Comparison between Cage-Rotor Induction Motor and Matrix-Rotor Induction Motor Using 3-D Finite Element Method

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***Abstract*—In this paper, the cage-rotor induction motor and the matrix-rotor induction motor, which are driven at the same rotational speed, are analyzed using the three-dimensional finite element method, and the characteristics of these motors are compared with each other.**

***Index Terms*—three dimensional finite element method, induction motor, cage-rotor, matrix-rotor, loss characteristic**

I. INTRODUCTION

In order to improve the performance of induction motors, the matrix-rotor induction motor has been proposed [1]. It is desired for the optimal design to analyze the characteristics of the matrix-rotor induction motor numerically, because it is not easy to make trial models. In our previous reports [2][3], the matrix-rotor induction motor was analyzed using the three-dimensional finite element method (3-D FEM), and the effects of the number of bars of the rotor core and the length of the secondary conductor on the torque and loss characteristics were numerically clarified. In this paper, the cage-rotor induction motor is analyzed using the 3-D FEM, and the calculated results are compared with those of the matrix-rotor induction motor at the same rotational speed.

II. ANALYZED MODEL AND CONDITIONS

Fig. 1 shows the analyzed model. Both of the stators are the same. The height of the cage-rotor is the same as that of the matrix-rotor

Fig. 2 shows the 3-D finite element mesh, which is 1/2 of the whole region because of the symmetry in the z-axial direction. The number of elements of the cage-rotor induction motor and that of the matrix-rotor induction motor are approximately 0.6 million and 2.7 million, respectively. The mesh of the matrix-rotor induction motor is finer than that of the cage-rotor induction motor to calculate the eddy current of the secondary conductor in the matrix rotor.

Table I shows the analysis conditions. The sinusoidal current of 640AT is excited to the coils.

TABLE I
ANALYSIS CONDITIONS

Rotor type	Cage-rotor	Matrix-rotor
Exciting current (AT)	640	
Conductivity of secondary conductor (S/m)	3.14×10^{7}	

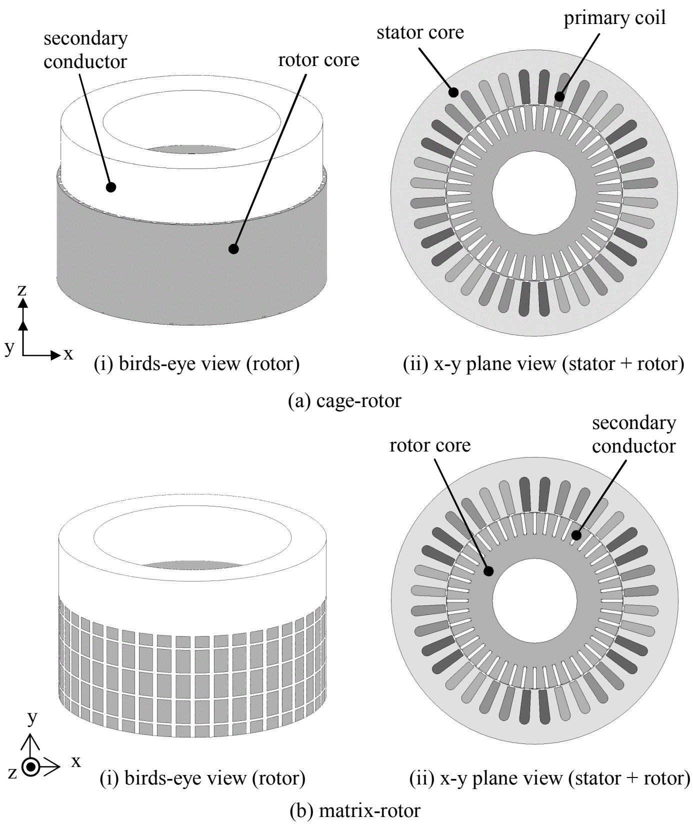

Fig. 1. Analyzed model.

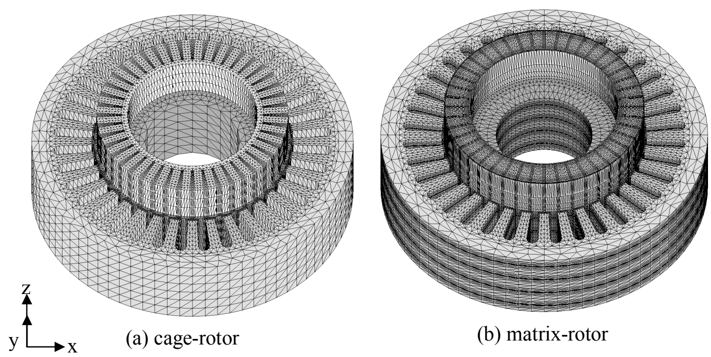

Fig. 2. 3-D finite element mesh.

