Simulation ensures operation of hydraulic bridges

The most famous hydraulic bridge is probably the Towerbridge in London. The Towerbridge in London is a bascule bridge (sometimes referred to as a drawbridge), a moveable bridge that opens to provide clearance for boat traffic on the River Thames.

Hydraulic bridges are designed to work in a broad range of environmental conditions. The motion cycle may face adverse wind conditions or additional loads like snow or water, but still, the bridge is expected to open and close in time while being able to stop at any time in case of an emergency.

Technical Challenges

The hydraulic system of bascule bridges has to maintain stable working conditions in a wide range of temperatures. Local requirements, e. g. the positioning of the bridge cylinders with respect to the hydraulic power station can have a strong influence as well. Parts of the piping system between pumps, control valves and cylinders are subject to different temperatures, which can affect the viscosity of the hydraulic medium. In addition, the hydraulic system has to cope with shifting lever arms and centers of gravity, which alter the stability criteria while the bridge moves.

## Modeling hydraulic systems of bridges with DSHplus

The operation of bascule bridges is a safety critical application. Although the movement is very slow, high dynamic forces can occur, e. g. during an emergency stop. For this reason, a simulation test of the hydraulic system is usually required when designing folding bridges. In consequence, all parts (mechanics, hydraulics, control, etc.) must be checked for function, operability and safety.
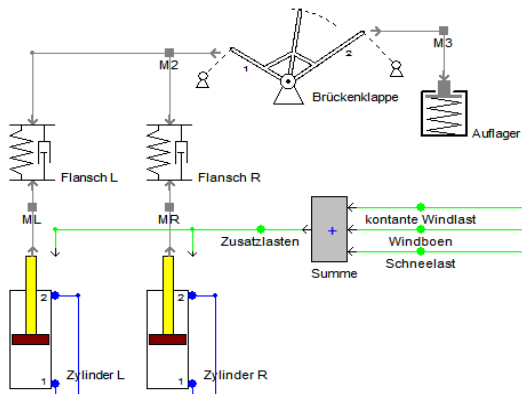
To set up bridge hydraulics and mechanics DSHplus provides all needed components, such as cylinders, swivel drives and hydraulic motors, translational and rotational mechanical gears/belts, translational and rotational masses, calculation of friction with parameters or look-up tables, complex levers to accurately model the actuator's line of movement while the bridge rotates, consideration of shifting lever arms and moving CGs on rotation.

On the system level, DSHplus completes the simulation model with pumps, all sorts of valves, reservoirs, accumulators, and the hydraulic pipe network. Pump time constants, line length and bridge inertia will all affect the acceleration/deceleration times, when movement speeds are changed. With DSHplus it is possible to analyze and optimize control sequences, pressure losses and the stability of the system.

Modeling is done in different levels of detail, starting from basic system simulation with main control valves to evermore complex systems by adding supply pumps, lines/hoses, emergency valves and sophisticated control cycles. Mechanical components calculate the correct lever arm for all angles of rotation for the actuators as well as gravitational forces. Inertia of masses is considered with respect to the rotational axis.
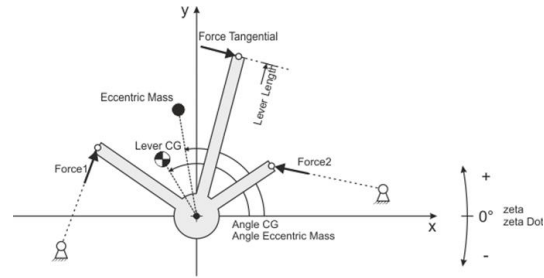
DSHplus has its limitation in modeling of more complex mechanical structures, e.g. modeling of differing cylinder forces of an unevenly loaded bridge due to flexing. In this case, it makes sense using co-simulation to exchange data with an MBD system. Different interfaces help improve this part of the simulation model. Within the Altair Partner Alliance, DSHplus can co-simulate with Motion Solve and solidThinking Activate.

Solution Highlights

By offering an easy to use graphic based modeling concept for dynamic, nonlinear 1D-system simulation, DSHplus enables the user to:

- Model hydraulic systems in any desired level of detail
- Simulate the dynamic behavior of hydraulic systems
- Link DSHplus models with other software via FMI for model exchange or co-simulation

DSHplus is able to support the general engineering of hydraulic systems with simulation models with typical system level detail as well as with high-fidelity physical models.

As a part of the Altair Partner Alliance, DSHplus offers multiple options to exchange data and to interface with programs in the HyperWorks suite. MBD programs such as Motion Solve are used, for example, in co-simulation with DSHplus to improve the mechanical model.

Furthermore, FLUIDON is a member of Matlab® Third Party Program and DSHplus models can be interfaced with Matlab® Simulink®.