27th International Conference on MAGNET TECHNOLOGY
November 15-19, 2021, Fukuoka, Japan
WED-PO2-718-07

High-temperature superconducting cable optimization design software based on 2-D finite element model

Jiajie Long, Li Ren, Ying Xu, Yuejin Tang, Jingdong Li, Jing Shi

Huazhong University of Science and Technology, Wuhan 430074, China

***Abstract*——**With the increasing electricity power demand in major cities, the existing conventional power cables is difficult to meet the requirements of high-density and large-capacity power transmission. Compared with conventional power cables, high-temperature superconducting cables can significantly increase transmission capacity, reduce power losses, and save land occupation, which have great potential in future urban high-density power transmission applications. However, the process of designing a complete set of HTS cable that can be used in engineering is very complex, and many factors need to be considered comprehensively, such as current distribution, AC loss calculation, thermal stability analysis. In this case, a HTS cable design platform is under development to simplify design process and improve the work efficiency of designers. Based on the software, a set of a three-phase coaxial 10 kV/2 kA cold insulated HTS cable design scheme is given. Through MATLAB / COMSOL joint simulation, the 2-D AC loss finite element model of HTS cable is established. The simulation results show that at low voltage level, the HTS cable with three-phase coaxial structure has less AC loss, and can save more land, which is more suitable for the expansion of urban power grid in the future.

1. HTS Cable Design Software programing process and key points

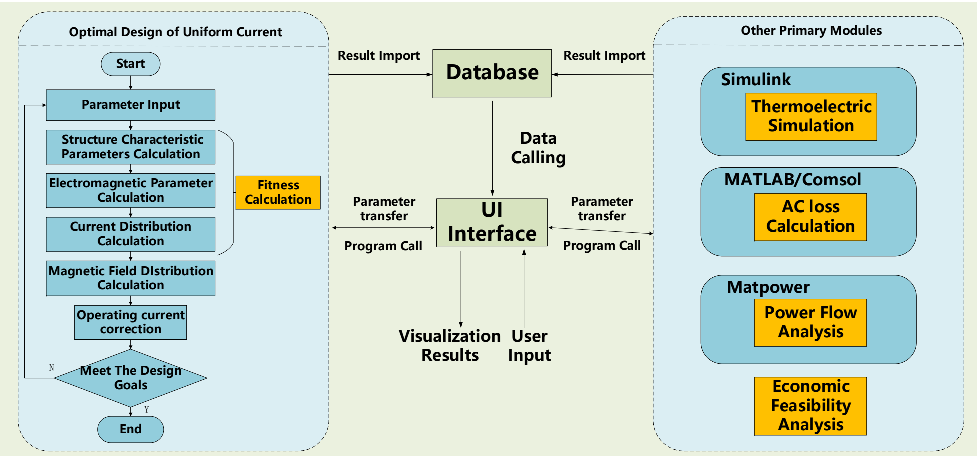

Fig.1. Overall structure frame diagram of HTS cable design software

2. 10kV/2kA HTS cable design scheme by the software

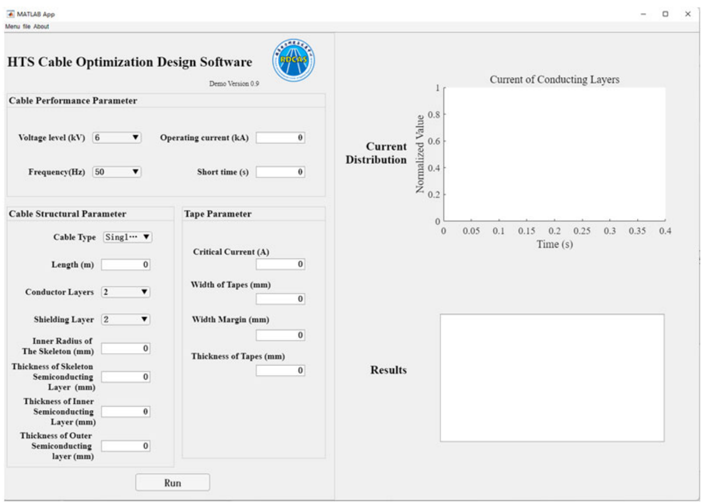

Fig.2. Interactive interface of HTS cable design software (demo version)

