§45. Estimation on Behaviors of Plumes Near the Center of Laser Fusion Liquid Wall Reactor Chamber Based on 2-dimensional Simulation

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One of the critical issue of a laser fusion reactor with a liquid wall is the chamber clearance[1]. After micro explosion with 100 MJ nuclear yield, about 10 kg of liquid metal evaporates from the surface due to heating by α particles, ions and debris from the target. The evaporated plume makes, then, mist and clusters by collisions between plumes near the center of the liquid wall chamber. To prevent such phenomena, the structure of the first wall of the chamber is like tiles as shown in Fig. 1.

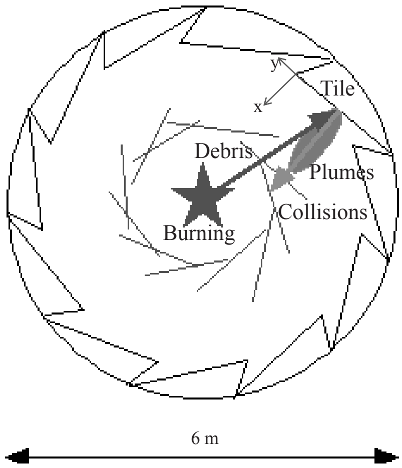

Fig. 1 The structure of the first wall of the chamber.

We estimate behaviors of plumes after collision by Moving Particle Semi-implicit method (MPS)[2]. Navier-Stokes equation is written as follows.

$$\frac{d\mathbf{u}}{dt} = -\frac{\nabla P}{\rho} + \nu \nabla^2 \mathbf{u}$$

Mass density ρ is written using weight function w as follows.

$$\rho = m\tilde{n}_i / V = m\sum_{j\neq i} w\left(\left|\mathbf{r}_j - \mathbf{r}_i\right|\right) / V$$

$$w(r) = \begin{cases} r_e / r - 1 & (r < r_e) \\ 0 & (r > r_e) \end{cases}$$

$$V = \frac{4\pi}{3} r_e^3$$

Where r_e is interaction length.

Gradient of pressure is written as follows.

$$\left\langle \nabla P \right\rangle_i = \frac{3}{\tilde{n}_i} \sum_{j\neq i} \frac{P_j - P_i}{\left|\mathbf{r}_j - \mathbf{r}_i\right|} \frac{\mathbf{r}_j - \mathbf{r}_i}{\left|\mathbf{r}_j - \mathbf{r}_i\right|} w\left(\left|\mathbf{r}_j - \mathbf{r}_i\right|\right)$$

Diffusion term of velocity is witten as follows.

$$\left\langle \nabla^2 \mathbf{u} \right\rangle_i = \frac{6}{\lambda \tilde{n}_i} \sum_{j\neq i} \left(\mathbf{u}_j - \mathbf{u}_i\right) w\left(\left|\mathbf{r}_j - \mathbf{r}_i\right|\right)$$

We perform the simulation of collisions between plumes using MPS. Fig. 2 shows initial positions of particles.

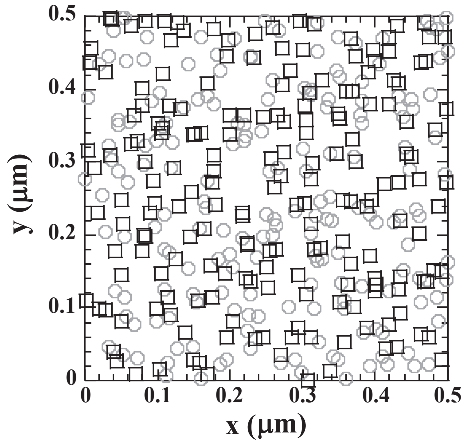

Fig. 2 Initial positions of particles.

Initial velocity of circle particles is $v_x(0)$, and initial velocity of square particles is - $v_x(0)$. Boundary conditions are periodic. Fig 3 shows the time evolution of average velocity of circle particles. More long time simulation is needed.

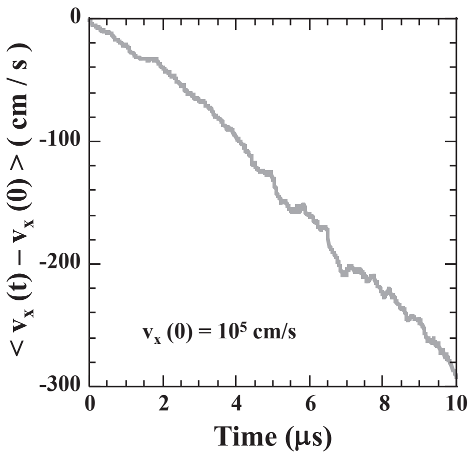

Fig 3 The time evolution of average velocity of circle particles.

[1] Y. Kozaki: Fusion Science and Technology **49** (2006) 542-552.

[2] S. Koshizuka, K. Shibata, and K. Muroya; Introduction of Particle Method, Maruzen. (in Japanese).