Lashgari, Iman; **Pralits, Jan O.**; **Giannetti, Flavio**; **Brandt, Luca**

First instability of the flow of shear-thinning and shear-thickening fluids past a circular cylinder. (English) Zbl 1248.76061

J. Fluid Mech. 701, 201-227 (2012).

Summary: The first bifurcation and the instability mechanisms of shear-thinning and shear-thickening fluids flowing past a circular cylinder are studied using linear theory and numerical simulations. Structural sensitivity analysis based on the idea of a 'wavemaker' is performed to identify the core of the instability. The shear-dependent viscosity is modelled by the Carreau model where the rheological parameters, i.e. the power-index and the material time constant, are chosen in the range $0.4 \leqslant n \leqslant 1.75$ and $0.1 \leqslant \lambda \leqslant 100$. We show how shear-thinning/shear-thickening effects destabilize/stabilize the flow dramatically when scaling the problem with the reference zero-shear-rate viscosity. These variations are explained by modifications of the steady base flow due to the shear-dependent viscosity; the instability mechanisms are only slightly changed. The characteristics of the base flow, drag coefficient and size of recirculation bubble are presented to assess shear-thinning effects. We demonstrate that at critical conditions the local Reynolds number in the core of the instability is around 50 as for Newtonian fluids. The perturbation kinetic energy budget is also considered to examine the physical mechanism of the instability.

MSC:

76E09 Stability and instability of nonparallel flows in hydrodynamic stability
76A05 Non-Newtonian fluids

Cited in **5** Documents

Keywords:

instability; non-Newtonian flows; wakes

Full Text: DOI

References:

[1] DOI: 10.1016/j.jnnfm.2006.02.003 · Zbl 1123.76328 · doi:10.1016/j.jnnfm.2006.02.003
[2] DOI: 10.1017/S0022112008004023 · Zbl 1165.76337 · doi:10.1017/S0022112008004023
[3] DOI: 10.1017/S0022112009992345 · Zbl 1183.76719 · doi:10.1017/S0022112009992345
[4] DOI: 10.1017/S0022112007005654 · Zbl 1115.76028 · doi:10.1017/S0022112007005654
[5] DOI: 10.1017/S0022112006004058 · Zbl 1119.76325 · doi:10.1017/S0022112006004058
[6] DOI: 10.1016/S0045-7825(94)80009-X · Zbl 0826.76060 · doi:10.1016/S0045-7825(94)80009-X
[7] Coelho, J. Non-Newtonian Fluid Mech. 121 pp 55– (2004)
[8] DOI: 10.1017/jfm.2011.382 · Zbl 1241.76340 · doi:10.1017/jfm.2011.382
[9] DOI: 10.1016/S0377-0257(03)00008-9 · Zbl 1024.76504 · doi:10.1016/S0377-0257(03)00008-9
[10] DOI: 10.1017/S002211200200318X · Zbl 1041.76029 · doi:10.1017/S002211200200318X
[11] DOI: 10.1016/S0377-0257(03)00007-7 · Zbl 1024.76505 · doi:10.1016/S0377-0257(03)00007-7
[12] Bird, Dynamics of Polymeric Liquids (1987)
[13] DOI: 10.1017/S0022112096002777 · Zbl 0882.76028 · doi:10.1017/S0022112096002777
[14] DOI: 10.1063/1.3292009 · Zbl 1183.76071 · doi:10.1063/1.3292009
[15] DOI: 10.1017/S0022112009993764 · Zbl 1189.76216 · doi:10.1017/S0022112009993764
[16] DOI: 10.1016/j.jnnfm.2006.07.003· doi:10.1016/j.jnnfm.2006.07.003
[17] DOI: 10.1016/j.ces.2009.03.029· doi:10.1016/j.ces.2009.03.029
[18] DOI: 10.1016/0021-9991(84)90128-1 · Zbl 0535.76035 · doi:10.1016/0021-9991(84)90128-1
[19] DOI: 10.1016/j.jnnfm.2010.07.006 · Zbl 1274.76053 · doi:10.1016/j.jnnfm.2010.07.006
[20] DOI: 10.1063/1.3152632 · Zbl 1183.76388 · doi:10.1063/1.3152632
[21] DOI: 10.1017/S0022112007008439 · Zbl 1128.76026 · doi:10.1017/S0022112007008439
[22] DOI: 10.1016/j.jnnfm.2011.03.006 · Zbl 1282.76037 · doi:10.1016/j.jnnfm.2011.03.006

[23] DOI: 10.1016/j.jnnfm.2010.08.001 · Zbl 1274.76050 · doi:10.1016/j.jnnfm.2010.08.001
[24] DOI: 10.1140/epjst/e2009-00895-9· doi:10.1140/epjst/e2009-00895-9
[25] DOI: 10.1016/j.ces.2006.05.031· doi:10.1016/j.ces.2006.05.031
[26] DOI: 10.1115/1.4001478· doi:10.1115/1.4001478
[27] DOI: 10.1017/S0022112073001102· doi:10.1017/S0022112073001102
[28] DOI: 10.1016/j.jnnfm.2011.02.005 · Zbl 1359.76029 · doi:10.1016/j.jnnfm.2011.02.005
[29] DOI: 10.1017/S0022112009994083 · Zbl 1189.76057 · doi:10.1017/S0022112009994083
[30] DOI: 10.1017/S0022112087002222 · Zbl 0641.76046 · doi:10.1017/S0022112087002222
[31] DOI: 10.1063/1.3425625 · Zbl 1190.76089 · doi:10.1063/1.3425625
[32] DOI: 10.1017/S002211201000279X · Zbl 1205.76112 · doi:10.1017/S002211201000279X
[33] DOI: 10.1017/S0022112008003662 · Zbl 1165.76012 · doi:10.1017/S0022112008003662
[34] DOI: 10.1146/annurev.fluid.37.061903.175810 · Zbl 1117.76027 · doi:10.1146/annurev.fluid.37.061903.175810
[35] Kunde, Fluid Mechanics (1990)