

Mossaz, Stéphane; Jay, Pascal; Magnin, Albert

Criteria for the appearance of recirculating and non-stationary regimes behind a cylinder in a viscoplastic fluid. (English) [Zbl 1274.76050](#)

J. Non-Newton. Fluid Mech. 165, No. 21-22, 1525-1535 (2010).

Summary: The appearance of a recirculation zone and the formation of non-stationary vortices behind a cylinder in the unconfined flow of a Herschel-Bulkley fluid have been studied by numerical simulation. The Herschel-Bulkley constitutive equation was regularised by using the Papanastasiou model. Special attention was paid to determining the numerical parameters and comparing them to existing results. The influence of the Oldroyd number and power-law index on flow morphology and, in particular, on the unyielded zones was studied over a wide spectrum ($0 \leq Od \leq 10$) and ($0.3 \leq n \leq 1.8$). It was seen that the greater the Oldroyd number, the greater the critical Reynolds numbers and Strouhal number for the two flow regimes. The influence of the power-law index is more complex.

MSC:

76A05 Non-Newtonian fluids

Cited in 4 Documents

Keywords:

circular cylinder; inertia; viscoplastic fluid; instabilities; shear-thinning; shear-thickening; Strouhal number; unyielded zones

Full Text: [DOI Link](#)

References:

- [1] A. Roshko, On the development of turbulent wakes from vortex streets, Ph.D. Thesis, California Institute of Technology Pasadena, California, 1952.
- [2] Clift, R.; Grace, J.; Weber, M. E.: Bubbles, drops and particles, (1978)
- [3] Williamson, C. H. K.: Defining a universal and continuous Strouhal – Reynolds number relationship for the laminar vortex shedding of a circular cylinder, *Phys. fluids* 31, No. 10, 2742-2744 (1988)
- [4] Karniadakis, G. E. M.; Triantafyllou, G. S.: Frequency selection and asymptotic states in laminar wakes, *J. fluid mech.* 199, 441-469 (1989) · [Zbl 0659.76043](#) · [doi:10.1017/S0022112089000431](#)
- [5] Liu, C.; Zheng, X.; Sung, C. H.: Preconditioned multigrid methods for unsteady incompressible flows, *J. comput. Phys.* 139, 35-57 (1998) · [Zbl 0908.76064](#) · [doi:10.1006/jcph.1997.5859](#)
- [6] Provansal, M.; Schouveiler, L.; Leweke, T.: From the double vortex street behind a cylinder to the wake of a sphere, *Eur. J. Mech. B: fluids* 23, 65-80 (2004) · [Zbl 1045.76521](#) · [doi:10.1016/j.euromechflu.2003.09.007](#)
- [7] Mittal, S.: Excitation of shear layer instability in flow past a cylinder at low Reynolds number, *Int. J. Numer. methods fluids* 49, 1147-1167 (2005) · [Zbl 1284.76178](#)
- [8] Kumar, B.; Mittal, S.: Effect of blockage on critical parameters for flow past a circular cylinder, *Int. J. Numer. methods fluids* 50, 987-1001 (2006) · [Zbl 1330.76072](#)
- [9] Kumar, B.; Mittal, S.: Prediction of the critical Reynolds number for flow past a circular cylinder, *Comput. methods appl. Mech. eng.* 195, 6046-6058 (2006) · [Zbl 1119.76031](#) · [doi:10.1016/j.cma.2005.10.009](#)
- [10] Morzynski, M.; Afanasiev, K.; Thiele, F.: Solution of the eigenvalue problems resulting from global non-parallel flow stability analysis, *Comput. methods appl. Mech. eng.* 169, 167-176 (1999) · [Zbl 0959.76045](#) · [doi:10.1016/S0045-7825\(98\)00183-2](#)
- [11] Williamson, C. H. K.: Oblique and parallel modes of vortex shedding in the wake of a circular cylinder at low Reynolds numbers, *J. fluid mech.* 206, 579-627 (1989)
- [12] Coutanceau, M.; Defaye, J. R.: Circular cylinder wake configurations: a flow visualization survey, *Appl. mech. Rev.* 44, 255-305 (1991)
- [13] Norberg, C.: An experimental investigation of the flow around a circular cylinder: influence of aspect ratio, *J. fluid mech.* 258, 287-316 (1994)
- [14] Norberg, C.: Flow around a circular cylinder: aspect of fluctuating lift, *J. fluids struct.* 15, 459-469 (2001)
- [15] Huang, P. Y.; Feng, J.: Wall effects on the flow of viscoelastic fluids around a circular cylinder, *J. non-Newtonian fluid mech.* 60, 179-198 (1995)
- [16] M.S. Guerrouache, Étude numérique de l'instabilité de Bénard-Kármán derrière un cylindre fixe ou en mouvement périodique. Dynamique de l'écoulement et advection chaotique, Ph.D. Thesis, University of Nantes, 2000.

