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Power-law fluids flow and heat transfer over two tandem square cylinders: effects of Reynolds number and power-law index

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Abstract The low-Reynolds numbers free-stream flow of power-law fluids and forced convection heat transfer around a square cylinder and two square cylinders in a tandem arrangement are numerically investigated. In the single cylinder case, the power-law index and Reynolds numbers range from $n = 0.7 - 1.4$ and $Re = 60 - 160$ at $Pr = 0.7$. In the tandem case, the spacing between the cylinders is four widths of each cylinder side and the power-law index ranges from 0.7 to 1.6 at $Re = 40$, 100, 160 and $Pr = 0.7$. All simulations are performed with a finite volume code based on the SIMPLEC algorithm and a non-staggered grid. The effect of spatial resolution on the results is also studied for a single cylinder and tandem cylinders. The mean and instantaneous streamlines, vorticity and temperature contours, the global quantities such as pressure and friction coefficients, the *rms* lift and drag coefficients, Strouhal and Nusselt numbers are determined and discussed for various power-law indexes at different Reynolds numbers. A comparison between the results of the single cylinder case and the two cylinders in tandem arrangement shows that there are relatively similar results for the single cylinder and the upstream cylinder of the tandem case.

1 Introduction

The majority of the works reported in the literature deals with the flow of Newtonian fluids past a single cylinder or groups of cylinders. These bodies can be arranged in tandem, one behind another one, in an in-line arrangement, side by side, or in a staggered arrangement relative to the free stream flow. There are lots of practical flows in industrial applications and environmental situations which can be modeled as a flow over cylinders such as flows over tubular and pin-type heat exchangers, buildings, cooling of electronic components, etc.

In contrast, little information is available on the flow of power-law-type non-Newtonian fluids over a single cylinder, even in the laminar regime. In general, many materials of industrial significance exhibit non-Newtonian flow behavior, for example, most multiphase mixtures (foams, suspensions, emulsions) and high molecular-weight polymeric systems (solutions, melts and blends) exhibit a range of rheological complexities. It should be noted that most such fluids exhibit shear-thinning and/or shear-thickening viscosity behavior under appropriate flow conditions (e.g., see [1,2]). The simple power-law model is able to describe satisfactorily both the shear-thinning ($n < 1$) and shear-thickening ($n > 1$) behaviors over moderate ranges of shear rates in external flows. Therefore, the non-Newtonian fluid flow, for example, the power-law type, past cylinders, has attracted a great deal of attention these years.

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