Comparison of Rotor Strength of Various Rotor Structures for Ultra-high-speed PM Motors

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In this paper, the rotor strength of four rotor structures of ultra-high-speed PMSMs are compared. Combining the rotor sleeve materials and the PM mechanical structures, the rotor stresses of the four rotor structures under different influencing factors are compared by 3D finite element method, and the influence of temperature, interference fit and sleeve thickness on the stresses of different rotor structures are summarized. Finally, the stresses of the four rotor structures are analyzed under different operating states.

II. ROTOR STRUCTURES

The structure of 7 kW, 150 000 rpm UHSPMM and the two rotor mechanical structures are shown in Fig. 1 and Fig. 2.

The four rotor structures with different sleeve materials and PM structures are shown in Table I.

<table>
<thead>
<tr>
<th>Case</th>
<th>Sleeve</th>
<th>PM</th>
<th>PM Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Ti-Alloy</td>
<td>SmCo</td>
<td>Struct-A</td>
</tr>
<tr>
<td>B</td>
<td>Carbon Fiber</td>
<td>SmCo</td>
<td>Struct-A</td>
</tr>
<tr>
<td>C</td>
<td>Ti-Alloy</td>
<td>SmCo</td>
<td>Struct-B</td>
</tr>
<tr>
<td>D</td>
<td>Carbon Fiber</td>
<td>SmCo</td>
<td>Struct-B</td>
</tr>
</tbody>
</table>

Table I. Four Structures of Rotors

III. STRESS COMPARISON OF ROTOR STRUCTURES UNDER STEADY STATE

The rotor strengths of the four rotor structures under stable operating conditions are compared and rotor stress distribution of the four structures under the same operating conditions is shown in Fig.3, Fig.4, Fig.5 and Fig.6.

IV. INFLUENCE OF SINGLE FACTOR ON DIFFERENT ROTOR STRUCTURE

The influence of magnitude of interference, sleeve thickness and temperature are taken into account in order to analyze the influence of each factor on the stability of the four rotor structures. The stress effects of different factors on different rotor structures are shown in Fig.7, Fig.8 and Fig.9. The interference and sleeve thickness mainly affect the rotor stress by affecting the sleeve.

V. ROTOR STRENGTH ANALYSIS OF OPERATION STATE

The stability of different rotor structures under different operating conditions are analyzed. Then, as shown in Fig.10, according to the permissible stress of the rotor material, the safe operating criticality is set up to compare the stability of the four rotor structures under various operating conditions.

VI. CONCLUSION

Compared with ring PM structure, the maximum tangential stress of solid PM structure decreases faster with increasing temperature. In order to improve the safe operating range of the rotor, the rotor structure with solid PM is more suitable for the use of Ti-alloy sleeve, and the rotor structure with ring PM is more suitable for the use of CF sleeve.