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Comparison of single-solver FSI techniques for the FE-prediction of a blow-off pressure for an elastomeric seal

Niall Morrison[1], Yevgen Gorash[2] and Robert Hamilton[3]

Department of Mechanical and Aerospace Engineering, University of Strathclyde, Glasgow G1 1XJ, UK
[1]niall.morrison.2014@uni.strath.ac.uk
[2] yevgen.gorash@strath.ac.uk
[3] r.hamilton@strath.ac.uk

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Assessment of leakage performance is a fundamental aspect in the design of elastomeric fluid seals. The key characteristic of the leakage performance is the blow-off pressure, which when it is reach, the leakage rate through the seal is no longer acceptable and the seal no longer performs its function. Prediction of the blow-off pressure under different operating conditions such as the amount of preload, pressure build-up rate, etc., would facilitate improvement in the seal design methodology and would allow subsequent efficient optimisation of a seal design. For an accurate prediction of the blow-off pressure, any computational methodology should ideally include Fluid-Structure Interaction (FSI), since the geometrical disposition of the seal, its deformation and its contact conditions with respect to the main structure are adversely affected by the fluid pressure. Three FSI single-solver techniques, available in the commercial FE-code Abaqus, are investigated in this study with application to the simulation of leakage. The most basic technique is Pressure Penetration Interaction, available for general structural analysis using a static implicit solver, which propagates the applied fluid pressure into contact openings. A more advanced technique is Acoustic Pressure Interaction available for coupled acoustic-structural analysis in a dynamic implicit solver, which is used to model the total pressure within the fluid surrounding the seal. The most advanced FSI technique is the Coupled Eulerian-Lagrangian (CEL) approach available for coupled fluid-structural analysis in a dynamic explicit solver. The CEL approach is the most versatile and can be applied to a wide range of FSI problems, e.g. simulation of a seal blow-off and fluid leakage through the resulting contact gap [1]. When trying to develop the art and science involved in the simulation of leakage phenomenon, a robust FSI technique appears potentially to be a critically important design tool which could be applied to a wide range of more complex sealing geometries. This paper addresses a typical hollow rubber seal and investigates how the amounts of initial compression and initial stretching affect the leak tightness of the seal using three different FSI techniques. The complexity of problem setup, the efficiency of the solver and the robustness of obtained solution will be compared and discussed.

REFERENCES

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