replacing DFD17-2017-003159.

Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Permeable disks at low Reynolds numbers[1] IGNAZIO MARIA VIOLA, CATHAL CUMMINS, Institute for Energy Systems, School of Engineering, University of Edinburgh, ENRICO MASTROPAOLO, Institute for Integrated Micro and Nano Systems, Scottish Microelectronics Centre, School of Engineering, University of Edinburgh, NAOMI NAKAYAMA, Institute of Molecular Plant Sciences, School of Biological Sciences, University of Edinburgh — The wake of a permeable disk can be rather exceptional: a toroidal vortex can form and remains stably at a fixed distance from the disk. The streamwise length of the vortex depends on the Reynolds and Darcy numbers. We investigate this fascinating flow for Reynolds numbers from 10 to 130 and Darcy numbers (Da) from 10^{-9} to 1. Direct numerical simulations are performed on a 2D grid with axisymmetric boundary conditions. Three flow regimes are observed: for low Da (effectively impervious), the wake is characterized by the presence of a toroidal vortex whose length is approximately equal to that of an impervious disk. For $10^{-6} < Da < 10^{-3}$, the increase in Da causes the vortex to shorten, and eventually vanishes at a critical Darcy number. It is demonstrated that increasing the permeability can lead to large variations in the length of the recirculating wake but with minimal effect on the drag coefficient. For higher Da (highly permeable), there is no recirculation, and an analytical expression for the drag force on the disk is derived, showing good agreement with the numerical results.

[1]This work was supported by the Leverhulme Trust [RPG-2015-255]

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Date submitted: 04 Aug 2017 Electronic form version 1.4