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Generalized Internal Boundary method applied to multi motion in ICE

Daniel Deising[1], Thomas Schumacher[1], and Paolo Geremia[2]

[1]*Engys GmbH, Rostock, Germany*
[2]*Engys Ltd., Trieste, Italy*

In the numerical modelling of internal combustion engines, one particularly challenging part is the modelling of geometrical changes through moving parts (piston, injection valve). Standard mesh motion/deformation algorithms are suitable only for relatively small topological changes and especially the modelling of completely closing a geometry – like a fully sealed valve – becomes unfeasible.

For such purposes we have developed a different type of dynamic mesh algorithm named Generalized Internal Boundaries or GIB in short. The basic mechanism of this method is through snapping of cell faces to a geometric representation (e.g. stl) of a moving boundary. In this new framework, standard boundary conditions (fixedValue, zeroGradient etc.) can be applied on new immersed boundaries which are constructed from existing faceZones and produce identical results to the standard boundaries. This framework is powerful in applications with moving parts such as rotating gears, FSI, multiphase applications and also internal combustion engines. Using GIB [1, 2], the point coordinates of the faces near the interface are snapped on the interface. After the snapping, a faceZone which contains the faces which are located exactly on the interface is constructed. A new boundary is created based on the faceZone and boundary conditions are applied. The matrix contributions of each OpenFOAM operator (fvm::, fvc::) using GIB and body-fitted meshes are the same which guarantees that the results are identical. The implementation is generic, and no additional numerical schemes or executables are required.

References

[1] G.K. Karpouzas. A Hybrid Method for Shape and Topology Optimization in Fluid Mechanics. PhD thesis, National Technical University of Athens, 2019

[2] G.K. Karpouzas and E.D. Villiers. Generalized Internal Boundaries (GIB). arXiv.org, 2017