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A Superconducting Vernier Motor for Electric Ship Propulsion

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Abstract –This paper presents a vernier motor using high temperature superconducting (HTS) field winding for the electric ship propulsion. The proposed motor adopts a homopolar configuration, where both the copper armature winding and the HTS field winding are accommodated in the stator. The rotor has no excitation sources. Thus, no cryo-moving components are required. A dual-body Dewar for cooling the pancake HTS field winding is proposed. The motor performance is analyzed and evaluated by the 3-D finite element method. Both the brushless AC and brushless DC operation modes are assessed.

I Motor Configuration

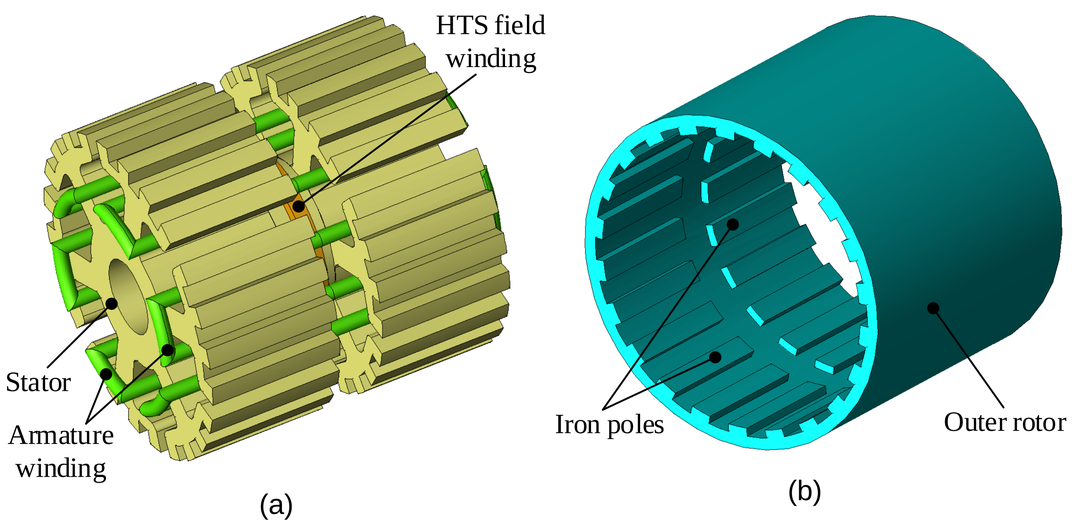

Figure 1. Proposed HTS homopolar vernier motor for ship propulsion. (a) Inner stator. (b) Outer rotor.

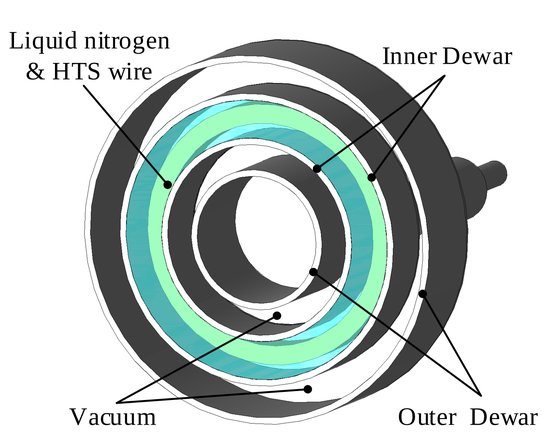

Figure 2. Dual-body Dewar for cooling the HTS field winding.

- Vernier topology for high torque density
- Homopolar configuration for stationary HTS field winding
- No moving cryogenic part and rotating transfer coupler
- Flexible flux control via the HTS field winding
- BLDC and BLDC operation

