Boundary-layer streaming in viscoelastic fluids

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Oscillations of immersed bodies are known to generate a steady streaming flow, originating from Reynolds stresses within the viscous non-stationary boundary layer in the vicinity of the object. This phenomenon is very similar to acoustic streaming generated by sound or ultrasound waves within a fluid. Streaming flows have applications in fluid homogenization and mixing especially in microluidics, in heat transfer enhancement, in particle sorting or in fluid pumping. A typical situation is that of a cylinder oscillating perpendicularly to its axis, generating two pairs of counterrotating vortices due to the transfer of vorticity from the inner boundary layer. Outer vortices can be observed far from the object as a result of convection of vorticity [1]. Here, we consider the situation of a viscoelastic fluid : by using PIV, we carry out an experimental study of the streaming flow's structure and magnitude in function of the amplitude and frequency of the cylinder's oscillation.

A systematic comparison with a purely Newtonian fluid has been carried out and results showed several qualitative differences. First, when elasticity is significant enough, we observe that the inner boundary layer vortices are much larger than for a Newtonian fluid of the same viscosity. This is generally associated to the disappearance of outer vortices. We propose that elongational viscosity is a potential mechanism for this enlargement of vortices.

Second, for high enough forcing, the streaming flow moves away from the usual the four-vortex pattern. The pairs of vortices can become uneven, i.e. they are not mirror image of each other with respect to the axis of vibration and to the axis perpendicular to the vibration. Finally, a more complex structure can appear where each initial vortex splits into two smaller ones, showing a steady eight-vortex structure. To the best of our knowledge, these phenomena were unobserved so far.

Références

1. S. A. Bahrani, N. Périnet, M. Costalonga, L. Royon and P. Brunet, Exp. Fluids, *DOI : 10.1007/s00348-020-2926-8* (2020).