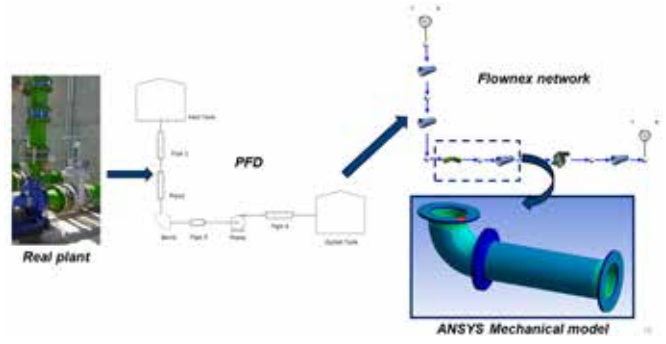
Using a 1D-3D co-simulation of a hydraulic pump failure to measure the pressure surge in a 2km pipeline

FLOWNEX® SIMULATION ENVIRONMENT

Hydraulic systems, from the smallest to the largest, operate in many different situations and under many, often extreme conditions. They can also undergo various operational and emergency procedures, such as the pump tripping or valve closure, that may cause severe pressure surges. The so-called "water hammer effect", which can damage a system and cause serious safety issues, is a frequent problem affecting hydraulic systems.

Since it is not possible to test most of these systems before their installation, it is very important to create the most reliable design possible in the early phase of a project. One solution is to create a virtual system model that includes the Piping and Instrumentation Diagram or the Process Flow Diagram of the pipeline.

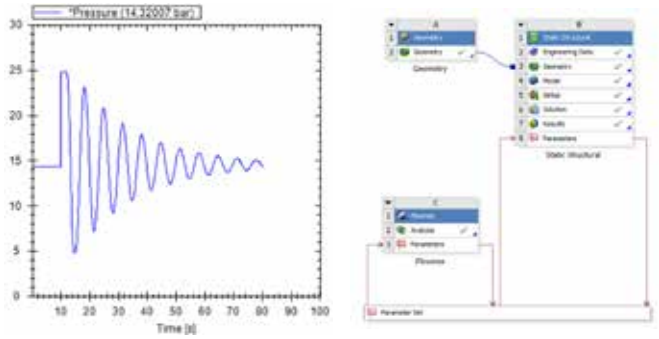
Flownex can be used to model both simple and complex hydraulic networks, and to simulate and predict critical scenarios such as the pump



tripping or valve closure. Generally speaking, Flownex is a Computational Fluid Dynamics (CFD) system simulation software that solves equations for conservation of mass, energy, linear and angular momentum. Its fundamental approach is based on a thermal-fluid network of 1D flow components, together with two-dimensional rotating components, and heat transfer building blocks. The solution is calculated with an implicit and fast steady-state and dynamic solver.

In this example, a 2-km water pipeline was modeled in Flownex. The modelled pump moves the fluid flow by rotating at 1450 rpm with a rated mass flow of 140 kg/s. The scenario simulated a sudden critical event that causes the pump to trip and fail.

Flownex dynamic transient solver is able to simulate the pressure wave that would be produced by such an event,



providing the user with the resulting pressure distribution all along the 2-km discretized pipe, at every time-step simulated.

The software is very easily coupled with ANSYS 3D models for instant co-simulation results, such as the total deformation in the pipe bend due to the pressure wave. In a 1D-3D coupling, the 1D system's accuracy in modelling complex and critical elements is greatly increased by the detailed three-dimensional model. Similarly, the 3D simulation can take advantage of the boundary conditions provided by the 1D simulation. Combining large but fast-solving 1D networks with accurate 3D models can create very high fidelity simulations, for both steady and transient states.

In this case study, the Flownex network was embedded in the ANSYS Workbench environment. The WB Parameter Set enabled the output pressure data from the water hammer simulation to be passed to the Static and/or Transient structural models of the pipe.

ANSYS Mechanical calculated the deformation and the Von Mises stress in the model of the local critical part of the pipeline, in this example a bend, allowing the user to understand if the intensity, duration and frequency of the pressure wave could be dangerous for the pipe's integrity.

The simulation time required for this kind of 1D-3D coupling naturally depends on the type of mechanical model, and ranges from a few tens of seconds for a coupling with the Static Structural model, to a few minutes for a coupling with the Transient Structural model.

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