VIBRATION AND STRESS ANALYSIS DUE TO ELECTROMAGNETIC FORCE IN THE LINK OF INTERIOR PERMANETNT MAGNET TYPE SYNCHRONOUS MOTOR

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Introduction

This paper deals with the stress analysis of the link and the rotor vibration caused by the electromagnetic forces for Interior Permanent Magnet type Synchronous Motor (IPM). As the increase of energy density gives rise to noise and vibration in electromagnetic devices, the performance of a brushless motor is deteriorated.

The IPM has one disadvantage of weak mechanical structure in small size of the link width while it has an advantage of high power per volume. Thus, the size of link width should satisfy both high performances of the motor and the stable structure in mechanical strength. So the prediction of the mechanical behavior and the exact calculation of the electromagnetic force are required at its design stage.

Analysis Flow

The procedure of the vibration calculation can be divided into eight steps as shown in Fig. 1. Fig. 2(a) shows the cross section of analysis model and Fig. 2(b) shows the magnified structure of the link having 7.125[mm] length, which keeps permanent magnet from the rotor under operating. The permanent magnet is buried into the rotor.

First, in order to calculate the accurate electromagnetic force acting on the surface of the link, the evaluation of the exciting force is done by using the method of the Equivalent Magnetizing Current [1]. The stress is analyzed by analytical method, and whose analysis model is a beam fixed at both ends [2]. In addition, the natural frequency and mode shape are simply analyzed by using Transfer Matrix Method (TMM) because it takes long time as well as a great amount of expense to analyze the rotor vibration by using 3-D FEM. In the analysis model to apply this method, each point including discrete lumped mass replaced by distributed mass is connected by field with stiffness [3].

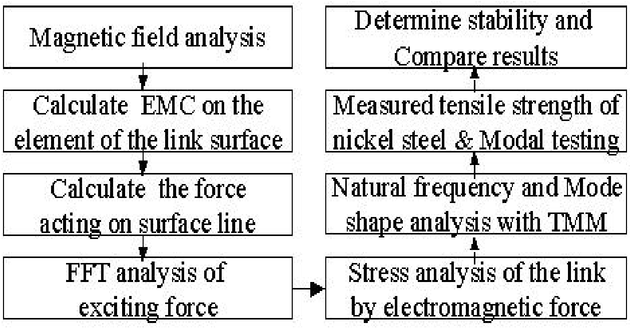

Fig. 1 Vibration and stress analysis flow

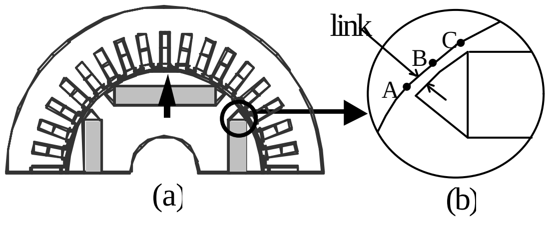

Fig. 2 Analysis model

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Colclusion

Fig. 3 shows variation of the electromagnetic force that is radial force acting on the link with changing in slot width. The local force of radial direction is calculated at current angle 90°. The increase in slot width causes the increase of the radial force and wave deformation. Hence, it includes many harmonics. From the results of Fig.4 and Fig. 5, as the link width is decreased, the stress tends to be increased noticeably. This leads to unstable structure which in, in turn, caused by the load of magnetic force while the magnetic torque is increased. In Fig. 5, the stress at both ends marks higher than that from any other place. So the link structure at both ends becomes weaker than that in the center. When the stress for the link width 1 [mm] is compared with a sheet of core tensile strength value 363[Gpa], the safety factor is only 2.115. This figure represents unstable mechanical structure of the link. Fig. 6 shows the mode shape at second mode with 1176.4[Hz]. The natural frequency of analysis model used as a way of TMM is respectively 462.26, 1176.4 and 3584.4[Hz].

To verify the validity of the result, the rotor's modal testing will be done. These results might be compared with harmonics of the radial force leading to vibration.

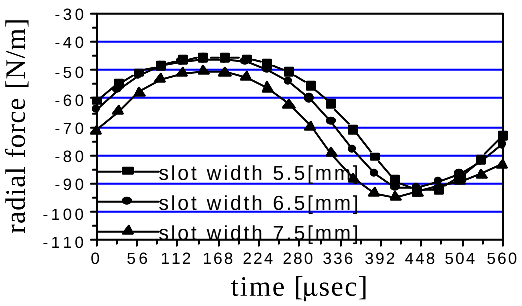

Fig. 3 Radial force acting on the link according to slot width at point C of Fig. 2(b)

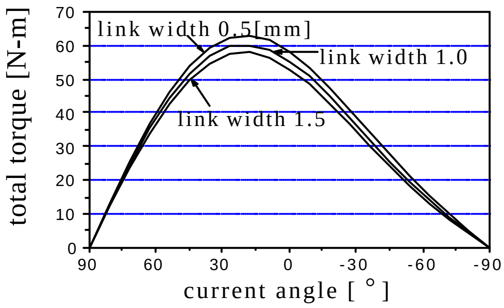

Fig. 4 Torque vs. current angle for variation of the link width

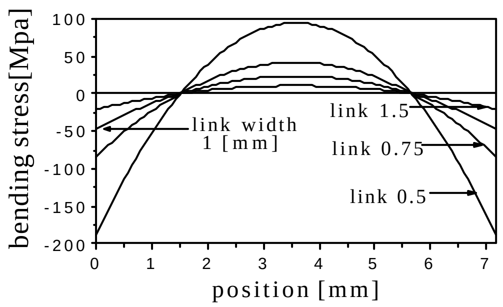

Fig. 5 Stress distribution in the link

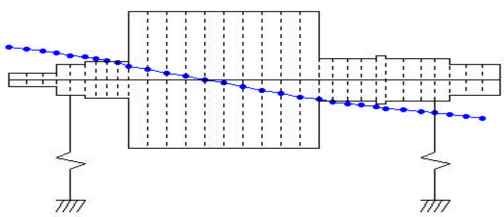

Fig. 6 Second mode shape of the rotor

References

[1] G. Hemmber, K. Satter, D. Shen, "Nature of the equivalent magnetizing current for the force calculation," IEEE Trans. on MAG, Vol. 28, No. 2, pp. 1086-1072, 1992.

[2] S. J. Rao, Rotor Dynamics, John Wiely & Son, New York, 1983.

[3] Gere & Timoshenco, Mechanics of Material, International Thomson Publishing Asia, 1995.