1-3 Smooth and Calm Flow in a Compact Reactor Vessel
—Flow Optimization in a Compact Sodium Cooled Reactor—

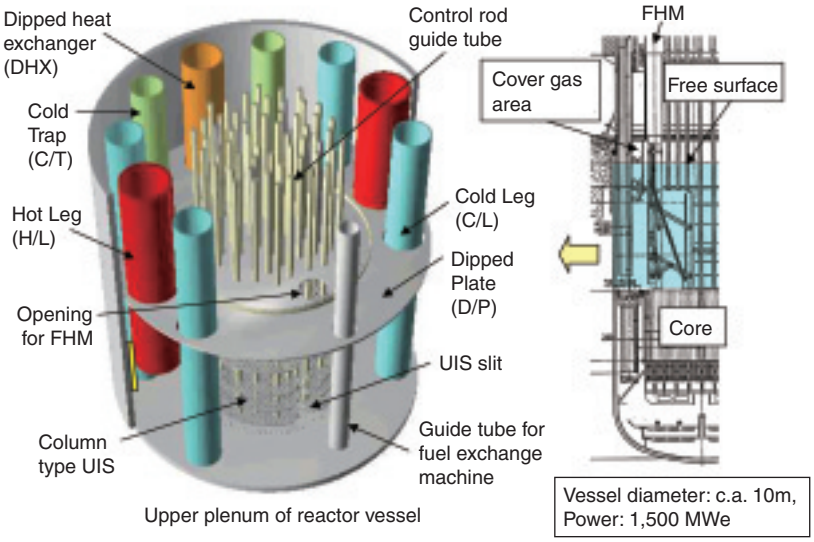
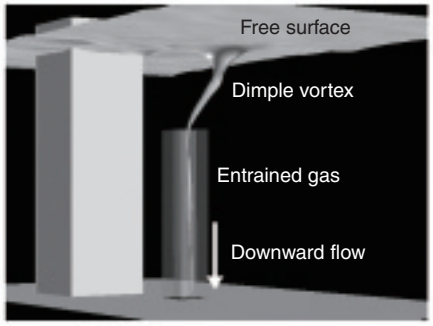


Fig.1-6 Schematic of reactor vessel of sodium cooled reactor

(1) Flow visualization of gas entrainment due to dimple vortex in the water experiment



(2) Example of numerical analyses: Application to a basic experiment for dimple vortex

Fig.1-8 Visualization of gas entrainment and example of numerical analyses

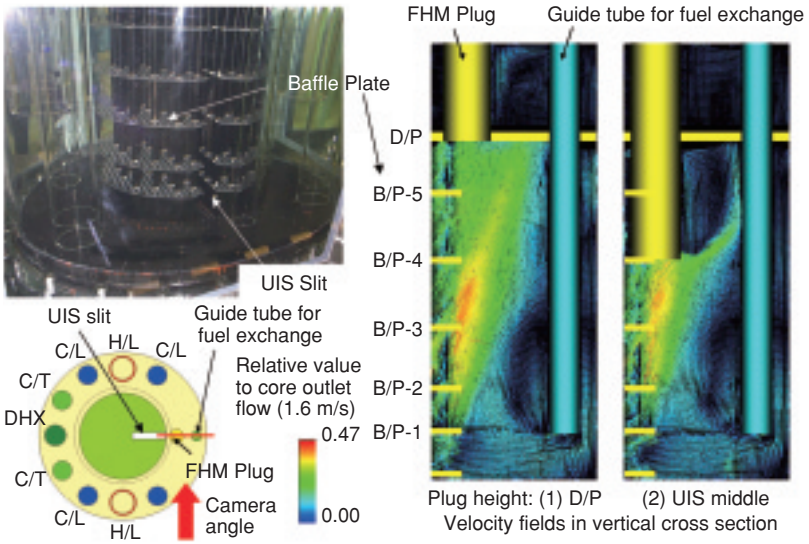


Fig.1-7 Velocity measurement and effect of FHM Plug in 1/10 scaled model
Flow velocity field was measured in the 1/10 scaled water test model of the reactor vessel. The FHM plug at middle height could change the flow direction and reduce the velocity near the free surface. Particle Image velocimetry was applied to get the detailed flow velocity fields.

Development of advanced technology for a sodium cooled reactor has been carried out as a part of the fast breeder reactor (FBR) feasibility study. A compact, high power system as shown in Fig.1-6 is planned to reduce construction cost. The Upper Inner Structure (UIS) has a slit where an arm of Fuel Handling Machine (FHM) can go inside so as to reduce the diameter of the reactor vessel (RV). Further, sodium can flow through the UIS.

Because of these design features, the sodium exiting from the core flowed upward with high velocity through the UIS slit. As a result, flow velocity near the free surface in the RV was increased. This may results in gas entrainment (GE) at the free surface. Dipped plates were set below the free surface to reduce the flow velocity near the surface. However, prevention of the GE is still a significant issue in the design.

A flow optimization study based on experiments and numerical analyses has been performed. An FHM plug was invented to shut the high velocity flow toward the free surface based on the velocity calculation shown in Fig.1-7. Velocity near the free surface was reduced by half.[1] Further, numerical analyses as shown in Fig.1-8 were applied to the GE phenomena and an estimation method of the GE was developed.[2] The prospect of preventing GE in the reactor was obtained by these studies.

References

1) Kimura, N., Hayashi, K., Kamide, H. et al., Experimental Study on Flow Optimization in Upper Plenum of Reactor Vessel for a Compact Sodium-Cooled Fast Reactor, Nuclear Technology. vol.152, no.2, 2005, p.210-222.

2) Sakai, T. et al., Study on the Gas Entrainment Design Method by CFD Data on Steady Cylindrical Systems for a Sodium-Cooled Reactor, Proceedings of 2006 International Congress on Advances in Nuclear Power Plants (ICAPP '06), Reno, USA, 2006, Paper 6409, 7p., in CD-ROM.