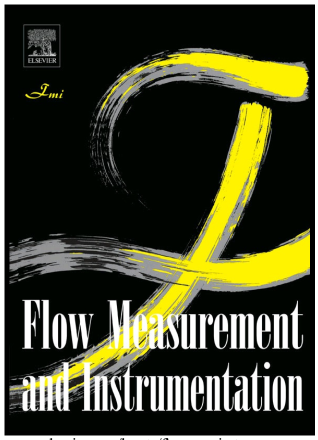

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Scaling of turbulence intensity for low-speed flow in smooth pipes

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Abstract

In this paper, we compare measured, modelled, and simulated mean velocity profiles. Smooth pipe flow simulations are performed for both incompressible (below Mach 0.2) and compressible (below Mach 0.1) fluids. The compressible simulations align most closely with the measurements. The simulations are subsequently used to make scaling formulae of the turbulence intensity as a function of the Reynolds number. These scaling expressions are compared to scaling derived from measurements. Finally, the found compressible scaling laws are used as an example to show how the flow noise in a flowmeter is expected to scale with the mean flow velocity.

Keywords:
Flowmeters, Turbulence intensity scaling, Flow in smooth pipes, Incompressible and compressible flow, Princeton Superpipe measurements, Semi-empirical modelling, CFD simulations

1. Introduction

Pipe flow noise is generated by turbulent fluid motion. For flowmeter manufacturers, it is important to understand and quantify pipe flow noise since it impacts the measurement performance, i.e. repeatability.

Reviews of wall-bounded turbulent flows at high Reynolds numbers are presented in [1] [2]. For an overview of the logarithmic region of wall turbulence see [3]: here it is shown that the logarithmic mean velocity profile is accompanied by a corresponding logarithmic streamwise Reynolds stress profile.

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