



# Design study of a 10 kW-Class fully superconducting synchronous generator



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#### **INTRODUCTION**

In this work, a 15 kW / 150 rpm fully-superconducting synchronous generator was designed and sent for manufacturing, which installs HTS coils in both the stator and the rotor. It has a basic structure of eight poles and nine slots. There are 16 field coils and 18 armature coils wound by using 5 mm wide YBCO tapes. The total tape consumption is around 2.0 km. The peak gap field of 0.82 T can be achieved with a 45 A excitation current in field coils. The armature electric loading can reach 500 A/cm at the rated output.

The present machine is designed to be cooled by using liquid nitrogen. The cryogenic structure can be divided into two parts: the conduction cooled rotating part for field coils, and the immerse cooled static part for armature coils. Both parts share the same vacuum chamber. A novel thermal insulated torque coupling (TITC) will be installed to link the cold rotor and the warm shaft. The ac loss of the armature coils was studied by H-formulation and it is within an acceptable limit.

#### **THE GENERAL STRUCTURE**



**ELECTROMAGNETIC SIMULATION** 

a) Vacuum chamber b) Stator cryostat and support c) Stator iron d) Rotor iron e) Rotor cryostat and support f) HTS coils g) Thermal insulated torque coupling (TITC)

h) Electric feedthroughs

#### **PREVIOUS WORK**

We have developed a 2.5 kW synchronous generator with permanent magnet rotor and HTS armature windings successfully.



~600 A/cm

volumn dimension	Rotating speed	Air-gap flux density
Parameter		Value
Rated power		15 kW
Armature frequency		10 Hz
Rated rotating speed		150 rpm
Air gap flux density		0.82 T
Armature load		500 A/cm
Slot number		9
Pole number		8
Stator inner diameter		300 mm
Stator length		300mm
Air gap length		7 mm
Total wire amount		2 km
Working temperature		77 K
HTS material		YBCO



## THE YBCO MAGNET DESIGN AND TEST

Output power vs armature current

The ac loss vs armature current

## **CRYOGENIC STRUCTURE DESIGN**



Stator – Immerse cooling Rotor – Conduction cooling Coolant – Liquid nitrogen

The whole generator are enveloped in vacuum chamber

Displacement (mm)

(b)

0.2755

0.2451

(a)

A Novel Thermal Insulated Torque Coupling (TITC)

Von Mises stress (MPa)

274.60

244.11

Stainless steel flanges



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213.63 0.2148 183.14 0.1844 152.66 0.1540 122.17 0.1237 91.687 0.0933 61.201 0.0630 30.716 0.0326 0.2312 0.0023 G10 rods FE simulation results under a 1000 Nm load **Corresponding author: Timing QU, PhD (**瞿体明) Phone: +86 10 6279 4261 Mobile: +86 139 1188 9441 **Email: tmqu@mail.tsinghua.edu.cn**