THERMAL AND HYDRAULIC MEASUREMENT IN THE ITER QUELL EXPERIMENTS

K. Hamada,1 Y. Takahashi,1 N. Koizumi,1 H. Tsuji,1
A. Anghel,2 B. Blau,2 A. Fuchs,2 B. Heer,2 G. Vecsey,2
S. Smith,3 S. Pourrahimi,3 and M. Zhelamskij4

1 Japan Atomic Energy Research Institute
   801-1, Muko-yama, Naka-machi, Naka-gun, Ibaraki, Japan
2 EPFL-CRPP, CH-5232 Villigen PSI, Switzerland
3 Massachusetts Institute of Technology, Cambridge, MA 02139, USA
4 Scientific Center, SINTEZ, St. Petersburg, Russia

ABSTRACT

The Japan Atomic Energy Research Institute has a collaboration with the European Union, the United States of America and the Russian Federation for the International Thermonuclear Experimental Reactor (ITER). In the engineering design activity for ITER, a test coil named QUench Experiments on Long Length (QUELL), using 91 m and 1/5-size ITER superconducting conductor, was fabricated by JAERI. The performance tests were carried out at the SULTAN facility in Switzerland where quench propagation, thermal and hydraulic characteristics were determined and development and test of new quench detection system were conducted. The thermal and hydraulic behavior was not known well. This conductor has a central channel to reduce the pressure drop. In order to investigate the thermal and hydraulic characteristic of the conductor, the pressure drop has been measured at 5-13 K and 2-11 g/s, and the friction factor of the central channel was calculated. In heat slug propagation, an inductive and resistive heater on the conductor has been used and the velocity of the heat front and input energy are estimated from the temperature change of conductor.

INTRODUCTION

Japan Atomic Energy Research Institute (JAERI) has participated in the International Thermonuclear Experimental Reactor (ITER) project. The development of
superconducting magnets for ITER is one of the large hardware R&D works in the engineering design activity (EDA) of ITER. ITER superconducting magnets use a cable in conduit conductor (CICC) with a central channel to reduce the helium pressure drop and to improve the cooling performance in the conductor. However, there is little experimental data on pressure drop and friction factor and also the thermal and hydraulic behavior were not understood clearly. The QUench Experiment on Long Length (QUELL)\(^2\), which has an ITER sub-size and 91-m conductor, was planned in order to clarify the thermal, hydraulic, electrical, and quench characteristic\(^3\) of CICC with central channel, to test new quench detection systems\(^4\) and to validate numerical codes, with the purpose of establishing the design criteria of ITER superconducting magnets.

QUELL coil has been fabricated by JAERI and the experiment has been performed in collaboration with the European Union (EU), the United States of America and the Russian Federation, using a large scale superconducting test facility “SULTAN” at the Centre de Recherche en Physique des Plasma (CRPP) in Villigen, Switzerland.

The measurement of thermal and hydraulic characteristic using an ITER-like conductor with a central channel is one of main items in this experiment. The pressure drop has been measured and the friction factor of the central channel was estimated. QUELL coil has an inductive heater (IH) and a resistive heater (RH) in order to initiate a quench propagation and to carry out a stability experiment. Using these heaters, heat slug propagation in the conductor has been performed and hot helium flow velocity and input energy have been measured. These results are discussed in this paper.

QUELL COIL

QUELL coil and cross section of the conductor are shown in Figure 1. Outer diameter and winding length of the QUELL coil are 507.2 mm and 735 mm, respectively. The coil has a two layer winding structure and the number of turns is 30 turns/layer. In order to reduce the mutual inductance between QUELL and background field coil (SULTAN), a non-inductive winding structure is used.

\(1990 100 400\)

**Figure 1.** Over views of QUELL coil and cross-section of the conductor. Dimensions are in mm.