Title

Design and fabrication of bespoke vane geometries for accurate rheometric measurements of yield stress fluids

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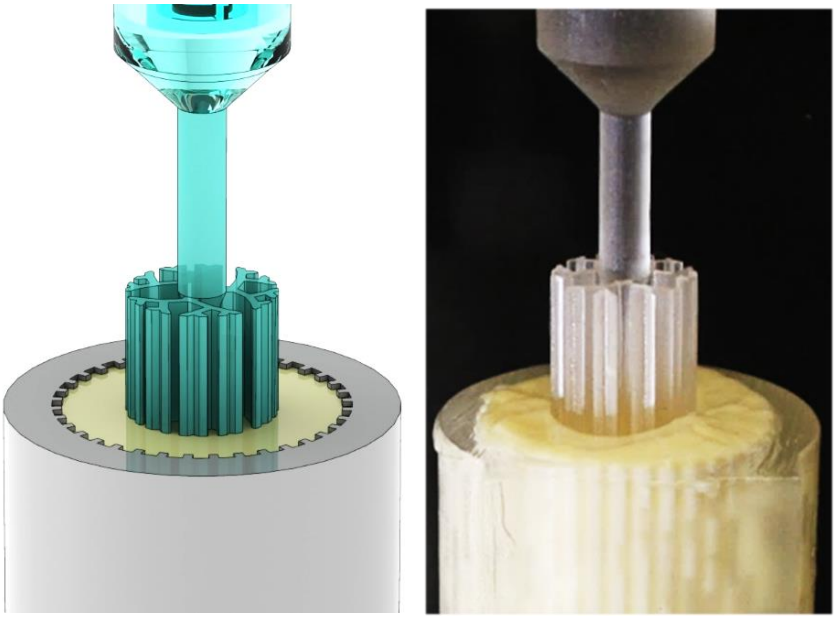
Any preference for a regular oral presentation or a short oral and poster presentation.

How long is the ”short” oral presentation? Prefer short oral + poster if it is ≥ 5 min, otherwise it’s probably not enough time.

Abstract text

For history-sensitive and slip-sensitive materials, the measurement technique selected can dramatically affect the reported values of the material’s rheological properties, and the 4-bladed vane is a common rheometric tool of choice that provides an acceptable compromise between simple kinematics and robust measurements. Here, we introduce a modified vane-like geometry with a fractal structure that can be readily manufactured using rapid prototyping methods. The design of this new fixture gives a larger surface area-to-volume ratio to the tool, leading to improved cylindricity of the yielded region at the point of yielding, and was optimized by experiment and by simulation (adaptive finite element/augmented Lagrangian method). We describe use of the fractal vane to measure both the static and dynamic yield stress as well as the steady flow curve of a range of simple and thixotropic yield stress fluids. Moreover, this tool provides an expanded range of measurement compared to traditional 4-bladed vanes with an accuracy within 3% of roughened cone-and-plate reference measurements for viscous Newtonian fluids and simple yield stress fluids. The vanes in this study were entirely 3D printed using a desktop stereolithography machine, making them inexpensive, disposable, chemically compatible with a wide range of solvents and readily adaptable to future design innovations. We illustrate the use of these fixtures in determining the thixo-elasto-visco-plastic (TEVP) response of a Carbopol-based hair gel, a jammed emulsion (mayonnaise), and an especially difficult-to-handle particulate suspension (tomato ketchup).



Computer rendering and photograph of fractal vane modeled after a Bethe lattice with 24 end points. It sits partially submerged in a cup of material (mayonnaise).