Particle pressure in flowing dispersions:
a bridge from osmosis to granular dilation

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A nonequilibrium form of osmotic pressure is described. This quantity is called the "particle pressure" and results from interactions between solid particles dispersed in viscous liquid driven by shearing flow. Since it is provides a continuous description of the dispersed phase pressure from equilibrium to completely athermal systems, the particle pressure provides a description of phenomena which span from osmosis in colloids to granular dilation. An experimental method to measure the particle pressure, based on measurement of osmotic pressure using a semi-permeable membrane, is described and its application to noncolloidal suspensions is demonstrated. The experimental work is complemented by dynamical simulation using the Stokesian Dynamics method. The simulations when coupled to analytical theory allow evaluation of the particle pressure for a wide range of the ratio of shearing to thermal motion (Peclet number) and solid fraction. At small Peclet number, the particle pressure is shown to approach the well-known equilibrium osmotic pressure of a hard-sphere dispersion. The underlying microstructural origin of the particle pressure at nonequilibrium conditions will also be discussed with reference to simulation and experimental data.