# An Introduction of HTS-SMES Project in Korea

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***Abstract* - These days, a momentary power interruption or voltage sag have increased in the factories and distribution lines due to the widespread use of power electronics devices and renewable energy sources.**
**For this background, a 10 year High Temperature Superconducting Magnetic Energy Storage (HTS-SMES) Project was started in Sept. 2004. We successfully developed a 600kJ HTS-SMES pilot system in 2007. Currently we are studying on "A Development of 2.5MJ Class HTS-SMES" project for a four year period. Our final target will be the commercialization of this system.**
**This paper describes on an overview of HTS-SMES Project in Korea.**

## I. INTRODUCTION

The first SMES (Superconducting Magnetic Energy Storage) research in Korea was started in 1987. Twenty years later, HTS-SMES projects are undergoing in Korea.

Several projects to develop SMES followed the first study, such as the 1 MJ [1] and 3 MJ systems [2] developed by KERI based on low temperature superconductors like the NbTi.

Nowadays, high-temperature superconductor (HTS) technologies achieved remarkable progress, and also brought a merit of increasing operating temperature. Therefore we estimated that HTS-SMES would be more cost-effective than low-temperature SMES in the near future. From this point of view, we have started the HTS-SMES in Sept. 2004 for ten years. Our final goal will be a commercialization of a MJ class HTS-SMES system.

During the last three years(phase Ⅰ) since 2004, the 600 kJ HTS-SMES has been successfully developed and tested in 2007. Currently, the magnet design for a 2.5 MJ HTS-SMES is continuously doing in Korea and we are planning to finish phase II by 2011.

## II. A 600 kJ HTS-SMES

For the 600 kJ SMES coil, 4-ply HTS tape was used in order to increase the operating current level of the coil. This tape was made by stacking two Bi-2223 tapes and used two brass stabilizer tapes. The stabilizer is soldered to each side of the conductors, and lapped with Kapton tape for insulation.

Table 1 describes the specifications of the 600 kJ HTS-SMES coil, which consists of 22 double pancakes.

The HTS SMES cooled by conduction cooling method, has to maintain a temperature of a reasonable level for normal operation, however the temperature of the HTS coil is raised by joule heating caused by eddy current and AC losses during the charging and discharging time.

TABLE 1
Specifications of a 600 kJ HTS-SMES coil

| Specifications | |
|---|---|
| Number of double pancake coils | 22 |
| Inner diameter of the coil (mm) | 500 |
| Outer diameter of the coil (mm) | 691 |
| Height of the coil (mm) | 308 |
| Total length of 4-ply tape (km) | 11 |
| Inductance (H) | 16 |
| Operating current (A) | 275 |
| Stored Energy (kJ) | 600 |

Thermal stability evaluation of the total system was performed to find out the maximum operating current of this coil. As shown in figure 1, the thermal runaway was not observed up to 360 A. This means that the energy stored in the system stored was over 1 MJ, and this is the world record among HTS SMES systems developed until now.

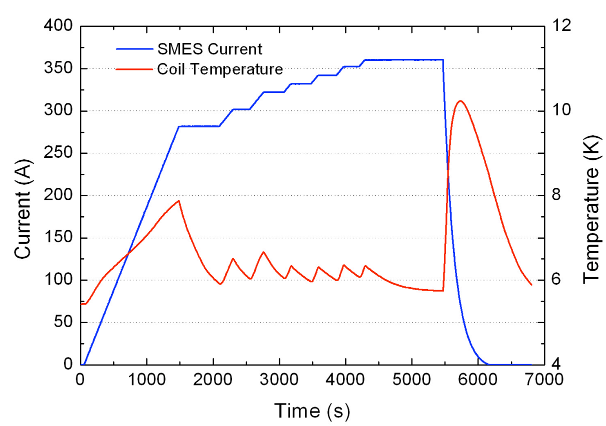


Fig. 1. Charge and discharge test results

## III. 2.5 MJ HTS-SMES

The magnet for a 2.5 MJ HTS-SMES is designed to the toroidal shape with a single pole composed of modular double pancake coils (DPCs) as shown in the Table 2, and conductively cooled down to operating temperature by GM cryocoolers. 2.5 MJ HTS-SMES magnet is optimized by using a multi-modal optimization technique which is named Multi-Grouped Particle Swarm Optimization (MGPSO). The objective of the optimization is to minimize the total length of HTS wire and satisfying some given constraints at the same time. The constraints are calculated using 3-D magnetic field analysis techniques and an automatic tetrahedral mesh generator. (Fig. 2 and Fig. 3)

