# [1259] Wed-Mo-Po3.09-01 : Fabrication and Performance Test of Fault Current Limiting Element Made of Non-Laminate Coated Conductor

## Before Title : Fabrication and performance test of fault current limiting elements made of non-stabilizer coated conductors


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## 1. Abstract

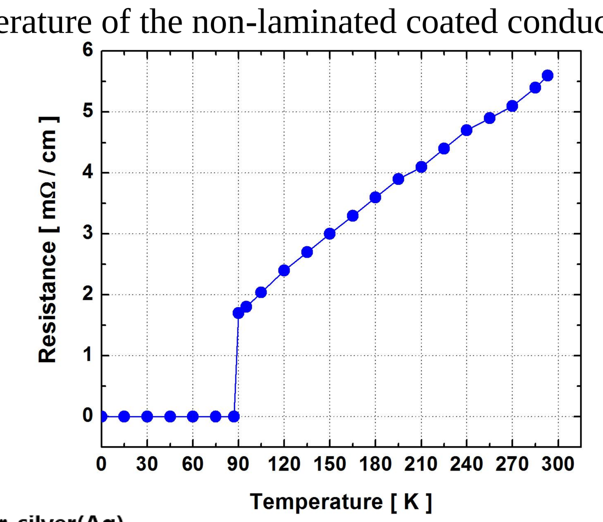

The priority for determining the performance of the superconducting current limiter depends on the manufacture and adoption of the superconducting current limiting element with excellent properties. The basic conditions for the superconducting current limiting element are a high critical current density and index value, and simultaneously the stable normal operation against the diverse fault conditions within the power system. Further, since the superconducting current limiting element is operated in the extreme low-temperature environment, it should be manufactured in a compact structure. The compact structure can reduce the coolant consumption, and is beneficial as the superconducting current limiting element applicable to diverse superconducting current limiters. Based on the above premise, this study manufactured the superconducting current limiting element using coated conductors without laminate layer. Using the manufactured superconducting current limiting element, the current limiting performance test against fault current was carried out, the superconductivity recovery test by measuring the time required for the superconductivity recovery was carried out, and the temperature distribution was analyzed.

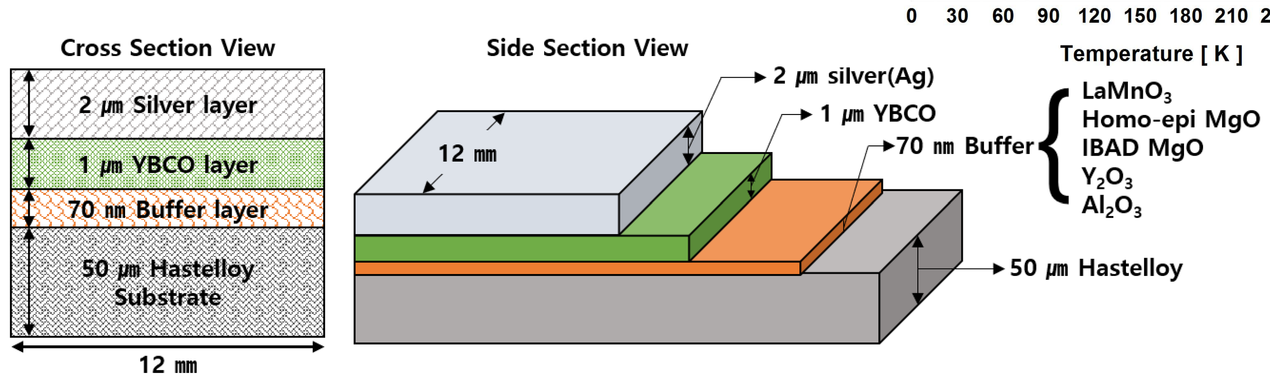
For the test of the performance of the superconducting current limiting element that limits the fault current, the results of testing the effective limiting of the applied fault current according to established fault angles were presented. Further, the superconductivity recovery test derived the required time for the recovery of the superconductivity state by the superconducting current limiting element according to the applied voltage size and power application cycles. Lastly, the temperature distribution analysis according to the applied voltage size and current transport cycles offered the data for the applicable maximum voltage per unit length of the superconducting current limiting element, and this became the evaluation index for determining the voltage class of the superconducting current limiting element.


## 2. Properties of REBCO thin-film wire

- Physical configuration of the non-laminated coated conductor(SF12050 model made by SuperPower Co.) and the specific resistance value variations according to temperature of the non-laminated coated conductor.

