

FOSSEE-CFD Learning Program

CFD Analysis of Shear-Thinning Fluid Flow in a Converging–Diverging Channel

Samuel Sagar Ambati¹ , Evan Fernandes²

¹Department of Chemical Engineering, Rajiv Gandhi University of Knowledge
Technologies-RKvalley, Andhra Pradesh, India

²FOSSEE project, Indian Institute of Technology Bombay, Mumbai, Maharashtra, India

Abstract

The present study investigates the flow behaviour of a shear-thinning non-Newtonian fluid through a two-dimensional converging-diverging channel using Computational Fluid Dynamics (CFD). The study focuses on the influence of channel geometry on the pressure and velocity characteristics of the fluid, particularly in the throat region where significant changes in flow behaviour occur.

The simulations are performed using OpenFOAM v2012 with the nonNewtonianIcoFoam solver under incompressible laminar-flow conditions. A structured computational mesh is generated using blockMesh. The working fluid is represented as a dilute aqueous partially hydrolyzed polyacrylamide (HPAM) polymer solution exhibiting shear-thinning behaviour and the fluid is modelled using a power-law viscosity model with $k=0.02$ and $n=0.6$. The value of $n<1$ represents shear-thinning behaviour. OpenFOAM v2012 supports generalized-Newtonian viscosity models including the power-law model.

A mesh-independence study is conducted using five mesh levels: coarse, moderate, fine, very fine, and very very fine. Area-averaged pressure and velocity are evaluated at several locations from the inlet to the outlet, while solver information and residual convergence are monitored to assess numerical stability. The results from the different mesh levels are compared to identify a suitable mesh for subsequent simulations.

Finally, four converging-diverging channel geometries with different diverging angles are investigated. The resulting pressure and velocity variations are analysed along the channel, with particular emphasis on the throat and pressure-recovery regions. The study provides a systematic assessment of the combined effects of mesh resolution, channel geometry, and shear-thinning rheology on non-Newtonian flow through a converging-diverging channel.