

§2. Construction of Helical Coil Winding Machinery

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Helical-coil winding machinery is now under on-site construction. It is used for shaping helical-coil conductors with high precision and feeding continuously and smoothly without extra bending. The main components are two sets of conductor shaping devices and conductor supplying devices, ten up-down supports, a center stage, a working floor, a clean room, and a set of numerical control unit. Figure 1 shows the entire figure in a test run in a factory. The major parameters are shown in Table 1. Both the conductor shaping devices and the conductor supplying devices rotate independently on the center stage in the toroidal direction. There are a large bearing inside and a chain outside in the center stage. The shaping head is attached on a poloidal rotating ring in the conductor shaping devices. There is a poloidal rotating bobbin in the conductor supplying device. A winding core with lower part of helical-coil cans will be set on the up-down supports in crossing the conductor shaping devices and the conductor supplying devices.

Since the helical coil has three dimensional curvature and twisted shape, the conductor should be in-plane bent, out-plane bent and twisted simultaneously. The bending radius and torsion angle change complicatedly and continuously along the helical coil. The shaping head, therefore, has 7 numerically controlled driving axes; feeding conductor (I axis), in-plane bending (X axis), out-plane bending (Y axis), twisting (Z axis), turning the head (U axis), moving the head in the minor radius direction (V axis), and rotating the head (W axis). The accuracy of shaping conductors was confirmed to be within 5 % in the tests in a factory. Furthermore, there are 6 numerically controlled axes for toroidal and poloidal rotating (A, B, C and D axis) and supplying the conductor (K and J axis).

The helical coil is wound by solenoid winding. The helical-coil conductor carried by a drum is once wound up on the bobbin in the conductor supplying device. The maximum length is 1200 m which is enough for the longest layer. The conduc-

tor is fed from the bobbin to the shaping head and shaped by the three sets of rolls in the shaping head. The shaping head is rotated in the poloidal and toroidal direction in coincidence with the shaping data. The conductor is finally fixed by hand at the position after about one pitch from the shaping head. Since the out-plane curvature of the helical coil changes the direction, it is difficult to pull the conductor and to apply tension by the winding machinery. However, tension should be necessary to make a good coil, and it is planned to apply tension on the conductor by striking slantly and shifting sideways in the fixing work.

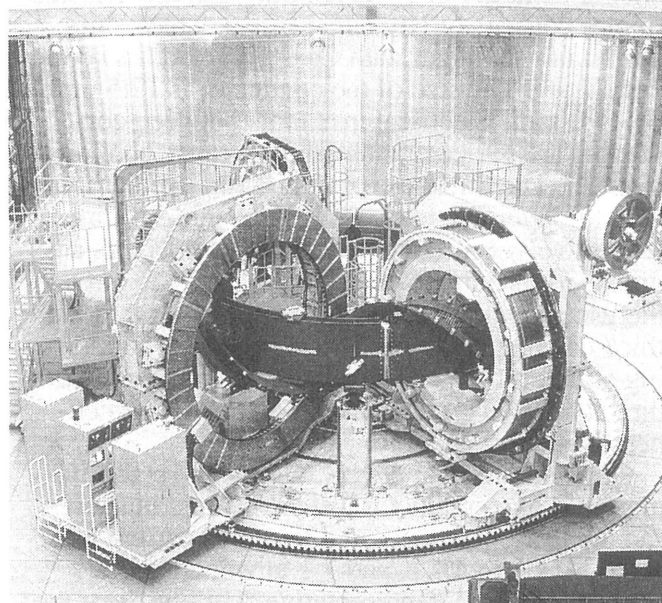


Fig.1. Helical coil winding machinery in a test run.

Table 1. Major parameters of the helical coil winding machinery

Diameter of the center stage	13.1 m
Size of the working floor	24.2 m x 27.7 m
Height of the working floor	3.6 m
Height of the clean room	12.4 m
Total weight	280 ton
Work weight	< 320 ton
Toroidal rotating speed	< 0.1 r.p.m.
Poloidal rotating speed	< 0.5 r.p.m.
Load on a up-down support	< 180 ton
Length of a conductor	< 1,200 m
Number of NC axes	13
Range of shaping conductors	
out-plane bending	$5.8\sim 7.0\times 10^{-4} \text{ mm}^{-1}$
in-plane bending	$-3.1\sim 3.1\times 10^{-4} \text{ mm}^{-1}$
torsion	$3.4\sim 7.7\times 10^{-4} \text{ rad/mm}$
Input power	180 KVA (3 ϕ 200 V)