FLOWNEX®

SIMULATION ENVIRONMENT

CASE STUDY

TRANSIENT ANALYSIS OF A BOILER FIRE SAFETY SYSTEM

Fire protection systems are installed in power stations, petrochemical plants, warehouses, etc. to extinguish or suppress a fire. These protection systems, although not often used, form an integral part in the safe operation of most plants.

This case demonstrates a transient analysis of the boiler head fire safety system of a coal fired power station using Flownex.

FOSSIL FUEL POWER GENERATION

CHALLENGE:

An engineer observed excessive pressure spikes during pump start-up in the fire water system of a coal-fired power station. A system analysis was required to understand the cause and test possible mitigating measures.

BENEFITS:

Flownex offered the following benefits when used for this system analysis:

1. Enabled testing of different transient scenarios to identify worst-case pressure spikes.
2. Allowed accurate and realistic simulation of pump performance and monitoring of NPSH under varying conditions.
3. Provided a quick way to simulate and evaluate new control philosophies and justify the best option for plant implementation.

SOLUTION:

The system was successfully modelled in Flownex and the pressure spike behaviour replicated. The worst-case scenario was identified as a Direct-On-Line start-up of a single pump in operation. Possible mitigation measures were investigated using the Flownex model and the option to modify the start-up procedure of the pump motors to a star-delta start-up procedure proved to be the most effective in reducing the pressure spike.

The Flownex model showed a reduction in the maximum pressure spikes from ±1500kPa to ±1250kPa. This served as a motivation for later implementing this modification on the plant.

FLOWNEX MODEL

Direct-On-Line start-up applies full line voltage to the motor immediately, causing the pump to accelerate very rapidly and generate a large pressure spike. To investigate this problem, a Flownex network was set up according to plant documentation, as shown in Figure 1.

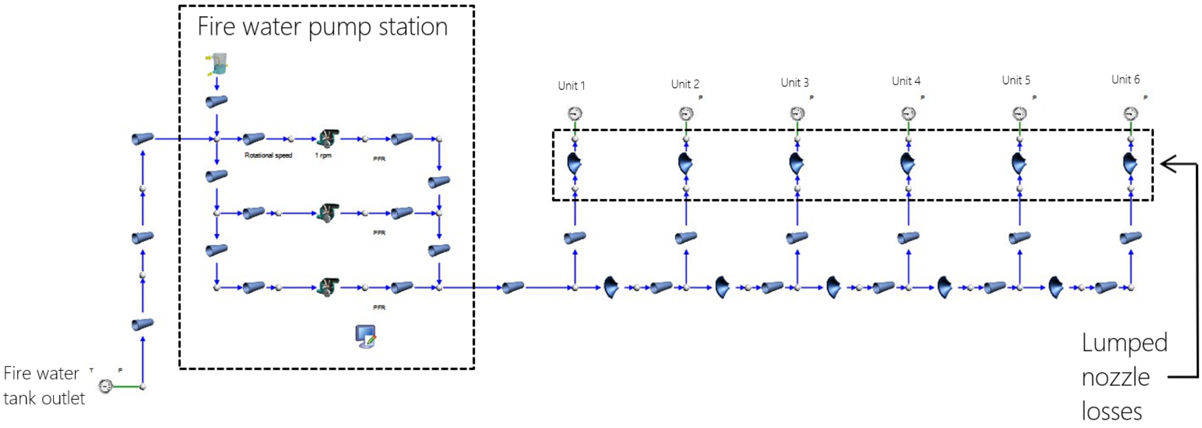

Figure 1: Flownex model of the boiler head fire safety system

The Pipe components are characterised according to the known piping geometry and account for losses due to elevation changes, pipe roughness and fittings. Flow resistance due to nozzle losses were accounted for using Restrictor components on the supply side of the fire system.

