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Theory and numerical simulations of the Lorentz force flowmeter

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Abstract

A Lorentz force flowmeter is a device for the contactless measurement of flow rates in electrically conducting fluids. It is based on the measurement of a force on a magnet system that acts upon the flow. We describe the theory of the Lorentz force flowmeter which connects the measured force to the unknown flow rate. We first discuss three specific cases, namely (i) pipe flow exposed to a longitudinal magnetic field, (ii) pipe flow under the influence of a transverse magnetic field and (iii) interaction of a localized distribution of magnetic material with a uniformly moving sheet of metal. These examples provide the key scaling laws of the method and illustrate how the force depends on the shape of the velocity profile and the presence of turbulent fluctuations in the flow. Moreover, we formulate the general kinematic theory which holds for arbitrary distributions of magnetic material or electric currents and for any velocity distribution and which provides a rational framework for the prediction of the sensitivity of Lorentz force flowmeters in laboratory experiments and in industrial practice.

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