II Analysis

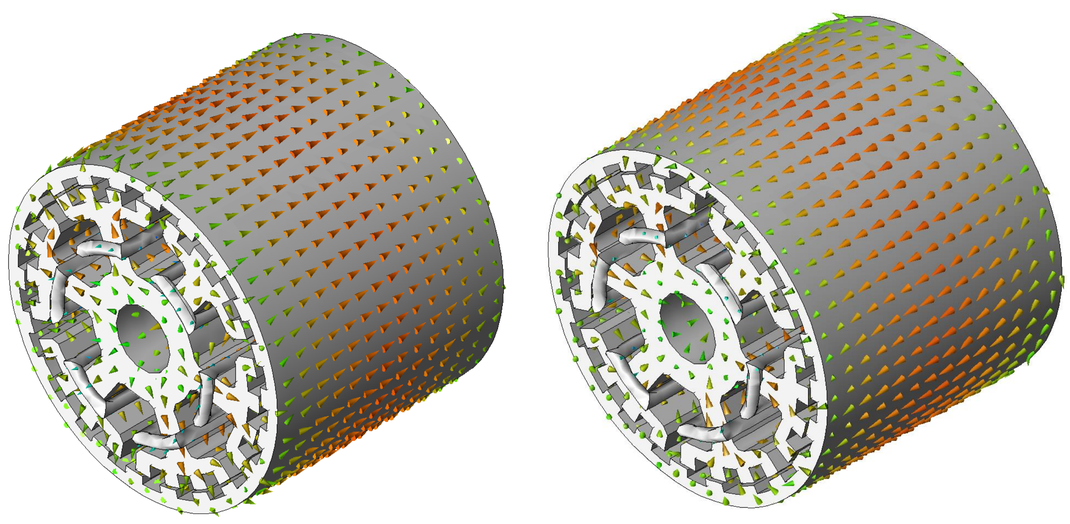

Figure 3. Flux vector based on 3-D finite element analysis. (a) Positive magnetization . (b) Negative magnetization

