FLUID-STRUCTURE-INTERACTION SIMULATION OF PASSIVE AIR BLAST SAFETY VALVES

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Abstract:

Protective structures are usually equipped with ventilation systems, where passive air blast safety valves are important components in the latter. In case of an explosion outside the structure, their purpose is to substantially reduce the occurring blast loading. This assures the protection of human individuals as well as technical installations inside the structure. At the present date, the behavior of such safety valves is mostly characterized by means of experimental tests in a shock tube or with small explosive loads. In order to gain further insights into the behavior of the various safety valve closing mechanisms and to support novel developments for modern civil protection systems as well as the error analysis, additional methods are required.

For this reason, this paper presents a practice-oriented procedure, with the aim to obtain the full structural response and blast pressure leakage of passive air blast safety valves by fluid-structure-interaction (FSI) simulations. This comprises three main steps, where first of all potential software solutions have been investigated by means of expert knowledge and literature research. As a second step after the initial theoretical assessment, two different software pairs were tested by carrying out indirectly coupled numerical simulations, i.e. implementing the safety valve as a moving rigid body in the fluid dynamic analysis after the structural assessment. The most promising software pair has been then applied to perform fully coupled FSI simulations. Ultimately, the procedure is exemplified with existing safety valves as a case study.

In comparison to the experimental results, good agreement was achieved with both, indirectly and fully coupled simulations, when analyzing the pressure-time history of the blast pressure leakage. However, it was observed, that two-way coupled simulations performed superior considering the closing behavior and arrival time of the residual blast wave. This might be explained by the fact that the full structural response as well as the corresponding effects on the fluid flow are considered. Furthermore, the closing time was confirmed by high-speed camera registrations of the safety valve during blast loading.