New Journal and we have not received input yet 33 (2022) 101364

Contents lists available at ScienceDirect

Thermal Science and Engineering Progress

journal homepage: www.sciencedirect.com/journal/thermal-science-and-engineering-progress

Cooling of hot cylinder placed in a flexible backward-facing step channel

Duna T. Yaseen [a], Amani J. Majeed [b], Muneer A. Ismael [c,*]

[a] Technical Institute/Basra, Southern Technical University, Iraq
[b] Petroleum Engineering Department, Engineering Collage, University of Basrah, Iraq
[c] Mechanical Engineering Department, Engineering Collage, University of Basrah, Iraq

ARTICLE INFO

Keywords:
Backward-step channel
Flexible wall
FSI
Mixed convection
Obstacle

ABSTRACT

This paper copes with the mixed convection heat transfer and fluid–structure interaction (FSI) of a hot cylinder placed in a backward-step channel. The step is set to be flexible and deforms according to the force imparted by fluid. To attain the best cooling, different configurations of the flexible step were assessed. Equations governing the problem are solved using the finite element technique with the Arbitrary Lagrangian–Eulerian (ALE) approach to go along the moving domain. The influential parameters of such a problem are the Reynolds number Re, Richardson number Ri and the configuration of the flexible back step. Results demonstrated an improvement in the Nusselt number where at Ri = 100, a step of horizontal flexible wall augments the Nusselt number by 7.3% and 1.4% when Re = 100 and 500, respectively. Including the pressure drop in a performance criterion, it is shown that making the vertical wall of the step flexible (VFW) improves the aspects of heat transfer and the hydrodynamic of low Reynolds number, while at high Reynolds number, all suggested configurations of flexible step do not improve the performance criterion. It is found also that Reynolds number greatly improves the performance criterion while Richardson number does not.

2. Introduction

In fluid dynamics, the phenomena of flow separation and reattachment have a significant impact on heat transfer rates. The researches into this area of study have a wide range of applications, including the design of aircraft wings, turbines, diffusers, and structures. These problems have a large extent of literature dedicated [1–6]. Due to the increasing requirements of the relative compactness systems, the heat flux in thermal devices has become very vast. In the literature, numerous studies have presented fluid behavior during flow in sudden expansion or sudden contraction and the greatest focus had been on the fluid behavior in the boundary where eddies had been generated [7–9]. Moreover, the study of heat transfer in these domains has attracted the attention of many scientists [10–12]. Comprehensive experimental and numerical studies have been introduced for the unconfined flow of Newtonian fluid over a cylinder of rectangular cross-section [13–14] where they focused on delineated the vortex shedding frequency from the cylinder and predicted the corresponding Strouhal number. Kelkar and Patankar conducted the simulation of 2D fluid flow around a square cylinder forced convection for steady and transient flow [15]. They revealed that the overall heat for steady and unsteady flow from the square cylinder is the same.

Vast kinds of literature studied the artificial enhancement of heat transfer in laminar flow by modifying the structure of the flow either actively by pulsating blowing, sucking, etc. [16–20], or passively by placing an obstacle in the flow path [21–24]. Abu-Mulaweh presented an inclusive review of combined effects of natural and forced convection for forward and backward-facing steps in diverse inclinations, where the effect of various parameters such us expansion ratio, Reynolds number, and Prandtl number have been examined on the heat transfer and fluid flow features [25]. For backward-facing step flow, Kumar and Dhiman examined the increase of the characteristics of laminar forced convection in a 2D channel when an adiabatic cylinder has been introduced to the domain. They showed growth in the value of peak Nusselt number to 155% compared to the same domain without cylinder [26]. Sarma et al. studied the influence of adiabatic square obstacle on the heat transfer enhancement in the two-dimensional laminar flow over the Backward Facing Step [27]. Moreover, Anupam and Dash analyzed the behavior of turbulent flow along with forced convective heat transfer for a rectangular channel having dual forward-facing steps with cylindrical, where the obstacles are placed near the steps [28]. They revealed that at the same obstacles position ratio, where both obstacles are vertically positioned, increasing in position ratio causes increasing in the rate of heat

* Corresponding author.
E-mail addresses: duna.yaseen@stu.edu.iq (D.T. Yaseen), Amani.majeed@uobasrah.edu.iq (A.J. Majeed), muneer.ismael@uobasrah.edu.iq (M.A. Ismael).

https://doi.org/10.1016/j.tsep.2022.101364
Received 10 October 2021; Received in revised form 26 May 2022; Accepted 27 May 2022
Available online 30 May 2022