§13. 3-dimensional Measurement of the Strand Locations in Cable-in-Conduit Conductor

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The superconducting coils wound with Cable-In-Conduit Conductors (CICCs) which are composed of several stages of sub-cable has been applied to large devices such as experimental fusion reactors and Superconducting Magnetic Energy Storage (SMES) devices because of its high mechanical and dielectric strength. In recent years there has been a growing interest in coupling loss with long time constants (from several second to several hundred seconds) which are not observed in test result using short sample conductor[1)]. The loss is due to the coupling current loop flowing across the contact point between strands and depends on both inter-strand contact resistance and inductance of the coupling current loop. The time constant which is proportional to the loss is supposed to be long with large inductance of the loop and small contact resistance. For investigating the time constant in a large CIC conductor, it is necessary to measure the strand positions along the conductor axis, which leads to clear the contact conditions between strands and forming coupling current loops.

In this work, we newly developed the 3 dimensional measurement system of strand trajectories and report the initial result of the traces of 486-strand OV coil conductor for LHD.

The procedure of the measurement of 486 strands (210mm in length) are as follows:

1) Fix all strands by epoxy resin.
2) Cut the conductor at an interval of 10mm.
3) Identify the strand positions at both sides of a cross section by the 4-terminal method.
4) Connect the positions of each strand along the conductor axis.

The sample conductor for the measurement system is the OV coil conductor of 210mm in length which consists of 486 ($3^4 \times 6$) NbTi strands. The strand diameter is 0.889mm without any surface coating. Figure. 1 shows a typical picture of the cross section. All the strands are well hardened by epoxy resin. There is no crack on the cross section of strands, so we can easily identify all the strand positions.

Figure. 2 shows the measurement system of strand trajectories. In order to determine each strand position, we have to identify the same strand cross section on both sides. The set of electrods are the constant current lead on purpose to measure the resistance between two cross sections. When two electrodes feed current to the cross sections of one strand, the measured resistance includes only strand resistance without contact resistances. In other words, the minimum measured resistance indicates both sides of the same strand. To reduce the measurement time, we introduced the semiautomatic measurement system. The pictures of a cross section are obtained by CCD cameras and displayed on the panel and software can control the 3-dimensionally movable manipulator. When we select the cross section of strands on one side, the measurement of the resistance and getting the strand positions are simultaneously finished. That is why this system drastically reduce the measurement time. The detail strand trajectories of real large CIC conductor can be automatically obtained.

Figure. 3 shows the 3 dimensional plot of all the strands about 50mm in length. The real trajectories will help to clarify the mechanism producing the loss with long time constant.

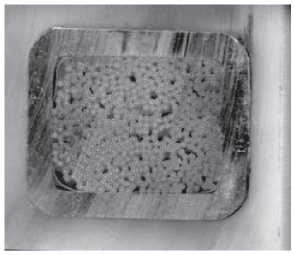

Fig. 1: Picture of the cross section of the conductor sliced at an interval of 10mm.

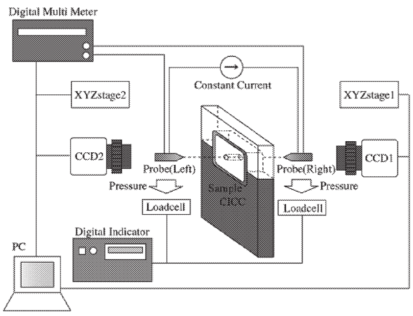

Fig. 2: Schematic view of the 3-dimensional measurement system for strand traces.

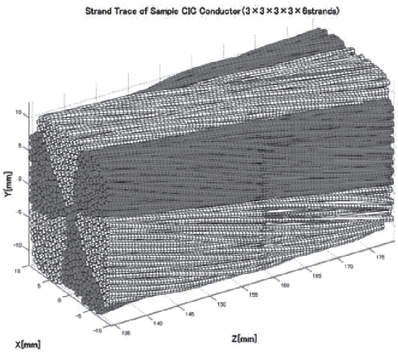

Fig. 3: Three-dimensional plot of trajectories of 486 strands OV coil conductor.

Reference

1) Hamajima, T., et al.: Cryogenics, **39** (1999) 947.