- [17] Zovatto, L.; Pedrizzetti, G.: Flow about a circular cylinder between parallel walls, *J. fluid mech.* 440, 1-25 (2001) · [Zbl 1020.76030](#) · [doi:10.1017/S0022112001004608](#)
- [18] Sahin, M.; Owens, R. G.: On the effects of viscoelasticity on two-dimensional vortex dynamics in the cylinder wake, *J. non-Newtonian fluid mech.* 123, 121-139 (2004) · [Zbl 1131.76009](#) · [doi:10.1016/j.jnnfm.2004.08.002](#)
- [19] Sivakumar, P.; Bharti, R. P.; Chhabra, R. P.: Effect of power-law index on critical parameters for power-law flow across an unconfined circular cylinder, *Chem. eng. Sci.* 61, 6035-6046 (2006)
- [20] Bharti, R. P.; Chhabra, R. P.; Eswaran, V.: Steady flow of power-law fluids across a circular cylinder, *Can. J. Chem. eng.* 84, 406-421 (2006)
- [21] Soares, A. A.; Ferreira, J. M.; Chhabra, R. P.: Flow and forced convection heat transfer in cross flow of non-Newtonian fluids over a circular cylinder, *Ind. eng. Chem. res.* 44, 5815-5827 (2005)
- [22] Soares, A. A.; Ferreira, J. M.; Chhabra, R. P.: Steady two-dimensional non-Newtonian flow past an array of long circular cylinders up to Reynolds number 500: a numerical study, *Can. J. Chem. eng.* 83, 437-449 (2005)
- [23] D'alesio, S. J. D.; Pascal, J. P.: Steady flow of power-law fluids past a cylinder, *Acta mech.* 117, 87-100 (1996) · [Zbl 0868.76007](#) · [doi:10.1007/BF01181039](#)
- [24] Putz, A.; Frigaard, I. A.: Creeping flow around particles in a Bingham fluid, *J. non-Newtonian fluid mech.* 165, 263-280 (2010) · [Zbl 1274.76059](#)
- [25] Tokpavi, D. L.; Magnin, A.; Jay, P.: Very slow flow of Bingham viscoplastic fluid around a circular cylinder, *J. non-Newtonian fluid mech.* 154, 65-76 (2008) · [Zbl 1273.76028](#)
- [26] Williamson, C. H. K.: Vortex dynamics in the cylinder wake, *Annu. rev. Fluid mech.* 28, 477-539 (1996)
- [27] Zdravkovich, M. M.: Flow around circular cylinders, volume 1: fundamentals, (1997) · [Zbl 0882.76004](#)
- [28] Zdravkovich, M. M.: Flow around circular cylinders, volume 2: applications, (2003) · [Zbl 0882.76004](#)
- [29] Burgos, G. R.; Alexandrou, A. N.; Entov, V.: On the determination of yield surfaces in Herschel – Bulkley fluids, *J. rheol.* 43, 463-483 (1999)
- [30] Papanastasiou, T. C.: Flow of materials with yield, *J. rheol.* 31, 385-404 (1987) · [Zbl 0666.76022](#) · [doi:10.1122/1.549926](#)
- [31] Blackery, J.; Mitsoulis, E.: Creeping motion of a sphere in tubes filled with a Bingham plastic material, *J. non-Newtonian fluid mech.* 70, 59-77 (1997)
- [32] Mitsoulis, E.: On creeping drag flow of a viscoplastic fluid past a circular cylinder: wall effects, *Chem. eng. Sci.* 59, 789-800 (2004)
- [33] Zhu, H.; Martys, N. S.; Ferraris, C.; De Kee, D.: A numerical study of the flow of Bingham-like in two-dimensional vane an cylinder rheometers using a smoothed particle hydrodynamics (SPH) based method, *J. non-Newtonian fluid mech.* 165, 362-375 (2010) · [Zbl 1274.76237](#)
- [34] Thompson, R. L.; Soares, E. J.; Bacchi, R. D. A.: Further remarks on numerical investigation on gas displacement of a shear-thinning liquid and a visco-plastic material in capillary tubes, *J. non-Newtonian fluid mech.* 165, 448-452 (2010) · [Zbl 1274.76071](#)
- [35] Braza, M.; Chassaing, P.; Minh, H. Ha: Numerical study and physical analysis of the pressure and velocity fields in the near wake of a circular cylinder, *J. fluid mech.* 165, 79-130 (1986) · [Zbl 0596.76047](#) · [doi:10.1017/S0022112086003014](#)
- [36] Adachi, K.; Yoshioka, N.: On creeping flow of a viscoplastic fluid past a circular cylinder, *Chem. eng. Sci.* 28, 215-226 (1973)
- [37] Jay, P.; Magnin, A.; Piau, J. M.: Viscoplastic fluid flow through a sudden axisymmetric expansion, *Aiche J.* 47, No. 11, 2155-2161 (2001)

This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.