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Numerical Study of Convective Heat Transfer Flow of Non-Newtonian Nanofluid Over Backward Facing Step

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ABSTRACT

This paper presents the numerical predictions of hydrodynamic and thermal characteristics of non-Newtonian nanofluid flow through backward facing step. The governing equations are solved through the finite volume method, as described by Patankar, by taking into account the associated boundary conditions. The SIMPLER algorithm is used to handle the pressure-velocity coupling. Empirical relations were used to give the effective dynamic viscosity and the thermal conductivity of the nanofluid. Effects of different key parameters such as Reynolds number, nanoparticle solid volume fraction and nanoparticle solid diameter on the heat transfer and fluid flow are investigated. The results are discussed in terms of the average Nusselt number, streamlines and velocity profiles.

Keywords: backward facing step, non-Newtonian nanofluid, heat transfer.

1. Introduction

The backward facing step flows have been undertaken both numerically and experimentally since they are related to many real flow situations. The separation and reattachment phenomena occurs in many applications like flow over airfoils at large angles of attacks, cooling of electronic equipment, sudden expansion in channels combustion chambers and flow in valves. Significant advances in nanotechnology have made possible to synthesize particles of nanometric size (10^{-9} m), which, dispersed in a base fluid, constitute nanofluid. All works devoted to the study of this mixture have shown that adding nanoparticles can improve the thermal conductivity of the base fluid and hence enhance heat transfer performance.

2. Numerical procedure

A FORTRAN code is developed to solve the governing equations, namely, continuity, momentum and energy equations. The Finite Volume Method is used to discretize the governing system of equations and the SIMPLE algorithm is used to handle the pressure-velocity coupling [1]. The discretized algebraic equations are solved iteratively by a line by line procedure, combining the tri-diagonal matrix algorithm (TDMA) and the Gauss-Seidel method.

3. Results and Discussion

To check the accuracy of our code, the present results have been compared against the results of Cheng and Tsay [2]. We consider the Newtonian fluid flow inside a channel having backward facing step and baffle. A good agreement between the two results is observed with a deviation less than 3.9 % (Figure 1).
The heat transfers and flow characteristics of non-Newtonian nanofluid over backward facing step have been investigated in this study. All computations are carried out for Pr =10.

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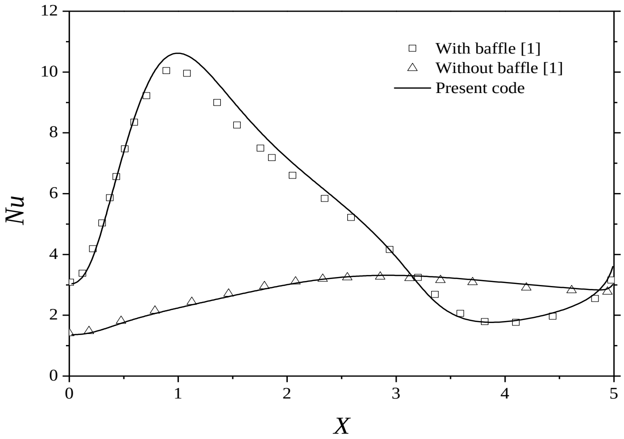

Figure 1: Comparison of the local Nusselt number distribution with Cheng and Tsay [1]

The figure 2 presents the average Nusselt number for different Re number and that for ϕ = 0 and ϕ = 0,06. It is observed that for the pure fluid and the nanofluid, the Nusselt number increases with increasing the Re number. By increasing the Re number, the velocity of the fluid increases and so the temperature gradient between the fluid and the heated wall. It is also observed that the nanofluid (ϕ = 0,06) presents the highest values of the Nusselt number compared to the pure fluid (ϕ = 0.0). This is because the nanoparticles lead to increase the thermal conductivity of the fluid.

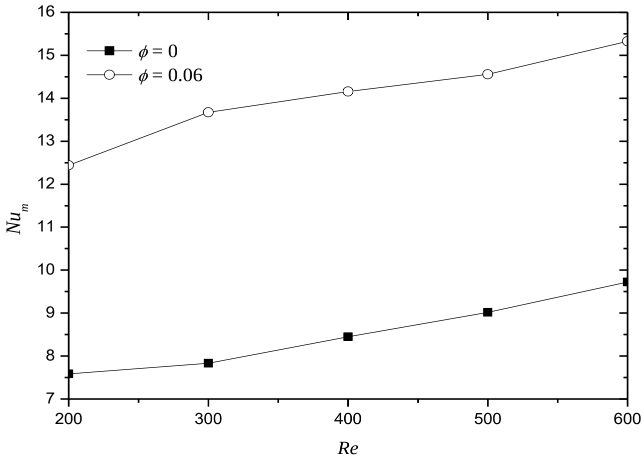

Figure 2: Average Nusselt number for different *Re* number

ϕ = 0,0 and ϕ = 0,06.

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