II Analysis

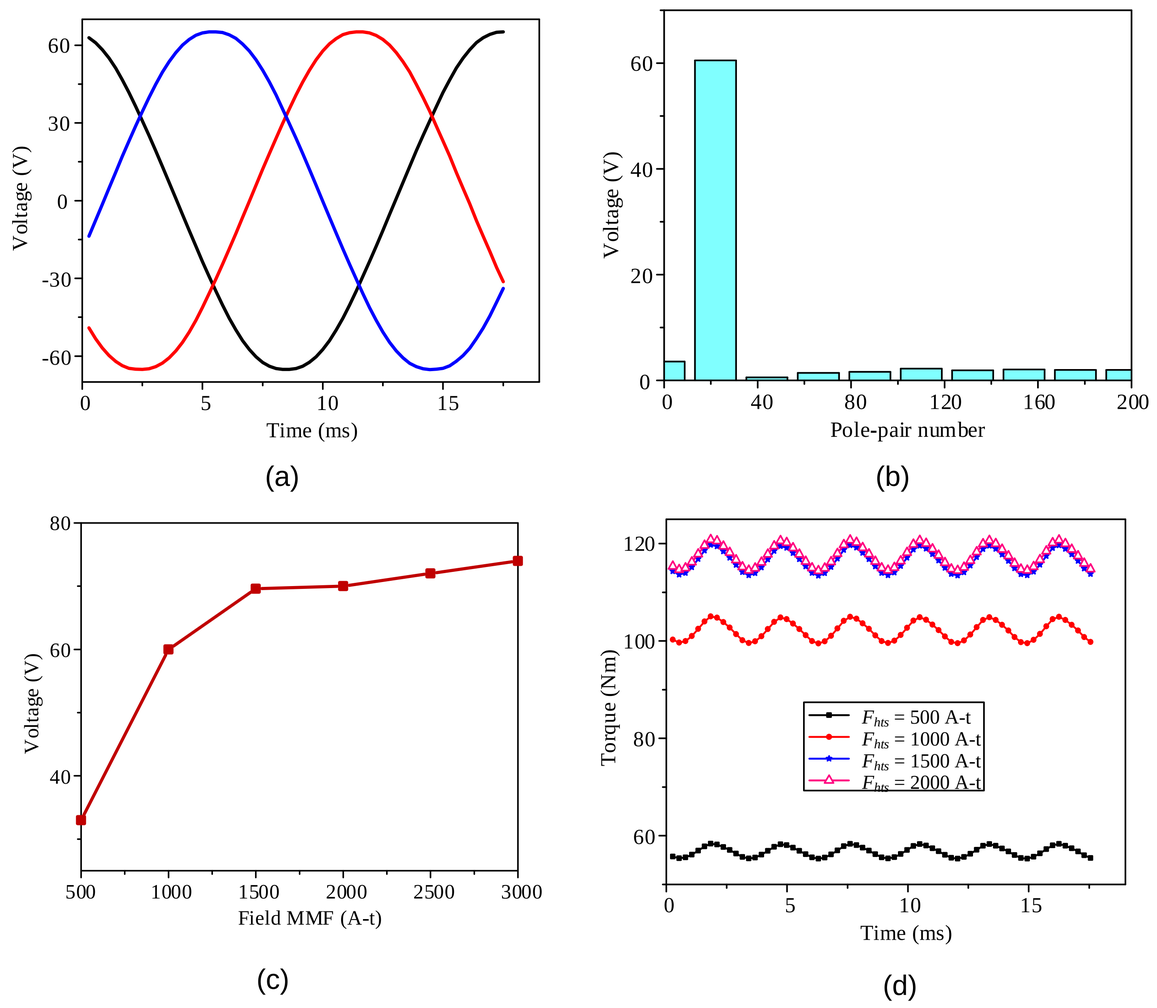

Figure 4. (a) Back EMF waveforms. (b) Spectrum of the Back EMF waveform. (c) Voltage amplitude under different excitation levels at the rated speed. (d) BLAC operation under different excitation levels.

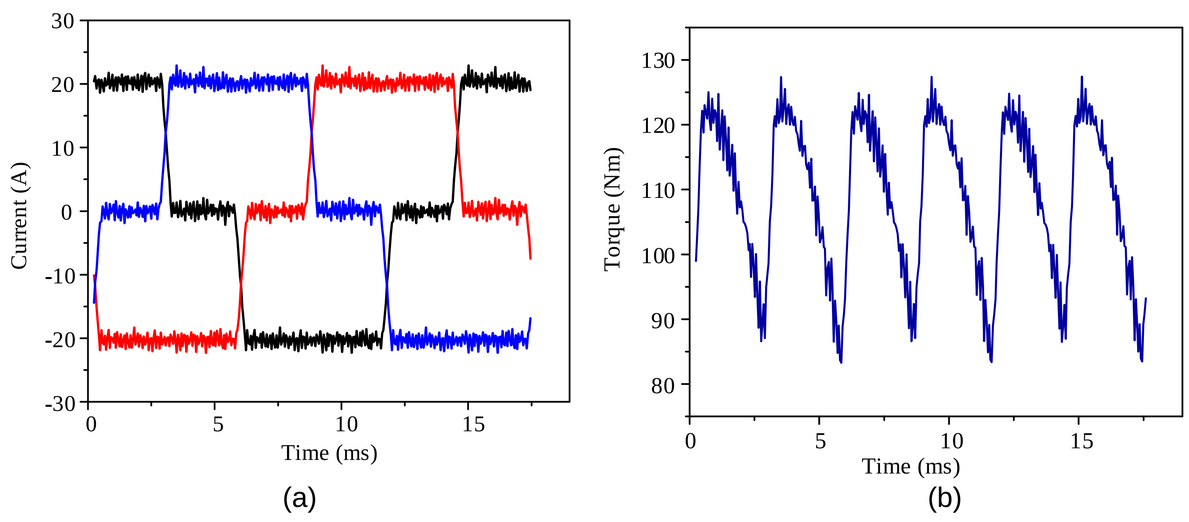

Figure 5. BLDC operation. (a) Phase current waveforms. (b) Torque waveform.

III Conclusion

A superconducting vernier motor is proposed for electric ship propulsion. By using the vernier structure, the low-speed and high-torque operation can be realized. The proposed motor adopt an outer-rotor and inner stator design using the homopolar topology. The HTS field winding and the copper armature winding are housed in the stator. A stationary dual-body pancake Dewar is design to cooling the HTS field winding. The proposed motor can operation in both BLAC and BLDC modes which can directly utilize the conventional motor drives.

Note: More details please refer to the full paper or contact with the author via wlli@eee.hku.hk

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