Water Flow Analysis of a Frozen Block

Thawing phenomenon by water flow is validated with melting/solidification analysis using scSTREAM

Modeling by Maximum Solid Packing Fraction

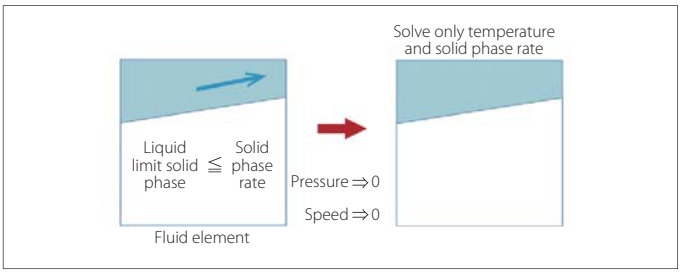

Figure 1: Modeling by maximum solid packing fraction

The flow of the liquid phase in solid-liquid coexistent state is affected by the volume fraction of the solid phase (solid phase rate). If the solid-fluid interface is smooth as in the case where ice is melted by water, modeling of a fluid element is possible by analyzing it only with the temperature and the solid phase rate, with the solid phase rate of the fluid element equal to or larger than the maximum solid packing fraction, and the pressure and the speed equal to 0.

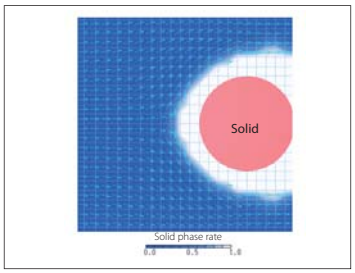

Figure 2: Velocity vector of a sample analysis

Figure 2 shows velocity vector for a sample analysis of thawing of ice around a solid by flowing water. The grids are shown to distinguish fluid elements, and vectors of uniform length are shown for each of the elements.

Analysis of a Frozen Block

Analysis Model

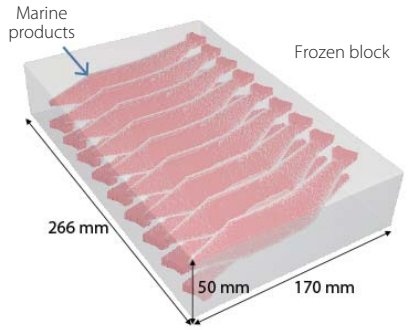

Figure 3: Frozen block

Marine products	Marine products 18 pieces (9 pieces/row), 266 mm long, 170 mm wide, 50 mm high
Material property	Density 900 kg/m³, specific heat 2,000 J/(kgK), thermal conductivity 1.40W/(m·K)
Temperature	-20 ˚C (initial temperature of the frozen block) 4 ˚C (flowing water)
Simulation time	20 minutes
Analysis	Transient analysis
Maximum solid packing fraction	0.9

Analysis Results

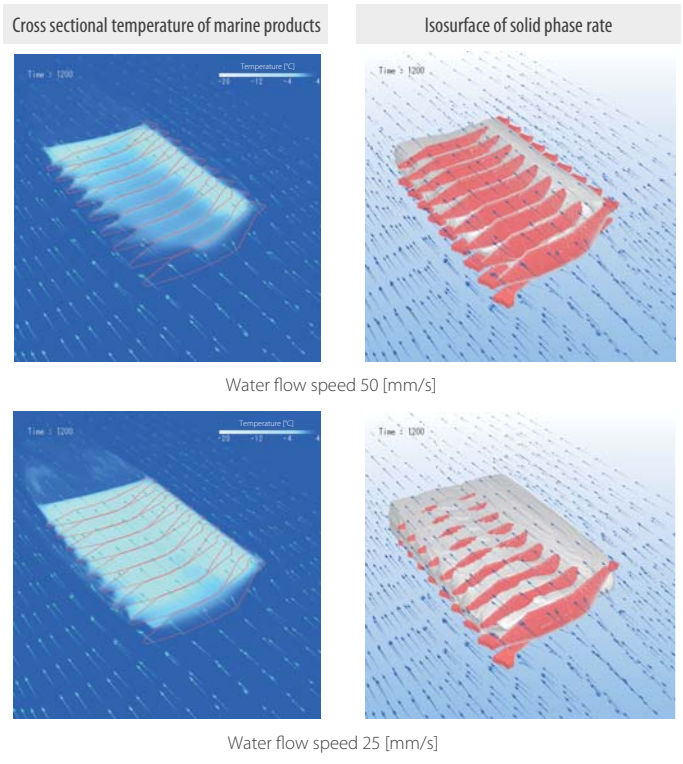

Figure 4: Analysis results
Cross sectional temperature and isosurface of solid phase rate (20 minutes later)
Water flow speed 50 [mm/s] (top) and 25 [mm/s] (bottom)

Notes

From the cross sectional temperature, all but one piece in front are below 0 ˚C, and it can be estimated that most of marine products are half-thawed. They can be drawn out of the flowing water at this point for natural thawing, which will allow for thawing in a short time without water dripping.