INFLUENCE OF CHOSEN PARAMETERS ON ELECTRICAL MACHINES BEARINGS EXPLOITATION

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Abstract

This article focuses on the occurrence of bearing degradation in motors powered by alternating current of the inverters drive system with different carrier frequencies using the IGBT switching method based on PWM signal modulation. Due to wide application of inverters to control multi-phases motors (usually three-phase current motors), this article highlights the matter of the occurrence that current flows and voltage drops in the circuit: shaft - bearings - ground, their influence on bearing damages and suggestions for counteractions.

Key words: *bearing degradation, bearings currents, electrical machines,*

INTRODUCTION

Due to its simple design, efficiency and low price, synchronous and asynchronous motors are gaining a predominant position in the electrical machinery market. The main disadvantage of such motors was the speed regulation resulting from the fact that motor rotation speed depends mainly on two parameters: frequency and number of poles. Speed of asynchronous cage motor is calculated by equation (1)

$$n_0 = \frac{f*60}{p} rev/min \tag{1}$$

Where n_0 is synchronous rational speed (rev/min), f is power supply frequency (Hz), p is number of motor poles (-).

Synchronous rotational speed is the speed at which the stator flux rotates and it is called the synchronous speed, and it depends on number of poles of the motor and the power supply frequency.
The problem with frequency regulation has been eliminated with the common use of cheap inverter systems, both in new solutions and as a replacement of the controls of the operating motors as well. Because of use of alternating current, between the rotor and the grounded stator the leakage currents are generated. Those currents flow through the shaft and then through the bearings and causes their degradation. The disadvantage of frequency converters is that they generate not only the given carrier frequency but at the output they generating also many harmonic frequencies being the result of switching transistors. The motor is powered by three-phase voltage CMV (Common Mode Voltage). Voltage discharges through the lowest resistance between the rotor and the motor housing, usually through the oil filter. The main sources of bearing currents (Hadden, T., Jiang, J.W (2016)) deriving from capacitive voltages that are inducted on the motor shaft and high frequency currents made by CMV.

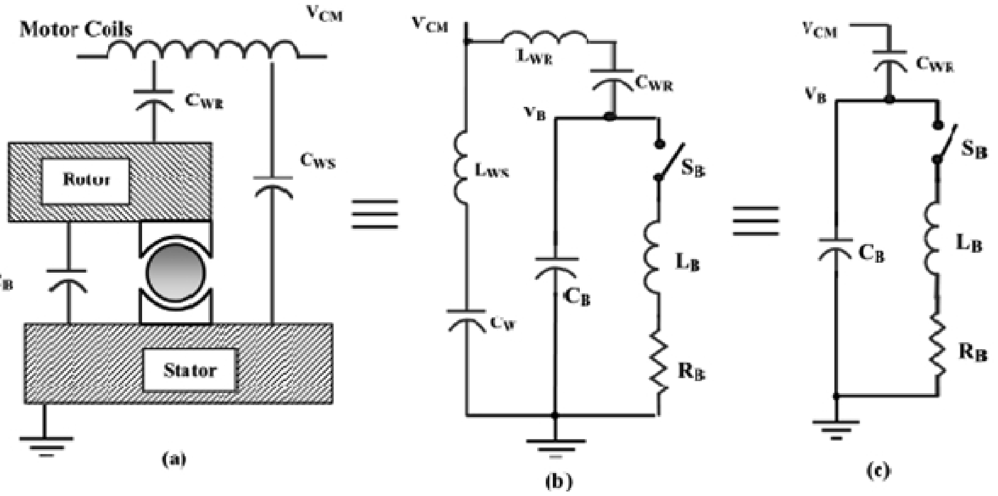

Fig. 1 Simplified electrical motor bearing current model (Hadden, T., Jiang, J.W (2016)).

Because of the fact that in short time periods the voltages and currents can reach very high values on the bearings, microscopic cavities and pits on the bearing spheres and its raceways are being formed (Willwerth, A. (2014)).

