**Ondřej Vítek**
**Brno University of Technology, Brno**

# INDUCTION MACHINE DIAGNOSIS USING STATOR CURRENT AND MAGNETIC FIELD ANALYSIS

**Abstract:** Fault diagnosis is currently a target of wide research activities. There is large number of diagnostic methods based on various source of diagnostic signal, signal processing and data evaluation approach. Stator current is traditional diagnostic signal for fault detection of induction machines. Monitoring of this signal is mainly effective in case of diagnosis of broken rotor bars and rings. However, analysis of external magnetic field appears to be more powerful in case of rotor eccentricity detection. The measurement system based on LabVIEW platform is now presented and it includes both stator current and external magnetic field analysis.

## 1. Introduction

A large number of IMs has a direct influence on production in many industrial applications. This fact gave rise to requirement of higher reliability and it has also evoked the research activity in condition monitoring and fault diagnosis of induction machines.

The fault occurrence knowledge is important for development of diagnostic methods. Apparently the largest survey focused on faults in electric machines was reported in an EPRI publication (1982). The survey comprises 5000 motors, 97% of those are three-phase induction motors [1]. Results show that the bearing and stator winding faults are the most frequent (Fig.1).

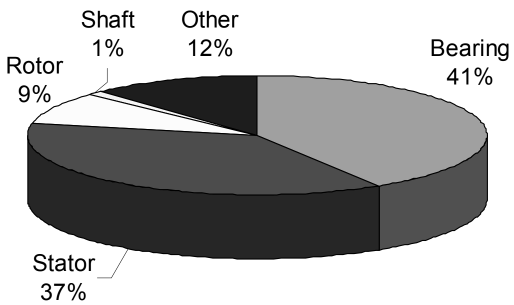


*Fig. 1. Faults distribution of el. machines [1]*

## 2. Rotor eccentricity

Detection of the rotor eccentricity is an actual problem of the induction machine diagnosis. The eccentricity causes an excessive stress on the machine and increases considerably bearing wear. In addition, the radial magnetic force waves produced by eccentricity can also act on the stator core and subject to stator windings unnecessary and potentially harmful vibrations [2]. The rotor eccentricity in induction motors takes two forms: static and dynamic. Both types of eccentricities usually exist together due to necessary tolerances in manufacturing process.

The rotor eccentricity diagnosis has often been based on stator current or motor vibration analysis. The large theoretical and experimental study of low frequency current and vibration components caused by air-gap eccentricity was introduced by Dorrell [2]. It is widely known that the dynamic eccentricity produces airgap field components

$$f_e = f_1 \pm f_r \qquad (1)$$

where $f_1$ is a line frequency and $f_r$ is a rotational frequency. Dorrell claims [2] that due to some inherent static eccentricity being present with a dynamically eccentric rotor, the same frequency sidebands (1) can be observed in stator current spectrum. Although Dorrell shows some different effects of static and dynamic eccentricity on the higher and lower sideband under various loading conditions of induction motor, mentioned frequency components are significantly dependant on both types of eccentricity simultaneously. Combination of monitoring of sideband currents and certain low frequency casing vibration components was proposed in order to clear identification of increasing dynamic eccentricity and a good indication of increasing static eccentricity.

## 3. Measurement system

The measurement system is focused on diagnosis of rotor eccentricity of induction motors. It provides the analysis of three phase stator currents and simultaneously the analysis of the magnetic field in proximity to the machine. The stator currents are measured by three transducers LEM LAH 25-NP. The external magnetic field is measured by Hall probe connected to teslameter Bell 7030. Speed and torque related signals are provided directly by dynamometer. All signals are sampled by data acquisition device NI USB-6281 and they are analyzed using the LabVIEW (Fig.2).

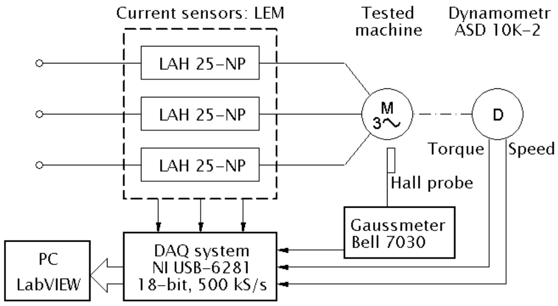


*Fig. 2. Block diagram of measurement system*

## 4. Experimental results

The diagnostic method based on external magnetic field analysis can also be used for rotor eccentricity determination. As was mentioned above, the dynamic eccentricity causes airgap field components $f_1 \pm f_r$ and these frequency components could be clearly observed in magnetic flux round the induction motor. More detailed method description is presented in [3].

The results of experimental analysis of three induction machines (200W, 6-pole) under no load operation are presented. The real level of dynamic rotor eccentricity of induction machine number two (IM2) is 17%. The level of dynamic eccentricity of IM1 and IM3 is approximately 5%.

*Tab.1: Measurement and FEM calculation*

| Frequency / Results | $f_1$-$f_r$ | $f_1$+$f_r$ |
|---|---|---|
| 5% ecc. ($B_t$ calc.) [%] | 5,4 | 3,6 |
| 15% ecc. ($B_t$ calc.) [%] | 16,1 | 10,6 |
| IM1 ($B_t$ meas.) [%] | 4 | 2,2 |
| IM2 ($B_t$ meas.) [%] | 14,2 | 8 |
| IM3 ($B_t$ meas.) [%] | 3,7 | 2,5 |
| IM1 (current meas.) [dB] | -54 | -60 |
| IM2 (current meas.) [dB] | -48 | -56 |
| IM3 (current meas.) [dB] | -64 | -71 |

The tangential components of the magnetic flux density were measured 9 mm above the stator packet surface. The axial position of the measurement point is in the middle of the stator packet. The eccentricity related frequencies of the magnetic flux density $B_t$ for each motor were analyzed and they are presented in Tab.1. The values are related to the amplitude of the first harmonic component. It can be seen that good correlation with the finite element model results was achieved.

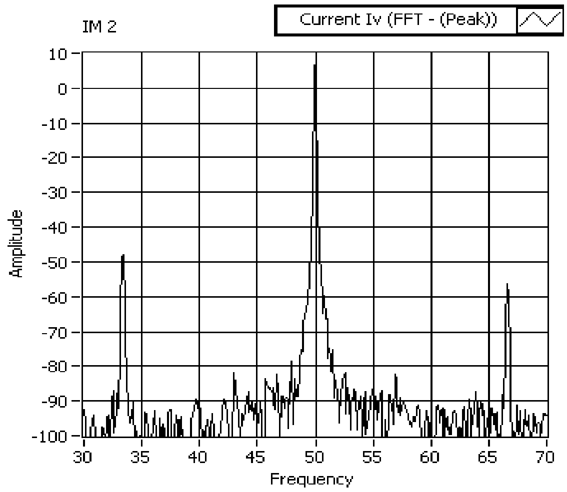


*Fig. 3. Stator current spectrum of IM2*

## 5. Conclusion

Due to the low influence of unknown static eccentricity on magnetic flux density sidebands, obtained results correspond with the real levels of dynamic eccentricity. However, in case of the stator current analysis the frequency components $f_1 \pm f_r$ are significantly dependants on both types of eccentricity simultaneously. It can be supposed that the static eccentricity caused increase of the IM1 current sidebands in comparison with IM3 sidebands.

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## 6. Bibliography

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## Author

OndřejVítek, Ing.,Ph.D.– viteko@feec.vutbr.cz
Brno University of Technology, UVEE,
Technicka 8, Brno 616 00, Czech Republic