The project's research aims to obtain knowledge about changes occurring in second-generation high-temperature superconducting tapes (HTS 2G) with the YBCO superconductor operating in superconducting fault current limiters (SFCL).

Modern SFCL systems use high-temperature superconductors (HTS). HTS tapes have the form of thin-layer tapes and have the ability to conduct large critical currents at the boiling point of liquid nitrogen (77 K).

High-temperature superconductors, as ceramic materials, are characterized by low mechanical strength. During operation in the SFCL, the tapes are exposed to short-circuit currents exceeding the critical current of the superconductor, which causes them to rapidly exit the superconducting state, increase resistance and temperature, and cause high forces. This may result in mechanical damage to the tapes (deformation, separation of the stabilizer layers, damage at the soldering points—confirmed in the literature on the subject).

The literature has also reported that the value of the critical current I_C also changes, which is a parameter characterizing the superconductor used in the tape and is a crucial parameter for SFCL as it activates its operation. Under operating conditions, the main factors influencing the change in the value of the critical current I_C of the tapes are the number of SFCL terminals from the superconducting state, the current values short circuit/surge and their duration. The source of changes in the value of the critical current can be seen in the superconducting layer of the HTS tape. Therefore, comprehensive microstructural tests are needed to clearly determine the places and causes of damage in the belts, which may decrease the I_C value, and to establish methods for detecting these damages.

The primary test for determining and comparing the layer structure of HTS tapes is a microstructural examination (of control samples and samples with changed IC values) using a scanning electron microscope. This allows for the observation of changes in the form of micro-cracks in individual layers, initial stages of delamination, or other micro-damages.

Another cause of changes in the I_C value may be diffusion changes in the tape that occur during the tape's heating due to the action of short-circuit currents. The superconductor layer in the tape is separated from the substrate by buffer layers intended to constitute, among other things, a diffusion barrier. The use of buffer layers in tapes as a diffusion barrier between the superconductor and the substrate may indicate the possibility of diffusion. Diffusion changes may occur at the border of other tape layers, e.g. silver and YBCO, which can be determined by analyzing the chemical composition of individual tape layers and using a scanning electron microscope.

HTS 2G tapes contain layers of type II superconductors in which, at a specific value of the B_{C1} magnetic field induction, the magnetic field penetrates the superconductor and creates a mixed state, and above a particular B_{C2} magnetic field induction value, the superconducting state is destroyed. The magnetic field penetrating the superconductor in the mixed state creates a characteristic, regular network of vortices (vortexes). The location of the single vortex corresponds to the normal (non-superconducting) region. Therefore, vortices tend to form in places of existing defects (vortexes pinning). The location of these places may disturb the regularity of the vortex lattice. Observation of the lattice structure seems to be a method to assess micro-damage to the superconducting layer.

At the same time, various scenarios of network disturbance events and algorithms necessary for the proper operation of power automatic protection systems (PSP) in the presence of SFCL will be analyzed. Correct selection of PSP settings (e.g. overcurrent protection) should be recommended because the short-circuit current flowing in the network with SFCL will be much smaller than in the network without SFCL. It should be added that the changing value of the critical current I_C will affect the correct operation of PSP - this should be considered when selecting protection settings. As part of the project, recommendations will also be established regarding methods for detecting damage in HTS 2G tapes operating in SFCL systems, as well as testing of protection systems for HTS tapes against short-circuit currents and recommendations for methods of securing HTS tapes in SFCL systems.

The expected effects of this research include a deeper understanding of the degradation processes of HTS tapes in SFCL and the development of effective methods for monitoring their condition.

Due to the interdisciplinarity of the issues considered, the project will be implemented in a consortium composed of the Institute of Automation, Electronics and Electrical Engineering of the University of Zielona Gora and the Department of Electrical Power Engineering of the Wroclaw University of Science and Technology. The consortium members have the necessary competencies in the field of analysis of the operation of distributed systems and research on superconducting materials, as well as broadly understood problems in the field of power system protection.