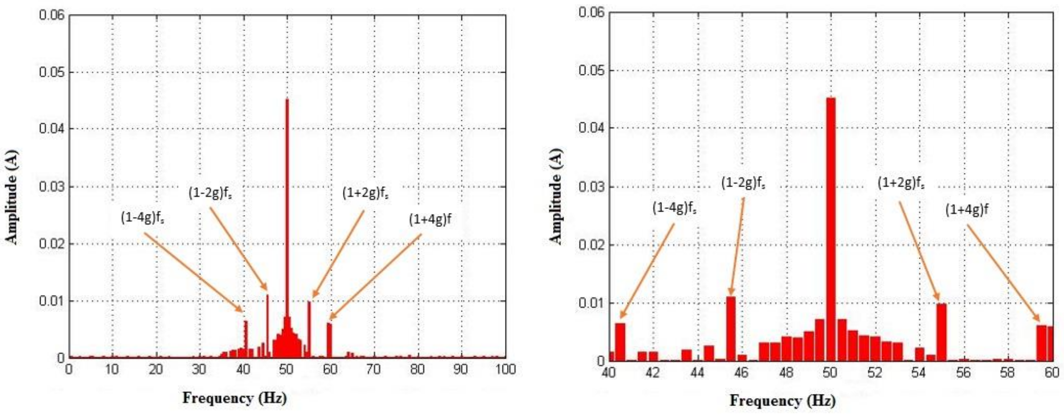


(a) Spectrum of the current *(b) Zoom of spectrum of the current*

Figure 4. Spectrum of the current with healthy rotor

Rotor with entirely broken bar

The spectrum of the current in the case of an entirely broken bar leaves to create more significant lines to the frequencies $(1\text{-}4g)f_S$ $(1\text{-}2g)f_S$ $(1+2g)f_S$ and $(1+4g)f_S$.



(a) Spectrum of the current *(b) Zoom of spectrum of the current*

Figure 6. Spectrum of the current with an entirely broken bar

The weak components which appear at the frequencies characteristic (1-2g)f_S and (1+2g)f_S in the case of an operational machine are due to a certain natural asymmetry of the rotor.

In the case of a partially broken bar the lines clearly visible with the frequencies (1-4g)f_S (1-2g)f_S (1+2g)f_S and (1+4g)f_S are due to the presence of the partial defect.

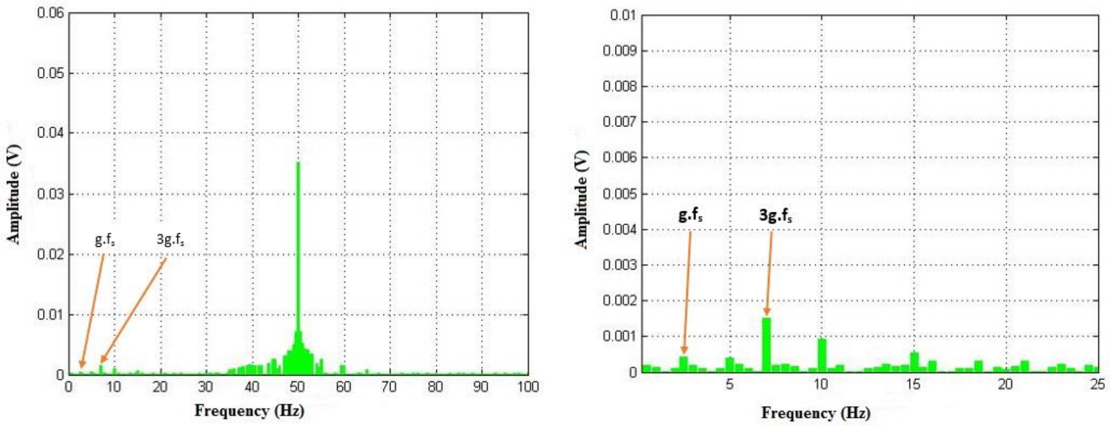
In the case of an entirely broken bar, more significant lines which appear at the frequencies (1-4g)f_S (1-2g)f_S (1+2g)f_S and (1+4g)f_S are due to the gravity of the defect.