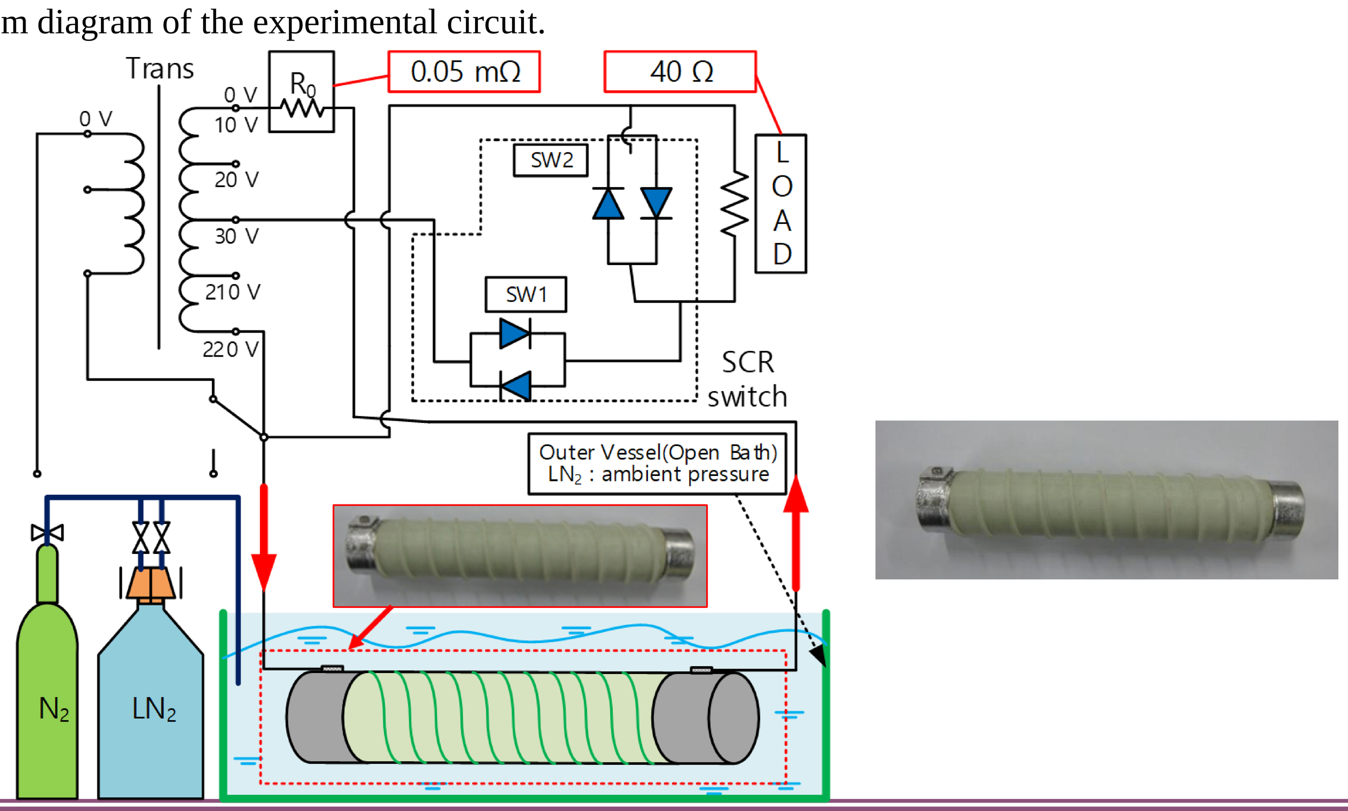
| Non-laminated ReBCO coated conductor(Superpower SF12050) | |
|---|---|
| Stabilizer | Ag (Copper stabilizer free) |
| Length of pattern/width/thickness | 250 mm/12 mm/0.055 mm |
| Layer of stabilizer/substrate | Ag 2 ㎛/Hastelloy 50 ㎛ |
| $I_c$ & $T_c$ | 352 A (1 ㎶/㎝, @77 K), 90 K |
| Resistance | 5.5 mΩ (@300 K) |
| Resistance at room temperature | 80 mΩ |



