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Experimental Study on Torque Density Maximization of High Temperature Superconducting Induction/Synchronous *M*otor

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INTRODUCTION

Our group researches on High Temperature Superconducting Induction/Synchronous Motor (HTS-ISM). Basic structure of the HTS-ISM is based on a conventional squirrel-cage induction motor, by replacing rotor (secondary) windings with the HTS materials. Benefitting from the use of HTS materials, the HTS-ISM shows excellent characteristics comparing with conventional (normal conducting) one. Among these characteristics, we focus on the overload tolerance and the maximization of torque density.

OBJECTIVES

- Realization of overload (slip) output more than twice of 20 kW class prototype HTS-ISM.
- Discussion of maximization of torque density as well as output density for 20 kW class HTS-ISM.

CONCLUSION

- The 20 kW class prototype HTS-ISM successfully work with the slip power over 40 kW at around 1758 rpm, which is 2 times as large as the rated one (20 kW).
- The overload slip power of the 20 kW class prototype HTS-ISM reaches for 19.4 kW, and the corresponding torque at 341 Nm in low speed mode (600 rpm).

ACKNOWLEDGMENT

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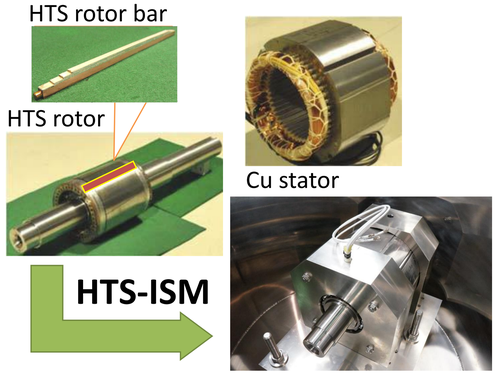
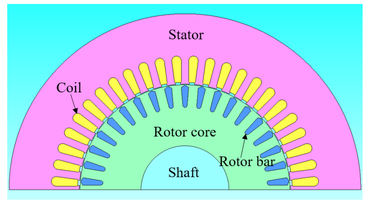
STRUCTURES/ MODEL

Structures



Analysis model

Rotating characteristics of the fabricated motor is analyzed based on two-dimensional Finite Element Method (2D-FEM), by use of commercial software JMAG®.



Stator core : Pink
Rotor core : Green
Coil : Yellow
Rotor bar : Blue
Shaft : Light blue

EXPERIMENT

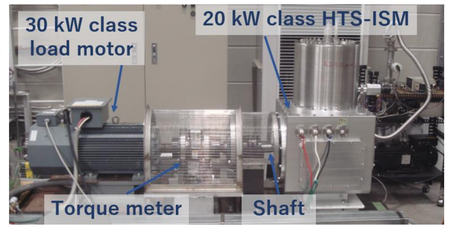
Cryostat

Parameters of 20 kW class prototype HTS-ISM

	Stator	Rotor
No. of poles	4	--
No. of slots	48	38
Outside diameter	200.0 mm	119.3 mm
Inside diameter	120.0 mm	50.0 mm
Axial length	106.0 mm	106.0 mm
No. of turns	32	--
Materials	Copper	Bi-2223

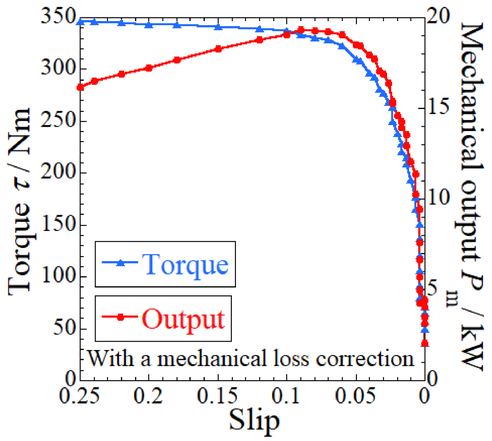
Experimental system

The HTS-ISM is installed at the bottom of the cryostat, and then connected with the load motor.

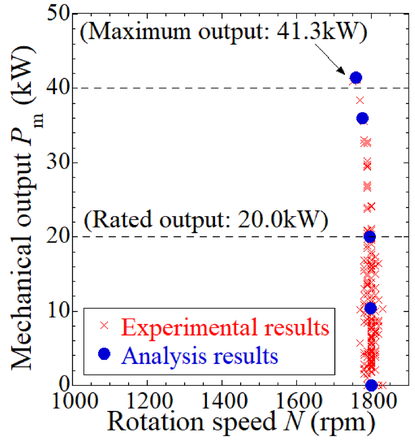


HTS-ISM is immersed in liquid nitrogen at 77 K, in order to make HTS windings work in superconducting state.

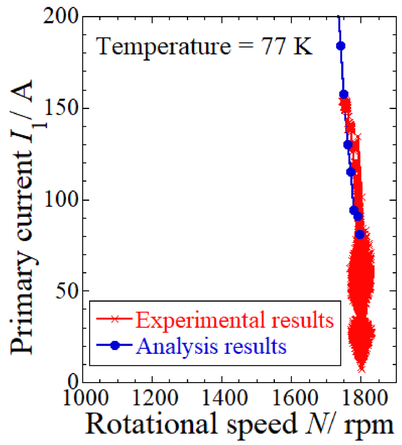
RESULTS



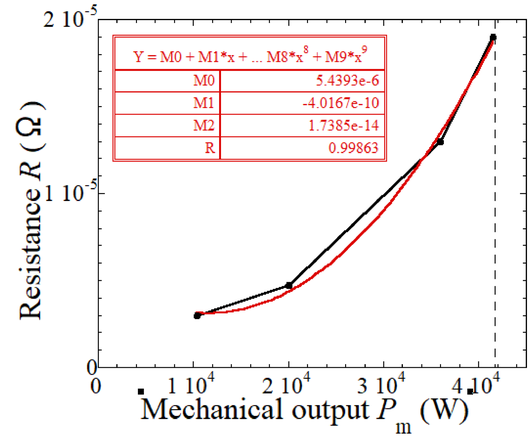
Experimental results of low speed load test, the overload (slip) output reaches for 19.4 kW, the corresponding torque at 341 Nm (@20 Hz, 53 V).



Experimental results and analysis results by adjusting the rotor's resistance (@60 Hz, 225 V).



Primary current of the analysis results agree with that of the experimental results, which could show the validity of our analysis method.



Fitted resistance of the HTS rotor bar is varied by the following equation.

Equation: $R = 1.74e^{-14}P_m{}^2 - 4.02e^{-10}P_m + 5.44e^{-06}$

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