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## 4C analysis of thermal-hydraulic transients in the KSTAR superconducting magnet system

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The KSTAR tokamak [1] is operating since 2008 at the National Fusion Research Institute in Korea. KSTAR is equipped with a full superconducting magnet system including the central solenoid (CS), which is made of 4 symmetric pairs of coils PF1L/U-...-PF4L/U, the poloidal field coils PF5L/U-...-PF7L/U and the toroidal field coils TF1-...-TF16. The CS coils, the PF5 coils and the TF coils are pancake wound using Nb<sub>3</sub>Sn cable-in-conduit conductors with a square Incoloy 908 jacket, while PF6 and PF7 are made with NbTi and a square 316LN jacket. All coils are cooled with supercritical He in forced circulation at nominal 4.5 K and 5.5 bar inlet conditions.

The 4C code [2], already validated against different types of thermal-hydraulic (TH) transients in different superconducting coils [3], [4], has been recently applied to the analysis of the TH transient due to AC losses in the PF1L/U coils associated to a trapezoidal current scenario [5], confirming some inconsistency between the expected [6] and the measured [7] maximum temperature rise in the winding.

In order to clarify this issue, in this paper we will present a broader TH analysis of the PF coils, including the PF5, where the same strand was used as in PF1, as well as different current scenarios. The computed results will be compared with the experimental results obtained during the KSTAR campaigns.

[1] Y. K. Oh, et al., "Commissioning and initial operation of KSTAR superconducting tokamak", *Fusion Engineering and Design* 84, 344 (2009).

[2] L. Savoldi Richard, et al., "The 4C Code for the Cryogenic Circuit Conductor and Coil modeling in ITER", *Cryogenics* 50, 167 (2010).

[3] R. Zanino, et al., "Validation of the 4C Thermal-Hydraulic Code against 25 kA Safety Discharge in the ITER Toroidal Field Model Coil (TFMC)", *IEEE Trans. Appl. Supercond.* (2011) in press.

[4] R. Bonifetto, et al., "Modeling of W7-X superconducting coil cool-down using the 4C code", *Fus. Eng. Des.* (2011) in press.

[5] R. Zanino, et al., "Simulation of thermal-hydraulic transients in the KSTAR PF1 coil using the 4C code", to be presented at ICOPS-SOFE 2011, June 26-30, 2011, Chicago, USA.

[6] H. J. Lee, et al., "The AC Loss Measurement of the KSTAR PF1 Coils During the First Commissioning", *IEEE Transactions on Applied Superconductivity*, 20, 551 (2010).

[7] Y. M. Park, et al., "Analysis of the Helium Behavior Due to AC Losses in the KSTAR Superconducting Coils", *IEEE Transactions on Applied Superconductivity*, 20, 530 (2010).

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