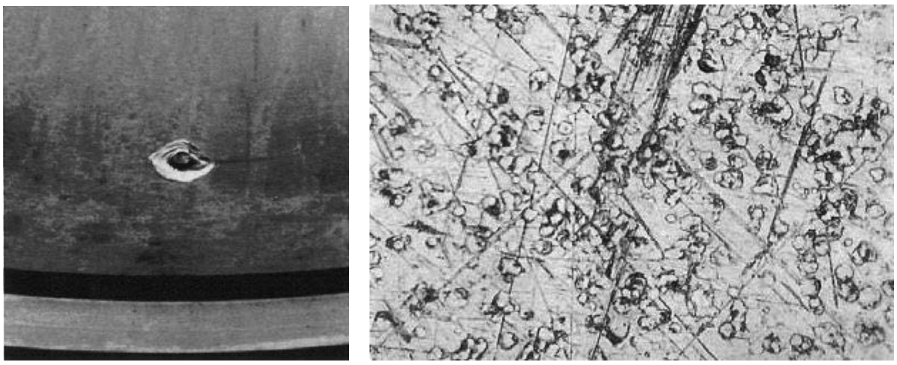

Fig. 2 Pit (0.1 -0.3 mm) and group of pits (1-5 micrometers) in the raceway of the bearings produced during the bearing current flow (Baldor. (2014)).

MATERIALS AND METHODS

Inverter control circuit consists of Analog Devices ADSP-21065L 66MHz Harvard Architecture 32-bit processor (40 digital I/O pins), which realizes control algorithm and the Altera Flex FPGA which was programmed as IGBT modulator (Abramowicz, K. (2014)). Algorithm was able to control the output voltage with carrier frequencies from 3 to 15kHz and the angular speed of the motor from 25 to 300 rad / s. The tested engine was Bessel RSH 80-4b Insulation class F, 4 poles. Supply voltage 400V, rated current is 2.5A, Synchronous speed 1500u / min, phase shift 0.53. Bearing with SKF6204-2Z bearings (Deep groove ball bearings, single row), maximum 9000 rpm and AC6204-GL SMB (max 1100 rpm) with plastic balls (high resistance). Measurements were performed by Tektronix Oscilloscope and low-voltage probe.

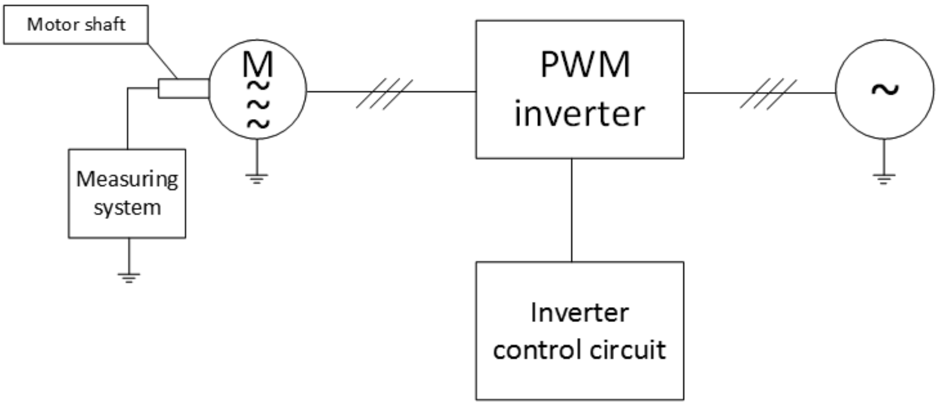

Fig. 3 Block diagram CMV and bearings currents measurement system (own fig.)

RESULTS AND DISCUSSION

The results were adjusted for selected frequencies and angular velocities. Figures 3 and 4 show the registered measurements for carrier frequencies of 6kHz and 12.5kHz of angular speed of 150rad/s, 4.5kHz and 10.5kHz, and angular speed of 300rad/s.

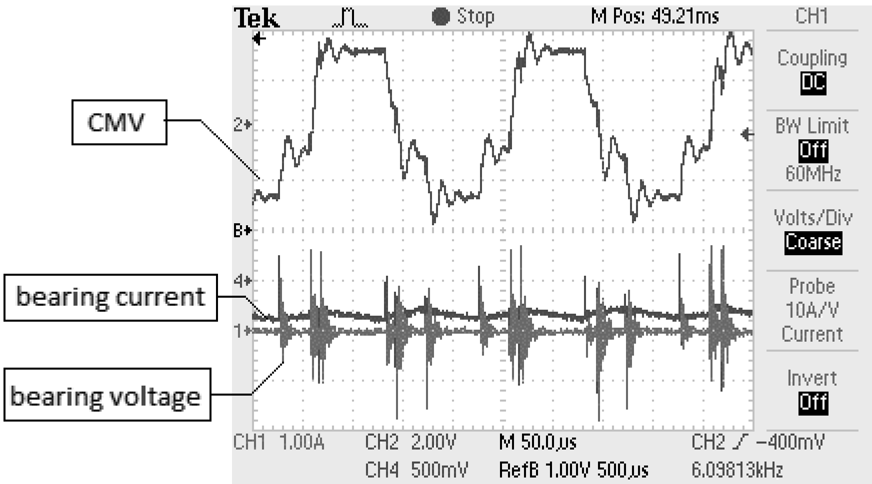

Fig. 4 Measured data for f= 6kHz angular speed 150 rad/ s (Abramowicz, K. (2014)).

