SIMPLE DYNAMIC MODELING OF EXPANDING VOLUME FLOW CALIBRATORS

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Abstract

Flow calibrators using the constant pressure expanding volume method employ an extensible circular cylinder as the collection volume, so the length increases as more gas enters the cylinder. At constant gas temperature and pressure, the volume collected in a measured time is computed from the measured axial displacement to determine mean flow rate.

It is often assumed that such calibrators will exhibit a precisely linear displacement vs. time response for a constant gas mass flow, after a startup transient has died out. Residual acceleration of the movable mass that seals the collected gas will frustrate the linear expansion of the collection volume, introducing a flow measurement error. The actual startup motion is properly a dynamical question, and can be modeled based on ideal gas laws and classical dynamics. Surprisingly, the simplest dynamical model including inertial effects predicts that a frictionless expanding volume system (started from rest and driven by constant flow) will go into spontaneous oscillation with growing amplitude. In real systems, vibration amplitude is limited by friction or flowrate restrictions, but even a small residual vibration can degrade accuracy.

It is necessary to understand and overcome these dynamic effects if we wish to improve measurement accuracy. The purpose of modeling the dynamics is to contribute to that improved understanding.