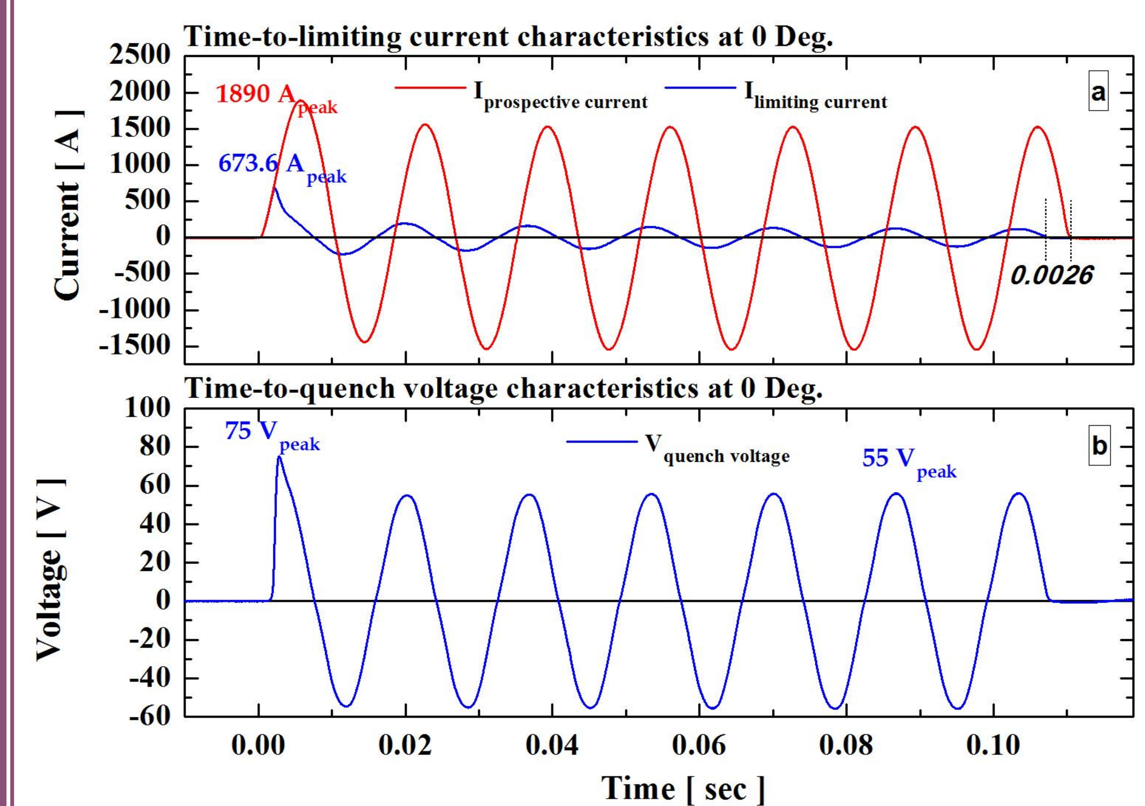

## 3. Experimental Set up

- Test system diagram of the experimental circuit.

