

Operation of superconducting fault current limiter in Moscow high-voltage power grid

Mikhail Mozyzhk, Petr Ustyuzhanin, Eldar Magommedov, Anastasiya Telnova, Lenar Sabirov, Kirill Baburin, Daria Gorbunova, Sergey Samoilentov

SuperOx CJSC, Russia

Motivation

- Reliability and environmental reasons require dense power grid
- Dense power grid results in high fault current levels
- Traditional measures (grid splitting, reactors, oversizing) manage fault currents only temporarily
- Superconducting fault current limiter (SFCL) is a novel technology aimed to provide long-term solution due to unique superconductor electricity-carrying properties
- Russia's pilot SFCL built by SuperOx is in operation since 2019 in Moscow high voltage grid
- SFCL in high voltage grid long-term operation has not been studied yet

Objects of study

- SFCL 220 kV-class in power grid in central Moscow, Russia (Fig.1) during 2019-2021
- SFCL in-grid position was specifically chosen due to high fault current levels in the adjacent grid (over 40 kA)

Key properties for analysis:

- Reliability of power transmission to customers
- Fault current limitation
- SFCL system and subsystems maintenance



Fig.1 SFCL at substation in Moscow

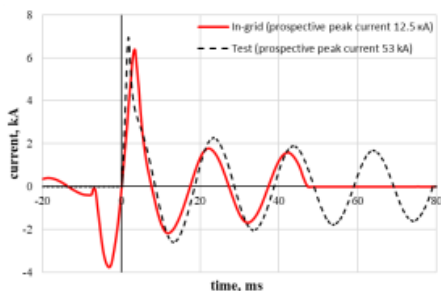


Fig.2 In-grid and test current limitation comparison

Results and Discussion

Power transmission

- Continuous operation throughout 2019-2021, over 240 million kW*h transferred to roughly 0.5 million customers daily

Fault current limitation

- Over 5 faults observed (Table 1), all operated correctly and matching design and test expectations (fig. 2)

Table.1 In-grid faults observed

Date	Fault type	I SFCL, RMS (Pk)	Transition
2020-04-16	Remote	4.5 kA (6.4 kA)	Yes
2020-07-14	Remote	1.6 kA (2.2 kA)	No
2020-10-12	Remote	1.6 kA (2.2 kA)	No
2020-11-05	Remote	2.1 kA (2.9 kA)	No
2021-01-16	Remote	1.5 kA (2.1 kA)	No

Maintenance

- SFCL used sheduled maintenance only, consistently providing power supply to in-grid customers
- Limited number of SFCL auxillary system faults were observed and resolved during sheduled operations (Table 2)
- Successful 3-month SFCL operation on limited cryogenic cooler power (2 of 3 coolers in operation)

Table.2 SFCL malfunction list (minor issues amended)

No	Date	Description	Counter-measures
1	2019-09-06	Auxiliaries shutdown	Auto-restart upgrade
2	2020-05-06	LN2 pipeline damage	Reinforced pipeline installed
3	2020-06-19	LN2 loss - control system fault	Control system software update
4	2020-07-07	Chiller failure - low coolant	Chiller inspection update
5	2020-09-28	Cryocooler failure - manuf. error	Replacement of main turbine
6	2021-07-28	Chiller failure - manuf. error	Condenser repair (leak eliminated)

Conclusion

- SFCL in Moscow city grid provided consistent power supply to customers and easy maintenance
- Successful in-grid fault limitation demonstrated
- Operation experience confirmed SFCL technology readiness for series utilization in power sector