World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:13, No:07, 2019

Laminar Periodic Vortex Shedding over a Square Cylinder in Pseudoplastic Fluid Flow

Authors : Shubham Kumar, Chaitanya Goswami, Sudipto Sarkar

Abstract : Pseudoplastic (n < 1, n being the power index) fluid flow can be found in food, pharmaceutical and process industries and has very complex flow nature. To our knowledge, inadequate research work has been done in this kind of flow even at very low Reynolds numbers. Here, in the present computation, we have considered unsteady laminar flow over a square cylinder in pseudoplastic flow environment. For Newtonian fluid flow, this laminar vortex shedding range lies between Re = 47-180. In this problem, we consider Re = 100 (Re = U∞ a/ ν, U∞ is the free stream velocity of the flow, a is the side of the cylinder and ν is the kinematic viscosity of the fluid). The pseudoplastic fluid range has been chosen from close to the Newtonian fluid (n = 0.8) to very high pseudoplasticity (n = 0.1). The flow domain is constituted using Gambit 2.2.30 and this software is also used to generate mesh and to impose the boundary conditions. For all places, the domain size is considered as 36a × 16a with 280 ×192 grid point in the streamwise and flow normal directions respectively. The domain and the grid points are selected after a thorough grid independent study at n = 1.0. Fine and equal grid spacing is used close to the square cylinder to capture the upper and lower shear layers shed from the cylinder. Away from the cylinder the grid is unequal in size and stretched out in all direction. Velocity inlet (u = U∞), pressure outlet (Neumann condition), symmetry (free-slip boundary condition du/dy = 0, v = 0) at upper and lower domain boundary conditions are used for this simulation. Wall boundary (u = v = 0) is considered on the square cylinder surface. Fully conservative 2-D unsteady Navier-Stokes equations are discretized and then solved by Ansys Fluent 14.5 to understand the flow nature. SIMPLE algorithm written in finite volume method is selected for this purpose which is the default solver in scripted in Fluent. The result obtained for Newtonian fluid flow agrees well with previous work supporting Fluent's usefulness in academic research. A minute analysis of instantaneous and time averaged flow field is obtained both for Newtonian and pseudoplastic fluid flow. It has been observed that drag coefficient increases continuously with the reduced value of n. Also, the vortex shedding phenomenon changes at n = 0.4 due to flow instability. These are some of the remarkable findings for laminar periodic vortex shedding regime in pseudoplastic flow environment.

Keywords : Ansys Fluent, CFD, periodic vortex shedding, pseudoplastic fluid flow
Conference Title : ICCE 2019 : International Conference on Chemical Engineering
Conference Location : Stockholm, Sweden
Conference Dates : July 15-16, 2019