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Title

Subtitle

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1 Introduction

P_n ASM

2 Design

The Permanent Magnet assisted synchronous reluctance motor (PMSynRelM) is widely used for its significant advantages of small size, low loss, high efficiency, better performance than plain synchronous reluctance motors SynRelM and wide constant power to speed range. [1, 2]

2.1 Stator and Rotor

There are many solutions on how to connect the stator winding. Research has been carried out for standard Delta or Star winding, but to increase the torque for same stator current the combined Start-Delta winding was proposed. The first research has been carried out for standard SynRelM in [3] and then extended to PMSynRelM prototypes in [4]. The main idea of the hybrid Delta-Star connection is to split the standard phase wiring into two parts. The one part is for the Delta connection, the other for Star connection. Then the coils of wiring are connected to series. Motors utilizing hybrid stator winding with PMs inserted in the rotor flux barriers exhibit constant power factor over 0.9

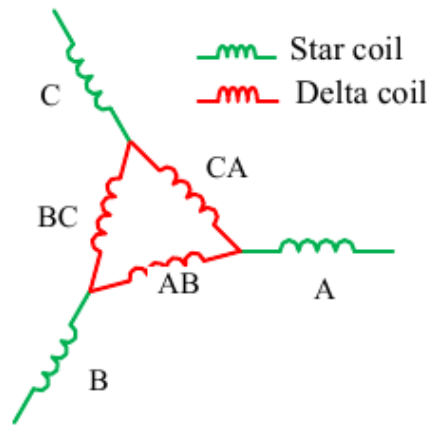


Figure 2 - 1 Hybrid Star-Delta wiring of PMSynRelM. *CHANGE THIS IMAGE FOR YOUR OWN, IT IS FROM [4]*

In [4] the authors manufactured proposed four prototypes. The prototypes consist of two stators, with either conventional star winding or hybrid star-delta winding, and two rotors, with ferrite permanent magnets or without. Maxwell transient simulations were carried out on the four prototypes, which were then manufactured and experiment using the simulation results was conducted.

According to [4] the researches state, that when using the hybrid stator winding connection, the efficiency increase is rather low compared to efficiency increase when comparing SynRelM with and without PMs.

The design of the PMSynRelM rotor with PM oriented solely in the q -axis is depicted in the figure 2 - 2.

2.2 Magnets

PMSynRelM are very often compared to Permanent Magnet Synchronous Motors (PMSM) used in the automotive field in terms of power and torque density, efficiency and costs. Though the PMSM are very popular [6], the PMs used in their design often consist of rare-earth materials such as neodymium or dysprosium. That is the reason why PMSynRelM motors with rare-earth-free materials are now being the subject of many research studies. Experiments comparing the production-used PMSM and experimental

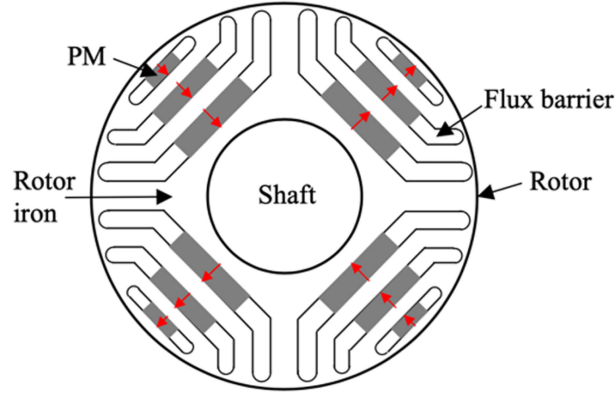


Figure 2 - 2 Rotor design of a Permanent Magnet Assisted Synchronous Reluctance Motor with permanent magnets oriented solely in the q -axis. [5]

prototype PMSynRelM show, that the proposed prototype in [7] achieve close values of power density and an efficiency as rare-earth PMSM counterpart, but with much lower costs [8].

It has been observed, that when inserting the PM in the center of the flux barrier, a magnetic flux lines are forced to pass through the flex barriers in the q -axis. This results in the decreased linked magnetic flux in the q -axis and therefore improves the output torque. [4, 9] The two general types of rotor with embedded PM are depicted in figure 2 - 3.

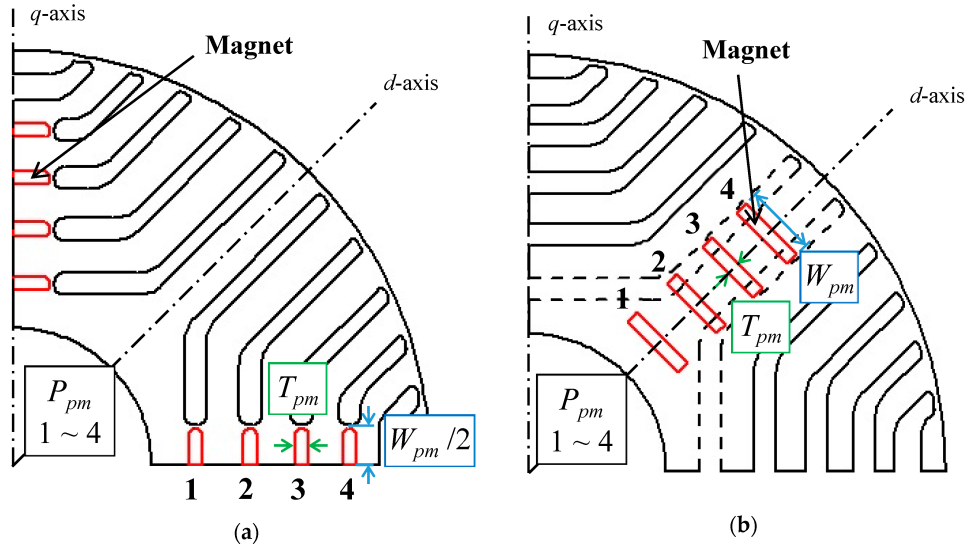


Figure 2 - 3 Different approaches to permanent magnet orientation in the rotor of a Permanent Magnet Assisted Synchronous Reluctance Motor. (a) PM embedded along the flux barriers, facing the q -axis; (b) Permanent magnets are crossing the flux barriers, therefore facing the d -axis. [9]

3 Control

3.1 Mathematical model

The stator voltage equation of PMSynRelM denoted in the general axis is as follows

$$\underline{u}_1^k = R_s \underline{i}_1^k + \frac{d\underline{\psi}^k}{dt} + j\omega_k \underline{\psi}^k. \quad (3 - 1)$$

Where \underline{u}_1^k (V) is space vector of stator voltage, R_s (Ω) is stator resistance, \underline{i}_1^k (A) space vector of a stator current, $\underline{\psi}^k$ (Wb) space vector of a stator flux linkage, ω_k (rad s^{-1}) general angular speed

3.2 Control strategies

4 Comparation to others

5 Usage

Conclusion

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Appendix A: List of symbols and abbreviations

A.1 List of abbreviations

ASM	Asynchronní Motor
PM	Permanent Magnets
PMSM	Permanent Magnet Synchronous Motor
PMSynRelM	Permanent Magnet Assisted Synchronous Reluctance Motor
SynRelM	Synchronous Reluctance Motor

A.2 List of symbols

P_n (W) jmenovitý výkon