

Characteristics of a Current-limiting DC circuit breaker with a superconducting coil applied to the commutation circuit

Hye-won Choi, Hyo-sang Choi, Hui-seok Gu
Chosun university, South of KOREA

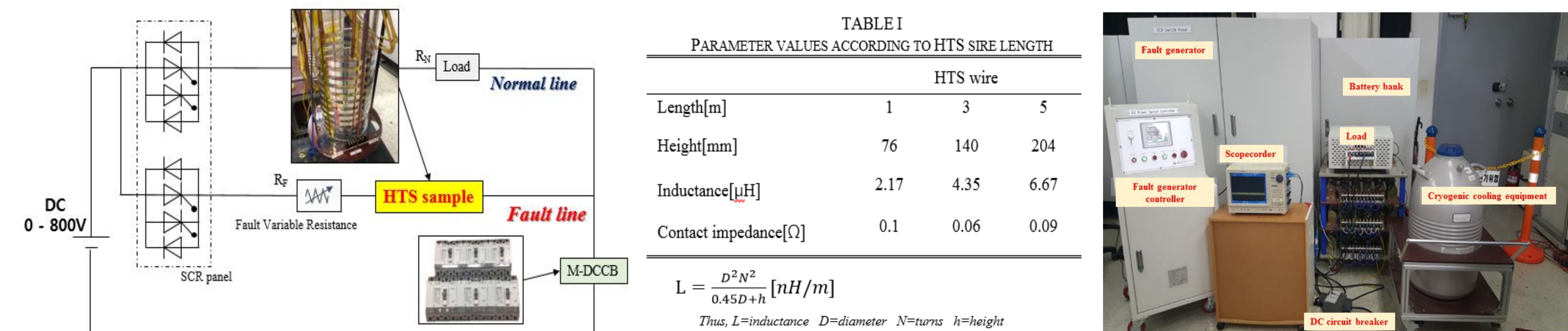
Abstract

- We research team has proposed a current-limiting superconducting DC circuit breaker that combines a superconductor with a DC circuit breaker, and secured its operation performance in our previous study via simulation.
- In this paper, we designed and produced an actual current-limiting superconducting DC circuit breaker, as well as analyzed its current limiting and breaking performance. In addition, the operation characteristics at different lengths of the superconductor with increasing voltage were analyzed.
- The operation reliability of the proposed DC circuit breaker was demonstrated by a simulation system that was built similar to the actual system.

Current-limiting DC circuit breaker(CLS-DCCB)

1) CLS-DCCB Structure and experiment condition

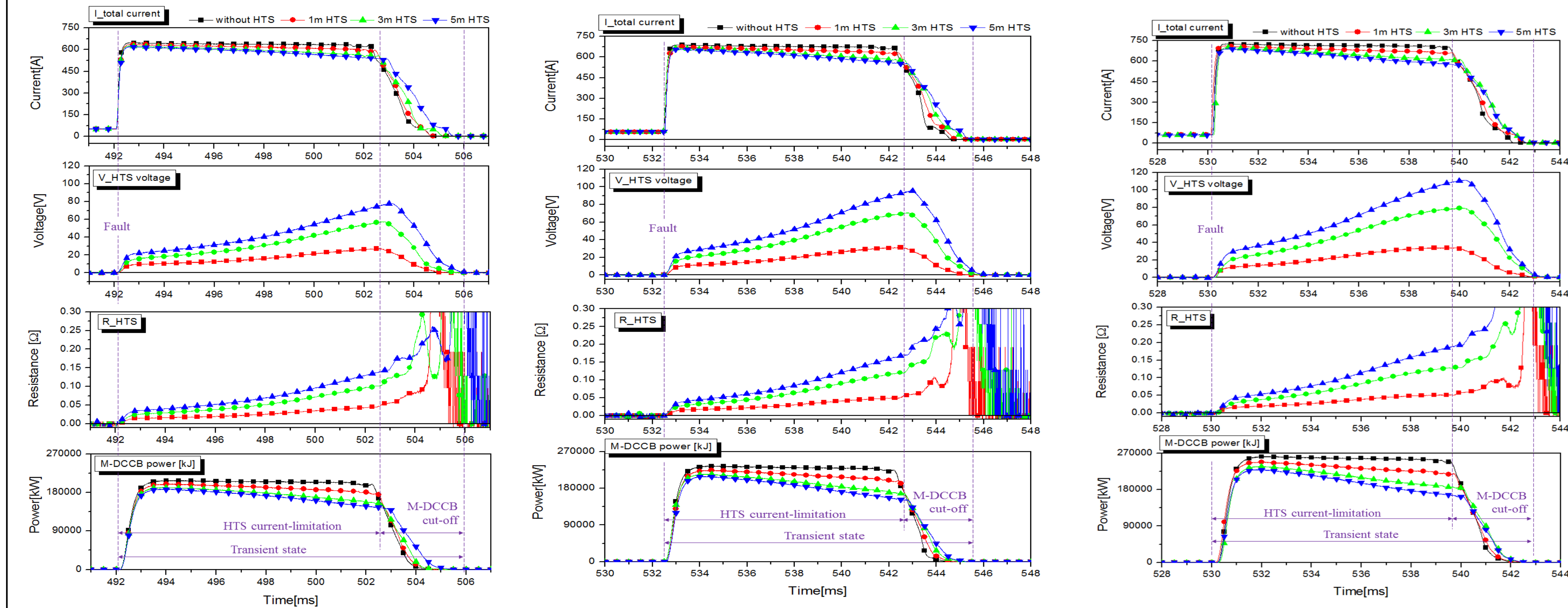
- CLS-DCCB is a system that applies a current-limiting technology to the interruption technology.
- The superconducting coil was selected on the basis of capacity. The superconducting wire has a stabilization layer of stainless steel and AMSC's 8602 wire with a resistivity of $=1.00 \times 10^{-7} [\Omega m, 20^\circ C]$ was selected. The critical current is 226[A]; the lengths are 0[m](without Superconducting coil), 1 [m], 3[m], and 5[m]; the inductance values are 2.17[μH], 4.35 [μH], and 6.67[μH]; and the contact resistance is 0.1 [Ω].



