AP3-1-INV

Large Scale HTS Systems and Value Propositions

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In the past years, demonstrators of large scale HTS systems have been successfully installed in dedicated sites and sometimes even in the field for long term operation.
Nevertheless, there is no market or steady demand established yet.
In this presentation, the technical benefits of selected HTS devices are sketched and some prospects on the near-future technical challenges are presented.
In addition, in the context of "outreach", we will try to formulate a suitable value proposition for stakeholders to support the efforts to prepare a demand in power technology.

Keywords: HTS, power technology, value proposition, market

AP3-2

Development of a 20kV/400A Resistive Type DC Superconducting Fault Current Limiting Module

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Resistive type superconducting fault current limiter (SFCL) is one of the most promising SFCLs for HVDC systems. The resistance of SFCL is almost zero with the negligible influence on the system in normal operation. The increased impedance makes the current decreasing to levels below the breaker limit during a fault situation, which can effectively reduce the fault current in the DC system. Within a collaboration of Beijing Jiaotong University and Samri, one resistive type SFCL for the ±20kV Nano-Substation has been designed and manufactured. The active part of the SFCL module consists of 8 solenoids made of 14mm wide steel-stabilized YBCO conductor supplied by Samri, and is housed in a cryostat operated at normal state liquid nitrogen. The 8 solenoids are parallel assembled, and the windings of the neighbouring solenoids are series connected. The rated operation current is 400A, and the prospected limiting resistance if 9 Ω. By using of the SFCL, the maximum fault curren could be reduced to about 2.1 kA.

Keywords: Fault current limiter, YBCO tape, DC power grid

AP3-3

Heat leak of cryogenic pipe for superconducting dc power transmission line

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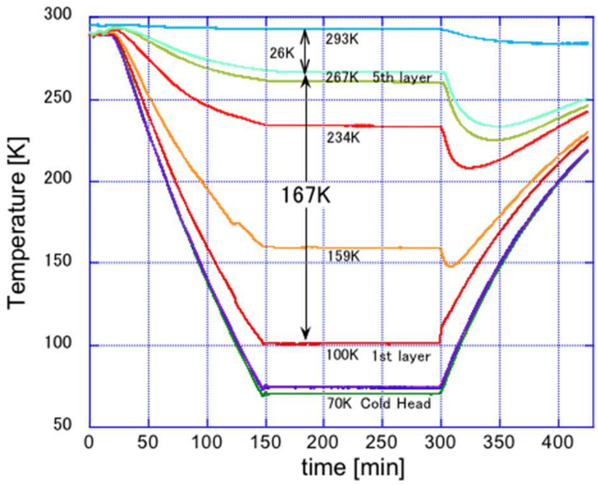
Main loss of the superconducting DC power transmission line (SCDC) comes from the heat leak of the cryogenic pipe because of no internal heat generation in the dc cable. It should be minimized to realize the high performance of SCDC. The major process of the heat leak is the heat transfer through the multi-layer insulation (MLI) and the second process is the thermal conduction of the support leg of the inner pipe. The MLI is made from the multi-layers of the aluminum-coated thin film with the spacer, and the support leg is made of the glass-fiber-reinforced plastic (G-FRP). The aluminum layer reflects the infrared light highly to reduce the heat transfer by radiation, and the spacer prevents the direct contact with the aluminum-coated thin films, and therefore it can reduce the heat transfer by the thermal conduction. Therefore, the weight of the MLI should be light to realize the thermal transfer of the spacer. We tested various types of MLI to find the optimum MLI structure. Unfortunately, computer simulation would not be effective for the MLI to estimate the heat leak. Usually, the measurement of the heat leak is not easy in an actual cryogenic pipe and we need a long time and a relatively large instrument to evaluate the heat leak. But there are several candidates of the structure of MLI. In these meanings, we could not find the optimum structure of the MLI for SCDC. To find the optimum MLI, we started to test three small samples of the MLI supplied from Kaneka Corp., and did not measure the heat leak directly, and measured the temperature of the MLI. Since the weight of the MLI is very light (several grams to ~15 gram per square meters), and therefore its heat capacity is quite low. To measure the temperature of the MLI, we used the 50-micron meters thermocouple (TC) and attached it carefully. To analyze the experimental data, we also adopt an analytical model of heat transfer [1]. This model can estimate the emissivity of the aluminum surface thermally, and its value accorded with the measurement value by the optical method. We summarize the results of the experiments and analysis, and finally, we will able to reduce the heat leaks of the cryogenic pipe to half of the Ishikari project [2].



