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The Difficulty and Charm of Computational Plasma Fluid Mechanics

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This talk presents and discusses the recent progress of studies with the concept of "Computational plasma fluid mechanics". Computational demonstrations show that the inhouse simulation codes have captured hydrodynamic instabilities and reproduced flow dynamics in thermal plasma – nonionized gas coexisting systems (Fig. 1) [1].

A unique method has made it feasible to study collective growth of binary alloy nanoparticles by numerical analysis (Fig. 2) [2].

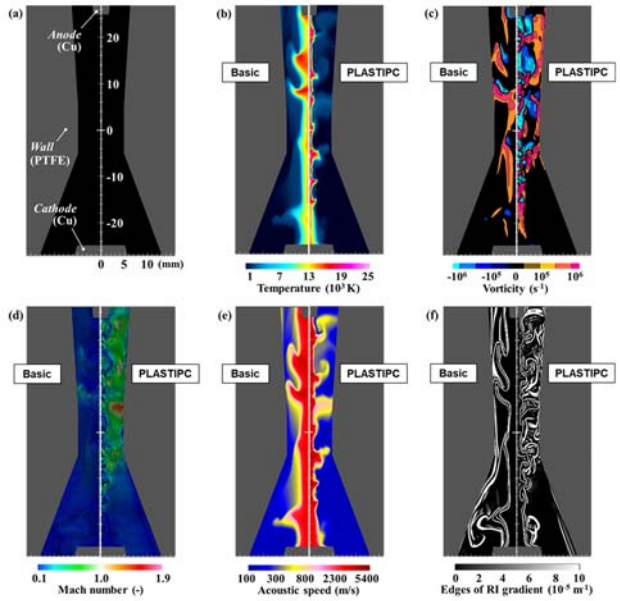

Figure 1. Snapshots of SF_6 arc plasma flow system obtained by a basic (left) and our inhouse (right) simulation codes: (a) cylinder geometry, (b) temperature, (c) vorticity, (d) Mach number, (e) acoustic speed, and (f) edges of approximated refractive index (RI) gradient [1].

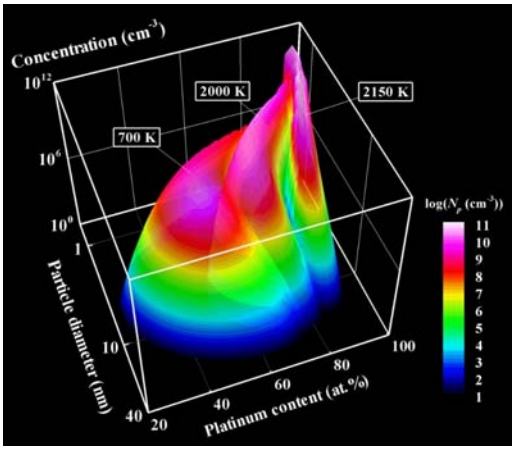

Figure 2. Evolution of size-composition distribution of Fe-Pt nanoparticles [2].

SPH (Smoothed Particle Hydrodynamics) method with incompressibility modification has achieved complex behaviors of molten metal involving phase change, flow, heat transport, material mixing, and large deformation during welding by arc plasma (Fig. 3) [3].

It is essential to study thermal plasma processes as comprehensive fluid systems in which hot plasma, cold nonionized gas, and materials coexist. The viewpoint and approaches of fluid mechanics as well as plasma physics are indispensable. Computational study will play a more important role in giving us new and deeper insights.

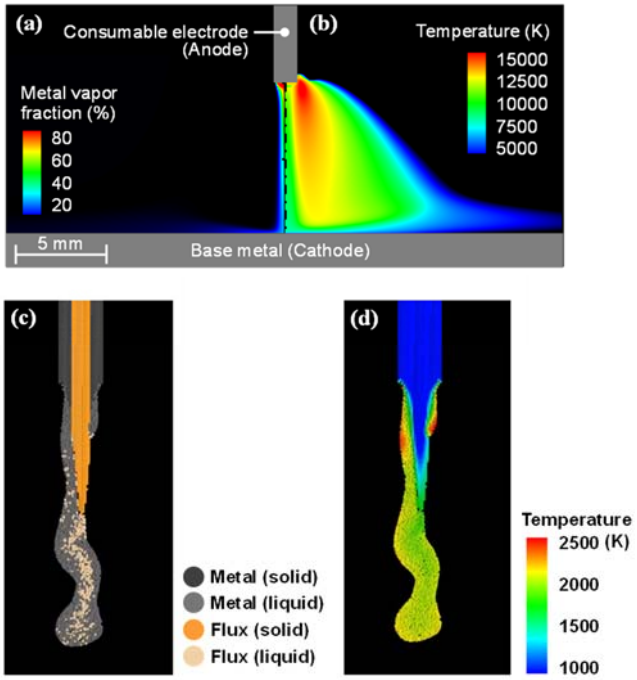

Figure 3. Snapshots of simplified simulation of flux-cored arc welding: (a) metal vapor fraction and (b) temperature in and around arc plasma, and (c) state and (d) temperature of calculation particles on the central cross-section [3].

References

[1] M. Shigeta, Jpn. J. Appl. Phys. **62**, SL0801 (2023)
[2] M. Shigeta *et al*, J. Appl. Phys. **108**, 043306 (2010)
[3] R. Ueno *et al*, Q. J. Jpn. Weld. Soc. **38**, 84s (2020)