Loss & Efficiency Comparisons of PMA-, CW-, Normal SynRMs by Coupled Preisach Models & FEM and Experiment

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***Abstract*— This paper deals with the loss and efficiency evaluations of permanent magnet assisted- (PMA-), concentrated winding- (CW-), normal synchronous reluctance motors (SynRMs) by coupled Preisach model & finite element method (FEM) and experiment.**

The focus of this paper is the output characteristics comparisons relative to stator, rotor types in SynRM and the efficiency evaluation relative to hysteresis loss, copper loss, etc. on the basis of rated load condition in each SynRMs.

Computer simulation and experimental result for the efficiency, losses evaluations using dynamometer show the characteristics of each SynRM and enable to select a proper industrial application field.

***Index Terms*—Normal SynRM, PMA SynRM, CW-SynRM, Loss & Efficiency Evaluations.**

I. Introduction

Synchronous Reluctance Motor (SynRM) has advantage such as low cost and higher efficiency than induction machines. Therefore, Considerable attention has been paid in the past to improve the design of SynRM [1].

If stator windings of a SynRM are not a conventional distributed type but the concentrated type, a decrease in copper loss and the production cost due to the simplification of winding in factory, is obtained. It is called concentrated winding synchronous reluctance motor (CW-SynRM) [2].

And, by adding a proper quantity of permanent magnets the torque density and power factor of SynRM can be greatly increased. It is called Permanent Magnet Assisted Synchronous Reluctance Motor (PMASynRM) [3].

The focus of this paper is the characteristics comparisons relative to torque density, efficiency, etc. on the basis of the configurations of stator and rotor in order to select a proper industry application field and production cost problem of SynRMs.

Comparisons are given with loss evaluations characteristics of normal-, PMA-, CW-SynRM using coupled FEM & Preisach model, respectively. To prove the propriety of the proposed method, the DSP installed experimental devices are equipped and the experiment is performed.

II. Combinations of SynRM

A. 4 Type Model

Fig.1 shows the combinations of normal-, PMA-, CW-SynRM.

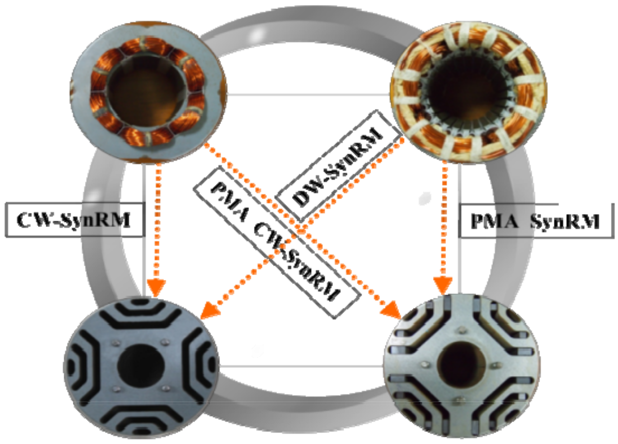


Fig. 1. Combinations of SynRMs

Where,
DW : Distributed Winding (340 W)
CW : Concentrated Winding (340 W)
IM : Induction Motor (340W)
PMA : Permanent Magnet Assisted

The DW-stator and normal rotor combination is a DW-SynRM, the DW-stator and PMA rotor combination is a PMA-SynRM, the CW-stator and normal rotor combination is a CW-SynRM, and the CW-stator and PMA rotor combination is a PMA CW-SynRM.

And, Common specifications of each SynRMs are shown in Table 1.

TABLE I
SPECIFICATION OF ANALYSIS MODEL

Article	Specification
Stator	Slot number : DW – 24 CW – 6 Full diameter : 107.8 mmr
Air gap	0.4 mm
Rotor	Internal diameter : 61 mm Laminated length : 77 mm
Phase number	3
Pole number	4
Rated	Rated output : 340 W Rated voltage : 220V