The fire safety system has three identical pumps in parallel. To accurately capture the dynamic behaviour of these pumps, their electrical motor torque curves and moment of inertia were included in the Pump component inputs along with the standard pressure rise vs. volumetric flowrate pump curves. This information was obtained from manufacturer pump and motor data sheets. The simulation was started with the water level in the main fire water supply tank at 3.6m - a conservative tank level to evaluate the risk of cavitation.

The following cases were investigated:

1. Starting a single pump while the rest are offline.
2. Starting a second pump while the first pump is already running.
3. Shutting down the only pump in operation.

CASE 1

Figure 2 below shows the transient results when a single pump is started up while the rest are offline.

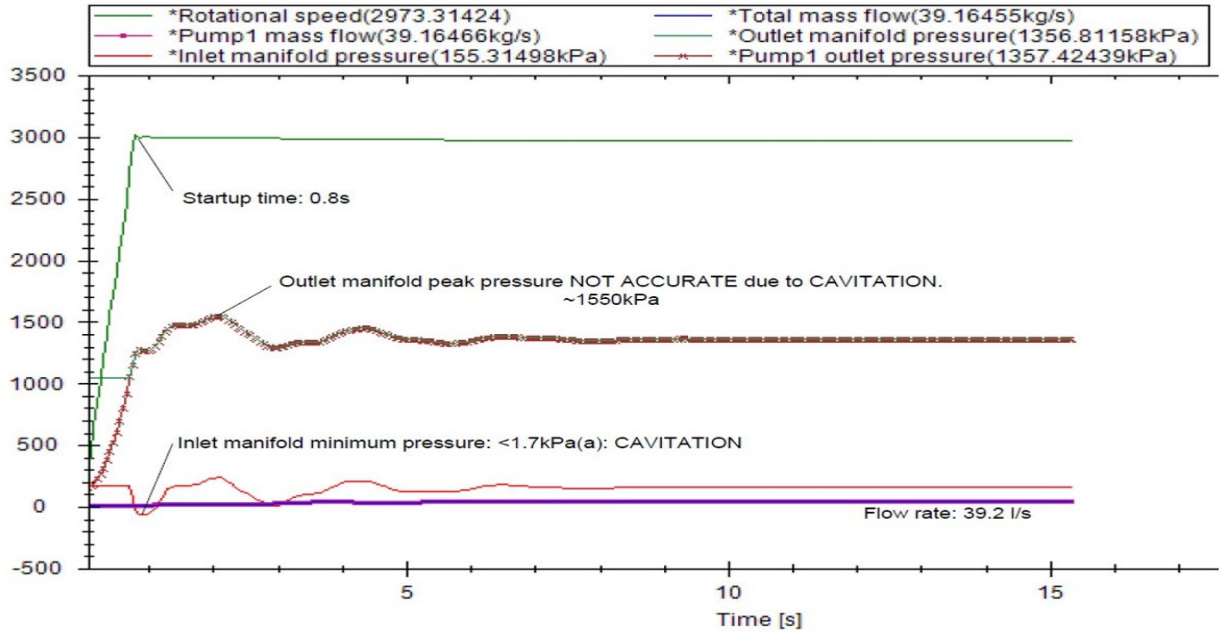

Figure 2: Case 1 results

The rapid startup of the pump resulted in an outlet manifold pressure spike of 1550kPa along with a substantial pressure drop below 1.7kPa on the inlet manifold resulting in pump cavitation.

CASE 2

Figure 3 below shows the transient results when a second pump is started up while the first is already running.

