MECHANISM OF VELOCITY DEVIATION FROM CLASSICAL LOG-LAW

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Abstract

An attempt has been made to explain the wisely observed phenomena- measured velocity often deviates from the classical log-law. This paper attributes the velocity deviation to the additional momentum "uv" caused by non-zero wall-normal velocity v. similar to the Reynolds shear stress $-\rho\overline{u'v'}$, the term "uv" having been neglected plays an important role in the region far from a solid wall, but it becomes negligible in the near wall region. This is way the log-law can be only applied to the near-wall region, but becomes invalid in the outer region. Based on the Reynolds equations in which the wall-normal velocity is retained, the theoretical study shows that the deviation of velocity from the log-law can be well described. As a preliminary study, the wall-normal velocity distribution is assumed to be linear, thus the theoretical distribution of streamwise velocity profile could be obtained. The dip-phenomenon in open channel flows and the wake-law in boundary layer flows could be well-explained using the proposed model. The computed and measured velocities are in good agreement. This study could be also extended to other phenomena of velocity deviation, e.g. sediment-laden flows, air flows with temperature gradient, etc..

Keywords: Velocity distribution; Wave-current flow; Karman constant; Bed shear stress; Reynolds shear stress; Wall-normal velocity.