III. SIMULATION FOR IRON LOSS EVALUATION

A. System Matrix

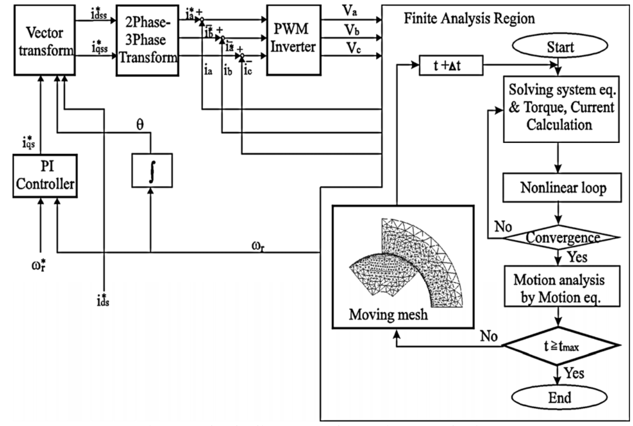
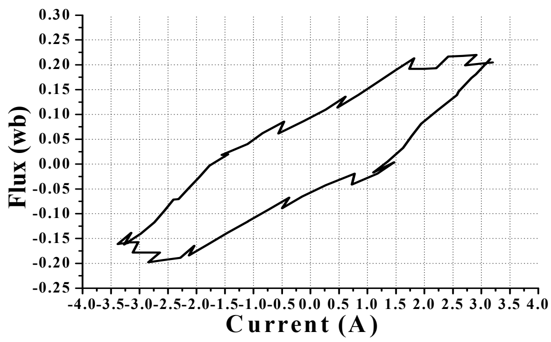
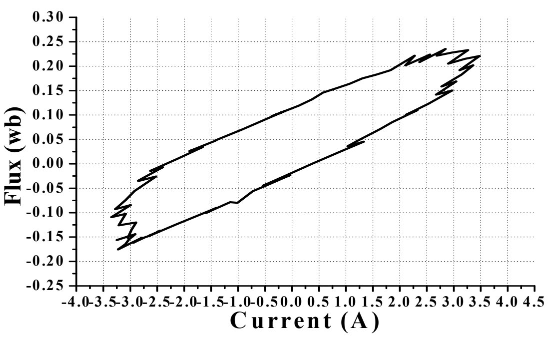


Fig. 2. Block diagram of transient analysis

This paper deals with also, the hysteresis characteristics analysis in PWM fed SynRM using a coupled FEM and Preisach modeling[4]-[7].



(a) CW-normal rotor type (Hysteresis loss 28.79 W)



(b) DW-normal rotor type (Hysteresis loss 25.46 W)

Fig. 3. Hysteresis characteristics in design solutions of each model

Fig. 3 shows the hysteresis loss responses in each analysis models by transient FE analysis of Fig. 4, when i_d = 2 [A], i_q = 2.5 [A], load = 16 kg-cm, frequency = 66.7 [Hz] (2000rpm), voltage=110 [V]. The hysteresis loss values in 6 slot models is 28.79 [W] and the 24 slot models have the loss value, 25.46 [W]. The value (28.79 [W]) is larger than the one (25.46[W]) for the 24 slot model, but is a similar one (about 1-1.5% of total loss in SynRM).

TABLE II
COMPARISON OF LOSS IN SYNRM AND PMASYNRM(2000RPM)

	Load (kg·cm)	Efficiency (%)	Core Loss (W)	Copper Loss (W)	Mechanical Loss (W)	Phase current(RMS) (A)
CW-SynRM	16.57	77.45	27.386	68.653	3	5.45
PMA CW-SynRM	15.68	77.38	38.456	57.981	3	5.01
DW-SynRM	16.79	81.32	22.057	53.020	3	3.94
PMA DW-SynRM	15.68	84.3	23.044	36.346	3	3.26

Table II shows the losses, efficiency, and current characteristics of SynRMs under the same output power condition , 340W (Experiment).

It is confirmed that the iron losses (6slot: 28.79 [W], 24slot: 25.46[W]) of each SynRM in simulation are closely match to those (6slot: 27.386 [W], 24slot: 22.057[W] at 2000rpm or 66.7 Hz) in experiment, as shown in Table II.

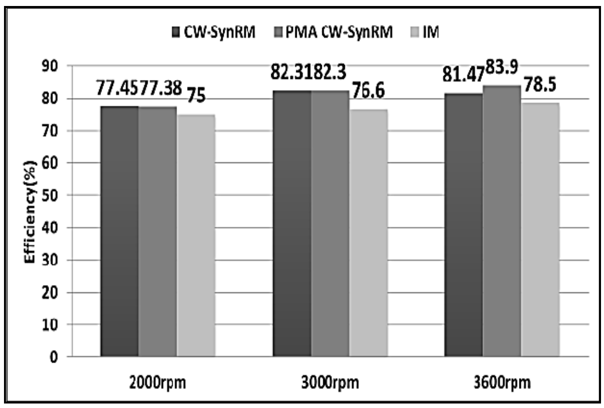


Fig. 4. Efficiency of each model

More detailed results and discussion will be given in final paper.

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