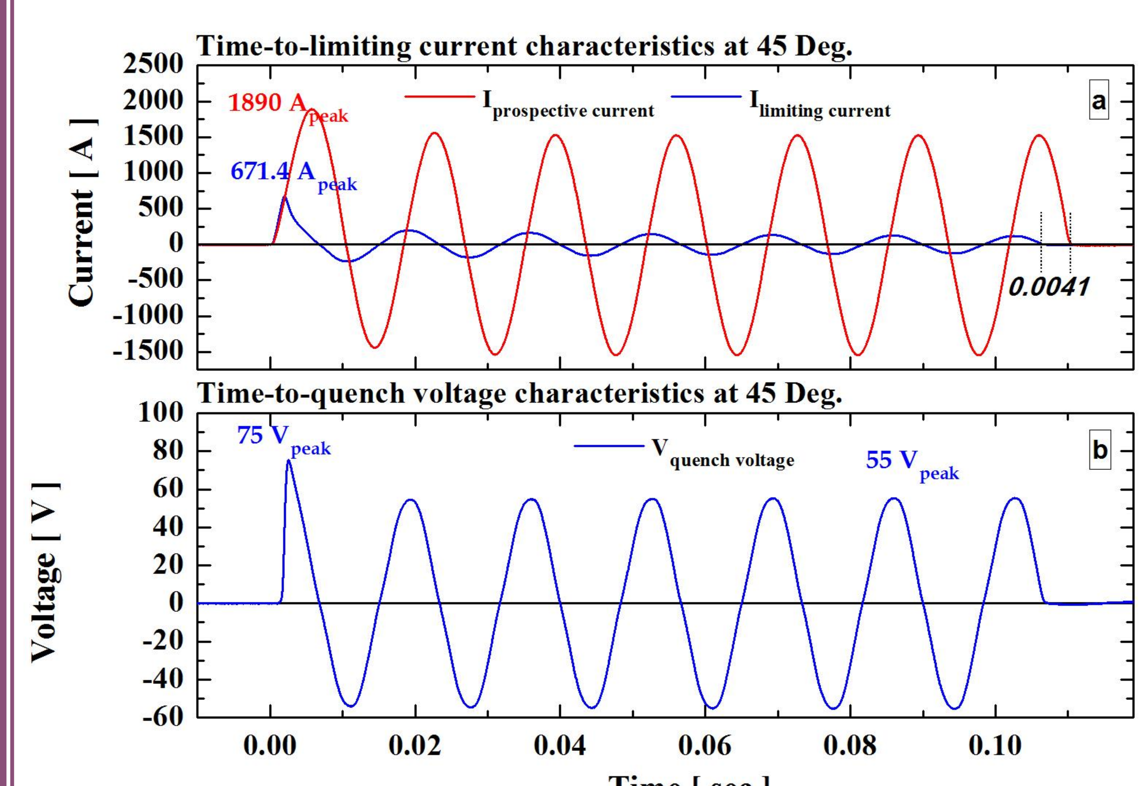



## 4. Current transport test of AC over-current according to fault angles of the superconducting current element

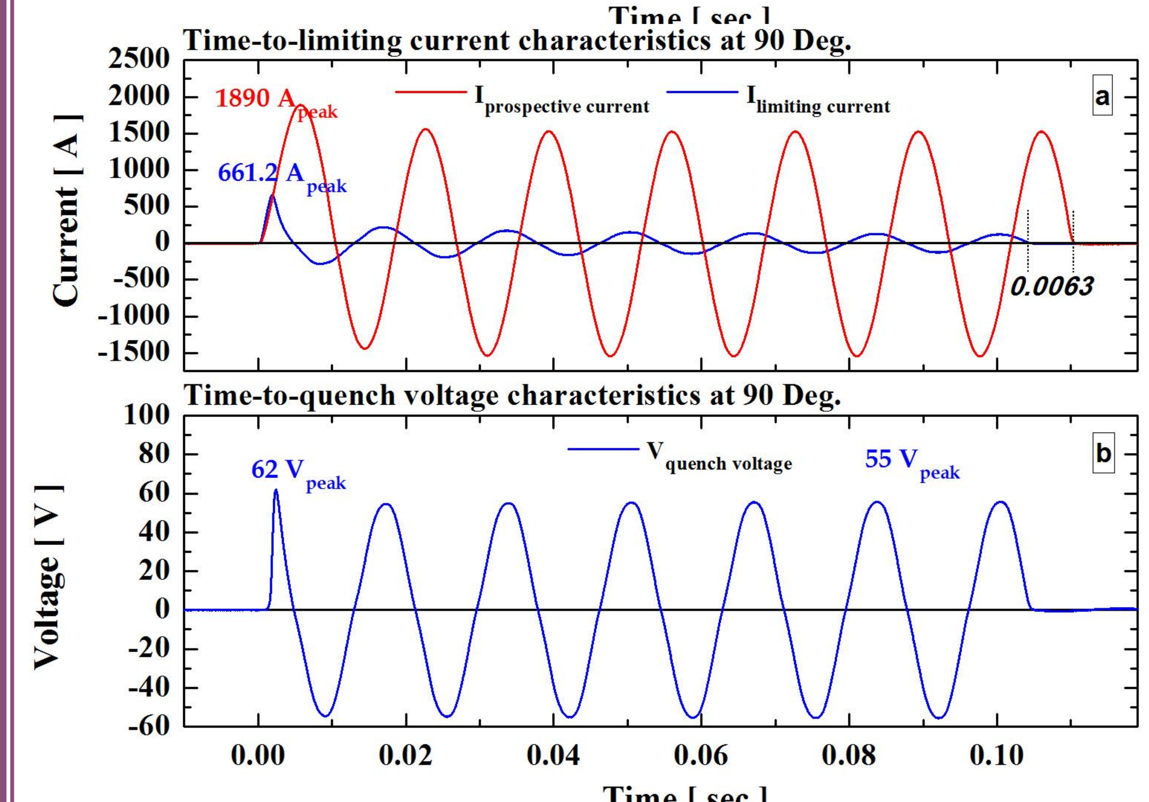
- Current transport test of AC over-current with fault angle (0°) (a) limited fault current characteristics, (b) quench voltage characteristics.




