Contribution ID: **378** Type: **Poster**

Sat-Mo-Po.03-05: Mechanical Behavior of the KSTAR Magnets for Long-Pulse Discharges

Saturday 5 July 2025 09:30 (1h 45m)

The KSTAR superconducting magnet system is designed to confine and control the high-temperature plasma necessary for nuclear fusion reactions. It comprises Toroidal Field (TF) coils, Poloidal Field (PF) coils, and Central Solenoid (CS). The TF coils generate a strong toroidal magnetic field to confine the plasma, the PF coils control the plasma's vertical position and shape, and the CS induces and sustains the plasma current. To improve the capability for sustained plasma operation, KSTAR has conducted long-pulse discharge experiments in each campaign.

During plasma operation, high current in the TF coils generates a primary electromagnetic field, while varying currents in the CS and PF coils produce additional electromagnetic fields. The interaction of these fields, along with the electromagnetic forces generated by the currents in each coil, exerts significant mechanical forces on the magnets and their supporting structures, resulting in complex mechanical behavior. This behavior is monitored using strain gauges and displacement gauges installed on the magnet system. By analyzing the measured physical quantities, the safety and stability of the system can be assessed and effectively managed. Furthermore, the development of accurate analytical methods for predicting these measurements under given operating conditions is critical for designing and advancing new devices.

Over the past three years, mechanical behavior during major long-pulse discharge experiments was systematically compared, and the reliability of the measurement devices was verified. Specifically, the vertical displacement of the stacked CS coils and the strain in high-stress regions of the TF magnet structures were analyzed by comparing measured values with those predicted by analytical models. These results confirmed that the mathematical analysis techniques and finite element analysis (FEA) models are suitable for accurately predicting mechanical behavior.

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Session Classification: Sat-Mo-Po.03 - Mechanics of Fusion Magnets