Capability improvement design method considering eddy current loss reduction of axial-flux permanent magnet coupling with Halbach array structure using 3-D FEM

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I. Abstract

This paper deals with torque parametric analysis of axial-flux magnetic coupling with Halbach array magnetized permanent magnet using the 3D finite element method (FEM). We have proposed a design method for the axial flux permanent magnet coupling (AFPMC), AFPMC is manufactured on the basis of parametric analysis results. Finally, this paper presents some methods to reduce eddy current loss. The results are compared with those obtained from 3D FEM.

II. Coupling Applications, Structure of AFPMC, and Torque fluctuation

The optimal design of the AFPMC was carried out on the basis of several parametric results.

- The maximum torque is determined by parametric analysis using several variables: PM thickness, radius of magnets, and the number of PM poles.
- The optimal design of the AFPMC was carried out on the basis of several parametric results.

III. Parametric Analysis for Optimal Design of AFPMC

- The maximum torque is determined by parametric analysis using several variables: PM thickness, radius of magnets, and the number of PM poles.
- The optimal design of the AFPMC was carried out on the basis of several parametric results.

- Analyzing AFPMCs with a Halbach array magnetized PM magnetic torque is very important because this torque provides overload protection in the machines.
- By anticipating the maximum allowable torque, the product can be minimized.

IV. Manufactured model, Design Specification, and Experimental Results

TABLE I. Axial Flux Permanent Magnet Coupling Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Poles</td>
<td>4</td>
</tr>
<tr>
<td>Inner radius</td>
<td>55 mm</td>
</tr>
<tr>
<td>Outer radius</td>
<td>71.5 mm</td>
</tr>
<tr>
<td>PM thickness</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>Core thickness</td>
<td>8.8 mm</td>
</tr>
<tr>
<td>PM remanence</td>
<td>1.3 T</td>
</tr>
</tbody>
</table>

V. Eddy Current Loss Analysis according to design methods

- Manufactured model
- Total number of PM = 32
- Eddy current loss = 512 W
- Pull out torque = 81.7 Nm

- Separated magnet in radial direction
- Total number of PM = 64
- Eddy current loss = 180 W
- Pull out torque = 76.6 Nm

VI. Comparison of Specification and Analysis Results

- In this study, we proposed a design method of Axial-Flux Permanent Magnet Coupling considering reduction of eddy current loss.
- Designed AFPMC capable of generating maximum torque using parametric analysis under limited conditions by 3D FEM.
- By using the divided permanent magnets in radial direction or tangential direction, the maximum torque value was slightly reduced, and much of eddy current loss generated in the permanent magnet could be reduced.

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