- fault angle of 0°
- first-cycle limited fault current size is 673.6 $A_{peak}$
- current limiting rate about 64.35%




- fault angle of 45°
- first-cycle limited fault current size is 671.4 $A_{peak}$
- current limiting rate about 64.47%

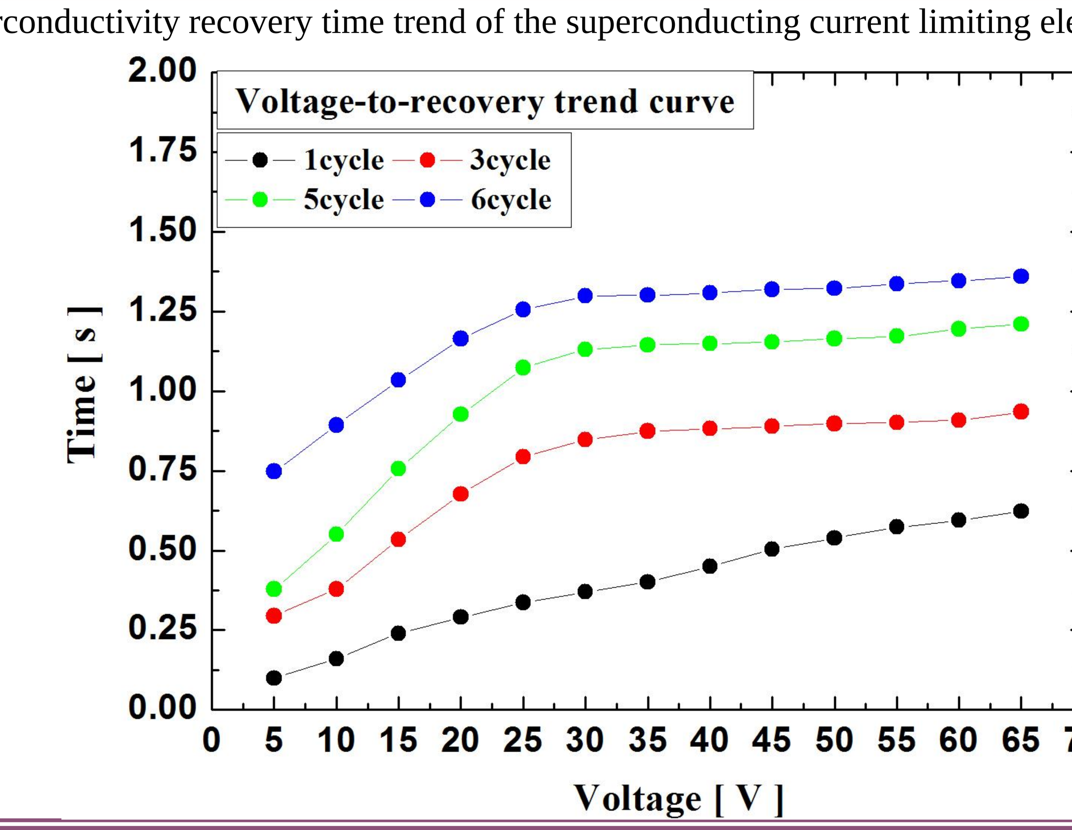



- fault angle of 90°
- first-cycle limited fault current size is 661.2 $A_{peak}$
- current limiting rate about 65.01%

- The fault current size : 1,890 $A_{peak}$
- The greater phase difference at 90°(the maximum point (90°) of fault current.)
- It is revealed that as the fault angle increases, the fault current limiting rate increases(as the fault time is raised due to fault angles, the fault current is limited in the front stage by the superconducting current limiting device.)
- The quench voltage, generated by the fault current, is the same at 0° and 45°, and is lowered to 62 Vpeak at only 90°(fault occurrence time is consistent with the maximum point of the first half cycle of the fault current.)
- the quench voltage is 55 $V_{peak}$ at all fault angles (0°, 45°, 90°) after cycle 5 (0°, 45°, 90°)

