MASTER

Fluid-Structure Interaction Analysis

A Study Based on the Turek-Hron FSI Benchmark

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M.Sc. Mechanical Engineering (Power and Flow)

Fluid-Structure Interaction Analysis: A Study Based on the Turek-Hron FSI Benchmark

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This report was made in accordance with the TU/e Code of Scientific Conduct for the Master thesis.

Declaration

I hereby certify that I have created this report (graduation assignment) independently[1] and exclusively using the specified literature and resources. The work has not been submitted to any other examination authority in the same or a similar form, nor has it been published. The work carried out and presented in this report is confidential. This report was made in accordance with the TU/e Code of Scientific Conduct for the Master thesis.

Eindhoven, February 7, 2024

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[1]Additionally, I acknowledge the use of artificial intelligence (AI) tools, such as ChatGPT and Google Bard, which provided support in very minimally generating, and enhancing the academic articulation and presentation of the content within this report. Furthermore, an online plot digitizer was utilized to extract numerical data from graphical representations in published papers, facilitating a more detailed analysis and comparison within this study.

Public Summary

This graduation project provides an examination of Fluid-Structure Interaction (FSI) analysis using the Turek-Hron FSI benchmark [1] as a basis. The primary goals of this study were to reproduce the benchmark, gain a thorough comprehension of FSI principles and scenarios, and, based on the results, suggest recommendations for future research relevant at Canon Production Printing (CPP) .

This report consists of six chapters, starting with an overview of FSI, its fundamental equations, followed by the specifics of the Turek-Hron benchmark. The text covers topics such as numerical methods, ANSYS simulation details, meshing, solver choices, and encountered problems. The Computational Structural Mechanics (CSM), Computational Fluid Dynamics (CFD), and the FSI results are compared to the benchmark findings, highlighting the intricate nature of steady versus transient simulations, the need of accurate meshing and solver selection in CFD, and the computational requirements of FSI situations, which involve data transfers and the management of the added-mass effect.

The key findings emphasise that CSM test cases are relatively simpler compared to the more intricate and computationally intensive CFD and FSI examples. The study highlights the significance of mesh quality, selection of solver, and under-relaxation parameters in attaining stability and convergence. Furthermore, it tackles the difficulties presented by the pronounced added-mass effect, particularly in situation where the densities of the structure and fluid are equal. The article concludes by suggesting potential areas for further research, taking into account the similarities with actual conveyor belt situations at CPP. This provides essential knowledge on FSI analysis and its practical applications in printing technology.

Bibliography

[1] S. Turek and J. Hron, "Proposal for Numerical Benchmarking of Fluid – Structure Interaction Between an Elastic Object and Laminar Incompressible Flow Proposal for numerical benchmarking of fluid-structure interaction between an elastic object and laminar incompressible flow," no. June, 2007.