§30. Development of a Helical Winding Using Advanced Superconductors for High Magnetic Fields

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The objective of this work is to establish the helical winding techniques without plastic deformations of the superconductors, and also evaluate the critical current dependence on the mechanical stresses caused by the shape of the helical windings. In this work, the research group focus on the feasibility of the helical windings using YBCO coated conductors.

During the winding process of the helical coils, the bending stresses, the tensile stresses and the torsional stresses will be simultaneously applied to the YBCO tapes. In order to evaluate the critical current properties of the YBCO conductors against the mechanical stresses caused by the shape of the helical windings, the research group developed a strain testing device as shown in Fig. 1. The novel feature of this device is that the flatwise, edgewise and torsional strains are simultaneously applied to the YBCO tape of 200 mm in length and 5 mm in width with controllable axial tension from 0 N to 200 N, which allows us to simulate elastic bending of hastelloy substrate in liquid nitrogen temperature. The device is able to measure the strain distribution with 1 mm special resolution and critical current up to 400 A. The research group starts carrying out the strain measurement tests using YBCO tapes without liquid nitrogen cooling as shown in Fig. 2. The obtained properties will feed back to the optimization of the helical winding techniques.

Fig. 3 shows a prototype of a helically winding machine for YBCO tapes. In this work, the research group investigate the feasibility of a geodesic trajectory of the helical windings. The geodesic windings will be one of the feasible solutions to minimize the variations of the in-plane curvature of the helical windings, which effect lead to minimize the edgewise stresses in the YBCO tapes. The prototype winding machine can control the rotational angles of the conductor bobbin both in poloidal (θ) and toroidal (ϕ) directions, and also enables the torsional angle control (yaw angle β and pitch angle γ) of the conductor bobbin in order to minimize the torsional stresses in the YBCO tapes. As a first step of this work, the authors successfully carry out the test winding using stainless-steel ribbon wires with the appropriate torsion control as shown in Fig. 3. After the test winding, the research group is planning to carry out the winding of a model coil using YBCO tapes.

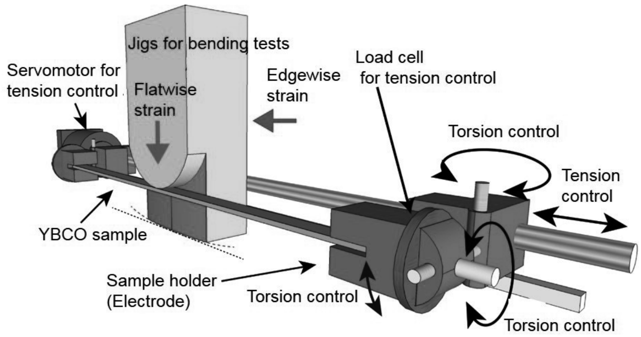

Fig. 1: Schematic illustration of the complex strain application system for YBCO conductors.

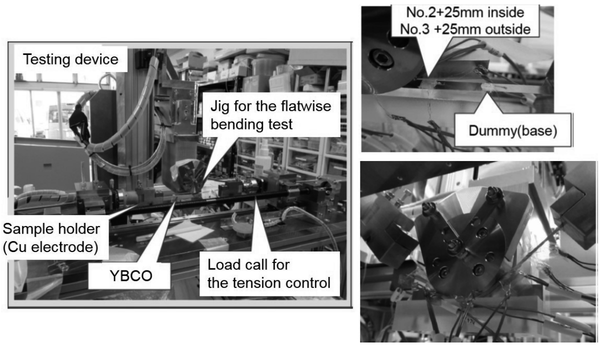

Fig. 2: Photograph of the strain testing device.

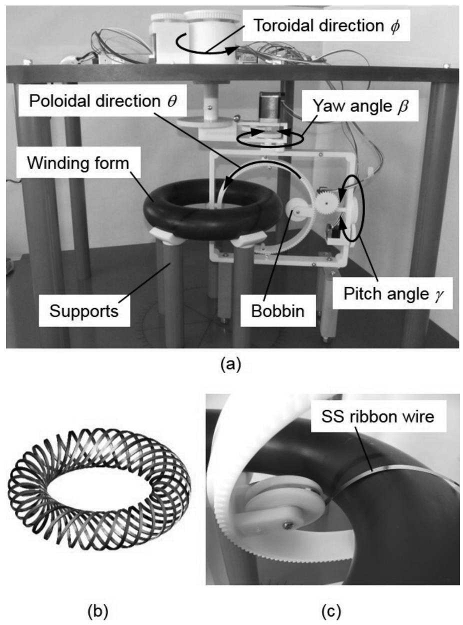

Fig. 3: (a) Protorype winding machine for (b) a model force-balanced coil using YBCO tapes. Test winding was successfully carried out (c) using stainless-steel ribbon wires with the torsion controls.