The break of bars entrains birth of harmonics of flows which will induce harmonics of current in the stator winding at certain frequencies: $f = (1 \pm kg)f_s$

Spectral analysis of the magnetic field

Healthy rotor

In the case of an operational machine, no significant component appears in very low tension. However on the zoom, one sees create components at the characteristic frequencies gf_S and 3gf_S[7, 8].

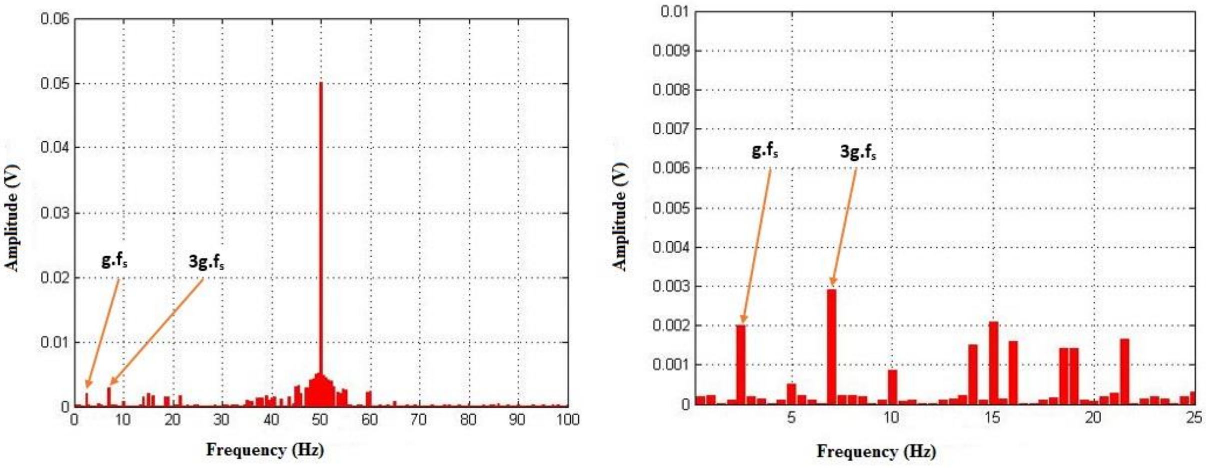


(a) Spectrum of the magnetic field *(b) Zoom of spectrum of the magnetic field*

Figure 7. Spectrum of the magnetic field with a healthy rotor

Rotor with entirely broken bar

When the bar is entirely broken, the components at the frequencies gf_S and 3gf_S are amplified and are easily detectable.



(a) Spectrum of the magnetic field *(b) Zoom of spectrum of the magnetic field*

Figure 9. Spectrum of the magnetic field with an entirely broken bar

In the case of an operational machine, the lines observed are due to the imperfections of manufacture. These components are not easily detectable with very low amplitude when one is in the presence of a partially broken bar. When the bar is entirely broken, the components at the frequencies gf_S and $3gf_S$ are amplified and are easily detectable. Appearance of a defect entrains a distribution of flows in the air-gap. The external magnetic field is a representation of the magnetic field of air-gap with the same harmonics. The defects of the electric machines influence the measurable field of escape in the neighborhoods of the machine.

CONCLUSION

The present article clarifies two methods of diagnosis, one using the spectrum of the current and the other the spectrum of the magnetic field. Method MCSA is very effective because the stator current is more accessible. The harmonics at the frequencies $(1-2g)f_S$ and $(1+2g)f_S$ are more sensitive to the defect of broken bar. On the other hand, the flow of the radiated magnetic field provided good results, but it is difficult to collect. The lines at the frequencies gf_S and $3gf_S$ are difficult to detect. The amplitudes of their components are lower in spite of the break of bar.

It would be desirable to test the results obtained on other types of machines, other types of defects and to study the impact of the variable speed transmissions on these two types of methods.

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