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# Shear-Based Hydraulic Energy Thresholds Governing Sediment Self-Cleansing in Pressurized Pipes

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**ABSTRACT**

This study experimentally establishes a shear-based threshold governing sediment self-cleansing in fully pressurized pipes through a dimensionless analytical framework. Controlled laboratory experiments (n = 55) were conducted using PVC pipes with diameters of 0.05 – 0.10 m, hydraulic heads of 0.15 – 0.25 m, and sediment grain sizes of 0.25 – 0.60 mm under fully turbulent conditions ($Re > 2 \times 10^4$). Bed shear stress and critical shear stress were computed to define a dimensionless Self-Cleansing Index (SCI). Results reveal a statistically significant transitional band at SCI ≈ 1.40 – 1.58, with sustained self-cleansing consistently achieved when SCI ≥ 1.6. Segmented regression confirmed breakpoint stability through bootstrap validation. Classification analysis shows that conventional velocity-based criteria achieved 60% accuracy, whereas the SCI framework improved accuracy to 78.2%, eliminated false-positive predictions (specificity = 1.00), and reduced risk-weighted misclassification cost from 110 to 12. Grain-size scaling indicates sublinear dependence of the critical velocity on grain size. These findings demonstrate that sediment stability in pressurised pipes is governed by shear force balance rather than by bulk velocity magnitude, providing a mechanistically grounded, performance-based criterion for hydraulic design.

**KEYWORDS**

Sediment deposition, Reynolds Number, Turbulent regimes, Pressurized Pipes, Hydraulic Transport