기존 12/8 및 새로운 6/5 SRM의 성능분석 및 비교

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Performance Evaluation and Comparison of Conventional 12/8 and Novel 6/5 Switched Reluctance Motors

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ABSTRACT

In this paper, a novel 6/5 switched reluctance motor (SRM) with segmental rotor is proposed for vehicle cooling fan application. Unlike conventional SRMs, the proposed motor adopts hybrid stator poles and segmental rotor structures, thereby making the motor operate in short flux paths and parts of the flux paths magnetically isolated between the phases. Therefore, compared with conventional SRMs, the proposed structure could improve the output torque density and reduce the core loss, thereby improving the electric utilization of the motor. To verify the proposed structure, the performance of the proposed structure is evaluated. Meanwhile, a conventional 12/8 SRM which has been used for vehicle cooling fan application is also evaluated. Finally, the effectiveness of the proposed SRM is demonstrated by the simulation and experimental results.

1. Introduction

Switched Reluctance Motor (SRM) is a double-salient and single-excited motor, in which windings are only located on the stator and no windings or PMs are located on the rotor. These mechanical structures allow SRMs to have many advantageous characteristics, including the following: good fault tolerance, robustness, low cost and applicability in harsh environments.[1] With these advantages, SRMs have gained more attention recently, and have been treated as good candidates for electric motor drive applications.

In this paper, a novel segmental rotor type 6/5 SRM with short flux path and no flux reversal in the stator is proposed. Meanwhile, for comparison, a conventional 12/8 SRM is presented. To verify the proposed structure, the performance of the two motors are evaluated and compared.

2. Structures of Conventional 12/8 and Novel 6/5 SRMs

2.1 Conventional 12/8 SRM

Fig. 1 shows a conventional 12/8 SRM with phase A windings. The windings of phase B and C are suited on 30 and 60 mechanical degrees apart from phase A, respectively. As shown in Fig. 1, the windings on the stator poles P_{A1}, P_{A2}, P_{A3} and P_{A4} are connected in series. However, they can be connected in parallel. This depends on different application requirements. For phase B and C, the winding connections are always the same as that of phase A.

2.2 Novel 6/5 SRM

Fig. 2 shows a novel 6/5 segmental rotor type SRM. Just as its name implies, the motor has six stator poles and five rotor poles. The stator poles are further divided into two types: exciting and auxiliary poles. The windings are only wound on the exciting poles and there are no windings on the auxiliary poles, so the auxiliary poles only act as the flux return paths. The rotor is comprised of nonmagnetic isolator and series of discrete rotor segments. The rotor segments are embedded into the nonmagnetic isolator, and are magnetically isolated from each other segments.

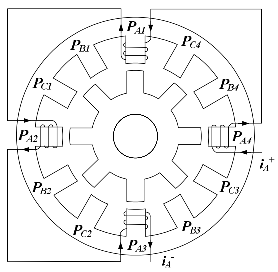

Fig. 1 Structure of conventional 12/8 SRM

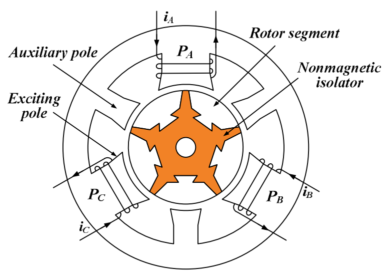

Fig. 2 Structure of proposed 6/5 SRM

3. Simulation and Experimental Results

To verify the proposed structure, simulation and experiments are performed to evaluate the performance of the conventional and proposed SRMs. Fig. 3 shows the control scheme for the two motors. Due to the low voltage and high current characteristics of the application, it may do not have enough time to control the current, so in the proposed control scheme, only the speed control is applied and the current control is not applied.

Figs. 4 and 5 show the simulation results of the conventional and proposed SRMs at rated load condition, 1.7N.m and 2800rpm. Figs. 6 and 7 show the experimental results of the two motors and the evaluated steady-state characteristics of the two motors at rated load condition are shown in Table 1. From the figures and table, it can be seen that the simulation and experimental results have a good match. Furthermore, the proposed SRM has better efficiency than that of the conventional one.