TABLE 2
Design Results of a 2.5 MJ HTS-SMES Magnet

| | |
|---|---|
| Total length of HTS wire [km] | 22.0 |
| Operating current [A] | 550 |
| Number of turns per DPC (Nr) | 138 |
| Total number of DPCs (Nd) | 50 |
| Inner diameter of a DPC (r) [mm] | 406 |
| Inner radius of the toroid magnet (l) [mm] | 140 |
| Outer diameter of a DPC [mm] | 608 |
| Length of HTS wire per DPC [m] | 439.4 |
| Storage energy [MJ] | 2.51 |
| Maximum parallel field [T] | 6.24 |
| Maximum perpendicular field [T] | 0.73 |
| Ratio of operating current to critical current | 0.68 |
| Maximum stray field at 2 m [mT] | 0.004 |

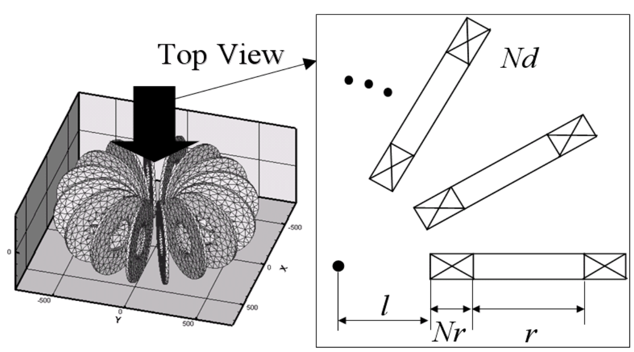


Fig 2. The configuration and design parameter of a 2.5 MJ HTS-SMES magnet

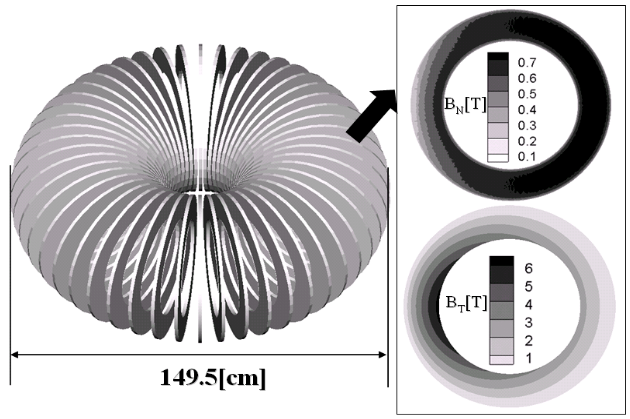


Fig 3. The magnetic field distributions in the designed 2.5 MJ HTS-SMES magnet

## IV. CONCLUSION

We finished our targets, which are the operating current of 275 A and storage energy of 615 kJ. In addition, we successfully accomplished 360 A of maximum operating current for the HTS SMES, which means that a HTS SMES with the largest storage energy in the world has been achieved.

We are doing the magnet design for a 2.5 MJ HTS-SMES as scheduled and we have a plan to finish phase II by 2011.

## ACKNOWLEDGMENT

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## REFERENCES

[1] K. C. Seong, H. J. Kim, S. W. Kim, J. W. Cho, Y. K. Kwon, S. R. Hahn, H. J. Jeon, and I. K. Yu, *IEEE Transactions on Applied Supercondu ctivity*, Vol. 12, No. 1, pp 391-394, 2002

2) Hae-Jong Kim, Ki-Chul Seong, Jeon-Wook Cho, Joon-Han Bae, Ki-Deok Sim, Kyung-Woo Ryu, Bok-Yeol Seok, Sang-Hyun Kim, Cryogenics, Vol. 46, pp 367-371, 2006