[1] R. Byron Bird et al, Transport Phenomena, p. 447, 1960, John Willey & Sons, Inc.
[2] H. Watanabe et al, *IEEE Trans. Applied Supercond.* Vol. 27, No. 4, 5400205.

Keywords: cryogenic pipe, heat leak, thermal analysis, multi-layer insulation

AP3-4-INV

Development of Test Device for Aluminum Metal Melting by Induction Heating Using DC HTS Coils

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Aluminum die-casting technology is widely applied for the production of industrial parts such as automotive parts, since it can produce large amount of complex parts in short time with high dimensional accuracy. In industrial aluminum casting factories, there are following problems to be solved:

- Low efficiency of the gas heating main furnace. Continuous energy consumption in the hold furnace to keep aluminum in molten condition.
- Conveyance of melted aluminum to hold furnace which leads accident risks such as falling-down and sudden drop off of vessel.
- Suppression of aluminum dross (aluminum oxide) which is produced around the surface of melted aluminum due to gradual reaction with air in the hold furnace. Aluminum dross degrades quality of die-casting production and it finally becomes waste.

If an aluminum melting device that can melt necessary amount of aluminum within a short time only when it becomes necessary (called just-in-time melting) can be developed, the melted aluminum material can be directly supplied to die-casting machines. The gas heating furnaces with low efficiency can be disused and the conveyance of melted aluminum also can be abolished. Therefore, in large scale aluminum die-casting factories, the just-in-time aluminum melting devices are required. To realize them, it is necessary to develop a high efficient and high speed aluminum melting technology. We have focused on the application of the induction heating using DC HTS coils to aluminum melting and have been investigating the possibility of aluminum melting. Fig. 1 shows the schematic illustration of our proposed induction heating device using HTS coils for aluminum melting. The aluminum materials are rotated in DC high magnetic field generated by HTS coils and the large eddy current joule heat induced in the aluminum material. In our former study [1], we have reported that 0.77 kg aluminum material can be melted by induction heating in DC magnetic field of 0.4-1.0 T. The results reported in [1] indicate that the induction heating with DC HTS coils can apply to aluminum melting. In this study to extend our former study [1], the 1/5 scale test device for aluminum melting by the induction heating using REBCO HTS coils are designed using the numerical electromagnetic and thermal analysis. In the paper, the design and fabrication process of the test device is reported.

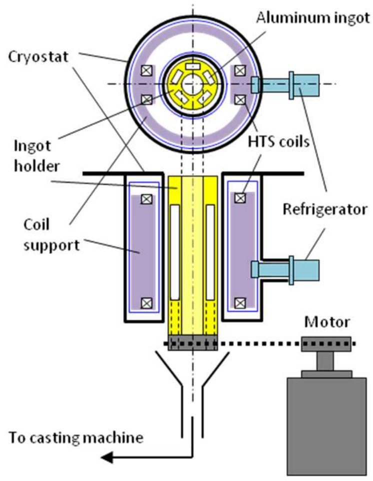

Fig. 1. Schematic illustration of proposed induction heating device for aluminum melting using DC HTS coils.

[1] T. Watanabe, S. Nagaya, N. Hirano, S. Fukui, "Elemental Development of Metal Melting by Electromagnetic Induction Heating Using Superconductor Coils", IEEE Trans. Appl. Supercond., Vol.26, Art. ID 3700504, 2016.

