§56. Three-dimensional Estimations of Behaviors of Metal Vapors in Laser Fusion Liquid Wall Reactor Chamber

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One of the critical issues of a laser fusion reactor with a liquid wall is chamber clearance[1-4]. After a micro explosion with a 200-MJ fusion power output, liquid metal ablates from the surface because of heating by α particles, ions and debris from the target. Plumes produced by ablation form mists and clusters owing to 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 made of components that similar to a tile, as shown in Fig. 1. The width of a tile of the first wall of KOYO-fast is roughly 80 cm at the chamber radius is 300 cm. The slope of a tile of the first wall of KOYO-fast is 30°.

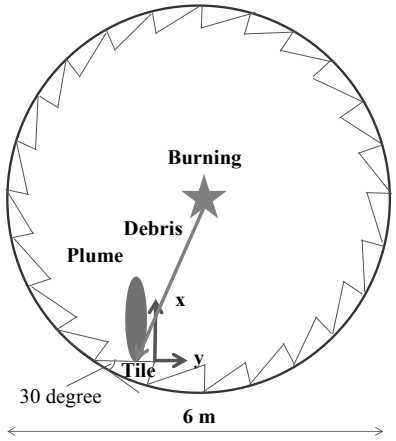

Fig. 1 The structure of the first wall of the chamber.

We estimate behaviors of plumes after collision by Moving Particle Semi-implicit method (MPS)[5]. Equation of motion is written as follows.

$$\frac{d\mathbf{u}}{dt} = -\frac{\nabla P}{\rho} - \nu \mathbf{u} \tag{1}$$

Where ν is collision frequency given as follows

$$\nu = \sigma n u \tag{2}$$

Mass density ρ is written using weight function w as follows[5].

$$\rho = m\tilde{n}_i / V = m\sum_{j\neq i} w\left(\left|\mathbf{r}_j - \mathbf{r}_i\right|\right) / V \tag{3}$$

$$w(r) = \begin{cases} r_e / r + r / r_e - 2 & (r < r_e) \\ 0 & (r > r_e) \end{cases} \tag{4}$$

$$V = \frac{4\pi}{3} r_e^3 \tag{5}$$

Where r_e is interaction length.

Gradient of pressure is written as follows[5].

$$\left\langle \nabla P \right\rangle_i = \frac{3}{\tilde{n}_i} \sum_{j\neq i} \frac{P_j - P_i}{\left|\mathbf{r}_j - \mathbf{r}_i\right|} \frac{\mathbf{r}_j - \mathbf{r}_i}{\left|\mathbf{r}_j - \mathbf{r}_i\right|} w\left(\left|\mathbf{r}_j - \mathbf{r}_i\right|\right) \tag{5}$$

We perform the simulation of collisions between plumes using MPS. Figure 2 shows time evolutions of average velocity of circle particles. The plume consists of 729 particles. Solid line indicates the result for the case the number of incident particles is 729. Dotted line indicates the result for the case the number of incident particles is one. Because of collisions between incident particles, the velocity decreases rapidly for the case the number of incident particles is 729.

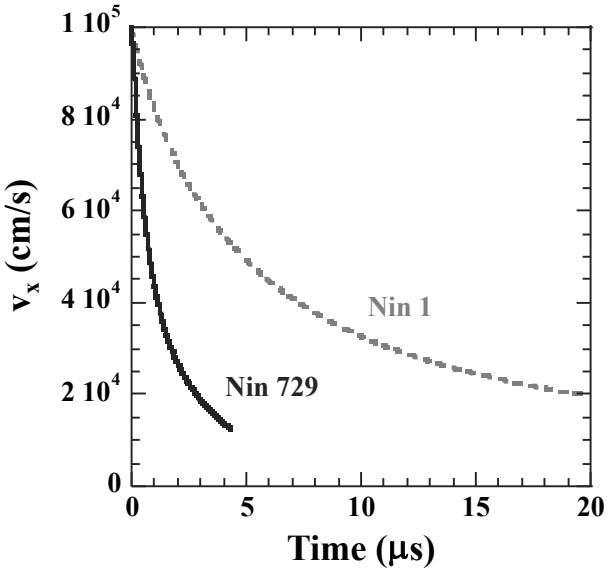

Fig. 2 Time evolutions of average velocity.

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[3] Y. Kozaki et.al.; J. Plasma and Fusion Research **82** (2006) 817-837. (in Japanese)

[4] Y. Kozaki et.al.; J. Plasma and Fusion Research **83** (2007) 3-29. (in Japanese)

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