Data assimilation for gas pipeline flow using observers based on velocity measurements

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Our goal is to estimate the system state of gas flowing through gas pipes from distributed measurements of the velocity. Therefore we construct a Luenberger-type observer system that combines these measurements with the one-dimensional barotropic Euler equations as a model of gas flow, which we complement with energy-consistent coupling conditions at pipe junctions. First, we show the existence of Lipschitz-continuous, semi-global solutions of the observer system and of the original system on general networks under the assumption that both posses smooth initial and boundary data satisfying suitable smallness and compatibility conditions. Then, based on a modification of the relative energy method we show that the state of the observer system converges exponentially in the long time limit to the state of the original system, i.e., we reconstruct the complete system state using measurements of only one state variable. This result can be shown for a single pipe and for star-shaped networks.

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