

An Indian-Australian research partnership

Project title Instability and mixing enhancement of pulsed jet flows

Project number: IMURA0134

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Research Academy theme/s

List only the research academy theme/s that is relevant to the project

1. Advanced computational engineering, simulation and manufacture
6. Biotechnology and stem cell research

The research problem

The aim of the project is to study instability and transition to turbulence of pulsatile jet flows. Steady jet flows where flow issues from either a pipe end or a wall orifice into a larger body of fluid are relatively well understood. However, pulsatile jet flows, where oscillatory flow is superimposed on the underlying steady flow are poorly understood, but have a number of important applications and very interesting dynamics. The dynamical behaviour results chiefly from the interaction of vortex rings introduced within the jet by the pulsatility. In a free jet, the resulting instability can lead to greatly enhanced mixing rate of fluid within the jet and the surrounding quiescent fluid, as shown in the flow visualization photographs of figure 1. This area has been studied experimentally by A/Prof Agrawal, resulting in enhanced physical understanding, quantification of mixing, and a number of international research publications.

Contained pulsatile jets, as for example in pulsatile stenotic arterial flows are another significant instance, this time with biological relevance when considering the uptake of blood-borne solutes such as cholesterol, oxygen and proteins. Stability analysis and numerical simulation of transition to turbulence in these flows has been under investigation by A/Prof Blackburn (see figure 2), resulting in a number of significant research publications.

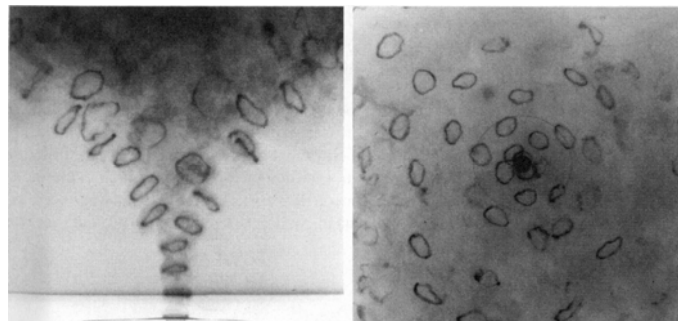


Figure 1: A bifurcating/ blooming pulsatile jet issuing from a wall. Reynolds et al., *Annu Rev Fluid Mech* **35**, (2003).

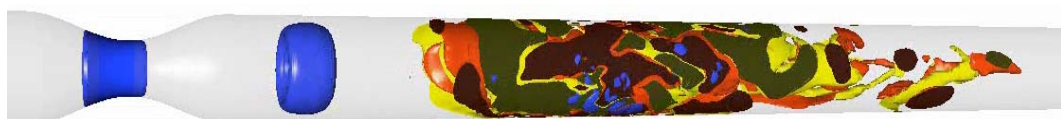


Figure 2: Period-doubling instability and transition of a pulsatile jet produced in an idealised arterial stenosis. Blackburn & Sherwin, *J Fluid Mech* **573** (2007).

Project aims

This project will be a joint numerical and experimental study of stability, transition and mixing resulting from flow of pulsed jets issuing from a wall. The aim is to find parameter regimes of pulsatility (e.g. dimensionless pulse period) that lead to reduced stability and optimal mixing between jet and surrounding fluid. Experimental work will be carried out at IITB facilities under direction of A/Prof Agrawal, while numerical stability analysis and flow simulation will be carried out under direction of A/Prof Blackburn.

Expected outcomes

The project will provide a sound basis for PhD research, leading to enhanced understanding and promotion of mixing with application to manufacturing processes involving mixing and reaction (including combustion). The work will also lead to a number of significant publications in high-ranking international journals such as *Journal of Fluid Mechanics* and *Physics of Fluids*.

Which of the above Themes does this project address?

1. Advanced computational engineering, simulation and manufacture
6. Biotechnology and stem cell research

How will the project address the Goals of the above Themes?

The research findings of the project will be technologically significant in a wide range of industrial processes involving jet flows. Enhanced mixing produced by pulsatile jet instability can lead to more complete combustion and reduced NOX emissions in non-premixed flames, and will also be potentially significant in low Reynolds number flows typical of biological laboratory and microscale applications, where laminar diffusion is a rate-limiting factor.