Acoustic analysis of a simplified oil pan using a coupled FE-SPH approach

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ABSTRACT

Already in an early stage of the design process the manufacturer has to be enabled to estimate the performance of new products. Thus, the design can be favorably influenced from the first draft in order to reach specific goals. Furthermore, expensive prototypes are only required to be built for the final testing.

The aim of the current contribution is to extend a holistic simulation approach for computing the acoustical behavior of the structure that has been proposed in a previous publication [1]. In this publication a motor engine block including its oil pan has been simulated using the finite element method (FEM). The results have been compared to acoustical measurements of a running engine recorded with a microphone array. A disagreement between the numerical and experimental data has been observed. The detected differences could be caused by the influence of the oil on the acoustical properties of the system. So far, only the mass of the fluid has been taken into consideration through additional mass elements that have been inserted in the fluid volume [2]. However, this methodology did not yield satisfactory results as it is not able to describe the observed frequency shift. To improve the quality of the numerical simulation and in order to develop high fidelity models the actual fluid-structure interaction (FSI) has to be taken into consideration.

To reach the mentioned goal we propose to couple the FEM with smooth particle hydrodynamics (SPH). Based on a higher order FEM code [3] and the open source program SPHysics [4] a straightforward coupling strategy is implemented. For initial studies a co-simulation approach is deployed. At the interface between the SPH- and FEM-regions the pressure distribution is transferred from the fluid to the solid as an external load. The pressure at the coupling nodes is calculated with Tait's equation [5] and the penetration of the FE mesh is prevented by the use of repulsive boundaries. Therefore, no master-slave-concept needs to be employed [6]. In the next step the response of the structure is computed and both the surface position and velocity of the finite elements in the interface region are passed to the SPH particles. Note that the coupling nodes/particles do not need to be conformal, as the required values can be derived from the elemental ansatz function.

The proposed method for the holistic acoustical simulation of automotive parts is validated based on an academic benchmark test. Here, we observe a shift in the natural frequencies of a simplified oil pan when using the coupled FE-SPH approach in comparison to the previously employed FE analysis. For future applications that are of practical relevance more sophisticated coupling techniques are implemented to further improve the quality of the numerical simulation.

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