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Pipeline Vibrations and Pressure Pulsations – Reasons and Solutions

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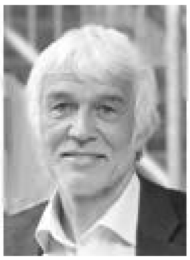

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ABSTRACT

Every pump has some kind of non-continual conveying behavior or effect. Because the conveyed liquids as well as the pipelines and support structures in the connected system are elastic, the conveyed liquid will transport these fluid-mechanical or -acoustical dynamics into the connected system and can excite them to vibrations up to critical resonance situations. The consequences of these dynamics can be fatigue ruptures or not acceptable deformations at or of all connected parts or structures as well as damages.

This tutorial covers all these topics, describes pump characteristics, how a system can react and what can be done to avoid pressure pulsations or vibrations in a system.

Centrifugal pumps or vane cell pumps i.e. always generate vane passing frequencies resulting in certain pulsations while reciprocating machinery and also some rotating positive displacement pumps have pulsating conveying behaviors. In connection with these behaviors also pressure shocks and water hammers can occur.

Pipelines or cantilevers but also more complex structures of process plants instead behave like strings or the corpus of a guitar. They can vibrate like acoustical music instruments and therefore also can be calculated like these.

When the system is simple analytical equations can be used to determine the natural frequencies. Based on this, a stable and stiff system can be designed. But when the system gets more complex only numerical methods can generate reliable results.

When the natural frequencies and the vibrating behaviors are available the correct damper design or damper combination can be selected.

INTRODUCTION

Each pump type is able to generate pressure pulsations and acoustic vibrations. Due to that each pump type is able to excite the connected systems to vibrate hydraulically but also structurally. The most severe type of such an excitation is resonance. The results of such effects are quite often malfunctions of the connected process, damages of the installed sensors, noise or deformations or ruptures of pipelines and the supporting structures. To reach a safe and economical operation of the system it is essential to avoid such effects. But this needs always a basic understanding of the pump characteristics, the usual system responses and how to solve such problems.

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The hardcopies of the ppt-slides enclosed should be used as a script. These slides are equal to the presentation slides.

CONCLUSIONS

The dimensioning of stiff, not excitable pipeline structures as well as the correct dimensioning of damper systems is just a question of correct estimations of natural frequencies. Based on these and the dynamics of the pumps used the speeds of sound, support length and damper sizes can be determined.

This can be simple as long as the system is simple but can get quite complicated, when a system is complex. Under such circumstances numerical tools should be used and also competent persons should be involved.

NOMENCLATURE

A	= Cross section Area	(m^2)
c	= speed of sound	(m/s)
D	= Diameter Tube	(m)
L	= Length	(m)
r	= Radius	(m)
v	= Velocity	(m/s)
λ	= pipeline friction factor	(-)
ς	=local flow friction factor	(-)

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