# Development of High Thermal Conducting Insulation for Turbine Generator Stator Coil

## Introduction

There has been increasing demand for turbine generators that are easy to maintain and have low life cycle cost. Indirectly hydrogen-cooled turbine generators (IH-TG) have met these needs in electric power generation applications, and they have simpler structures than directly water-cooled generators (DW-TG). However, the inferior cooling performance of their stator coils limits their capacity.

To overcome this problem, we have developed high thermal conducting (HTC) insulation, which has enabled us to manufacture a large-capacity IH-TG (more than 560MVA) for the first time in the world.

## Subjects of increasing capacity in IH-TG

Fig.1 shows a part cross sectional view of an IH-TG stator. The heat generated in the stator coil conductor is transmitted to the core through the insulation layer [1].

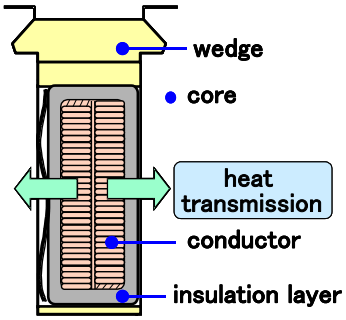


Fig.1 Cross sectional view of a part of stator

As shown in Fig 2, the thermal conductivity of the insulation layer is the lowest of the three materials. Thus, an insulation layer with increased thermal conductivity would greatly improve cooling performance.

## HTC Insulation

1) Concept

The requirements of the new insulation are as follows:

1. Twice the thermal conductivity
2. Equivalent insulation performance
3. The same production facility
4. Non-hazardous to human health

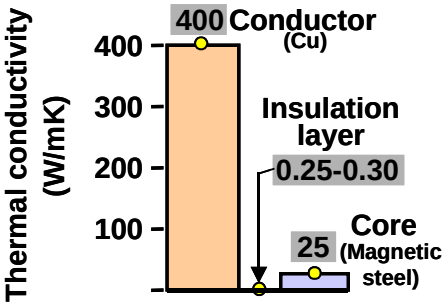


Fig.2 Thermal conductivity

2) Subjects

It has been reported that filling the insulation layer with HTC powder improves thermal conductivity but reduces the coil's voltage endurance performance [2]. However, the thermal conductivity must be consistent with electrical performance.

3) Performance

Material, particle size and amounts of HTC powder in the insulation layer have been investigated to meet this requirement.

The thermal conductivities of the developed HTC insulation layer removed from production-quality stator coils show twice the thermal conductivity of the conventional one, as shown in Fig. 3 [3].

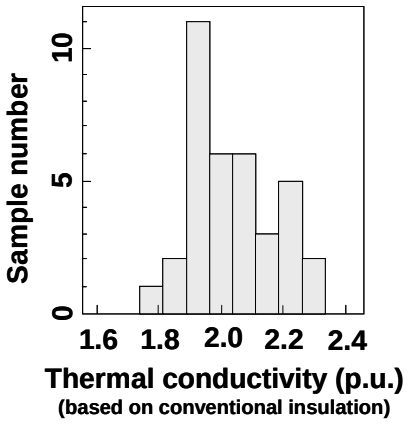


Fig.3 Thermal conductivity of developed HTC insulation

As shown in Fig.4, the developed HTC insulation shows the same voltage endurance life as the conventional one [3].

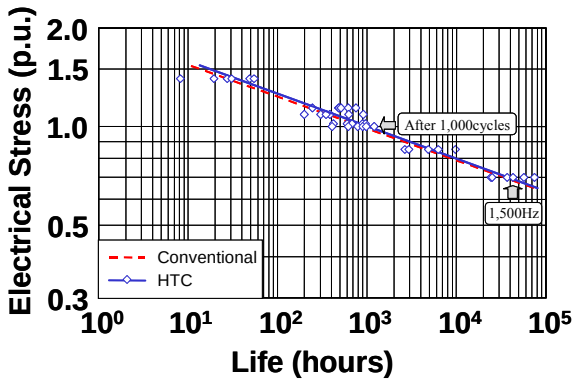


Fig.4 Voltage endurance life of HTC insulation coil

**Evaluation of cooling performance of turbine generator with HTC insulation**

We compared the temperature rises of IH-TGs of the same 350MVA class and the same frame size with HTC insulation and with conventional insulation.

As shown in Fig.5, the IH-TG with HTC insulation showed a remarkable temperature rise reduction (approximately 10 degree C) [3].

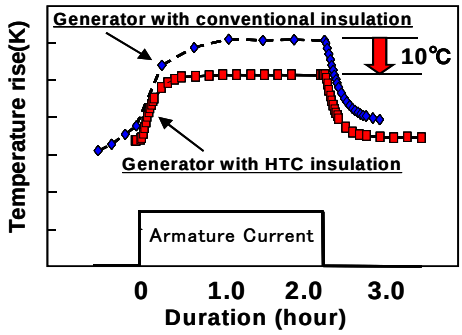


Fig.5 Temperature tests at rated stator current three-phase short circuit

**Design impacts of HTC insulation**

Adoption of HTC insulation improves the power density (capacity / weight) or the efficiency of turbine generators. Tentative generator designs with both conventional and HTC insulation have been carried out. Fig.6 shows the relation between the power density and the stator coil temperature rise of a 600MVA class IH-TG. Twice the thermal conductivity improves the power density of IH-TG by approximately 10% for the same frame size and the same stator coil temperature rise [3].

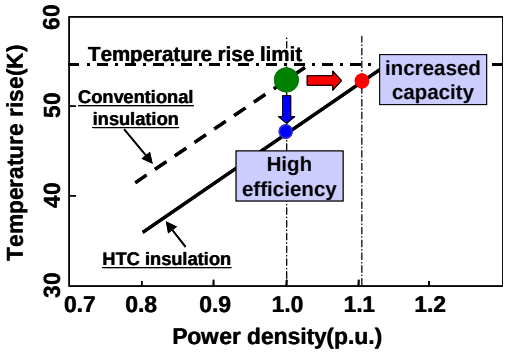


Fig.6 Impact of HTC insulation system on generator design

**Conclusion**

A new insulation system, HTC, has been developed that has twice the thermal conductivity as the conventional system. This new system provides a large-capacity IH-TG that has a simpler structure and is easier to maintain than a DW-TG. This enabled us to manufacture a 560MVA-class IH-TG in 2005.

The HTC insulation technology improves generator efficiency, increases generator capacity and simplifies coil cooling, enabling development of improved heavy electric apparatuses including turbine generators. Furthermore, the resulting improved generator efficiency contributes to environmental consciousness by conserving natural resources and reducing $CO_2$ emissions.

**References**

[1] S. Sekito, et al.: “Development and application of high thermal conducting insulation for turbine generator stator coil”, the thermal and nuclear power No.560 vol.54,(2003)

[2] C. –E. Stephan, et al.: ”An Improved Insulation System for The newest Generation of Stator Windings of Rotating Machines” ,CIGRE(1994) 35th vol.1, 11-101(1994)

[3] M. Tari et al.: “HTC Insulation Technology Drives Rapid Progress of indirect cooled turbo generator unit capacity”, IEEE PES summer meeting(2001)

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