The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

An extended beam element for piping analysis - Application to pipe whip phenomena

Y. Pascal-Abdellaoui[1,2,*], C. Stolz[2,3], F. Daude[1,2], P. Lafon[1,2] and P.Galon[2,4]

[1] EDF R&D Paris-Saclay, 7 Boulevard Gaspard Monge 91120 PALAISEAU, youri.pascal-abdellaoui@edf.fr

[2] IMSIA, UMR 9219, 828 Boulevard des Maréchaux 91120 PALAISEAU

[3] Institut GeM, UMR 6183, Ecole Centrale de Nantes, 1 Rue de la Noë 44321 NANTES

[4] CEA Saclay, DEN/SEMT, Université Paris-Saclay, 91191 GIF-SUR-YVETTE

Keywords: *Pipe Whip, Beam element, Cross-section variation, Fourier Series*

The pipe whip phenomenon is a consequence of a sudden rupture of a high-energy pipe filled by water or gas at a high pressure. The induced displacements can lead to impact on surrounding pipes and components. This phenomenon is complex as large displacements, large deformations, plasticity and potential impacts could be involved. Approaches based on advanced physical and numerical modelling of the previously mentioned phenomena are needed.

According to [1], both 1D and mixed 1D/3D computations are compared to experimental data issued from the Aquitaine II campaign. The 1D/3D model is shown to be able to retrieve the experimental pipe impact force when the impact zone is modeled with shell elements able to represent the deformations of the pipe cross-sections. In contrast, due to the reduced kinematics of the beam element considering a rigid cross-section, the 1D model leads to an overestimation of the impact force. For real piping systems, the complexity of the pipe networks makes the 3D or mixed 1D/3D computations unrealistic in regards to the corresponding high cost. Then the main objective of this work is to develop an extended beam element which takes into account the cross-section variation. For this purpose supplementary variables using Fourier series are introduced in order to describe the section changes. The new element is first tested in linear elasticity on simple loading conditions (tension, bending, internal pressure). Subsequently a local plasticity model is developed in order to detect the formation of a hinge. The enriched beam element will then be integrated in the 1D Fluid- Structure Interaction formalism described in [2].

REFERENCES

[1] Potapov, S. and Galon, P. Modelling of Aquitaine II pipe whipping test with the EUROPLEXUS fast dynamics code. *Nuclear Eng. Design* (2005) **235**:2045-2054

[2] Daude, F. and Galon, P. A Finite-Volume approach for compressible single- and two-phase flows in flexible pipelines with fluid-structure interaction. *J. Comput. Phys.* (2018) **362**:375-408