designing a vacuum system using lumped element modeling.

DEMCON MULTIPHYSICS

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Goal

To design a vacuum system, one must decide where/how to place the required components, such as vacuum pumps, control valves, piping, vessels, pressure sensors and natural gas inlets. To optimize the design, it is important to understand how the placement and usage of these components affect the pressure in the system. In this project, a lumped-element model (LEM) was used to provide insight into the overall system behavior and interaction between components.

The LEM was used to optimize the design of the vacuum system. The pressure and mass flows as a function of time were studied at multiple locations with several different configurations and types of vacuum pumps and flow control valves (which control the inlet flow of Argon gas). Since system performance can be determined quickly, rapid system design iterations become possible.

Approach

A LEM simplifies a system into a circuit consisting of coupled components which are linked through specific connections. Each component is simplified to a two-dimensional 'black box' with certain properties. For example, for a vacuum pump the performance curve can be included, based on the product specifications (Fig. 1). LEM enables rapid modelling of complex systems which can combine multiple physics domains as well as control system technology. The impact of design choices can quickly be tested, so that optimizing the system performance can be done efficiently.

At Demcon multiphysics, the software package SimulationX by ESI is used for system analysis using the LEM method. Since SimulationX is based on the Modelica programming language, all components can be customized if necessary.

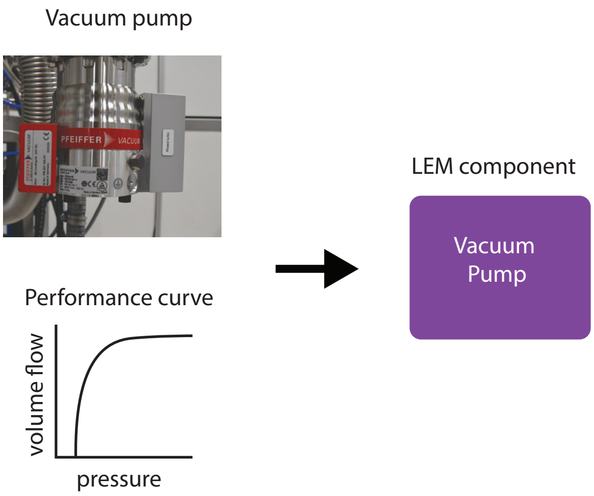

Figure 1. In a LEM, a complex component is simplified to a box with the properties of the component.

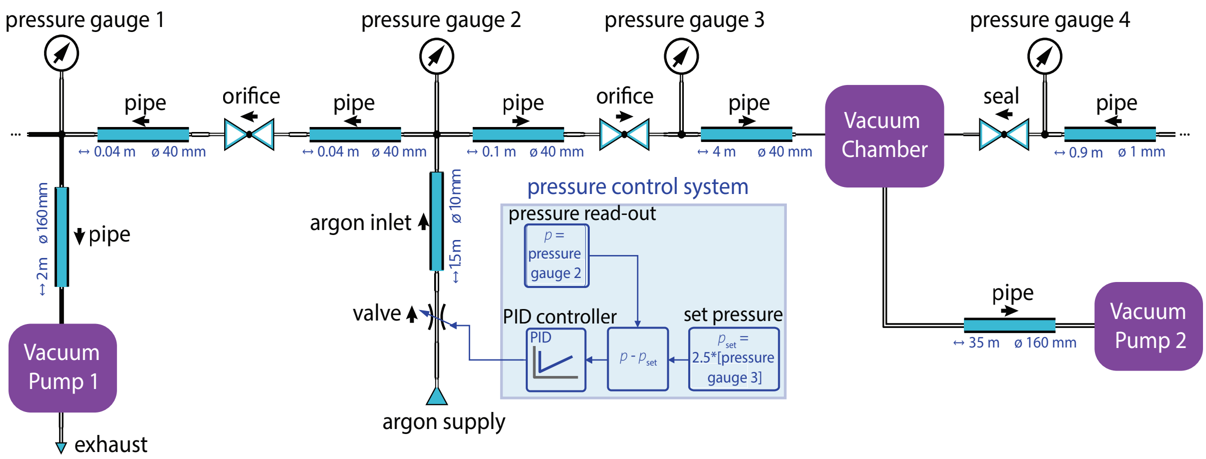

Figure 2. Schematic of the vacuum system, including the components that were considered in the LEM.

Results

Using the LEM of the vacuum system (Fig. 2) we were able to quickly assess the performance of different designs. Based on the predicted dynamic behavior of for example the pressures and mass flows in the system, we optimized the placement of several components. An example of pressures and mass flows in the system during the pump-down/emptying of the system can be seen in Fig. 3. With these graphs it can be determined whether the system meets its requirements and behaves as intended.

Do you want to learn more about our work with Lumped Element Modeling? Contact us!

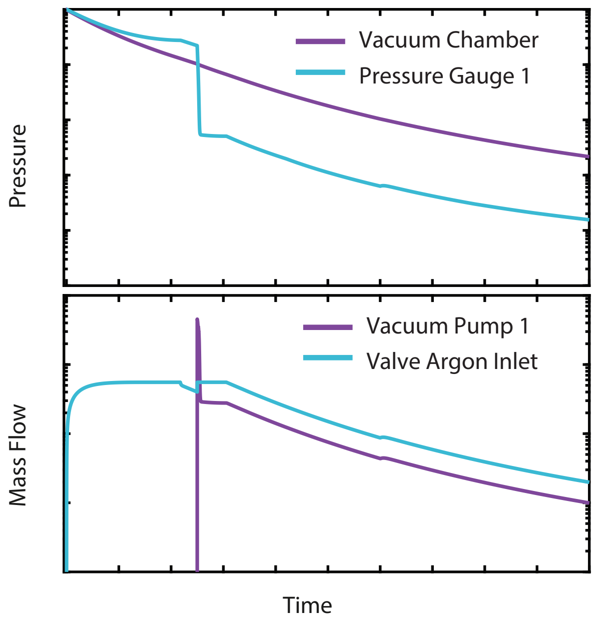

Figure 3. The simulated pressure and mass flow as a function of time during a pump-down of the system from ambient conditions.