Conditioning of swirling and stratified pipe-flow: Analysis with laser-Doppler velocimetry

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Flow conditioning can be used for eliminating swirl, restoring flow symmetry, and generating a repeatable, fully developed flow profile upstream from flow measurement devices. In particular, the conditioning with tube bundles and straightening vanes has found many applications in flow metering. In this article, we use laser-Doppler velocimetry (LDV) to analyze flow profiles downstream from three different flow conditioners – a tube bundle conditioner, a Spearman conditioner, and a Zanker conditioner. We study the performance of these three devices with respect to conditioning swirling and thermally stratified pipe flows. For a quantitative comparison, we use selected performance indicators measuring the profile flatness or peakness, the asymmetry of the profile, the swirl angle of the secondary flow, and the turbulence intensity in the core region with respect to a fully developed reference profile. We find that the Zanker conditioner performs best for decreasing the swirl angle, whereas flow profiles downstream from the Spearman conditioner and the tube bundle conditioner show higher secondary velocities at locations close to the wall. For the conditioning of thermally stratified asymmetric flow profiles, the utilized flow conditioners provide unfavorable results. None of the conditioners is able to fully restore a symmetric and fully developed flow profile in thermally stratified flow.