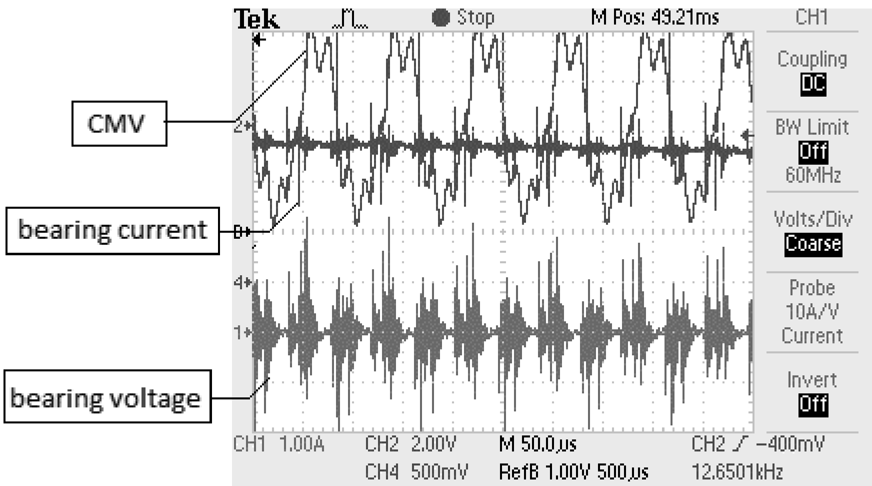

Fig. 5 Measured data for f=12,6kHz angular speed 150 rad/s (Abramowicz, K. (2014)).

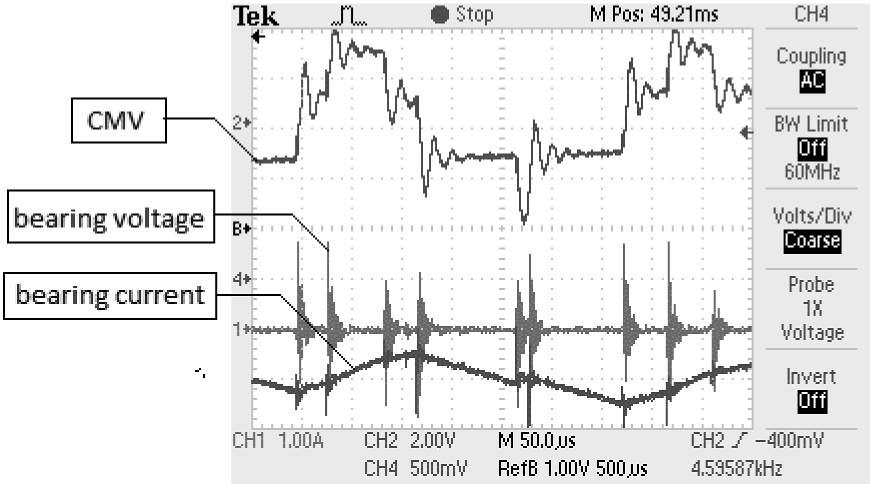

Fig. 6 Measured data for f= 4,5kHz angular speed 300 rad/s (Abramowicz, K. (2014)).

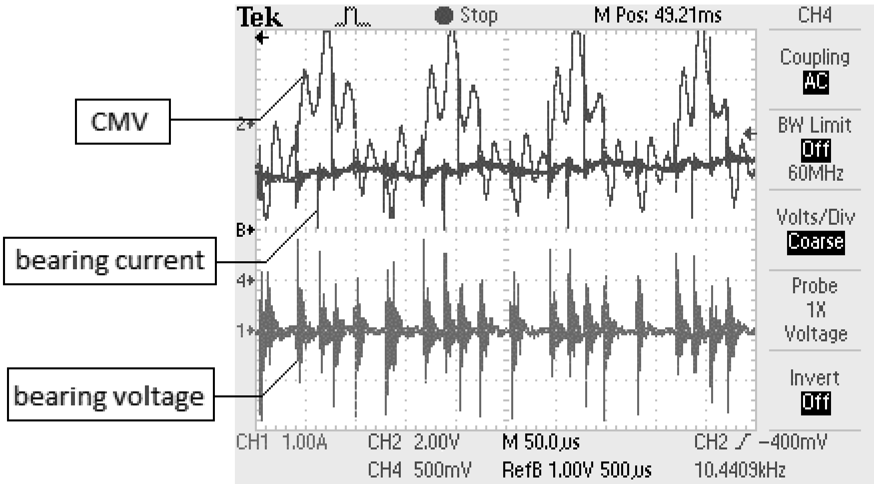

Fig. 7 Measured data for f= 10,5kHz angular speed 300 rad/s (Abramowicz, K. (2014)).

