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EXPERIMENTAL STUDY OF VELOCITY DISTRIBUTIONS IN THE TRANSITION REGION OF PIPES*

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Abatract: The accuracy of an ultrasonic flowmeter meaurement depends on the profile-linear average velocity. But this velocity in the transition region is not available at the present. In this article, the velocity in the transition region in pipes is studied by experimental methods. The Particle Image Velocimetry (PIV) is used to measure the flow field in the transition region in pipes, and the measured results from PIV are in good agreement with the Westerwell's experimental data. Based on the experimental data of PIV, the curves of the profile-linear average velocity in the transition region against the Reynolds number in the range from 2 000 to 20 000 are obtained, and it is shown that the coefficient k is constant when the Reynolds number is in the range of 2 000-2 400 and 6 000-20 000, and the coefficient k is increasing when the Reynolds number is in the range of 2 400-6 000. The results of this article can be used to improve the measurement accuracy of the ultrasonic flowmeters and as a theoretical basis for the research on the transition flow.

Key words: ultrasonic flowmeter, Particle Image Velocimetry (PIV), the profile-linear average velocity, transition region, pipe

Introduction

The principle of the ultrasonic flowmeter is shown in Fig.1, where θ is the incidence angle of the ultrasonic signal. The linear average velocity v_l is obtained by the control circuit via ultrasonic Transducers A (TRA) and Transducers B (TRB). The volume flow Q is expressed as

$$Q = \frac{\pi D^2 v_s}{4} \tag{1}$$

where v_s is the profile average velocity in pipes,

$$v_s = k v_l \tag{2}$$

The coefficient k is defined as the flow coefficient, the ratio of the profile average velocity v_s to the linear average velocity v_l. In order to insure the measurement accuracy, the linear average velocity measured by the ultrasonic flowmeter must be converted to the profile average velocity.

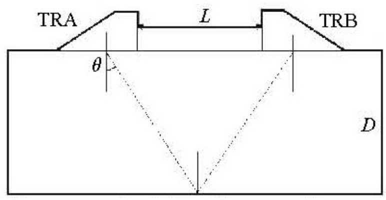

Fig.1 The principle of the ultrasonic flowmeter

Various issues related with the ultrasonic flowmeter were much studied. Iooss et al.[1], Raišutis[2], Willatzen and Kamath[3] and Inoue et al.[4] studied the influences of structure, roughness, velocity-profile, temperature on the fully-developed turbulent flow, Feng et al.[5], Li et al.[6] used the DNS method to study the turbulent flow in pipes, and measured the flow field by the Digital Particle Image Velocimetry (DPIV) method, Westerweel et al.[7], Van Doorne and Westerweel[8] used the PIV and DPIV methods to

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