About the compensating technique of low frequency components of magnetic electric motor noise

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Abstract

The magnetostrictive effect of the electric motor cores causes magnetic dependence the sound pressure of air noise from the core vibrations in the wide frequency range. A pair of identical electric motors were located in the small isolate box which had the maximal linear size not exceeding half length the same sound wave that is corresponded the double electric network frequency. The experimental data of the compensating technique of low frequency magnetic electric motor noise is analyzed.

1 Introduction

The design and development of pre-production models and the application of industrial electric motors must take into account the noise and the vibrating safety. The components of the magnetic, mechanical and aerodynamic noise are considered usually. Noted noise components are derivatives of the magnetic component as the initial electromagnetic field element and as full power accordingly.

So Lorentz electrodynamic force works tangentially on the winding conductors with the length l. The winding is allocated regularly on all circle of the electric motor rotor. The axially-directed rotor current I is passed under the stator radial field with magnetic induction B. The given forces move the rotor in the periodic rotation. At the same time the seeming linearity of dependence Fem (B, I) and a time constant rotor rotation can be broken owing to the high harmonics and subharmonics. This high harmonics and subharmonics cause to the current changes because of the spatial periodic induction in the step-type winding and delays.

Maxwell axial electromagnetic force works perpendicularly on the stator and the front rotor surfaces.

Joule magnetostrictive force causes to the radial deformation of electrotechnical steel ring plates of the stator magnetic core under the variable magnetic field action. The power lines of the variable magnetic field settle on the circles. The maximum value of these forces as time functions Bm.i is proportional to the square of stator voltage Um.i with number of coils n can be found from the ratio

$$F_{mci} = \pi a_i S_{ct} B_{mi}^2 = \pi a_i S_{ct} \left(\frac{U_{mi}}{n\omega_i} \right)^2 \qquad (1)$$

where $S_{ct} = (R_H - R_b)h$ - the sectional area of stator magnetic core (R_H and R_B - the external and the internal radiuses accordingly, h - its length; a_i - the magnetostrictive steel constant ; ω_i - the angular frequency of fluctuations.

2 Consideration the electric motor magnetic core as the elementary oscillator

If the electric machine stator is represented as a cylindrical ring then the thickness and the height are considerably smaller then the stator radius. It makes possible to arrange the fluctuation amplitudes directly along any stator radius. Thereby the stator ring can be considered as an elementary oscillator. Then the spatial stator fluctuations are excited by the electromagnetic forces and it caused to deforming of the magnetic core.

The radial deformation of the steel ring plates leads to multiperiodic changes of the geometrical magnetic core sizes on the internal ($Qb = 2\pi Rbh$) and on the external ($Q_H = 2\pi RHh$) contours. Such changes of the geometrical magnetic core sizes excite the vibrations. From (1) follows what the constant ai installs the interrelation between the amplitude of oscillatory displacement ψ_m for example an external cylindrical magnetic core contour (circle Q_H) and the known effect - dependences of the module steel elasticity EB (magnetic elasticity) from amplitude and the direction of the induction field

$$a_i \approx \frac{E_B}{B_{mi}} \frac{\triangle Q_H}{Q_H}, \qquad \xi_m = \frac{a_i B_{mi} R_H}{E_B} \tag{2}$$

where $\triangle QH/QH$ - the relative external magnetic core deformation, xi_m is the oscillatory displacement amplitude of the external magnetic core contour.

The magnetic component of electric motor noise can be searched by measuring the magnetic core vibrations especially in the low sound field and infrasonic frequencies. It is possible to carry out research in the small volume box SVB with the maximal linear size no more than 1/2 the air wave length of the most intensive component of double network frequency spectrum. Such box is used for microphone graduation and for an estimation of SVB sound insulation [1-3].

Let's consider a principle of action of the BSV system represented in the short pipe with the square section and the length equal l. Two identical single-phase collector electric motors were installed into the SVB system at the pipe ends. (Fig.1). Both of alternating current electric motors excited the flat sound waves into the pipe as the pulsing cylinders (EM1, EM2).