Keywords: Induction heating, HTS coil, Aluminum melting

AP3-5

Development of the 1 MW Superconducting Induction Heater

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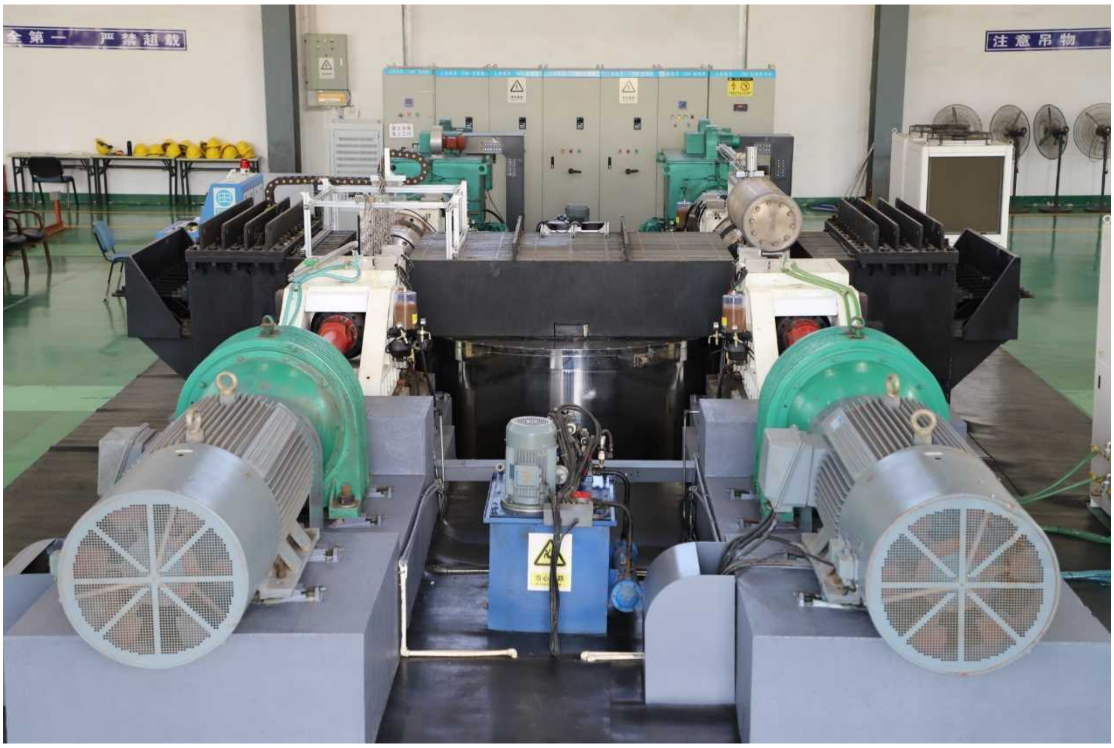
The 1 MW HTS induction heater has been developed for the non-ferrous metal industry where the HTS coil is used to generate a static magnetic field. The HTS magnet is made of YBCO conductor produced by Shanghai Superconductor, and the prospected operating temperature is about 25 K. The size of Aluminium billet was set to 446 mm of the diameter and 1500 mm of length, and the heating power of was determined to be 1000 kW with over 80% of system efficiency. The conduction-cooled HTS magnet consists of three solenoid coils wound with 18 km YBCO conductor. The inner and outer diameters of the YBCO magnet are Φ1960 mm and Φ2009 mm, respectively. The magnet system is cooled by two AL325 cryo-refrigerators. According to the testing results at an operation current of 130 A, the temperature of the HTS coils and the thermal shield are less than 20 K and 70 K, respectively, while are much better than the expected value.



Keywords: Induction heater, Superconducting magnet, YBCO