Pressure Oscillation Analysis

Pressure and flow ripple in fluid power systems are frequent causes of problems and complaints. The pulsations are significant if the ripple frequencies match the natural frequencies of the pipe network. The ripple causes fluid-borne noise that propagates through the pipe network and excites the surrounding parts to vibrate. This induces undesirable noise emissions, unfavorable dynamic structural loads and naturally, a general reduction of the reliability of the hydraulic system.

The problem in detail

Positive displacement pumps are identified as the main source of fluid-borne noise. Due to the discontinuous operating principle of these pumps, the flow discharge delivered to the pipe network consists of a mean, stationary flow with superimposed periodic fluctuations. If the pump is operated with varying rotational speed as is the case with frequency-controlled pump drives or vehicle and mobile hydraulic systems, the periodic fluctuations excite the pipe network with a broad spectrum of frequencies, rapidly increasing the risk of resonance problems to occur.

To obtain reasonable results when performing a pressure ripple analysis, it is recommending that all components connected to the pipe network should be considered. With the exciting ripples being modelled as realistic as possible, a reasonable analysis of different operating points and resonance conditions can be performed.

DSHplus is used to simulate hydraulic pressure ripple problems. By using numerical simulation, specific virtual experiments can be conduct without worrying about the limitations of the real-world system. Thus, specifically critical operating conditions are identified and examine the system responses, characterized by pressure and volume flow, at any given point within the system. In addition, also mechanical quantities like piston force or velocity can be displayed.

How to model the pipe network

To set up the computer model of the pipe network, the vast selection of different pipe and hose elements provided by the DSHplus component library is used. Even the most complicated pipe networks can be modelled with the supplied parts for valves, resistances, branches, hydraulic accumulators and sudden diameter changes. When simulating hydraulic transients, it is important to model the pressure dependent hydraulic line inflation properly, because it affects the pressure surge propagation and attenuation. The pipe wall parameterization is no problem for steel and other linear elastic materials. Familiar approaches like the Korteweg formula (based on Barlow's formula) are used to account for the pressure dependent pipe expansion.

For viscoelastic materials like polyamide or rubber, the material properties change significantly with pressure level, temperature and excitation frequency. In that case, the advanced wall models of DSHplus must be used to take the dynamic line expansion into account.

How to model the hydraulic excitation

To complete the pressure ripple analysis with DSHplus, a pump model is required which reproduces the characteristic pressure and speed dependent flow ripple as well as the pump impedance.

Therefor a hybrid pump model developed by FLUIDON can be used which is based on the real pump's flow characteristics that were measured by using special techniques such as the secondary source method or impedance matching.

The recorded experimental data of the flow ripple, saved as a multidimensional characteristic map, is used together with tailored physical models to compose the pump model.

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How to analysis and solve the problem

Now all required component models exist to assemble fluid power system, the time domain simulation with DSHplus can be started. A major advantage of the time domain simulation compared with the frequency domain simulation is the fact that nonlinearities and certain types of boundary conditions can be taken into account.

Due to the modularity of the simulation model, the validated components can be first analyzed, independently from the original system to which they are attached, and then combine them to a new and optimized system.

When analyzing the results, the virtual engineering lab tools provided by DSHplus can be used. For frequency domain analyses, DSHplus offers a fast Fourier transform, calculation of the frequency response and an order analysis. One of the main advantages of analyzing the calculated results in the frequency domain is the fact that small amplitudes of a certain frequency can be identified very easily, even if they are superimposed by amplitudes with substantially higher amplitudes at other frequencies.

With the frequency analysis tool of DSHplus the frequency response of two signals can be calculated. To illustrate the transfer function, a Bode diagram is plotted. In addition to amplitude and phase angle, also the coherence function of the two signals is calculated.

To generate a spectrogram the order analysis is used in the following. The amplitude of every point at a certain frequency and point of time (third dimension) is depicted through a color scale in the graph. If the excitation increases linearly with time, single frequency shares can be isolated from the signal.

Special expertise for customer support

The unique combination of DSHplus and specifically tailored test benches enables the FLUIDON-Team rapidly analyze the acoustic behavior of arbitrary pipe (and hose) networks and solve pressure oscillation problems.

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