MODELLING OF BODYWORK EDDY CURRENT LOSSES IN YOKELESS AND SEGMENTED ARMATURE PERMANENT MAGNET SYNCHRONOUS MOTOR USING FINITE ELEMENT METHOD

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In this work the eddy effects of the stator bodywork of proposed yokeless and segmented permanent magnet synchronous machine are modelled using finite element method software. During the research, several stator housing modifications where evaluated.

The yokeless and segmented armature (YASA) topology (fig.1) is an axial flux permanent magnet synchronous (PMSM) motor topology in which motor has a two permanent magnet rotor discs and a stator core divided into segments [1]. Utilizing concentrated winding scheme, that leads to a high coil fill factor and short end windings which all increase torque density and efficiency of the machine. Thus, the topology is highly suited for high performance applications.

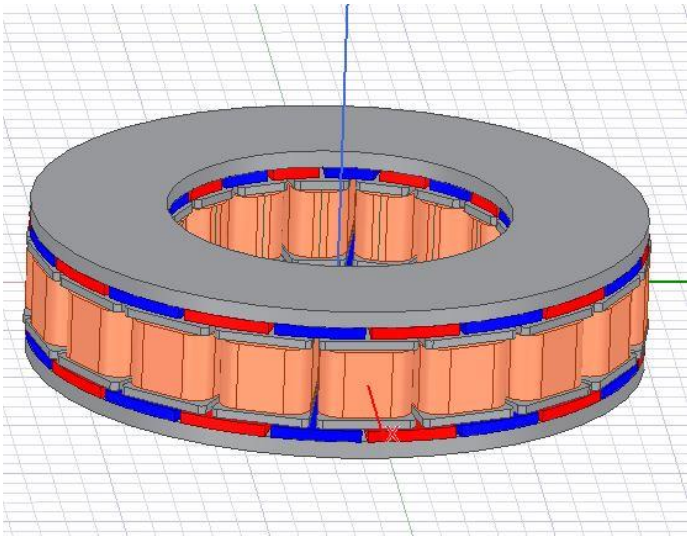

Figure 1 – yokeless and segmented armature motor topology

However, the stator core segmentation makes YASA motors challenging to manufacture. The most common approach to assemble stator part of the motor is potting with epoxy resin. The disadvantages of this method are difficulty of holding stator bars in their places before potting, and poor thermal conductivity of epoxy resin leading to inefficient heat transfer from stator to the surface of the machine and consequently low power and torque density.

In order to improve stator cooling efficiency, radial heat extraction fins are introduced in [2]. These fins provide a thermal conduction path from the windings to the stator surface, where they can be abducted by conventional cooling techniques such as forced air or water jacket cooling. At steady state and for the rated losses, the temperature difference between the winding and stator housing is less than 10 degrees Celcius for a proposed 4 KW YASA motor [2, 3].

However, the analysis of eddy current losses in the heat extraction fins and other parts of stator bodywork made from highly conductive aluminum aren't fully presented in works [2] and [3]. So, in my study, the eddy current losses in the stator housing have been evaluated for different number of bodywork laminations and different heat extraction fin thicknesses for a 5 KW 960 RPM permanent magnet synchronous YASA motor using Finite Element Method software.

As a result, it can be concluded that:

1. The short-circuited paths around stator segments should be avoided while designing stator bodywork for a YASA motor;
2. The eddy current losses inside heat extraction fins are increasing with bigger thickness, thus, there should be an optimal fin thickness value providing good enough thermal conductivity and on the other hand moderate eddy effect losses;
3. There is no nessesity to laminate stator housing for small-sized YASA motors with low rotating speeds.

References:

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2. Vansompel, Hendrik, Ahmed Hemeida, and Peter Sergeant. 2017. "Stator Heat Extraction System for Axial Flux Yokeless and Segmented Armature Machines." In 2017 IEEE INTERNATIONAL ELECTRIC MACHINES AND DRIVES CONFERENCE (IEMDC)
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