# Numerical study of the effect of viscoelastic Mach number in developing channel flow

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## ABSTRACT

This work presents a numerical study on the development length for viscoelastic fluid flow in both planar (parallel plates) and pipe geometries. Two different rheological models were studied, namely the simplified Phan-Thien−Tanner and Giesekus models (for the parallel plates geometry) and the upper convected Maxwell and Oldroyd-B models (for the pipe geometry). The Elasticity number, defined as the ratio of the Deborah and Reynolds numbers, took the values of $El$=0.1, 1, 10, while the solvent viscosity ratio was $\beta$=0, 0.11, 0.5, 0.9, for all simulated cases.

The analysis of the development length for the velocity showed a non-monotonic evolution as a function of the Deborah number. For very low Deborah numbers, the development length decreased with an increase of the Deborah number reaching a model-dependent minimum. The value of Deborah number corresponding to this minimum is nearly independent of Reynolds number and subsequently the development length increases with Deborah number. This non-monotonic variation is related to the existence of a velocity overshoot in the axial velocity profile, with values larger than those of the fully developed axial velocity. For the Giesekus model, this phenomenon is accompanied by a velocity undershoot, or a relative minimum. These behaviors are associated with fluid elasticity, since they occur at similar Deborah number for each model regardless of the Reynolds number. It was also found that for viscoelastic Mach numbers larger than unity, fluctuations were observed in development length for the velocity. In general, the highest entry length was observed for the development length obtained from the normal stresses, except for $El = 0.1$ and $\beta = 0$, where the velocity entry length is the largest.

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