Design and manufacture of Solenoid center deviation measurement device

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China Spallation Neutron Source (CSNS) is the first large scientific facility in southern part of China. The project construction started in 2011 and will be completed in March 2018. The Hall Probe measurement system in CSNS have finished the measurement task. We modified the system to measure the center deviation of the solenoid. The deviation between magnetic center and mechanical center of solenoid is an important parameter and has to be measured accurately. This work was supported by the Jia-Lin Xie Foundation (Y6546220U2).

The induction coil framework is made of G10, and the wire is winding on the groove of the framework. The size of the groove is 100mm*100mm.

The lever has six degree of freedom: three rotating degree of freedom and three translation degree of freedom. The accuracy of the rotation lever is 0.02mm.

Objectives

- The device can measure the angular deviation of solenoid is 0.015°
- The device can measure the center displacement deviation of solenoid is 0.1mm

Coil framework

The induction coil framework is made of G10, and the wire is winding on the groove of the framework. The size of the groove is 100mm*100mm.

Numerical calculation

We calculated the magnetic axis deviation in three cases:

1. When the angle of solenoid axial deviation in the case of 0.015°:
   \[
   \Phi = B S = \sin 0.015^\circ \times Bc \times S \quad (1)
   \]
   \[
   \Phi = 2.618 \times 10^{-4} \times 4000 \times 0.1 \times 0.1 = 1.0472 \times 10^{-6} \quad (2)
   \]
   \[
   V = \frac{Ncd\Phi}{dt} = \frac{200 \times 1.0472 \times 10^{-6}}{0.25} = 0.83 mV \quad (3)
   \]
   where \( \Phi \) is magnetic flux, \( B \) is the max magnetic field, \( S \) is the area, \( V \) is the induced voltage.

2. When the displacement deviation between mechanical centre and magnetic center in the case of 0.1mm:
   \[
   V = \frac{Ncd\Phi}{dt} = \frac{200 \times 0.9063 \times 10^{-6}}{0.25} = 0.72 mV \quad (4)
   \]
   where \( Nc \) is the number of turns of the measurement coils. The calculated results showed that the induced voltage was 0.72mV.

Conclusion

- A device is designed to measure the center deviation of the solenoid, which can be both used in conventional solenoid and superconducting solenoid.
- A new rotating coil built base on hall measurement system had successfully been developed.
- The precision of the device is good enough to meet the measurement requirements.
- Some key issues were solved in the process.

FE model of the solenoid

The distribution of center magnetic fields of the solenoid. The maximal magnetic field of the model is about 4240 Gs. The right curve shows the distribution of magnetic fields along longitudinal direction of the solenoid about 100mm.