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Direct numerical simulation of a turbulent pipe with systematically varied three-dimensional roughness LEON CHAN, MICHAEL MACDONALD, DANIEL CHUNG, NICHOLAS HUTCHINS, ANDREW OOI, University of Melbourne — Direct Numerical Simulations (DNS) are conducted at low to medium Reynolds numbers for a turbulent pipe flow with roughness. The roughness, which is comprised of three-dimensional sinusoidal elements, causes a downward shift in the mean velocity profile known as the Hama roughness function ΔU^+. In engineering applications, ΔU^+ (which is related to the coefficient of drag C_f) is an important parameter as it is used to quantify the increase in drag and the decrease in efficiency. To have a better understanding of roughness and how it affects the flow, a range of numerical studies were conducted where the roughness height h^+, wavelength λ^+ and Reynolds number of the flow are varied. For the range of cases simulated, it is found that the roughness average height k_a^+ (which is proportional to h^+) is strongly correlated to the roughness function ΔU^+ whereas λ^+ has a weaker influence on the flow. Results from simulations of more complicated surfaces comprised of two superimposed modes of different wavelength are also presented. Analysis of the turbulence statistics convincingly supports Townsend's outer-layer hypothesis for all of the cases simulated.

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