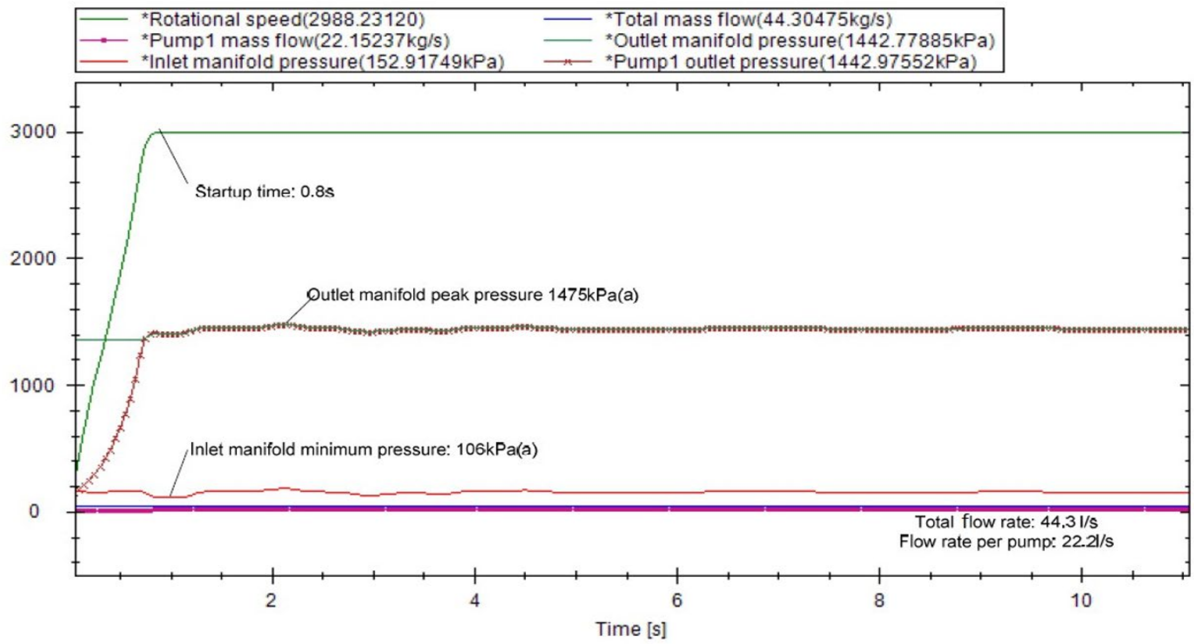

Figure 3: Case 2 results

Startup of the second pump results in no pressure spikes, likely due to an already high upstream pressure maintained by the first pump. The minimum inlet manifold pressure of the second pump decreased but remains far from cavitation pressure.

CASE 3

Figure 4 below shows the transient results when the only pump in operation shuts down.

