Laminar-turbulent intermittency in pipe flow for a non-Newtonian fluid : Receptivity and thermo-rheology

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Résumé

Turbulence being an ubiquitous flow behavior, the transition to this state is one of the most studied fields in fluid mechanics, yet it is not entirely understood. Turbulence, in addition to its academics appeal, is also a key element for the fluid transport optimization in many industrial processes. Among them, wastewater treatment processes require to control the transition to turbulence in the pipe with the added complexity of an Herschel-Bulkley fluid [1]. The transition to turbulence is realised through non linear amplifications of finite-size amplitudes perturbations [2]. The practical interest of modelling the intermittency is to optimize the sludge transport in pipe. For this reason the present work investigates the non-linear physics in the momentum equation that are essential to explain the intermittency and the non-linear interaction between turbulent and laminar regions leading to transition.

A one-dimensional model characterizing the transition to turbulence in Newtonian fluid has been developed by Barkley [3]. We generalized this model [4] to include power-law fluids, a particular case of an Herschel-Bulkley fluid without yield-stress, in a heated pipe. Recently, the model has further been extended [5] to study the radial receptivity to finite-size perturbations for an Herschel-Bulkley fluid. The objective of this work is to integrate the interaction between temperature and rheology to the model developed in previous works. We aim here to be capable to describe the receptivity to perturbations in pipe flow for different thermo-rheological properties and different heating conditions.

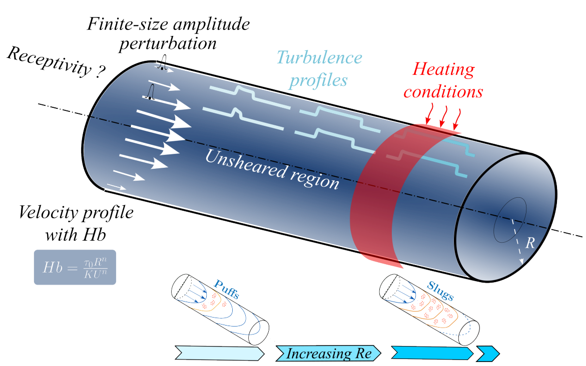

Figure 1. Illustration of the 1D model of the transition to turbulence due to non-linear amplification of finite-size amplitude perturbations for an Herschel-Bulkley fluid under thermal conditions

Références

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