Challenges in the simulation of hydraulic actuation systems

R. Scheidl[1], B. Manhartsgruber: Institute of Machine Design and Hydraulic Drives

B. Winkler, H. Kogler: Linz Center of Competence in Mechatronics

Abstract:

The basic hydraulic drive principles are very simple which for long kept hydraulic drive technologies a purely technical discipline without advanced scientific background. This started to change about half a century ago when William C. Moog invented the servo-valve and hydraulic servo drives became a predominant technology for aircraft-, aerospace-, tool machine-, and other industrial production system control. The dynamics of hydraulic systems must be modelled mathematically to systematically achieve adequate system performance of these closed loop controlled systems. The higher the wanted band-with of these actuators the more detailed and hence more complex the models must be.

Modern hydraulic drive systems are fairly mechatronic systems, comprising electromagnetic actuators (mostly solenoids) with the required power electronics, various types of valves with a band-with up to 500 Hz, hydraulic transmission lines, reciprocating pumps, hydraulic motors or cylinders, position, velocity, or pressure sensors, signal filters, and controllers. All these components interact dynamically and their dynamic properties may have effect on the system performance.

A rather complex dynamics results from the hydraulic transmission lines. This is of concern not only in closed loop control systems but also in systems with a pulsating extraction of hydraulic fluid, as is the case in fuel injection systems of internal combustion engines or hydraulic valve actuation systems.

Proper mathematical modelling of such systems for engineering purposes should fulfil the following demands

[1] Presenting author

- Sufficient accuracy
- Reasonable computational effort, because system tuning or optimisation ask for repetitive computation
- Compatibility of the models of the different components/subsystems
- Reveal the influence of the system (design) parameters on the system performance
- Facilitate the derivation of reduced order systems for controller design

In this presentation challenging modelling problem considering a novel actuation principle – hydraulic switching control will be treated as an example. This concerns the development of fast switching valves, from the power electronics to the processes in the hydraulic circuitry, including questions of design optimisation and the understanding of complex wave propagation phenomena

An important aspect of mathematical modelling and simulation from an engineering viewpoint – the understanding of the relation between system design parameters and system performance – will be highlighted.