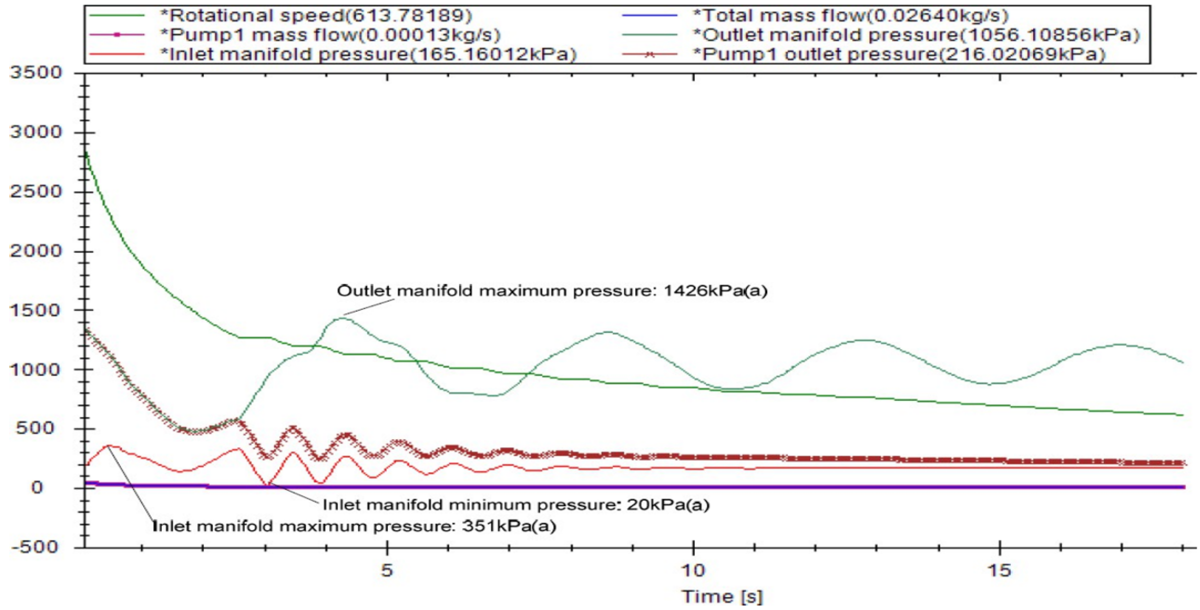

Figure 4: Case 3 results

Both inlet and outlet manifold pressures oscillate slightly, peaking at 20kPa and 1426kPa respectively. The shutdown behaviour therefore poses no risk of cavitation or excessive pressure spikes.

MITIGATING THE PRESSURE SPIKES

Following the analysis of the results, it was decided to implement a star-delta starting procedure for a more gradual startup of the pumps. Figure 5 below shows the transient results when applying the star delta starting procedure to a single pump that is started up while the rest remain offline.

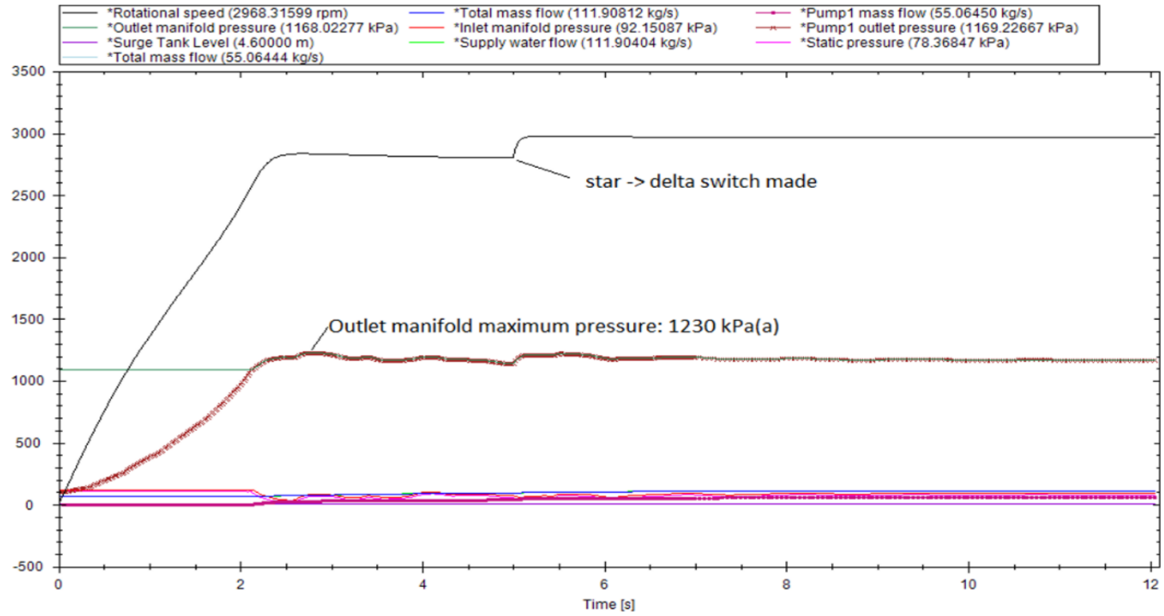

Figure 5: Applying a star-delta starting setup for single pumps startup

By applying a star-delta starting procedure, the maximum outlet manifold pressures during pump startup is reduced to 1230kPa, a reduction of ±250kPa.

CONCLUSION

By modelling the system in Flownex, the worst-case scenario was identified as a Direct-On-Line start-up of a single pump. A mitigation measure, in which a star-delta startup procedure was used, was then tested in the model, showing a reduction of about 250kPa in maximum outlet manifold pressure. These results provided strong motivation for implementing the necessary changes on the plant. Flownex reduced overall project costs by enabling rapid investigation and identification of the issue without causing plant downtime.