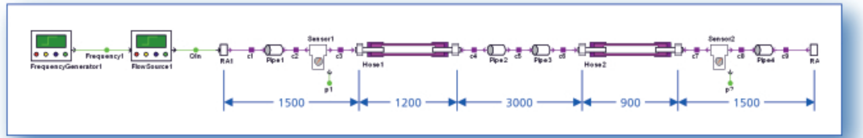
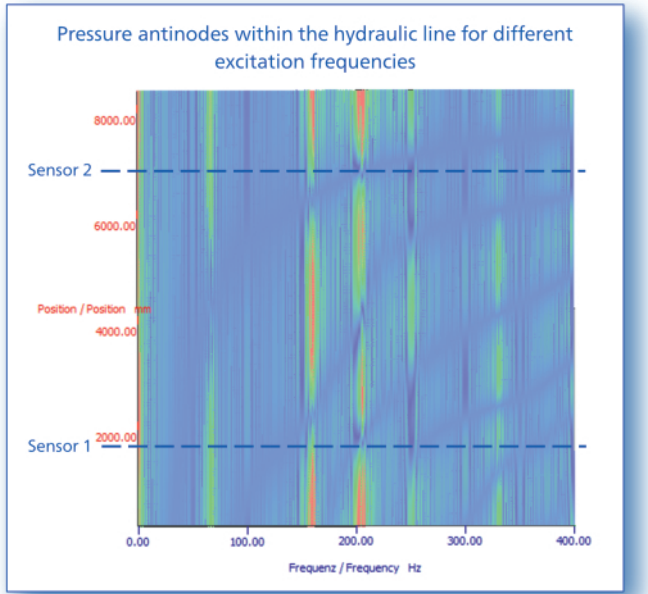


and identifying positions of high and low pulsations. Knowledge about the local pressures within the line is a precondition for the successful development and placement of possible measures. Simulation can provide this information and help to develop solutions while reducing or even avoiding expensive measurement campaignes at the real system.



Highlights

Practical applications have shown that RohrLEx approach provides results for the pressure vibration analysis which are comparable to a CFD simulation, but that needs only a fraction of the CFD computing time. Hence, if it is all about to carry out an effect analysis or to prepare or to optimize remedy measures by means of parameter variation, then RohrLEx approach is the suitable method for this.

Target audience and fields of application:

RohrLEx recommends the simulative pressure vibration analysis to all fluid technicians who are confronted with pulsation problems in branched hydraulic piping.

RohrLEx sees typical fields of application for the simulative pressure pulsation analysis for stationary hydraulic machinery and plants, mobile hydraulics in construction, municipal and agricultural machinery as well as for aeronautics, rail and maritime technology,

- where the piping is made by segments of different length and diameter as well as different tube and hose materials
- where the piping is exposed to strongly different environmental temperatures
- which have a cyclical or an intermittent mode of operation with higher clock cycles
- that are equipped with speed regulated pumps for energy supply.

About FLUIDON

Fluid power is our passion, in theory and practice. We place our know-how and our competence to your disposal to realise your ideas and to solve problems.

On theoretical side, our simulation tool DSHplus assists us in, for example

- checking circuit conceptions and ensuring system functionality
- calculating, analysing, and optimising system dynamics
- investigating oscillations in piping systems

In the field, our project-specific equiped test rigs enable us to support simulations by measurements. Typical tasks are

- parameter identification e. g. of valves and pumps
- determination of transmission behaviour of hoses and pipes
- measurements for validation of simulation models

The combination of both marks us as prime address for all those, who are engaged in simulation based design and development of fluid power systems.

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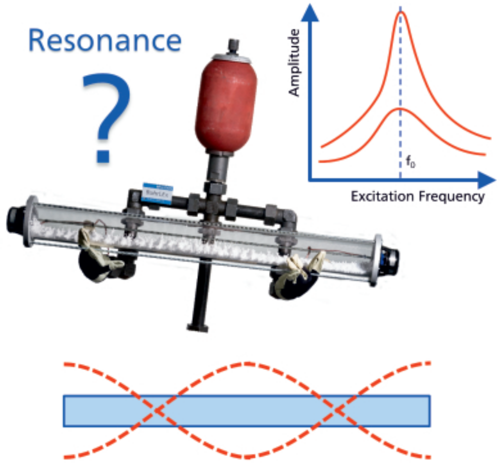
Formation of Resonances in Hydraulic Lines



Simulate
Analyse
Realise

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Simulate Analyse Realise

What does RohrLEx know about the formation of resonances in hydraulic lines?

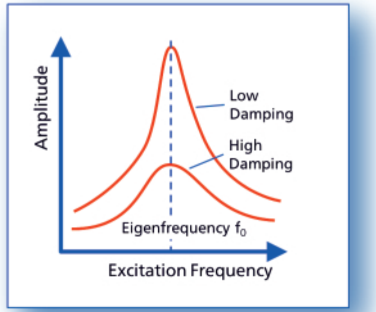
From his long working experience RohrLEx knows about the presence of several Eigenfrequencies in every hydraulic system. But the mere presence doesn't mean there's necessarily a resonance problem.

To provoke a resonance problem these frequencies have to be excited. Casually speaking the pulsation of the source has to “hit” a system resonance.

Problem definition

The dominant source of excitation in a hydraulic system is the flow pulsation of the pump which translates into pressure waves. Modern variable speed pump drives as well as combustion engines in mobile hydraulic applications provide a wide range of frequencies to excite the hydraulic system and are therefore prone to “hit” a resonance.

