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著者(和文)	Wiguna Candra Adi
Author(English)	Candra Adi Wiguna
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	Candra Adi Wiguna	指導教員（主）： Academic Supervisor(main)	千葉明
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis discusses two methods to reduce the vibration and acoustic noise in switched reluctance motors. These methods are “radial force sum flattening” for traction 18/12 switched reluctance motor and “selective radial force harmonics reduction” for 6/10 switched reluctance motor for industrial applications.

Electric-motor efficiency has become an important consideration in traction and industrial applications. The use of permanent magnets in electric motors meets the requirements of high efficiency and power density. However, limited supply and cost efficiency remain the main concerns when using permanent magnets, owing to the utilization of rare-earth materials. Therefore, it is necessary to investigate alternative solutions to reduce the dependency on rare-earth permanent magnets.

Switched reluctance motors are an alternative solution. These motors do not use rare-earth materials, have low manufacturing costs, are highly reliable, and can be operated at high temperatures and rotational speeds. However, switched reluctance motors have high acoustic noise, vibration, and torque ripple.

In general, switched reluctance motors excited by conventional square current generate the radial forces with high and sharp peak at stator teeth. The high and sharp peak of radial forces at stator teeth cause high deformation at stator structure of switched reluctance motor, which leads to high vibration and acoustic noise. Some of research have been investigated to reduce the vibration and acoustic noise in switched reluctance motors. Generally, the vibration and acoustic noise in switched reluctance motor can be reduced by structure improvement and voltage and current profiling. The examples of current profiling are the radial force sum flattening and selective radial force harmonics reduction.

The method of “radial force sum flattening” has been reported to be effective in reducing the vibration and acoustic noise in high-pole number of switched reluctance motors, such as three-phase 36/24, 24/16, 18/12, and 12/8 switched reluctance motors. Compared with conventional square current, the radial force sum flattening reduces the high fluctuation of radial force sum; thus, the vibration and acoustic noise are significantly reduced. However, the method is still limited to low speed. At middle and high speeds, the influence of the back electromotive force is high; thus, the current regulation could not properly regulate the current excitation. In this thesis, the improvement of the radial force sum flattening for 18/12 switched reluctance motor at middle speed is presented. The implementation of the radial force sum flattening is improved from only low speed to middle speed operation by considering limited input DC voltage and high back electromotive force into the calculation process of current derivation. To realize the consideration, the approximation of nonlinear inductance of switched reluctance motor is performed. Then, the procedure of current calculation is presented in the thesis. The effectiveness of the method is verified both in finite element analysis and experiment. The experimental results show a significant reduction of vibration and acoustic noise by the improved current in the highest and second-highest peaks of noise at 5.4 kHz and 1.8 kHz by 11.04 dB and 17.51 dB, respectively, compared with a conventional single pulse current. The other peaks of noise are also reduced. By flattening radial force sum in middle speed, the overall noise reduction of 3.64 dB is achieved.

In a three-phase 6/10 switched reluctance motor, a novel method for vibration and acoustic noise reduction is presented. The test machine has major vibration and acoustic noise at the 2nd, 4th, 5th, 7th, and 8th harmonics. Accordingly, a novel method called "selective radial force harmonic reduction" is proposed. The proposed method selectively reduces the specific radial force harmonics at the stator teeth. By reducing the specific radial force harmonics such as 2nd, 4th, 5th, 7th, and 8th, the corresponding vibration and acoustic noise can be reduced significantly in the test machine. Finite element analysis and experiments are conducted to verify the effectiveness of the proposed method. Compared with a conventional square current, the experimental results show that the overall sound pressure level is reduced by 7.1 dBA using the proposed method at the rated speed and torque. In addition, the proposed method also reduces the vibration and acoustic noise in the test machine at various rotational speeds. For practical implementation of the proposed method, the dynamic conditions of the test machine using the proposed method are also presented. The proposed method of selective radial force harmonics reduction is verified to be effective in the three-phase 6/10 switched reluctance motor.