ME Seminar

MECHANICAL ENGINEERING
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Flow through deformable systems: Laminar to turbulent transition and applications

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ABSTRACT

The fluid flow in deformable domains has always fascinated the research community due to its physiological proximity to biological systems. While the laminar to turbulent transition is well known for flow through rigid systems, the characteristics of such flows in biological systems are still a matter of research. Normally the blood flow in small blood vessels is laminar and any transition to turbulence may results to the initiation of vascular diseases such as brain aneurysms or atherosclerosis. Such diseases are attributed to the mechano-sensing properties of endothelial cells to various flow regimes. Therefore, it is important to develop a better understanding of this laminar to turbulent transition in flow through deformable/biological systems. Here, we show that laminar to turbulent transition in the deformable domains takes place much earlier than for rigid domains. The critical Reynolds number for this transition, which decreases as the elasticity modulus of the soft wall is reduced, is as low as 200 for the softest wall used here (in contrast to 1200 for a rigid-walled channel). This indicates that the coupling between the fluid stresses and the elastic stresses in the wall results in an instability of the laminar flow. We have also looked at the possibilities of delivery of the therapeutics to the desired injection site by utilizing the concepts learned. While the precision of the delivery of therapeutics to the desired injection site enabled multiple life-saving treatments, improper insertion or positioning of needles, catheters, and trocars can cause mechanical injury to adjacent tissues, and often require repeated attempts to achieve correct placement. Here, we show a highly sensitive, completely mechanical, and cost-effective injector for targeted tissue. The injector senses the loss of resistance to fluid flow on encountering a softer tissue or a cavity and stops advancing the needle and delivers the therapeutics at the desired injection site. This simple yet effective injector can be adapted for a broad variety of clinical applications including drug delivery to some of the challenging sites such as the suprachoroidal space of the eye.

ABOUT THE SPEAKER

Dr. M. K. S. Verma received the Ph.D. degree in chemical engineering from the Indian Institute of Science, Bangalore, India, in 2013. From 2013 to 2015, he was a Postdoctoral Research Fellow with Harvard Medical School, Boston, MA, USA. From 2015 to 2019, he was a Chief Engineer with Samsung R&D Institute, Bangalore, India. During this period, his scientific work was focused on the development of a battery management system (BMS) for electric vehicles (EVs). Since 2019, he has been with the Indian Institute of Technology Delhi, New Delhi, India, where he is currently an Assistant Professor with the Department of Chemical Engineering. His research interests include lithium-ion batteries, electro-chemical modeling, BMS, fluid mechanics, microfluidics, and medical devices.

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