Additional ways to excite a resonance are cyclic loads on a cylinder or fast switching cycles of valves. Regarding resonance analysis both would represent a source of pulsation as well.

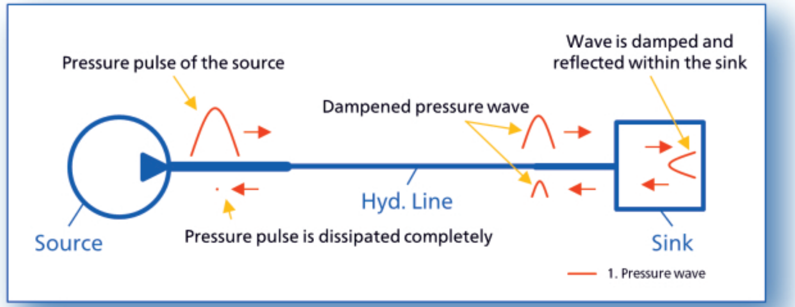


Whether hitting a resonance will result in problematic pressure pulsations or not depends on the systems damping characteristic, the initial pressure amplitude of the excitation and the position of the excitation source within the system.

RohrLEx illustrates the formation of a resonance as follows.

Pressure pulsation and system damping

A pressure pulse starts at the source and propagates through the hydraulic line finally reaching the opposite end of the system.



Due to internal friction within the fluid, partial reflection at fittings or diameter variations and especially due to the visco-elastic properties of hose walls (if present) the pressure amplitude is constantly reduced while running through the system. As a result a part of the pressure wave's energy is dissipated into heat, the remaining pressure pulse reaches the last element connected to the line and might experience further damping.

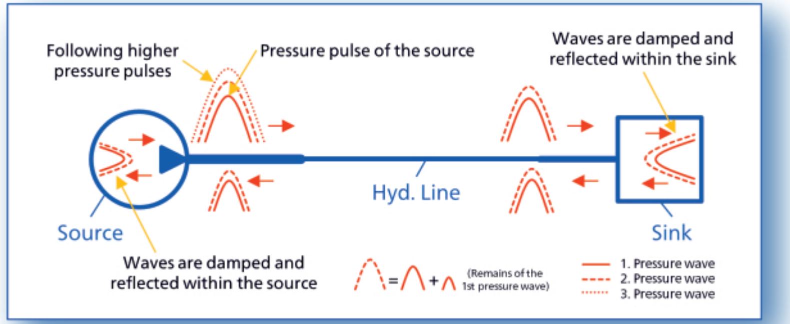
What's left of the original pulse is then reflected in the last element and travels back to the source, all the while dampened further.

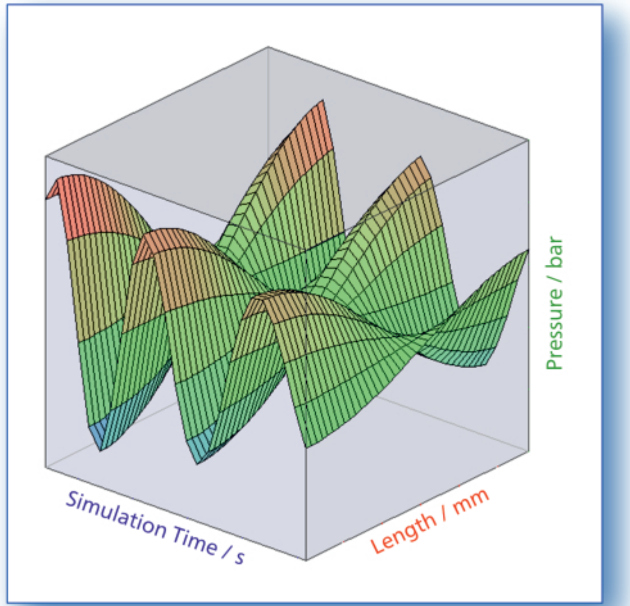
Ideally the inherent damping of the system is high enough to completely dissipate the pressure wave on the way from the source to the end and back. In that case hitting a resonance will not result in a pulsation problem which illustrates why a source with low pulsations is beneficial for the system.

Formation of the resonance

However, the pressure pulsation of the pump is usually high enough not to be completely dissipated. Furthermore the convenient damping characteristics of hoses are reduced with falling temperatures. The returning pressure wave is likely to be still high enough for interaction on its arrival back at the source. If this returning pressure wave happens to be in phase with a new pressure wave currently emitted from the source, the resonance will build up.

Both pressure waves are superimposed forming a wave of higher amplitude than the first one. After this wave travelled through the system and back the returning wave will now be even higher as before since the starting amplitude was higher. With every consecutive wave the amplitude is rising further reaching high levels in a short time frame.





What to do in case of a resonance?

As RohrLEx knows, identifying the Eigenfrequencies and the pressure amplitudes alone will not suffice to solve the pulsation problem. But with this information at hand a solution can be worked out. One way would be to avoid prolonged operation in a critical frequency range by a fast transition into higher or lower values. But more often than not this will not suffice to solve the problem and additional measures are necessary.

Despite the measurements of frequencies and pressures RohrLEx still needs detailed information about the waveform building up in the system. At this point 1-D system simulation is a handy tool to visualize the pressure pulsations in the hydraulic line