Conclusion

- The current-limiting and breaking characteristics of the CLS-DCCB were analyzed via experiments. A DC power test facility of the laboratory scale was constructed with essential equipment and instruments in order to enable the experimentation of DC power devices together with the design of a current-limiting superconducting DC circuit breaker.
- The circuit breaking characteristics were analyzed by using the existence or absence, as well as length, of the superconductor as variables. The results showed that when the superconductor only shared 10[%] on average of the power applied to the DC circuit breaker, the magnitude of the fault current rapidly decreased by approximately 63[%], and the breaking operation was completed three times faster. Moreover, the simulation result showed that as the maximum magnitude of the fault current applied to the DC circuit breaker was limited, the power burden of the DC circuit breaker was also reduced.
- The breaking performance and capacity could also be increased easily by adjusting the winding type and inductance size of the superconductor. If we produce a 100[kV]-class CLS-DCCB in the future, it will shorten the breaking time by at least 10 times and a fault current-limiting rate of at least 70[%] could be achieved.

Experiment results



	Without HTS	1[m] HTS	3[m] HTS	5[m] HTS
Max. fault current[A]	650.3	636.9	629.9	618.0
Limiting fault current[A]	621.4	590.6	560.2	532.8
Current-limiting rate[%]	4.4	9.18	13.86	18.07
dl/dt[A/msec]	31.52	47.98	70.90	86.24
M-DCCB power burden $\times 10^6$ [kJ]	2.14	2.02	1.90	1.88
HTS power burden $\times 10^6$ [kJ]	-	0.12	0.24	0.26
HTS current-limiting impedance magnitude[Ω]	-	0.052	0.12	0.14

	Without HTS	1[m] HTS	3[m] HTS	5[m] HTS
Max. fault current[A]	688.4	675.3	662.9	657.2
Limiting fault current[A]	670.6	631.0	657.2	553.0
Current-limiting rate[%]	2.67	8.59	17.11	20.69
dl/dt[A/msec]	21.52	45.96	88.20	104.98
M-DCCB power burden $\times 10^6$ [kJ]	2.31	2.17	2.03	1.95
HTS power burden $\times 10^6$ [kJ]	-	0.13	0.28	0.37
HTS current-limiting impedance magnitude[Ω]	-	0.06	0.14	0.19

	Without HTS	1[m] HTS	3[m] HTS	5[m] HTS
Max. fault current[A]	728.6	711.7	702.6	693.4
Limiting fault current[A]	701.1	664.5	609.5	568.3
Current-limiting rate[%]	3.83	9.06	17.01	23.18
dl/dt[A/msec]	30.01	48.82	93.94	125.73
M-DCCB power burden $\times 10^6$ [kJ]	2.52	2.34	2.16	2.03
HTS power burden $\times 10^6$ [kJ]	-	0.16	0.34	0.45
HTS current-limiting impedance magnitude[Ω]	-	0.055	0.13	0.19