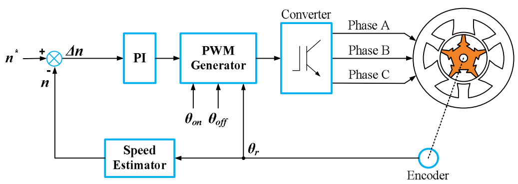

Fig. 3 Control scheme

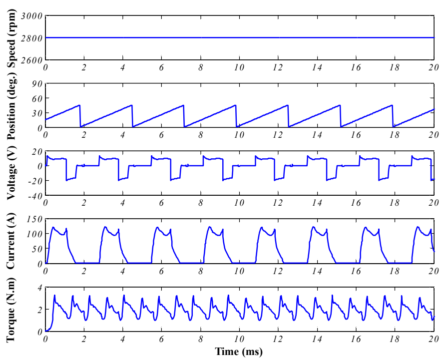

Fig. 4 Simulation results of the conventional 12/8 SRM at rated load condition

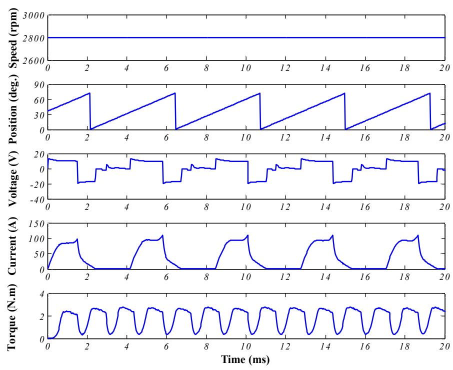

Fig. 5 Simulation results of the proposed 6/5 SRM at rated load condition

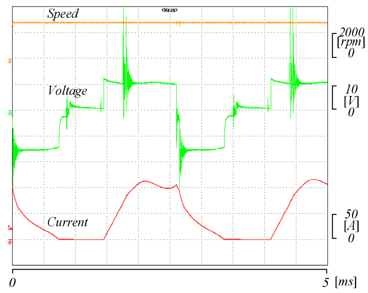

Fig. 6 Experimental results of the conventional 12/8 SRM at rated load condition

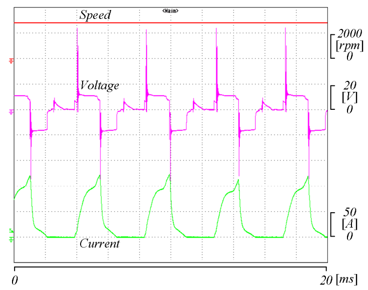

Fig. 7 Experimental results of the proposed 6/5 SRM at rated load condition

Table 1 Steady-state characteristics comparison of the conventional 12/8 and proposed 6/5 SRMs at rated load

Parameter	Conventional 12/8 SRM		Proposed 6/5 SRM	
	Sim.	Exp.	Sim.	Exp.
Mechanical loss (W)	12.50	14.32	12.50	13.36
Copper loss (W)	82.05	88.38	59.43	62.85
Core loss (W)	20.30	27.06	10.53	17.94
Stray loss (W)	7.33	8.28	5.26	6.01
Output power (W)	498.47	498.10	498.47	498.10
Input power (W)	620.65	636.14	586.19	598.26
Efficiency (%)	80.31	78.30	85.00	83.26

4. Conclusions

In this paper, a conventional 12/8 and novel 6/5 SRMs are presented, respectively. The structures of the two motors are illustrated. To verify the validity of the novel structure, the performance of the two motors are evaluated and compared through the simulation and experiments. The comparison results show that the proposed structure could generate higher efficiency than that of the conventional 12/8 SRM, thereby improving the electric utilization.

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Refernece

[1] D. H. Lee and J. W. Ahn, "Design and analysis of hybrid stator bearingless SRM," J. Elect. Eng. Technol., vol. 6, no. 1, pp. 94-103, Jan. 2011.