III. Results and Discussion

Fig. 3 and Table II show the torque waveform and the torque characteristics, respectively, which are normalized by the average torque of the cage-rotor induction motor. The average torque and the torque ripple of the matrix-rotor induction motor are almost the same as those of the cage-rotor induction motor.

Fig. 4 shows the contours of secondary copper loss. We can see that the secondary copper loss concentrates on the surface of the secondary conductor in spite of the rotor type. The secondary copper loss on the surface of the matrix-rotor induction motor is smaller than that of the cage-rotor induction motor.

Fig. 5 shows the electrical loss characteristics, which are normalized by the electrical loss of the cage-rotor induction motor. The secondary copper loss of the matrix-rotor induction motor is smaller than that of the cage-rotor induction motor. The electrical loss of the matrix-rotor induction motor is approximately 94.5% of that of the cage-rotor induction motor.

Table III shows the efficiency, which are normalized by the efficiency of the cage-rotor induction motor. The efficiency of the matrix-rotor induction motor is approximately 102% of that of the cage-rotor induction motor.

Table IV shows the discretization data and elapsed time.

IV. Conclusion

In this paper, the cage-rotor induction motor and the matrix-rotor induction motor were analyzed using the 3-D FEM, and the calculated results are compared with each other. Consequently, the efficiency of the matrix-rotor induction motor is slightly better than that of the cage-rotor induction motor at the same rotational speed. The result at different rotational speed is described in the full paper.

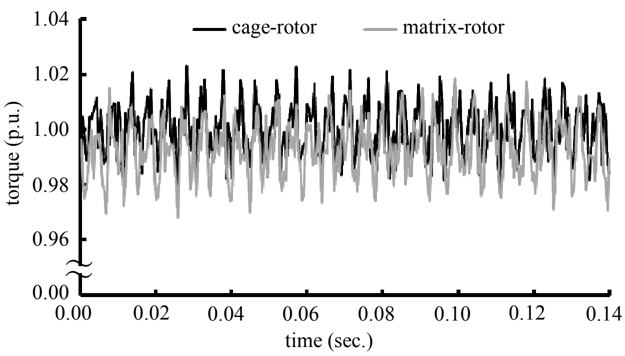

Fig. 3. Torque waveform.

TABLE II
TORQUE CHARACTERISTICS

Type of rotor	Cage-rotor	Matrix-rotor
Average Torque (p.u.)	1.000	0.993
Torque Ripple (p.u.)	0.047	0.050

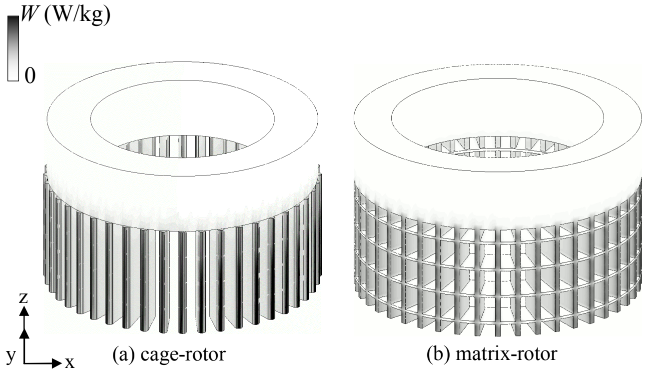

Fig. 4. Contours of secondary copper loss.

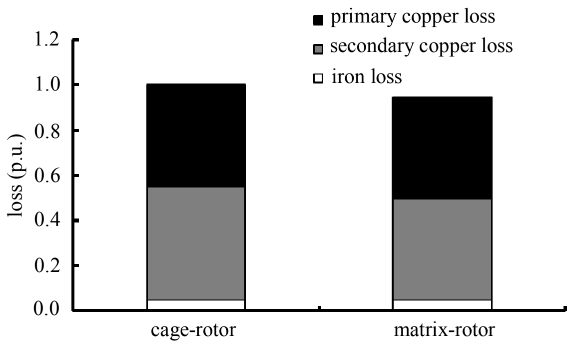

Fig. 5. Loss characteristics.

TABLE III
EFFICIENCY

Type of rotor	Cage-rotor	Matrix-rotor
Efficiency (p.u.)	1.000	1.018

TABLE IV
DISCRETIZATION DATA AND ELAPSED TIME

Type of rotor	Cage-rotor	Matrix-rotor
Number of elements	615,720	2,670,408
Number of nodes	113,113	457,320
Number of edges	749,756	3,152,111
Total number of time steps	900	870
Elapsed time (hours)	1,800*1	456.8*2

*1 Computer used: Intel Pentium4 (3.80GHz) PC
*2 Computer used: Intel Core2 Duo (2.66GHz) PC×8

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