Numerical Investigation of Non-Newtonian Laminar Flow in Curved Tube with Insert

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Introduction: Non-Newtonian laminar steady flows in curved circular tubes with inserts are investigated by computer simulations. 0.65% solution of NaCMC is considered.

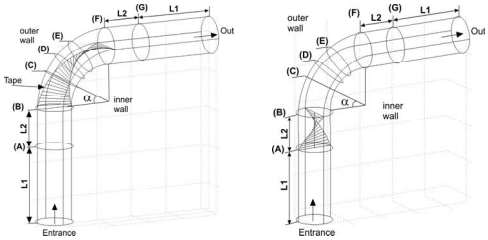

Figure 1. Geometric objects, (A), (B),..., (G) – cross-sections, where (C) – 30º cross-section, (D) – 45º cross-section, (E) – 60º cross-section.

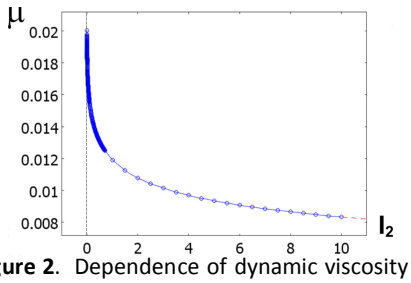

Figure 2. Dependence of dynamic viscosity (Pa·s) on the second invariant of the strain rate tensor (s-2) for Sodium Carboxymethyl cellulose (0.65% NaCMC), T=303K.

Computational Methods:
Three-dimensional incompressible Navier-Stokes equations are solved using COMSOL Multiphysics (Lagrange P2P1 elements over a trihedral mesh). To solve linear system equations we used "Direct (PARDISO)" Boundary conditions: in the inlet region of the channel velocity field is fully developed, in the outlet region of the channel normal stress is given (the total stress on the boundary is set equal to a stress vector of magnitude f0=0, oriented in the opposite normal direction). The no-slip condition is forced on the channel walls. The twisted tapes are designed and then imported from MatLab.

Results:

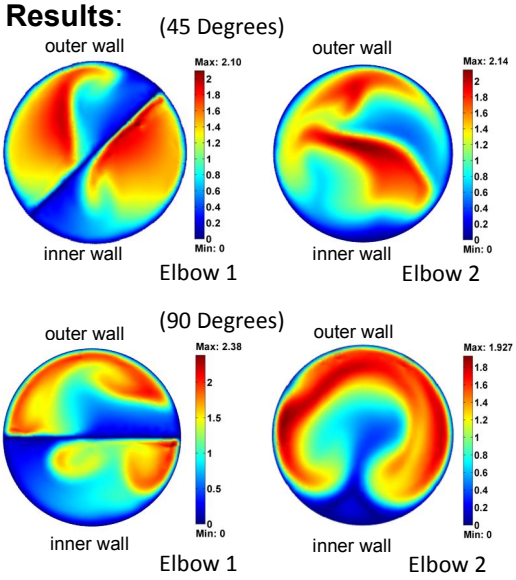

Figure 3. The velocity field in various cross-sections of the curved channel with inserts

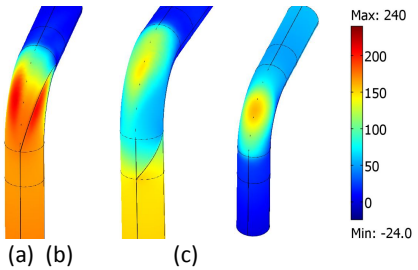

Figure 4. Pressure distribution on the walls; (a) Elbow #1; (b) Elbow #2; (c) the curved tube without insert; Re=1039.

Conclusions: For elbow #2 the most part of high velocity area is located in the center of the channel throughout its length. The twisted tape before the curved channel considered for elbow#2 reduces the pressure on the outer wall and consequently reduces the force on the pipe wall and increases its longevity.

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