Development of Surface Tension Model with Many-body Potential Force

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ABSTRACT

One of the advantages of particle methods is to capture the complex motion of the dynamic fluid flow. Surface tension is to be considered to capture fluid motion in microstructures or droplet break up behaviours. When the surface tension model is obtained by discretising the CSF (continuum surface force) model [1], complex formulation to estimate normal vector and curvature of the surface is needed. On the other hand, It is reported that surface tension can be calculated by introducing pairwise potential force [2, 3], which is long-range attractive and short range repulsive. The formulation for the pairwise potential is simpler than the models based on CSF, and it can stably and easily be applied in particle methods. However, the potential force acts not only on the surface of the fluid but also acts inside the fluid bulk. It results in unrealistic pressure increase or in the droplet or shrinkage of the droplet. Another disadvantage of the pairwise potential model is that the force acting on the particles tend to be large, which demands smaller time steps for stable calculation.

In this study, a new surface tension model for particle methods are developed. A many-body potential force is introduced instead of the pairwise potential force. The many-body potential force acts mainly on the particles near the surface, and only the small force acts on the particles inside the fluid bulk. Figure 1 shows the area where the potential force is acting. A droplet is calculated to confirm the potential of the many-body potential model and compared with the results obtained using the pairwise potential model.

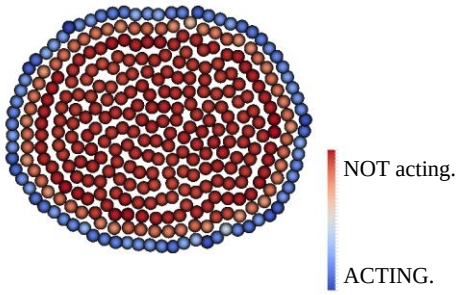

Figure 1 Area where the potential force is acting

REFERENCES

[1] Joseph P. Morris, “Simulating surface tension with smoothed particle hydrodynamics”, *Int. J. Numer. Meth. Fluids*, **33,** 333–353 (2000).

[2] Alexandre Tartakovsky and Paul Meakin, “Modeling of surface tension and contact angles with smoothed particle hydrodynamics”, *PHYSICAL REVIEW E* **72**, 026301 (2005)

[3] M. Kondo, S. Koshizuka and M. Takimoto, "Surface tension model using inter-particle force in particle mthod", *5th Joint ASME/JSME fluid engineering conference*, San Diego, July 30-August 2, 2007, FEDSM-37215.