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Experimental study of turbulent flow over and within cubically packed walls of spheres: effects of permeability and wall thickness

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Results of high-resolution particle velocimetry (PIV) measurements are presented to explore how the turbulent flow overlying a permeable wall is linked to the underlying pore flow and how their interplay is controlled by the topography of the wall interface and by the wall thickness. Two permeable walls were constructed from uniform spherical elements (25.4-mm diameter) in a cubically packed arrangement (porosity ~ 48%): one with two layers and the other with five layers of spheres. In addition, an impermeable rough wall with identical topography was considered as a baseline of comparison in order to explore the structural modifications imposed by permeability in the near-wall region. First- and second-order velocity statistics provide a quantitative assessment of such modifications of the local flow. A double-averaging approached allowed investigation of the global representation of the flow and assessment of conventional scaling parameters. A momentum deficit in the first pore layer and subsequent recovery beneath is observed, consistent with previous studies, as is a decay of the turbulent fluctuations. The transitional layer resides at the wall interface where free flow and pore flow interact, exchanging mass and momentum through intermittent turbulent events. Statistical investigation based on conditional averaging reveals that upwelling and down-welling flow events are associated with the passage of large-scale, low and high streamwise momentum free flow near the wall, respectively.

References

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