# Modeling intertial forces on cylinders in cross flow using moving frame of reference

# 

Seyed Hossein Madani/Jan Wissink/Hamid Bahai

College of Engineering Design and Physical study - Brunel University London

**Key** **words**: Immersed-Boundary, interpolation/Reconstruction method, pressure gradient, Vortex shedding, FSI

ABSTRACT

Fluid flowing around a moving bluff body with an irregular geometry has received significant attention in many applications in the recent decade [1,2]. Such a problem can be simulated using either an inertial frame of reference or a moving (non-inertial) frame of reference. In the latter case, which is mainly applicable when there is only one moving body or all bodies move in unison, the frame of reference, in which the governing equations are solved, is attached to the moving body. In both cases the solid body boundary can be modelled using conforming (e.g. ALE) or non-conforming (e.g. IB) methods. Here, an immersed boundary (IB) method is applied.

Paskin [3] was the first to employ the immersed-boundary method for solving flow problems in regions with complex/moving boundaries. These methods are normally classified into continuous and discrete forcing approaches depending on the way that the solid boundary is enforced on the fluid flow. In the discrete forcing approach, the interpolation/reconstruction method is often used: When the boundary does not align with a mesh line, the solution algorithm is locally replaced by a velocity interpolation to enforce the boundary conditions on the flow field [4].

In this paper, a comprehensive parametric study is performed to define an optimum grid size and computational domain extent. Also, the effect of the fluid inertial force in a moving frame of reference is investigated. It is shown that the difference between the governing equations in the relative form and inertial form of reference is the fluid inertial forces which can be added separately to the simulation results [5]. In addition, results of simulations using two frames of reference are contrasted. It is shown that the main source of noise in the lift coefficient is the lift due to the pressure in a non-inertial frame of reference.

Here, the flow governing equations were solved on a Cartesian mesh using a projection method. The intermediate velocity is integrated in time using a Runge-Kutta method for the convective and diffusive parts followed by solving the Pressure Poisson equation to project the intermediate velocity field on a divergence free vector field. The problem is investigated for flow around a circular cylinder in two dimensions for a forced vibration case. The drag and lift coefficients are compared to assess various pressure and velocity boundary conditions near the immersed boundary.

**References**

1. Mittal R, Seshadri V, Udaykumar HS. Flutter, tumble and vortex induced autorotation. *Theor Comput Fluid Dyn*. 2004;17(3):165-170.

2. Williamson C, Govardhan R. A brief review of recent results in vortex-induced vibrations. *J Wind Eng Ind Aerodyn*. 2008;96(6):713-735.

3. Peskin CS. Flow patterns around heart valves: A numerical method. *Journal of computational physics*. 1972;10(2):252-271.

4. Kang S, Iaccarino G, Moin P. Accurate immersed-boundary reconstructions for viscous flow simulations. *AIAA J*. 2009;47(7):1750-1760.

5. Meneghini J, Bearman P. Numerical simulation of high amplitude oscillatory flow about a circular cylinder. *J Fluids Struct*. 1995;9(4):435-455.