FIG. 1. (Color)

Patterns in a suspension contained in a horizontally rotating cylinder

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Suspensions of non-Brownian settling particles in a horizontally rotating cylinder are subject to gravitational, hydrodynamic and centrifugal forces. As the rotation rate increases from (A)–(D) (end views) in Fig. 1 and from (E)–(K) [side views except (G) and (I) which are end views], the particles exhibit a variety of concentration and velocity patterns. In (A), the particles (white) slide down the upward moving wall and resemble a fluid flow. A time-lapse photo (B) reveals the flow induced in the solvent. Increasing the rotation rate further disperses the particles [(C) and (D)]. Those particles

falling at the very top produce the vertical strings of particles (dark) seen in (E). Further increase in the rotation rate produces a fully corotational flow with the cylinder wall [(G) and (I)]. However, there is a periodic change in particle density along the length of the cylinder (F), while the time-lapse photo (H) shows the particle motion within the bands shown directly above (F). The center of rotation moves from close to the upward moving wall (I) for the most concentrated regions to close to the downward moving wall (G) for the least concentrated regions.[1]

Remarkably, within a "phase diagram" mapped out in the rotation rate versus fluid viscosity plane, there is a small region of uniform density that appears to rotate like a solid body (J). Finally shown in (K) is a structure where particles gather in irregularly spaced bands along the length of the cylinder. Here the centripetal forces are becoming dominant.[2]

[1]W. R. Matson, M. Kalyankar, B. J. Ackerson, and P. Tong, Phys. Rev. E **71**, 031401 (2005).
[2]W. R. Matson, B. J. Ackerson, and P. Tong, J. Fluid Mech. **597**, 233 (2008).