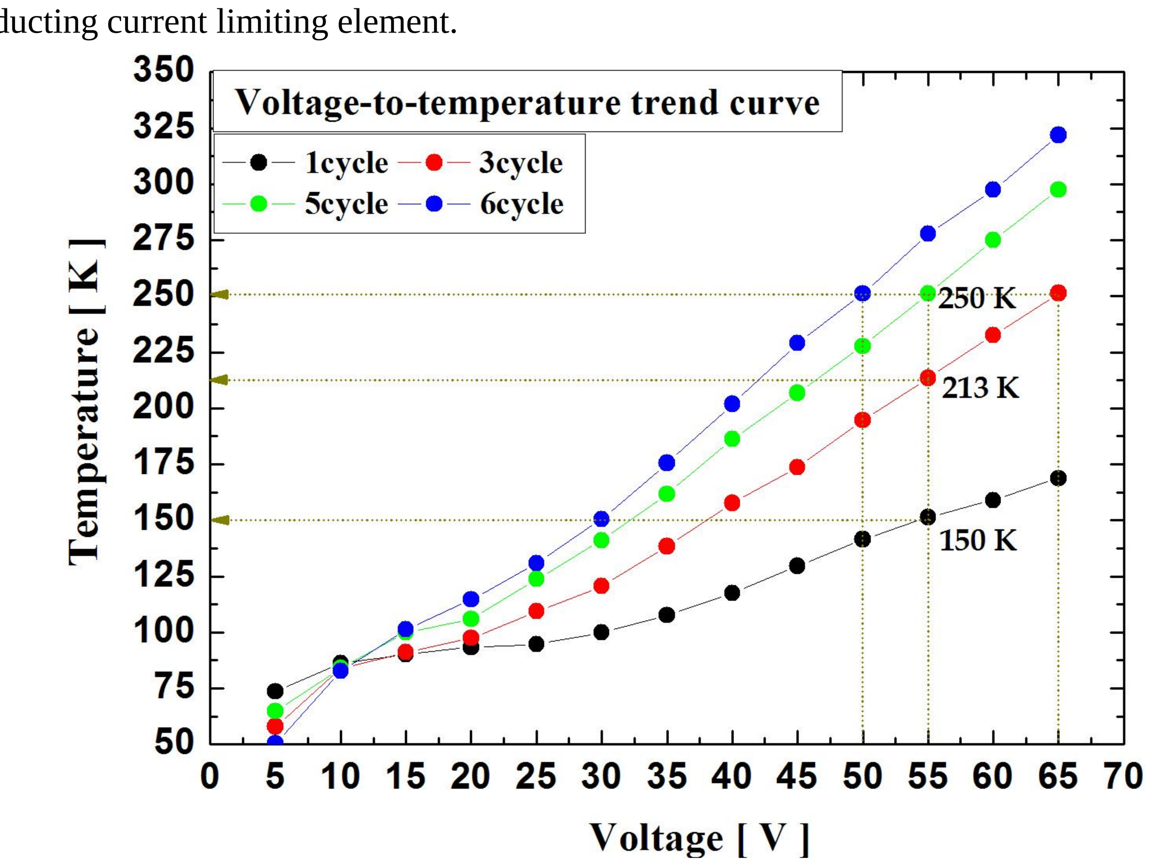
## 5. Analysis of the superconductivity recovery time of the superconducting current limiting element according to current transport cycles associated with the applied voltage size

- The superconductivity recovery time trend of the superconducting current limiting element.




## 6. Analysis of the maximum applied voltage per unit length using the temperature distribution of the superconducting current limiting element

- The temperature distribution curve by current transport cycle according to the applied voltage size of the superconducting current limiting element.




- This confirms that, as the application cycle of power supply voltage increases, the maximum voltage applicable to the superconducting current limiting element decreases.
- the current transport cycle decreases, the voltage applicable per unit length increases.

## 7. Conclusion

In this study, we manufactured the superconducting current limiting element using the coated conductor without laminate. Using the manufactured superconducting current limiting element, we carried out the current limiting performance test, the superconductivity recovery test, and temperature distribution analysis. The current limiting performance test was carried out according to fault angles. At all set fault angles (0°, 45°, 90°), the fault current was normally limited according to the fault angle characteristics. The superconductivity recovery test according to the applied voltage sizes and current transport cycles confirmed that, as the applied voltage size increased and the current transport cycle was lengthened, the superconductivity recovery time was lengthened. However, the analysis of the superconducting current limiting element's superconductivity recovery time required suggested that it can vary according to the unique characteristics of the superconducting current limiter. Lastly, the analysis of temperature distribution by current transport cycle according to the applied voltage sizes of the superconducting current limiting element serves as data for determining the maximum voltage size applicable to the superconducting current limiting element, and for determining the voltage rating of the superconducting current limiting element.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