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COUPLING NON-NEWTONIAN FLUID FLOW AND HEAT TRANSFER INSIDE A SCRAPED SURFACE HEAT EXCHANGER (SSHE)

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INTRODUCTION: The 3D model implemented by Hernandez-Parra et al. (2018) for studying the fabrication of a commercial lemon sorbet is here employed for diagnosing the maximum radius of air bubbles.

COMPUTATIONAL METHODS: The conservation of energy, momentum and mass in the fluid as well as the conservation of energy in the solids were reached, under steady-state conditions, by employing the COMSOL modules "Laminar Flow" and "Heat Transfer in Fluids".

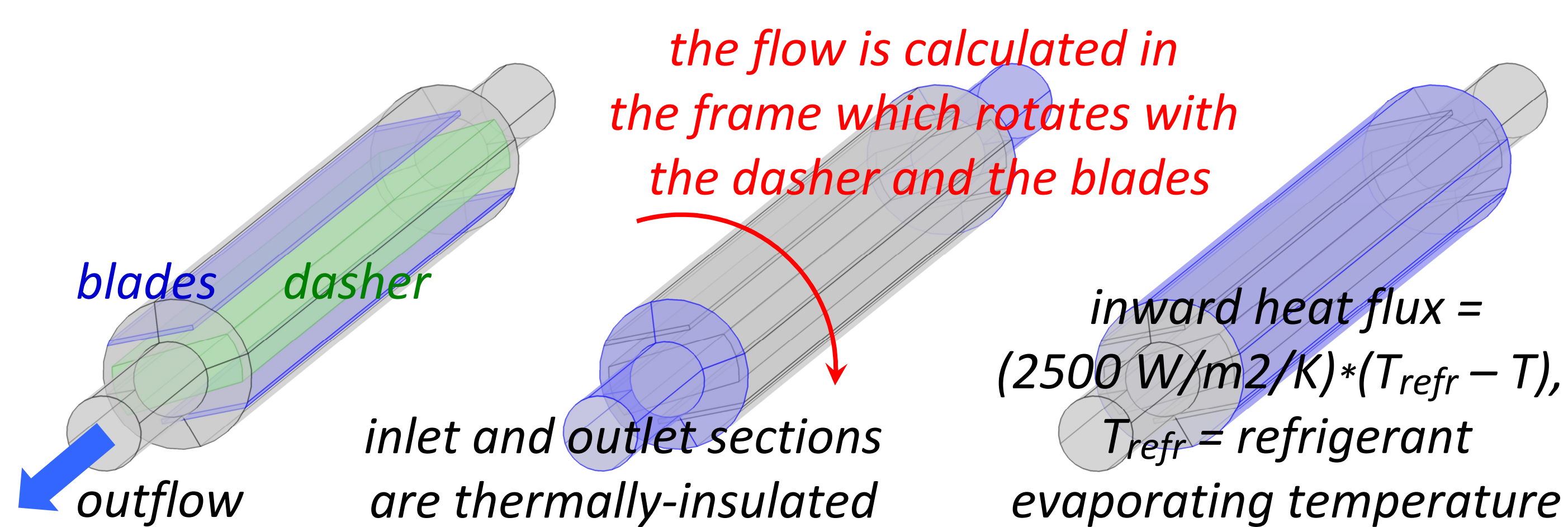


Figure 1. Geometry and selected boundary conditions.

RESULTS (1): Solving the conservation equations, assuming mass flow rate = 50 kg/h, rotor speed = 750 rpm, $T_{refr} = -15.3^\circ\text{C}$ and $T_{inlet} = 5^\circ\text{C}$.

