BJES Basrah Journal for Engineering Sciences

Basrah Journal for Engineering Sciences, Vol. 24, No. 2, (2024), 43-49

Original Article

Journal homepage: www.bjes.edu.iq
ISSN (Online): 23118385, ISSN (Print): 18146120

Simulation of Flow Around Circular Cylinders for Complex von Kármán Vortex Street Phenomenon Using SIMPLE, SIMPLEC and PISO

Ali K. Hadi [1]*, Rafid J. Mohammed [2], Qahtan A. Jawad [3], Imad A. Kheioon [4]

[1,2,3,4] Department of Mechanical Engineering, College of Engineering, University of Basrah, Basrah, Iraq

E-mail addresses: ali.k.hadi @uobasrah.edu.iq , rafid.mohammed@uobasrah.edu.iq , qahtan.jawad@uobasrah.edu.iq , imad.kheioon@uobasrah.edu.iq

Received: 6 June 2024; Accepted: 9 July 2024; Published: 15 July 2024

Abstract

Van Kármán vortex street is considered an important phenomenon that accompanies fluid flow, especially when exposed to a certain barrier, as periodic vortexes occur on both sides of the body that rotate in two opposite directions. This phenomenon occurs in the atmosphere around mountains, oceans, seas, and islands. Also, this phenomenon makes it possible to induce a fluid flow around a specific body present in the flow path. In this study, a model for fluid flow around a cylinder of a certain diameter was taken, where the flow near the boundary layers of the cylinder surface moves slower than near the free stream. In addition, the pressure distribution was studied, and it was observed that there is a pressure gradient due to the difference in momentum at the surface of the cylinder in distant areas due to friction. The study area was divided into fine meshes with Fluent software, especially in the irregular areas. The simulation was implemented for Reynolds numbers Re = 100 and Re = 1500 for incompressible flows. Consequently, the equations that do not depend on pressure are difficult to solve. Therefore, methods linking pressure and velocity were adopted, where the pressure-velocity coupling simple method was used. The first-order forward difference scheme was adopted in representing the differential equations as a function of time when performing the simulation. From the steady state and upwards to Reynolds number Re = 100, it was observed that a twain of vortices appeared on the body at a certain speed range. When the state was changed from the stable state to the transitional state, the results changed, as the flow became asymmetric and unsteady due to vortex shedding phenomena, which led to the generation of vortexes in different ways. The U-Velocity curve was studied for two different cases, and the results showed a large discrepancy between the first order and the second order, where the second order had better behavior but required great effort to reach accurate results. Also, pressure-velocity was studied to satisfy mass conservation, and numerical techniques were used to compute the equations of Navier-Stokes in CFD, such as SIMPLEC, PISO, and SIMPLE. An acceptable convergence was not reached with the PISO; therefore, the SIMPLE method was adopted. The pressure gradient was drawn around the cylinder, where it was observed that the pressure was greatest at the front of the cylinder and its lowest value at the end.

Keywords: von Kármán vortex street, Reynolds number, Vortex shedding phenomena, SIMPLE, SIMPLEC, PISO.

http://doi.org/10.33971/bjes.24.2.6

1. Introduction

Von Kármán vortex is a complex phenomenon in fluid mechanics, seen in many places. Vortices rotate in opposite directions from object sides. Common examples of the phenomenon in civil engineering include the structural dynamics of skyscrapers, chimney stacks, the atmosphere around mountains, suspension bridges, marine engineering, which includes the vibrations of pipelines resting in the seabed, and ocean engineering, as shown in Fig. 1 [1].

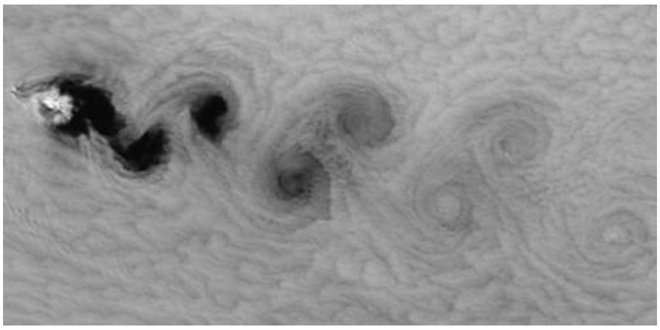

Fig. 1 von Kármán Vortex around an island on the sea [2].

Many researchers have been investigated in this field as will be reviewed by the following survey.

Gupta [3] introduced a new method to identify the vortex-shedding parameters. A wind-tunnel tests on two objectives, the first was a circular cylinder and the second was two bridge decks configuration. The author estimated the response of vortex-induced by determining the model parameters from the experiments.

Tapia and Chellali [4] developed a simplified model of Kármán Street by CFD simulations. They used this model to train neural network-based controllers of different robot fishes in order to control the frequency of fishes' tail beat before releasing them into water. They deduced that frequency of fishes' tail beat was well matched with Kármán Street.

Thoraval et al. [5] studied the irregular splashing which result from impinging a drop on a liquid pool. They used super-speed video technology in conjunction with numerical simulations of high accuracy to display the irregular splashing. They reported that, at higher Reynolds numbers, an axisymmetric von Kármán vortex was shed from the free surface into the liquid. Ali et al. [6] Numerically investigated a flexible flap that generated vortices in an environment of laminar flow to improve the performance of some kinds of heat