Parametric Investigation of the Common Geometry Shapes for Added Mass Calculation

Afsoun Koushesh[1], Jin Lee[1]
1. American University of Sharjah, Department of Mechanical Engineering, P.O. Box 26666, Airport Road, University City, Sharjah, U.A.E;

Introduction: Fluid-Structure Interaction (FSI) occurs due to the interaction of multiple continuum fields. The added mass loading, hydrodynamic mass, is one of the most common FSI phenomenon. Basically the added mass effect can be seen as when a structure acts as if it were heavier by an added amount while being overwhelmed by an external continuum. This work is aimed to demonstrate how variation of geometries' parameters would affect the fluid loading effect. Three-dimensional objects such as solid circular cylinder, a solid sphere, and a rectangular cantilever beam are placed in water.

Computational Methods: In COMSOL simulations, the eigenfrequencies and kinetic energies are used in the calculation of added mass in acoustic and fluid structure interaction modules respectively and compared with the analytical values.

Equations 1. Analytical FSI Equations [1]

$$KE_{fluid}\int \frac{1}{2} V_{rel}^2 dm = \frac{1}{2} mhU^2$$

for a sphere, $$m_h = \frac{2}{3}\rho\pi R^3$$

for a cylinder, $$m_h = \rho\pi R^2 L$$

Equations 2. Analytical Acoustic Equations [2]

$$m_{add} = \rho_{add} \times V$$

$$\rho_{add} = \frac{N^2 C_n^4 EI}{W_{wet}^2 AL^4}$$

Results: It has been found that increase in cross section and length of these three common geometries will result in a higher fluid loading effect.

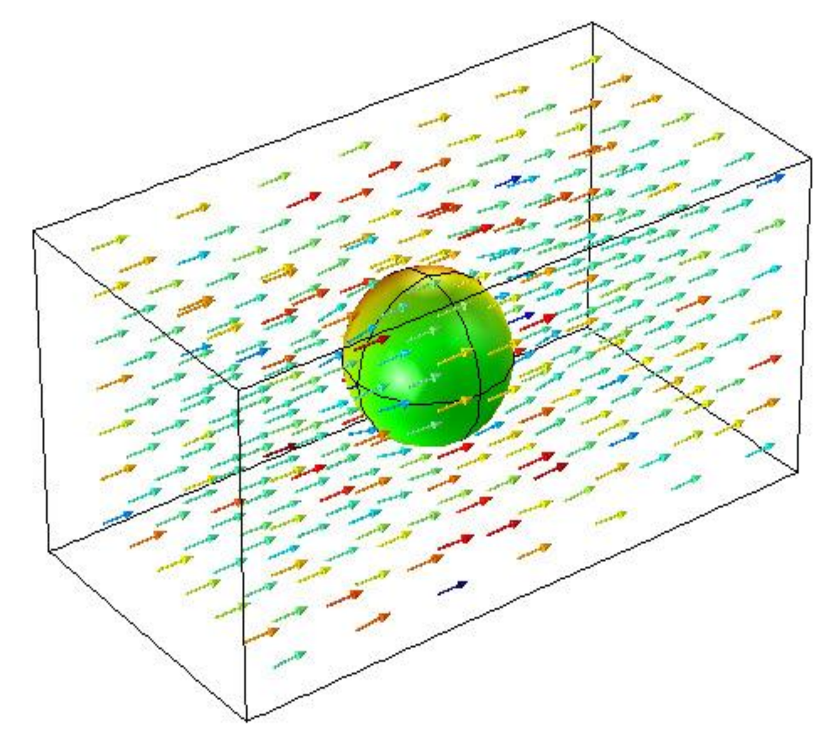

Figure 1.Solid Sphere FSI Domain

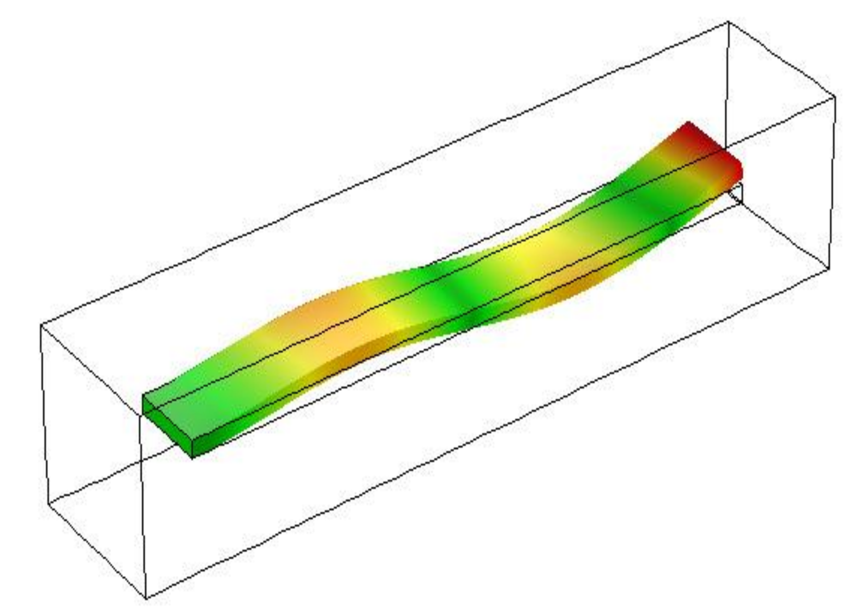

Figure 2. Rectangular Cantilever Beam FSI Domain

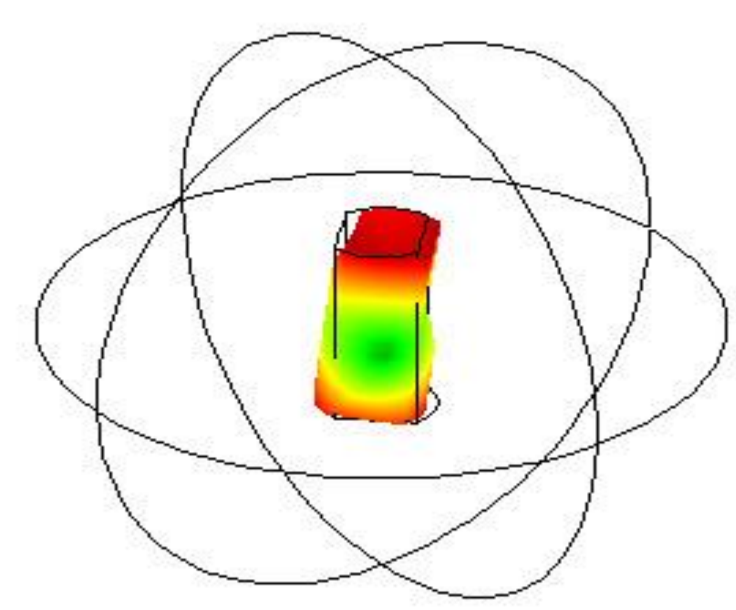

Figure 3. Circular Cylinder Acoustic Domain

Conclusions: An extension of this objective was to determine the computed added mass with the variation of geometric parameters so that such correlations may be used for design purposes.

References:

1.White F. M., *Fluid Mechanics*, 5th ed., McGraw-Hill, New York, NY, Chap.8. pp. 566-568, (2003)
2.Sader J. E. and Van Eysden C. A., Frequency Response of Cantilever Beams Immersed in Compressible Fluids with Applications to the Atomic Force Microscope, *Applied Physics*, **109**, pp. 1-8, (2009).