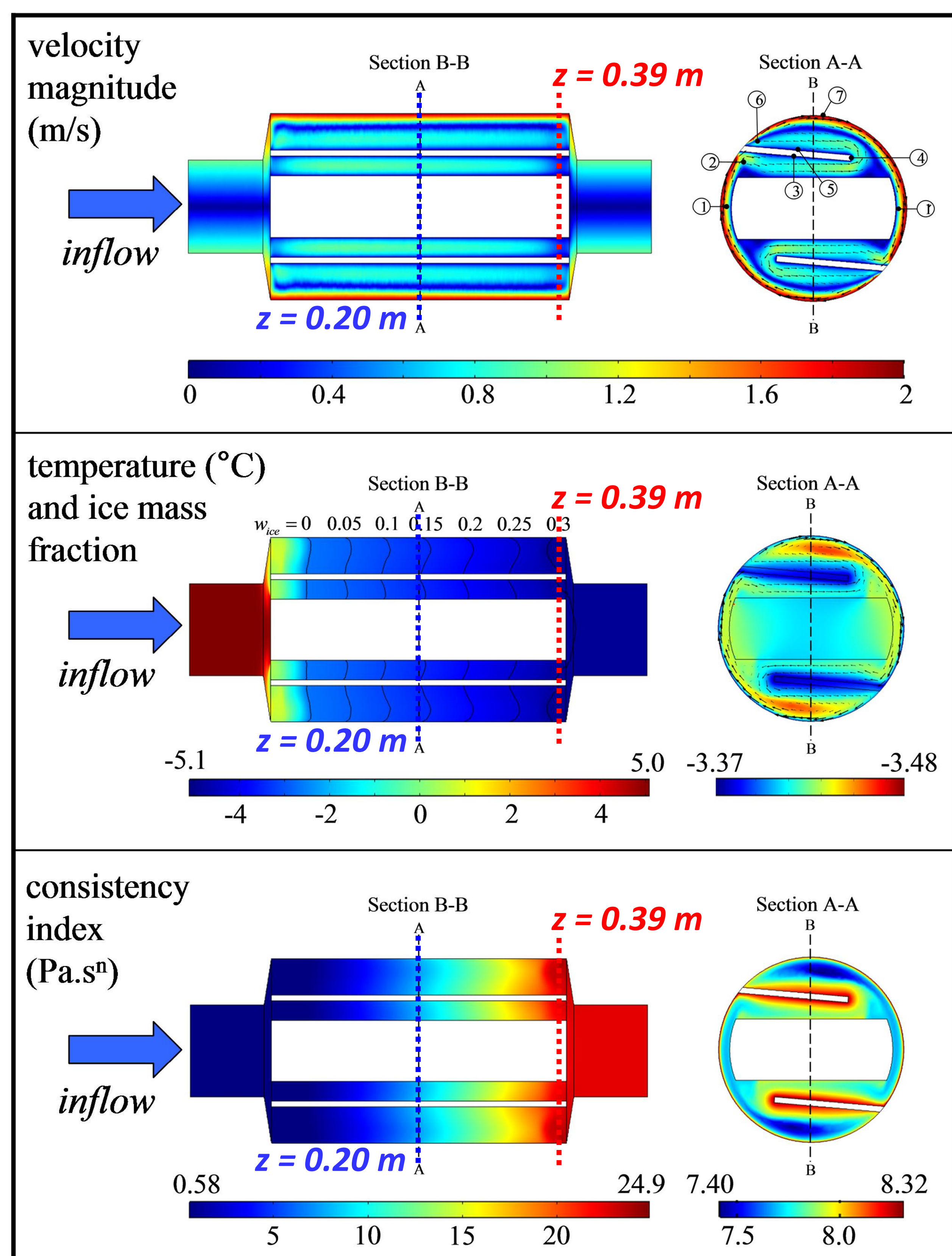


Figure 2. Numerical model predictions along the SSHE and in the middle cross-section.

RESULTS (2): The COMSOL module "Transport of Diluted Species" was employed in diagnosing the break-up of air bubbles. Here we follow the approach proposed by Vyakaranam & Kokini (2012): the maximum radius is estimated as a function of the shear rate, the extension rate, the apparent viscosity of the 'continuous' phase, the viscosity of the gas and the surface tension, by using correlations based on the Capillary number.

