Study of Unbalanced Voltage on Rotor Classes of Induction Motor according to the NEMA standard

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Abstract — Faults of the electrical system, for example unbalanced voltage condition and inconsistent frequency, are frequently occurred, which reduces quality of the electrical system and affects efficiency of electrical appliances. This research aims to study unbalanced voltage on rotor classes of induction motors according to the NEMA standard. Several tool methods, for example FEM, are selected to illustrate the effect of unbalanced voltage condition on the induction motor.

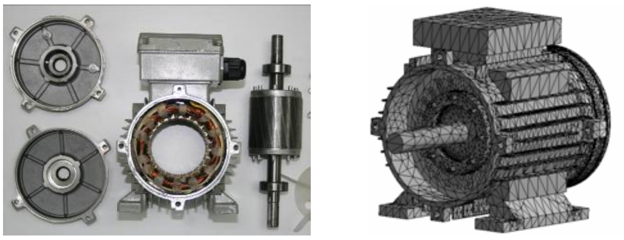
Index Terms— Induction motor, unbalanced voltage condition**,** FEM

I. Introduction

Faults of the electrical system, for example unbalanced voltage condition and inconsistent frequency, are frequently occurred, which reduces quality of the electrical system and affects efficiency of electrical appliances, especially electrical motors [1-4]. In this research, the effect of unbalanced voltage condition on induction motors is investigated.

II. Induction Motor of NEMA Designs Class

A series of standard rotor shape designs, which has different torque-speed characteristics, is defined by the National Electrical Manufacturers Association (NEMA). Figure 1 shows the prototype of a class B rotor induction motor which is main motor components and mesh of 3D FEM model. Figure 2 shows the motor dimension of the prototype induction motor.



(a) (b)

Fig. 1. Prototype of class B induction motor (a) main motor components (b) mesh of 3D FEM model

A. Stator Dimensions

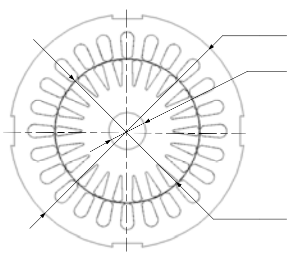
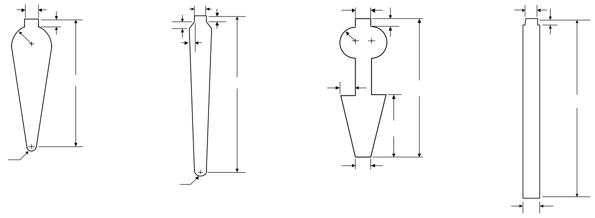


Figure 2.Dimension of the prototype induction

B. Rotor Dimensions of NEMA Designs

Rotors used in this research are designed according to the NEMA standard. Volume of all 4 classes of rotors is equal in order to make it possible for comparison. Figure 3 shows the prototype of rotor shapes, such as class A, class B, class C and class D rotors.



(a) (b) (c) (d)

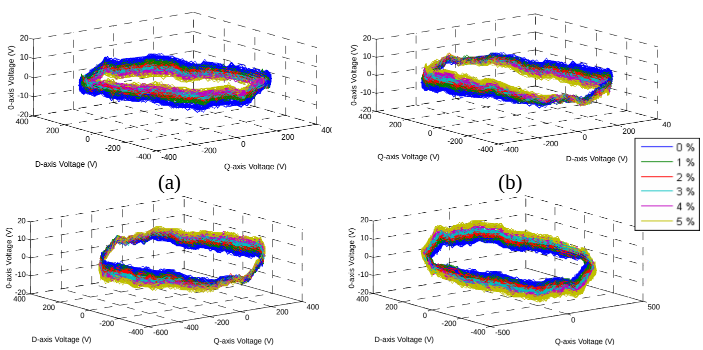
Fig. 3. Dimension of rotors (a) class A (b) class B (c) class C (d) class D

III. Analysis of Result

There are several methods that can analyze effect of unbalance voltage conditions on induction motor. In this paper, the Park's vector and FE calculation are focused. The Park's vector is usually used for the control methodology, however it sometimes can be applied to detect varying of current signal waveform. FEM is largely accepted as a significant method for analyzing the electromagnetic field in particular electrical machines performances.

A. Park's Vector

Figure 4 shows the measurement method of the prototype of class B induction motor by the Park's vector method for illustrating the vector transforms of d axis, q axis while the prototype motor was supplied by unbalanced conditions.



