FOREWORD

International Union on Theoretical and Applied Mechanics (IUTAM) Symposium: Deformable Tubes

Fluid flow past deformable solid surfaces and the use of surface deformation to generate flow are a highly inter-disciplinary field at the intersection of fluid mechanics, engineering, applied mathematics and biology. These flows are ubiquitous in biological systems, and are increasingly of importance in microfluidic technologies that employ soft elastomers such as polydimethyl siloxane for fabrication. In fluid flows past such soft solid boundaries, the dynamics of the flow is coupled to the elastic deformation in the solid, which in turn can influence the stability and subsequent transition of the laminar flow to a more complex flow state. While the problem of stability of flow past compliant boundaries has received much attention in boundary-layer flows relevant to aerospace and marine applications, the related problem of the stability of internal flow through deformable tubes and channels has seen much progress only recently. For instance, while it is well-known that the laminar-turbulent transition in a rigid tube occurs at a Reynolds number around 2000, in flow through deformable tubes, the transition can happen at much lower Reynolds numbers, depending on the elastic modulus of the soft wall.

An International Union on Theoretical and Applied Mechanics (IUTAM) symposium on this subject was held in Warwick, UK in 2001. Since then, there have been numerous advances, theoretical and experimental, in the field, and there has been a sharpening of focus on different areas of fluid–structure interactions. The objective of this IUTAM symposium is to bring together experts in the field, with emphasis on latest advances and challenges in the following areas:

(i) Effect of a dynamical coupling between fluid flow and soft surfaces on flow instability and the transition to turbulence, (ii) Tissue mechanics, and the rheology of soft solids, (iii) Flow–structure interactions in the cardio-vascular system, (iv) Respiratory flows, and collapsible-tube models of the respiratory system, (v) Use of soft and active materials for mixing and pumping in microfluidics.

This special section of *Sadhana* contains selected papers from the talks presented during the symposium held from 20 to 23 January 2014. The paper by Pedley and Pihler-Puzovi'c deals with flow in collapsible tubes with implications to airway closure in lungs, wheezing, etc. The model system used in such studies is the so-called Starling resistor (a finite length of flexible tubing mounted between two rigid tubes, and being pressurized from the outside). Experiments show that for steady upstream and downstream conditions, there are a rich variety of unsteady oscillations of the tube. This paper reports some simple 1D and 2D models towards explaining the experiments, and shows that some of the phenomenon is related to flutter instability of flexible walls. The paper by Kumaran reviews the recent experimental results on flow through tubes and rectangular channels with deformable walls. Interestingly, the transition in such systems happens at Reynolds numbers as low as 400, and is very different from the transition in a rigid tube. The paper reports that if the deformation of the tube is taken into account in the base-state, there is quantitative agreement between experiment and theory. The review article by Shankar provides a broad survey of the various instabilities that are present both in external and internal flow past soft solid boundaries. This article attempts to unify various instabilities reported for different types of wall models used in the literature. Tsigklifis and Lucey report computational studies on the type of instabilities that occur in a finite compliant panel that is flush between rigid upstream and downstream sections. They focus on the global nature of the instability, as well as report some non-normal (transient) growth in this system. The paper by Gajjar reports asymptotic analysis of the stability of liquid flow down an inclined flexible wall. A triple- deck asymptotic formulation is used to analyse the interactions between the wall layer and the free surface. The paper by Verma and Kumaran reports experimental results that show that the ultra-fast mixing that ensues the instability in a soft-walled channel could be exploited in the room-temperature synthesis of gold nanoparticles. The role of viscoelastic nature of the fluid on the nature of the instability in flow past a deformable channel is discussed by Chokshi. Both linear and weakly nonlinear analyses were carried out and the results show that the nature of bifurcation could change from subcritical to supercritical as a function of various parameters in the problem. The paper by Thaokar carries out a Floquet analysis for oscillatory flow over a deformable surface, motivated by many biological flows. The effect of an applied electric field on the flow-induced instability of the interface between a fluid and gel is also analysed. The role of slip on the thermocapillary spreading of a thin liquid film is analysed in the paper by Tiwari, with special attention paid to the role of gravitational counter flow. The paper by Gaurav and Shankar illustrates how soft solid layers can affect the interfacial instability at the interface between two shearing fluids in various geometries, and further shows that the interfacial instability could even be suppressed by the deformable nature of the solid.

May 2015

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(Guest Editors)