Tab.1. 10kV/2kA Coaxial HTS cable design scheme

Items	Value
Inner radius of the skeleton (mm)	15
I_c of HTS tape (A)	120
Thickness of tape (mm)	0.10
Number of tapes of A-phase	22
Number of tapes of B-phase	22
Number of tapes of C-phase	24
Winding angle of tapes of A-phase (°)	26.80/27.85
Winding angle of tapes of B-phase (°)	39.80/40.00
Winding angle of tapes of C-phase (°)	30.16/29.80
Outer radius of A-phase (mm)	21.00
Outer radius of B-phase (mm)	23.10
Outer radius of C-phase (mm)	25.20
Thickness of insulation layer (mm)	1.50

3. Analysis of the design results

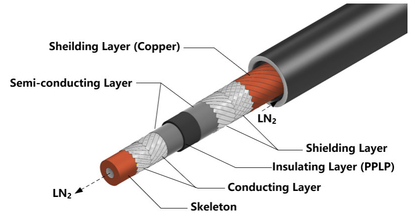

Fig. 3. HTS cable structure diagram

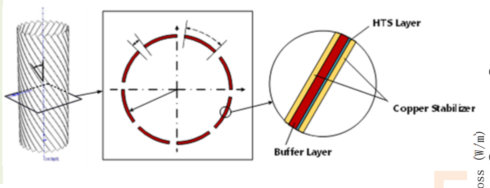

Fig. 4. 2-D AC loss finite element model

AC loss peak value (W/m)
Coaxial: 1.35
Triaxial: 1.18
14% higher but save a lot of land

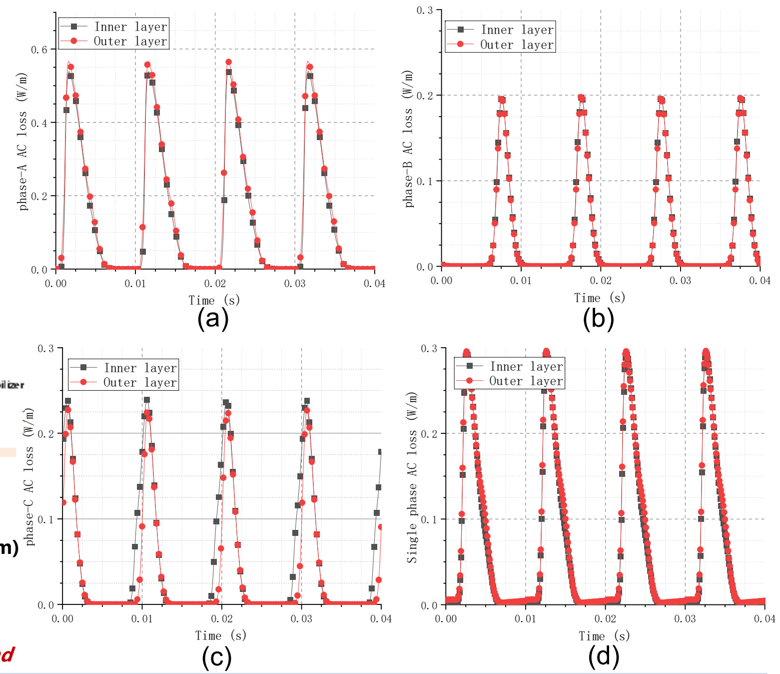

Fig. 5. HTS Cable AC loss based on 2-D finite element model . (a) A-phase of coaxial cable; (b) B-phase of coaxial cable; (c) C-phase of coaxial cable; (d) one phase of tri-axial cable; (All cables take 10kV / 2kA as the design standard)

4. CONCLUSION

1) According to the HTS cable optimization design software, the design schemes of 10kV / 2kA coaxial cable and tri-axial cable are obtained. The parameters are imported into the 2-D finite element AC loss calculation model built in COMSOL for calculation. The AC losses of the two schemes are 1.35W/m and 1.18W/m respectively.
2) The overall AC loss of coaxial cable is 14% higher than tri-axial cable. However, due to the lower voltage level and high integration, it saves the land occupation and has great application potential in the expansion and upgrading of urban power grid.
3) The HTS optimization design software can play an auxiliary role and greatly improve the designer's work efficiency. The platform continues to be optimized and improved, hoping to get a more comprehensive and comprehensive cable design scheme.

* Corresponding author: Prof. Ren Li. *E-mail address:* renli@hust.edu.cn