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NUMERICAL SIMULATION OF THE SEMI-SOLID CASTING BY THE PARTICLE METHOD

M. Kazama[1] **and T. Suwa**[2]

[1] Next Generation Technical Computing Unit, Fujitsu Limited
1-1, Kamikodanaka 4-chome, Nakahara-ku, Kawasaki 211-8588, JAPAN,
kazama.masaki@jp.fujitsu.com
[2] Next Generation Technical Computing Unit, Fujitsu Limited
1-1, Kamikodanaka 4-chome, Nakahara-ku, Kawasaki 211-8588, JAPAN,
suwa.tamon@jp.fujitsu.com

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In the casting process, we would like to get the casting of the objective shape by cooling the molten metal after having filled the mold with it. In order to reproduce the casting process by numerical computation, it is necessary to simulate the shrinking process of the liquid metal by the solidification in addition to the flow and the heat transfer. We report a particle-based numerical model of the casting process which include the processes mentioned above.
In the casting simulation, the study of mesh-based methods such as the finite element method or the finite difference method are advanced. However, as for the mesh-based method, treating of the moving boundary, which is needed to calculate the interaction between moving mold and liquid metal, is complicated. Therefore the mesh-based methods are weak in the simulation of the semi-solid casting(Fig 1). On the other hand, particle methods are suitable for the simulation of the semi-solid casting because treating of the moving boundary is relatively easy for the particle methods.

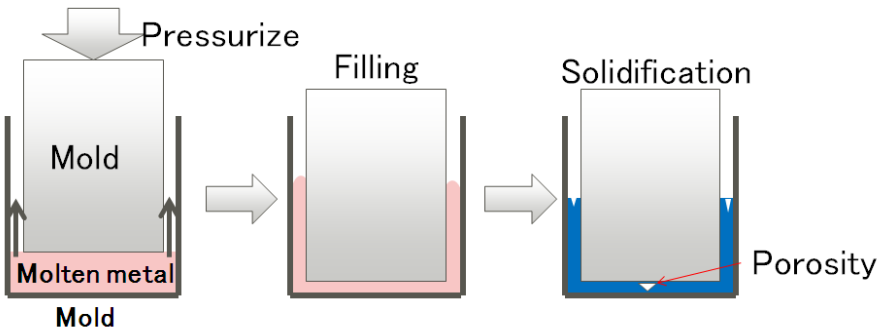

Figure 1: Example of the semi-solid casting

Cleary([1]) reported a particle-based numerical model of the casting process, which can be applied to low pressure die casting. They expressed the solidification and the shrinking as changes depending on temperature of the viscosity and the density, respectively. In their results, the shrinkage cavity and the residual pressure distributions in final castings are shown. These results imply possibility of the casting simulation by the particle method. However, the important elements in the calculation of semi-solid casting, which are mentioned later, were not introduced in their method. Then, in this study, we developed the numerical method based on that of Cleary for the semi-solid casting by the particle method.
When molten metal flows into the narrow space, the influence of the surface tension should not be ignored in the semi-solid casting. Moreover, when we calculate the pressurized fluid by the particle method, unnatural vibration of the density may become the problem. Therefore we enabled the numerical simulation of the semi-solid casting by introducing the numerical method controlling density vibration([2][3]), and the numerical model of the surface tension to the original method of Cleary.
Fig.2 is a preliminary result of our method applied to the cylinder casting. Although this is not the semi-solid casting, we can show the effect of surface tension and the improvement of pressure vibration. In the Fig.2(a), the red particles express the liquid and the blue particles express the solid. In the numerical result, we can observe the influence of the surface tension because the top of the molten metal becomes round and we can also observe that the liquid gradually solidifies from the boundary. The Fig.2(b) is a distribution of the density of the molten metal (the density is shown as a function of the x-component of the position of the particles). The variation of density is reduced significantly. We will show the numerical results of the semi-solid casiting.

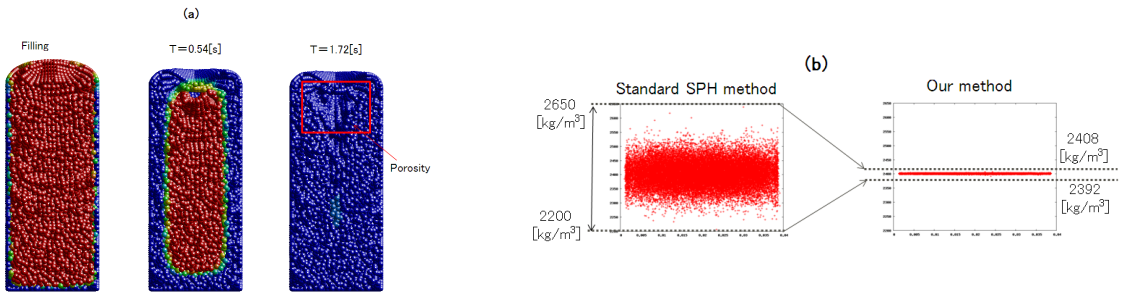

Figure 2: Numerical result

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