Available online at www.sciencedirect.com
ScienceDirect
Procedia Materials Science 10 (2015) 768 – 788
Procedia Materials Science
www.elsevier.com/locate/procedia

2nd International Conference on Nanomaterials and Technologies (CNT 2014)

Design and analysis of fluid structure interaction in a horizontal Micro Channel

K.Srinivasa Rao[a*], K.Girija Sravani[b], G.Yugandhar[c],G.Venkateswara Rao[d] and V.N.Mani[e]

[a]*Department of ECE, KL University, Green Fields, Vaddeswaram-522502, Guntur, A.P, India*
[b]*Department of ECE, Amrita Sai Institute of Technology and Sciences, A.P, India*
[c]*Department of Computer Science Engineering, GITAM University, Hyderabad-502329, Telangana, India*
[d]*Department of Information Technology, GITAM University, Vishakhapatnam, 530045,A.P India*
[e]*Department of Electronics, Centre for Materials for Electronics Technology(C-MET), Hyderabad, A.P, India.*

Abstract

This paper demonstrates techniques for modelling fluid-structure interactions using COMSOL Multiphysics v 4.2a, which illustrates how to solve for the flow in a continuously deforming geometry using the Arbitrary Lagrangian-Eulerian (ALE) technique and corresponding deformation, displacement analysis. The present work reports the computation of the deformation and displacement in structure along with the fluid flow in a continuously deforming geometry, for different types of structures like circular, rectangular, ellipse, which are placed inside of the flow channel as an obstacle. Fluid structure interaction between wind and sails, modelling of parachutes, fluid structure thermal calculation, stability and response of aircraft wings, the flow of blood through arteries, response of bridges and tall buildings to winds, prediction of aero elastic parameters in military aircrafts, vibration of turbine and compressor blades and the oscillation of heat exchangers can also be analysed using this method

Peer-review under responsibility of the International Conference on Nanomaterials and Technologies (CNT 2014)

Keywords: MEMS flow channel, structural interaction, COMSOL

1. Introduction

In the recent years, there has been rapid progress in the manufacturing of microfluidic devices used for various aspects of engineering and bio-medical purposes. Microfluidics refers to a set of technologies that control the flow of minute amounts of liquids or gases, typically measured in nano- and picoliters, in a miniaturized system and microfluidic devices are characterized by micro-channels having dimensions in the micrometer (µm) region. The most mature application of Microfluidics technology is in the commonly used inkjet printer which uses orifices

*Coorespong author:srinivasakarumuri@gmail.com;

2211-8128
Peer-review under responsibility of the International Conference on Nanomaterials and Technologies (CNT 2014)
doi:10.1016/j.mspro.2015.06.022

less than 100 μm in diameter to generate ink droplets. Microfluidic devices have over the years moved to applications in biotechnology such as the development of DNA chips and lab-on-a-chip technology where they are being used to detect bacteria, viruses and cancer cells and having many advantages as compared to conventional analysis. Some of these advantages are lower fluid consumption, better process control, higher analysis speed and a lower fabrication cost; all of which reduce cost and time and are beneficial to present and future patients. Microfluidic devices however are not just scaled down versions of conventional testing equipment as the physics changes at the micro-scale level. As the dimensions of a microfluidic device are small, particles suspended in a fluid become comparable in size to the device itself, which dramatically alters system behavior. Although the fluid properties remain the same as that at the micro scale, some properties such as surface tension, viscosity, and electrical charges can become dominant forces on a fluid because the surface-to-volume ratio is much greater than for macro-scale systems. Therefore the stresses and strains which act on biological cells as they flow through a microdevice can be quite different and more complex than through conventional lab equipment. Stresses and strains have been known to produce certain biological and biochemical responses in cells leading to events such as spontaneous cell movement, cell differentiation and even cell death. Hence, the study of forces acting on cells in microfluidic devices through the fluid medium and the resulting deformation is an important first step towards a quantitative study in the change of physical properties of cells or biomolecules which pass through microfluidic devices [1]. Another area of interest is in the trajectories of the cells as they pass through the microchannel as this has implications on cell sorting techniques whereby cells are sorted by size or other parameters through fluorescent excitation. As the field of microfluidics is relatively new, numerical simulations of microfluidic systems are helpful in providing a research tool. By incorporating the complexities of channel and cell geometry, fluid flow patterns as well as the structural mechanics of cells into a numerical model, the behavior of a system can be accurately predicted when an intuitive prediction may be difficult or impossible to be proven via mathematical methods. Numerical modeling also allows visualization of complex flow phenomena that will result due to fluid structure interactions that may not be easily obtained experimentally due to the minute dimensional nature of the system. The weakness of numerical modeling is the fact that it is not guaranteed to exactly replicate events in nature, particularly if there are physical phenomena that are not considered and incorporated into the model.

Fluid-structure interaction problems, as well as many other multi-field problems, have received much attention in recent years and their importance is still continuously growing. The main reason for this is that they are of great relevance in all fields of engineering (aerospace, bio, civil, mechanical, etc.) as well as in the applied sciences. Hence, the development and application of respective modelling and simulation approaches have gained great attention over the past decades. While modelling and simulation of most relevant problems were far out of reach still a couple of years ago, this possibility is now available or only a short distance away– thanks to advances in computational power, computational modelling approaches and methods. Many numerical structural models have been developed to describe the behaviour of structural interaction with the flowing fluid.

The Fluid-Structure Interaction (FSI) multiphysics interface combines fluid flow with solid mechanics to capture the interaction between the fluid and the solid structure. A Solid Mechanics interface and a Single-Phase Flow interface model the solid and the fluid, respectively. The FSI couplings appear on the boundaries between the fluid and the solid. The Fluid-Structure Interaction interface uses an arbitrary Lagrangian-Eulerian (ALE) method to combine the fluid flow formulated using an Eulerian description and a spatial frame with solid mechanics formulated using a Lagrangian description and a material (reference) frame.

The present work reports the analysis of the deformations made in the micro fluid channel by placing an obstructer, for various inlet mean velocities. Analysis of the displacements for various geometries was done i.e., by changing the shape to circle, ellipse etc., in which the pressure distribution is also observed. Changes in flow are observed after the deformation.