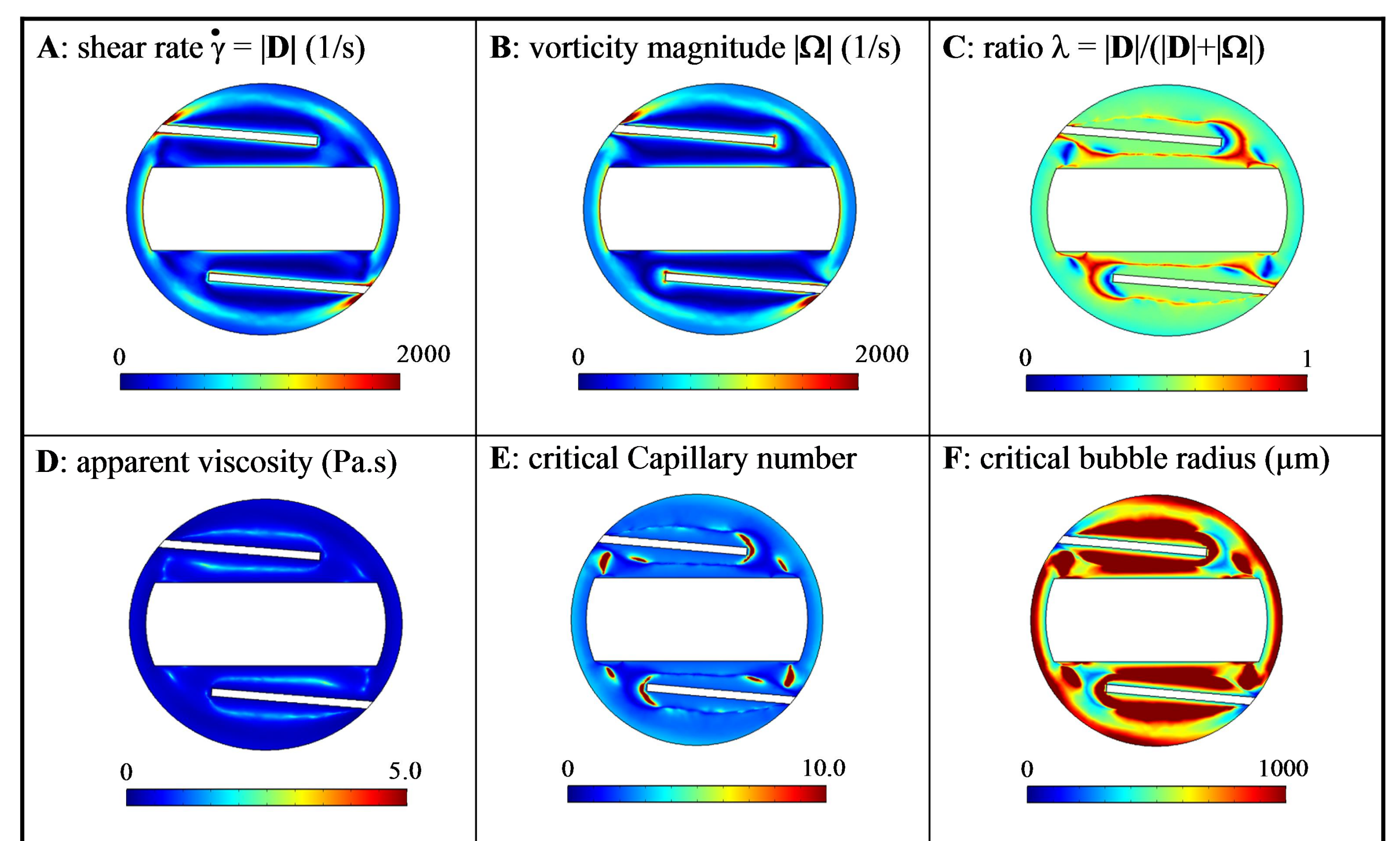


Figure 3. Model predictions at $z = 0.20\text{ m}$.

