

Summary

The transformer windings are made with the use of the YBCO 2G (second generation) superconducting layered tape, which allows limiting the transient currents occurring during the transformer connection to the power grid and during a short circuit. Second-generation superconducting tapes, which are characterized by high resistivity in emergency states, allow the construction of transformers with high short-circuit strength.

The simulation of a superconducting transformer requires the use of appropriate mathematical models for all nonlinear elements. The model of the superconducting strip takes into account the smooth transition of the YBCO superconductor layer to the resistive state, in which the relationship between the electric field strength and the current density is described by the Rhyner's power law. The mathematical description proposed by D, C, Jiles and D, L, Atherton in a modified form called the second level model was used to characterize the nonlinear magnetic circuit of the transformer.

Thermal and electromagnetic phenomena were implemented in the PSpice model of the HTS transformer. The influence of temperature and current on thermal and electrical properties of transformer windings made of HTS tape was taken into account. Using the developed model of a 10 kVA superconducting transformer, waveforms in steady and transient states were generated. The obtained waveforms were compared with the measurement characteristics of the physical model of a 10 kVA superconducting transformer, and a high degree of agreement was obtained.

The paper presents computer models of 21 MVA single-phase transformers: conventional - with copper windings and superconducting - with windings wound with 2G HTS SF 12050 and SCS 12050 tape.

The paper determines and compares the switching current waveforms of the Cu and HTS transformer model with a capacity of 21 MVA. The introduced mathematical dependencies make it possible to determine the maximum, average and effective value of the switching current pulses, as well as the amount of heat that is generated in the windings when the transformer is connected to the network. The short-circuit current waveforms, resistance and temperature waveforms in the primary and secondary windings made of copper, as well as high-resistance SF 12050 tape and SCS 12050 copper laminated tape with much lower resistivity than the SF type tape were also determined and compared.

Keywords: HTS tape; superconducting transformer; short-circuit current; inrush current