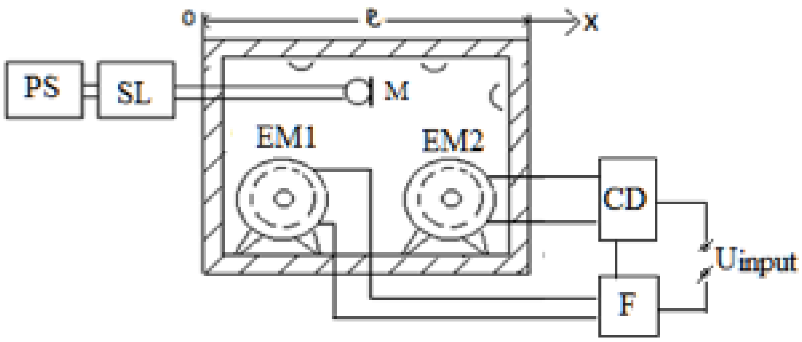

Figure 1: The block diagram of the installation with BSV: EM1, EM2 - electric motors; CD - the circuit of the electric delay; F - the phase-shift network; SL - the sound level meter; PC - the personal computer; M - the microphone

3 There are two effects of sound-suppressing process

The sound-suppressing process is provided with simultaneous realization of two effects: the correlation interaction of a pair of identical electric motors into acoustic space of the BSV and the electric circuit. So electric additivity of two voltage sources with frequency 50 Hz and the different phases with displacement 90 degree leads to reduction noise of their total effect and corresponding noise of mutual indemnification of the basic component magnetic noise (f = 100 Hz).

Under accepted all characteristics of the wave field the in the BSV it will be one-dimensional excited sound waves and it will be depended only from coordinate (x) except for time (t). Then the wave equation in partial derivative for potential of oscillatory speed φ will look like

$$\frac{\partial^2\varphi}{\partial t^2} = c^2\frac{\partial^2\varphi}{\partial x^2} \tag{3}$$

From the common decision for φ in view of the direct and reflected waves

$$\varphi = A\exp(\omega(t - x/c)) + B\exp(\omega(t + x/c)) \tag{4}$$

Let's receive expression for superfluous pressure

$$p = \rho\frac{\partial\varphi}{\partial t} = j\omega(A\exp(\omega(t - x/c)) + B\exp(\omega(t + x/c))) \tag{5}$$

and oscillatory speed

$$\nu = -\frac{\partial\varphi}{\partial x} = j\omega\rho(A\exp(\omega(t - x/c)) - B\exp(\omega(t + x/c))) \tag{6}$$

where A and B are some constants.

If Te is the circuit of the electric delay and Ta is the acoustic phase shift than we will have the expression for sound-suppressing effects. In view of equality $Te = Ta$ the phase of fluctuations of the stator core EM1 will be differed from the phase of fluctuations EM2 on size $\omega l/c = kl$ ($k = \omega/c$ is the wave number, c is the sound speed).

The measuring installation is consisted of the small volume box $V = 0,12m^3$ with the linear sizes $0,6 \times 0,5 \times 0,4$ m. The control of I and U network for a pairs of identical single-phase collector engines with $0,8kW$ by a switched voltmeter and a oscillograph was carried out. The noise level in the BSV was measured by calibrated microphone M102 and the sound level meter RTF0024 was used with fixing results in the special PC program. All electric input and output lines in the BSV were made as much as possible hermiticity.

4 Conclusion

It is follows from comparison its spectrograms. The anticorrelation phased effect between the basic magnetic harmonic components 100 Hz for application EM1 and EM2 follows from comparison its spectrograms and is shown in [4]. Thus the integrated level was decreases from $88dB$ (inphased inclusion) up to $81dB$ (phased inclusion) in wide frequency range $3Hz, ..., 16kHz$. As follows from searched the offered compensatory method of the magnetic component electric motor noise provides effective sound-suppressing technique in the wide frequency range and is quite accessible for more quiet electric motors realization on manufactures and developers.

References

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