An Introduction to Fluid Mechanics

Faith A. Morrison
Professor of Chemical Engineering
Michigan Technological University

A caution about sign convention

In *Understanding Rheology* (Morrison, 2001) and *An Introduction to Fluid Mechanics* (Morrison, 2012) two different stress sign conventions are used. In the rheology text we follow Bird, Armstrong, and Hassager, *Dynamics of Polymeric Fluids* (Wiley, 1986) ($\underline{\underline{\Pi}} = -\underline{\underline{\tilde{\Pi}}}$, $\underline{\tau} = -\underline{\tilde{\tau}}$),), while in the fluids text we follow the usual engineering sign convention ($\underline{\underline{\tilde{\Pi}}}, \underline{\tilde{\tau}}$). Any express that contains $\underline{\underline{\Pi}}$ or $\underline{\tau}$ is affected.[§]

$$\underline{\underline{\tilde{\Pi}}} = -p\underline{\underline{I}} + \underline{\tilde{\tau}}$$

$$\underline{\underline{\Pi}} = p\underline{\underline{I}} + \underline{\tau} \quad \text{(Bird et al.)}$$

$$\underline{\tilde{\tau}} = +\mu\left(\nabla\underline{v} + \left(\nabla\underline{v}\right)^T\right)$$

$$\underline{\tau} = -\mu\left(\nabla\underline{v} + \left(\nabla\underline{v}\right)^T\right) \quad \text{(Bird et al.)}$$

Force on surface with unit normal $\hat{n}$ and area S:

$$\underline{F} = \iint_S \left[\hat{n}\cdot\underline{\underline{\tilde{\Pi}}}\right]_{surface} dS = \iint_S \left[\hat{n}\cdot(-\underline{\underline{\Pi}})\right]_{surface} dS$$

Torque on surface with unit normal $\hat{n}$ and area S:

$$\underline{T} = \iint_S \underline{R}\times\left[\hat{n}\cdot\underline{\underline{\tilde{\Pi}}}\right]_{surface} dS = \iint_S \underline{R}\times\left[\hat{n}\cdot(-\underline{\underline{\Pi}})\right]_{surface} dS$$

Sorry about that.