DEVELOPMENT LENGTHS FOR NON-NEWTONIAN FLOWS IN PIPES AND TUBES BASED ON THE WALL SHEAR STRESS

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Key Words: *Development length, Newtonian, Power-law, Bingham Plastic, Tube, Pipe, Finite Elements.*

Knowledgeofthelengthof pipe orchannelneededfortheflowtobecomefullydevelopedisveryimportant in manyapplications. ForNewtonianflow, thedefinitionofthedevelopmentlength has beenstandardised as thatlengthrequiredforthecentrelinevelocitytoreach 99% ofthefullydevelopedvalue. However, thisdefinitionmaynot be appropriateforflowsof non-Newtonianfluids, such as mostbiologicalfluids, sincerheologicalqualitiessuch as shear-thinning and viscoplasticitymay cause theflowclosetothecentreline, wheretheviscosityishigher, toevolvefasterthanthatclosertothewalls. Forthese cases, variousalternativedefinitionsofthedevelopmentlengthhavebeenproposed in theliterature, allbasedontheevolutionofthevelocityfield, butnoneofthem has been so useful as tobecome standard [1,2].

In thepresentworkweproposeanalternativedefinitionbasedontheevolutionofthewallshear stress. In fact, formanyapplicationsthewallshear stress is more crucial thantheflowvelocity (e.g.,bloodflow in arteries), so thatthisdefinitionwill be usefulevenforNewtonianflows. The flow development of Newtonian and non-Newtonian fluids, such as power-law and Bingham-plastics, is studied in both pipes and channels by means of finite-element simulations for Reynolds numbers up to 2000. The finite-element results demonstrate that in the planar case, the wall-shear stress development is slower than the development of the centreline velocity and this effect becomes more pronounced as the Reynolds number is increased.

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