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Unsteady Granular Flows NICHOLAS A. POHLMAN, Northern Illinois University, JULIO M. OTTINO, RICHARD M. LUEPTOW, Northwestern University — The characteristics of steady granular flow in quasi-two-dimensional rotating tumblers have been thoroughly investigated and are fairly well understood. However, unsteady, time-varying flow has not been investigated in detail. Velocity measurements of granular flow in quasi-2D rotating tumblers are presented for periodic forcing protocols via sinusoidal variation in the rotational speed of the tumbler. Variations in the system level parameters of tumbler radius, particle size, and forcing frequency are explored. Similarities to steady flow include the fastest flow at the free surface of the flowing layer and an instantaneous linear velocity profile through the depth. The flowing layer depth varies between 9 and 13 particle diameters for minimum and maximum rotation rates. Unsteady periodic forcing also causes the flow to exhibit dynamic properties. The phase lag of the flow response increases linearly with increasing input forcing frequency to more than 0.6π radians over 0–20 cycles/revolution. The amplitude responses of the velocity and shear rate show a resonance unique to the system level parameters. The results indicate that unsteady granular flow analysis may be beneficial for characterizing the flowability or rheology of granular materials.

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