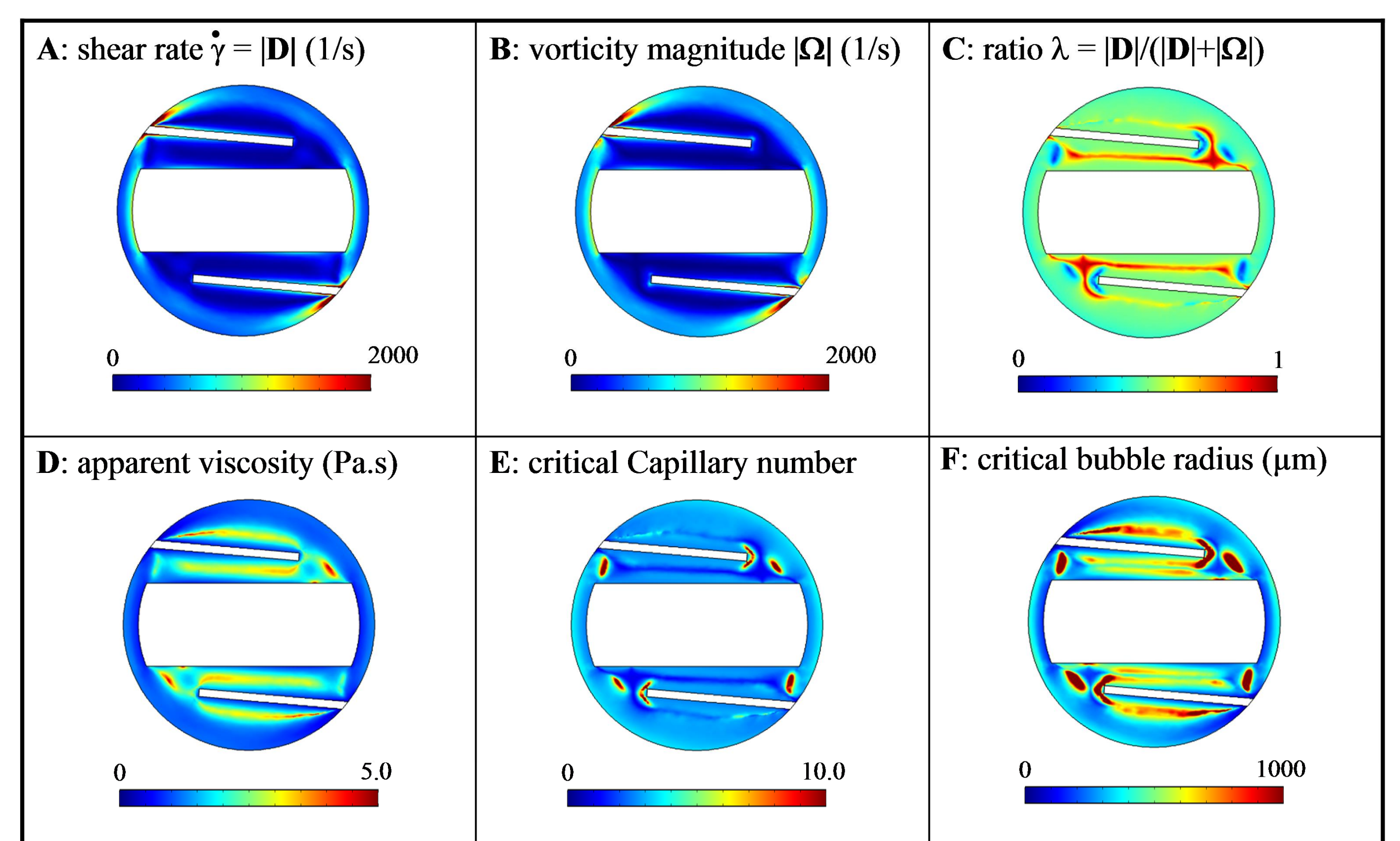


Figure 4. Model predictions at $z = 0.39\text{ m}$.

CONCLUSIONS: It appears that the smallest bubbles are generated a) near the contact between the blades and the scraped surface, where the highest shear rate is reached, and b) in the coldest region, where the continuous phase has the maximum apparent viscosity.

REFERENCES:

- Hernandez-Parra et al., Modeling flow and heat transfer in a scraped surface heat exchanger during the production of sorbet, Journal of Food Engineering, 221, 54-69 (2018)
- Vyakaranam & Kokini, Prediction of air bubble dispersion in a viscous fluid in a twin-screw continuous mixer using FEM simulations of dispersive mixing, Chemical Engineering Science, 84, 303-314 (2012)