(c) (d)

Fig. 4. Park's Vector a) under voltage 1 phase b) under voltage 2 phase c) over voltage 1 phase d) over voltage 2 phase

B. Flux distributions

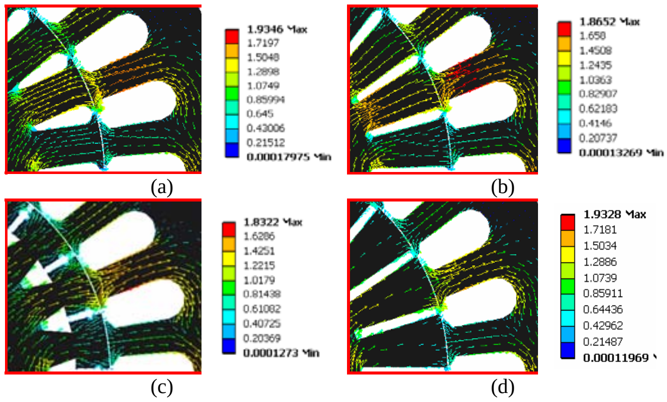


Fig. 5. Flux distributions of motors by FEM (a) class A (b) class B (c) class C (d) class D

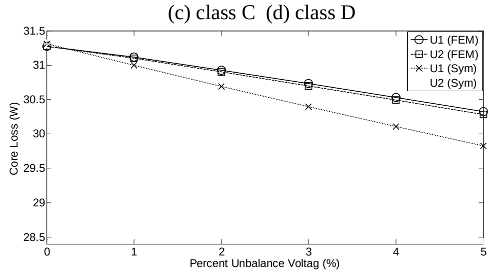


Fig. 6. Core loss of the class B motor with under voltage conditions

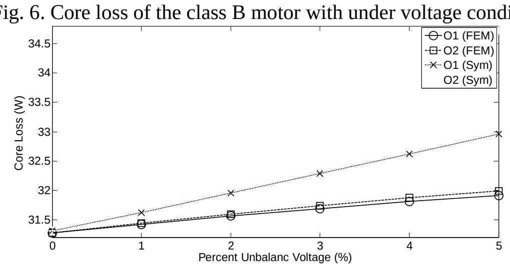


Fig. 7. Core loss of the class B motor with over voltage conditions

Figure 5 shows flux line distributions of FEM calculation. Figure 6 and 7 show results of core loss from FEM calculation and measurement methods when the class B prototype motor is operated under unbalanced voltage conditions. Figure 8 shows thermal distributions of different rotor classes that calculated by FEM.

C. Thermal Distributions

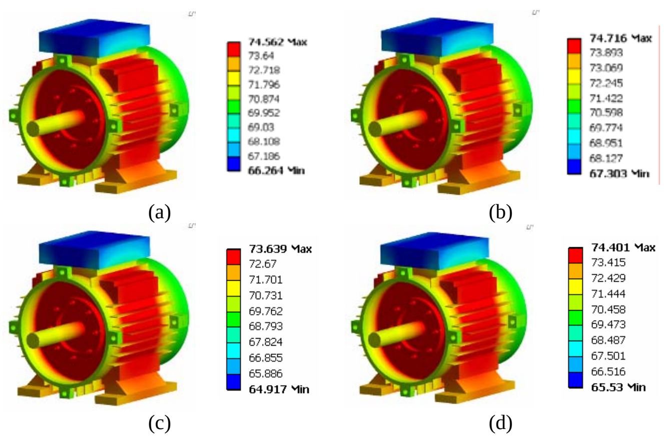


Fig. 8. Thermal distributions of motors by FEM (a) class A (b) class B (c) class C (d) class D

Figure 9 shows thermal distribution of the class B motor by measurement, which is similar to FEM calculation. Table I shows the comparison of result from FE calculations and measured method when the prototype class B motor was employed by different load that there are consistent. Figure 10 shows the comparison of core loss results that calculated by FEM.

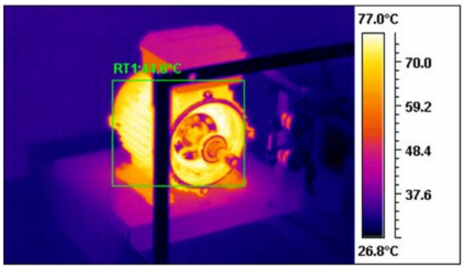


Fig. 9. Thermal distribution of the class B motor by measurement with balancing voltage at no load condition

TABLE I
MAXIMUM TEMPERATURE OF INDUCTION MOTOR CLASS B

	Maximum Temperature ($^{\circ}$C)		
	Test	FEM	Error
Load 0 %	47.9	47.375	0.7133
Load 25 %	48.9	49.379	0.6508
Load 50 %	53.1	54.831	2.3519
Load 75 %	61.0	63.388	3.2446
Load 100 %	73.6	74.716	1.5163

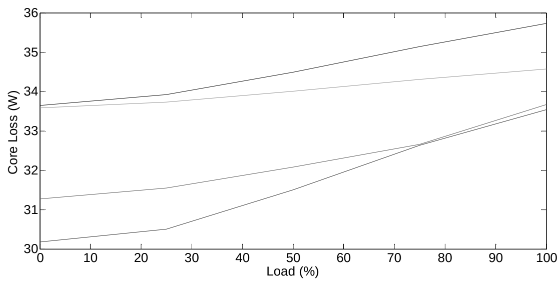


Fig.10. Core loss comparison of motors

IV. CONCLUSION

The rotor and stator parts of induction motor are significant to its performance. It is found that the class A rotor has the highest core loss and class D rotor has the lowest core loss under every load conditions.

V. REFERENCE

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