Blue line shows CMV, green line is bearing current, orange line shows the bearing voltage. The values of bearing currents as a function of the different frequencies are shown in the bar charts of Figures 8 and 9.

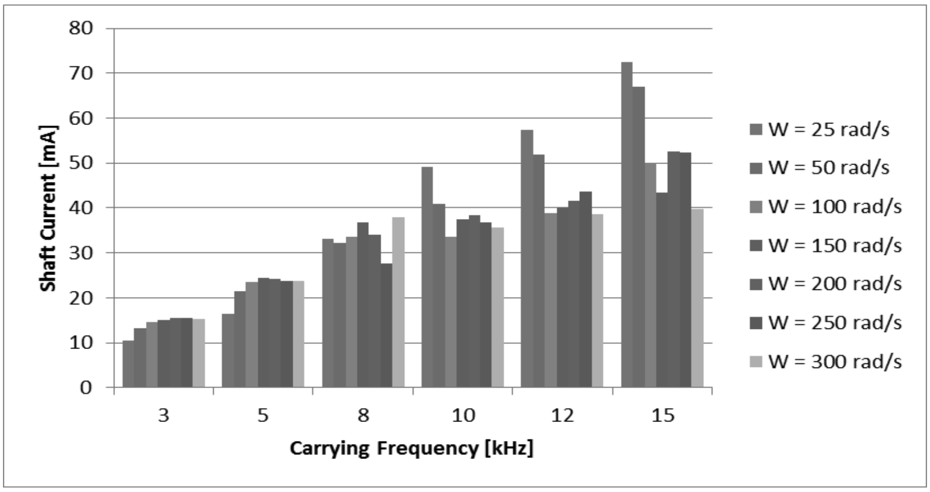

Fig. 7 Currents values measured for bearings SKF6204-2Z (Abramowicz, K. (2014)).

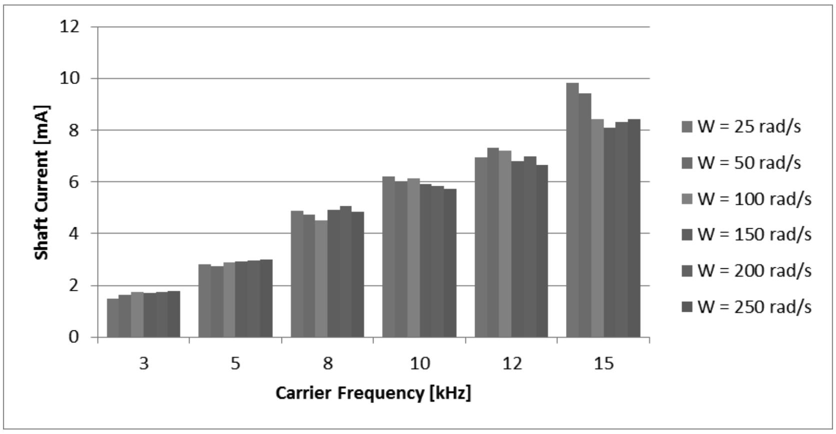

Fig. 8 Currents values measured for bearings AC6204-GL SMB (Abramowicz, K. (2014)).

CONCLUSIONS

Flowing currents cause micro damages to the bearings which may degrade them after some time. The progress of degradation is depending on many factors. This article depict fact that decreasing the carrier frequency of the inverter output voltage considerably reduces the degradation process. The use of plastic bearings can significantly reduce the impact of the bearing current on the damage. When replacing bearings, it would be advisable to use ceramic or plastic bearings which would increase the life of the bearings in case of low power electrical motors.

Other possibilities of limiting the common mode voltage and bearing currents are grounding the motor shaft with brushes and use filters and multilevel inverters in order to reduce the occurrence of higher harmonic frequency.

In many cases, for example of ships equipped with electrical main drives diagnostic bearings vibroacoustic systems are a must in spite of bearing currents possible damages (Tarnapowicz, D. (2016)).

Additionally, shielding of inverter - motor cable has matter to shaft currents and supply currents what is presented in (Kempski, A.(2005)).

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