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炉心プラズマと炉内構造物の過渡応答解析コードに基づく安全性研究
Safety Research based on Transient Response Code Coupled with Core Plasma and Plasma Facing Components

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Introduction

A safety analysis code RAILS has been developed to analyze in-Vessel anomaly events, for example, the plasma in LOCA (loss of coolant accident) event, loss of plasma control, excess energy output event and so on. This code evaluates the time evolution of plasma parameters and temperature distribution of plasma facing components (PFCs) in these anomaly events. This code goes by SAFALY code that used safety analysis of ITER, integrating a zero dimensional plasma model and one dimensional thermal analysis of in-vessel components [(1)].

RAILS code is firstly aim to research “passive” safety analysis with no active controls. It will give prospects of how much damage is in worst case, timescales and relative priority in various anomaly events. This research will also contribute to consider a necessity of- “active” safety functions - ,for example, plasma control for soft landing and safety interlocks in reactor.

Numerical models

RAILS code is composing of the plasma transport model and the thermal analysis model of PFCs. In the plasma model, particle balance and energy balance are calculated; the set of main parameters includes fuel density, alpha density, impurity density, electron density, ion temperature and electron temperature. Thermal analysis model is one-dimensional and the PFCs are divided into several regions. These models are interactively combined by heat flux to PFCs and impurity source to core plasma. Plasma model decides the boundary conditions of thermal model. PFCs become impurity sources, surface temperatures decide the amount of impurity emission, and some of them go into plasma.

In previous research, we composed code integrating a zero dimensional plasma model and one dimensional thermal model (wall material is assumed Carbon) and simulated some anomaly event (see Fig.1: irregular pellet injection and excess output). In fig.1, the top is the data of output (green) and fueling rate (red), the second is the data of surface temperature of divertor (red) and evaporation rate of surface (green), the third is data of ion (green) and electron (red) temperature , the bottom is the data of ion (green), impurity (blue) and electron (red) density. Excess output heats PFCs and surface temperature rises. The impurities from PFCs rise and go through plasma and cool plasma, and then plasma shuts down.

Now, to improve plasma model between the core and edge plasmas, zero-dimensional plasma model is subtended three regions, CORE, SOL and DIVERTOR region. CORE model is zero-dimensional, as well, and in SOL and DIVERTOR model is 2-point model [(2)] is introduced. CORE model give the flux across the separatrix to solve SOL/DIV 2-point model. In this model, we expect dividing and integrating features of core and edge plasma.

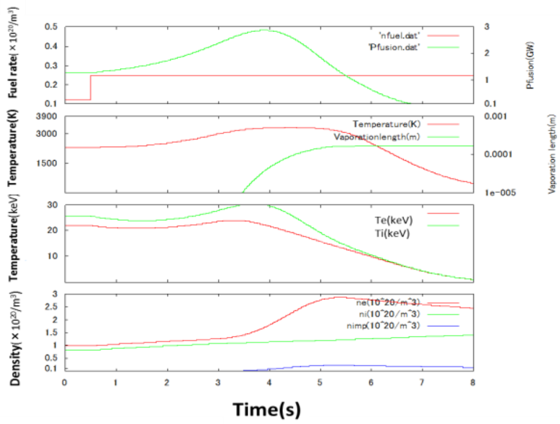

Fig.1 development of excess output scenario

Reference

(1) HONDA, T., et al.,”Development of Time Dependent Safety Analysis Code for Plasma Anomaly Events in Fusion Reactors”, J. Nucl. Sci. Tech. 34(1997)

(2) R. Hiwatari., et al.,” Simple Core-SOL-Divertor model and its application to operational apace of HT-7U”, Journal of Nuclear Materials, 337-339 (2005)