Fully Superconducting, Hydrogen-Cooled Motors for Electric Aircraft Propulsion

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CHEETA is a collaboration to research all-electric, hydrogen-powered commercial aircraft.
Illinois is designing a power-dense superconducting motor with hydrogen cooling

Power

Fuel Cell

Cooling other components

Liquid Hydrogen Storage Tank

Coolant supply

Shunt to fuel cell

Superconducting motor

Propeller
We designed an outer-rotor machine with **2.3 kW losses in the stator**

**Optimal design**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pole count</td>
<td>8</td>
</tr>
<tr>
<td>Power</td>
<td>2.5 MW</td>
</tr>
<tr>
<td>Rotor losses</td>
<td>&lt; 10 W</td>
</tr>
<tr>
<td>Stator losses</td>
<td>2.3 kW</td>
</tr>
</tbody>
</table>

**EM design optimization**

- Shielding coils (HTS tape)
- Field coils (HTS tape)
- Armature coils (MgB$_2$)

**Parameter**

- Pole count
- Power
- Rotor losses
- Stator losses

**Optimal values**

- Pole count: 8
- Power: 2.5 MW
- Rotor losses: < 10 W
- Stator losses: 2.3 kW
A helical-tube heat exchanger cools the stator

1D thermal analysis used straight-tube flow-boiling models

Experiment needed to determine tube curvature effect in flow-boiling cryogenic fluids
Helical tube cooling experiment underway

Nitrogen flow setup

Helical tube with heaters attached

Setup validated with water tests

Troubleshooting issues with nitrogen setup
The rotor is cooled using a rotating cryocooler

Heat is transferred by conduction to cryocooler

Approach avoids use of rotary transfer coupling with liquid hydrogen
Rotating cryocooler test shows satisfactory operation up to 1000 rpm

High-speed test (up to 4000 rpm) planned for future
Summary

The CHEETA partnership is researching all-electric, hydrogen-powered aircraft

Illinois is designing a superconducting motor for CHEETA

A helical-tube heat exchanger cools the stator
  • Experiment underway to assess tube curvature effect

A rotating cryocooler is used to cool the rotor
  • Experiment validates approach up to 1000 rpm

Questions?

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