Paper ID: Mon-Mo-Po1.07-Motors II

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Analysis of Characteristics of Permanent Magnet Synchronous Machines with Novel Topology of Fractional-Slot Concentrated Winding

Slot Phase Diagram

Fractional-Slot Concentrated Winding (FSCW)
- A type of winding topology which is featured for its short end winding, high torque density, lower copper loss and so on, but it is also characterized by a large content of space MMF harmonics which cause undesirable results.

Slot Phase Diagram
- A table that is decided only by the slot and pole numbers of the machine. It is like turning the spokes of the star of slot map into slot numbers in the slot phase diagram.

Slot Vectors Superposition Method
- The MMF produced by one coil side can be expressed as the sum of pole-pair sine waves, which is the fundamental basis for slot vectors superposition method. For pole-pair spatial MMF harmonics, we firstly get the sum of the MMF produced by one phase with phasor method, then we can calculate the winding factor for the total pole-pair harmonic.

Paper Overview
- For design of three-phase winding system, each axis of one phase share the spatial angle difference of 120 deg.
- For double layer winding, two same slot numbers (ignoring the sign) will be chosen to make up the winding.

Slot Vectors Superposition Method

2D FEA Method
A 7.5 KW PMSM is taken for finite element analysis and two different winding arrangements are applied for the machine.

Table 5 PMSM parameters

COUCLUSION
- Slot phase diagram is proposed to design winding system and a new FSCW topology is obtained by this way.
- Slot vectors superposition method along with complex number method is applied to calculate the winding factors for each MMF harmonic.
- 2D FEA is applied to verify the performance of the PMSM.