Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Investigation of secondary flows in turbulent pipe flows with three-dimensional sinusoidal walls LEON CHAN, Universiti Tenaga Nasional, MICHAEL MACDONALD, DANIEL CHUNG, NICHOLAS HUTCHINS, ANDREW OOI, University of Melbourne — The occurrence of secondary flows is systematically investigated via Direct Numerical Simulations (DNS) of turbulent flow in a rough wall pipe at friction Reynolds numbers of 540. In this study, the peak-to-trough height of the roughness elements, which consist of three-dimensional sinusoidal roughness, is fixed at 120 viscous units while the wavelength of the roughness elements is varied. The solidity or effective slope (ES) of the roughness ranges from the sparse regime ($ES = 0.18$) to the closely packed roughness/dense regime ($ES = 0.72$). The time-independent dispersive stresses, which arise due to the stationary features of the flow, are analysed and are found to increase with increasing roughness wavelength. These dispersive stresses are related to the occurrence of secondary flows and are maximum within the roughness canopy. Above the crest of the roughness elements, the dispersive stresses reduce to zero at wall-normal heights greater than half of the roughness wavelength. This study has found that the size and wall-normal extent of the secondary flows scales with the roughness wavelength and can reach wall-normal heights of almost half of the pipe radius.

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Date submitted: 24 Jul 2017 Electronic form version 1.4