World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:13, No:03, 2019

Non-Newtonian Fluid Flow Simulation for a Vertical Plate and a Square Cylinder Pair

Authors : Anamika Paul, Sudipto Sarkar

Abstract : The flow behaviour of non-Newtonian fluid is quite complicated, although both the pseudoplastic ($n < 1$, n being the power index) and dilatant ($n > 1$) fluids under this category are used immensely in chemical and process industries. A limited research work is carried out for flow over a bluff body in non-Newtonian flow environment. In the present numerical simulation we control the vortices of a square cylinder by placing an upstream vertical splitter plate for pseudoplastic (n=0.8), Newtonian (n=1) and dilatant (n=1.2) fluids. The position of the upstream plate is also varied to calculate the critical distance between the plate and cylinder, below which the cylinder vortex shedding suppresses. Here the Reynolds number is considered as Re = 150 ($Re = U_\infty a/\nu$, where U_∞ is the free-stream velocity of the flow, a is the side of the cylinder and ν is the maximum value of kinematic viscosity of the fluid), which comes under laminar periodic vortex shedding regime. The vertical plate is having a dimension of $0.5a \times 0.05a$ and it is placed at the cylinder centre-line. Gambit 2.2.30 is used to construct the flow domain and to impose the boundary conditions. In detail, we imposed velocity inlet ($u = U_\infty$), pressure outlet (Neumann condition), symmetry (free-slip boundary condition) at upper and lower domain. Wall boundary condition ($u = v = 0$) is considered both on the cylinder and the splitter plate surfaces. The unsteady 2-D Navier Stokes equations in fully conservative form are then discretized in second-order spatial and first-order temporal form. These discretized equations are then solved by Ansys Fluent 14.5 implementing SIMPLE algorithm written in finite volume method. Here, fine meshing is used surrounding the plate and cylinder. Away from the cylinder, the grids are slowly stretched out in all directions. To get an account of mesh quality, a total of 297×208 grid points are used for $G/a = 3$ (G being the gap between the plate and cylinder) in the streamwise and flow-normal directions respectively after a grid independent study. The computed mean flow quantities obtained from Newtonian flow are agreed well with the available literatures. The results are depicted with the help of instantaneous and time-averaged flow fields. Qualitative and quantitative noteworthy differences are obtained in the flow field with the changes in rheology of fluid. Also, aerodynamic forces and vortex shedding frequencies differ with the gap-ratio and power index of the fluid. We can conclude from the present simulation that fluent is capable to capture the vortex dynamics of unsteady laminar flow regime even in the non-Newtonian flow environment.

Keywords : CFD, critical gap-ratio, splitter plate, wake-wake interactions, dilatant, pseudoplastic
Conference Title : ICFMHTT 2019 : International Conference on Fluid Mechanics, Heat Transfer and Thermodynamics
Conference Location : Rome, Italy
Conference Dates : March 05-06, 2019