TAKING CARE OF FLARE HEADER PRESSURE

Josep Anton Feliu, Sergio Linuesa and Miquel A. Alós, Inprocess, Spain, discuss the application of dynamic simulation to analyse potential trips of the HIPPS system at the flare header of a central processing facility during trunkline pigging operations.

During trunkline pigging operations being carried out in a Middle East oilfield, a pressure build-up was being generated in the flare header of its central processing facilities (CPF). Due to the limit settings in the high-integrity pressure protection system (HIPPS), the pressure build-up risked a production trip. The operator employed Inprocess to analyse, through the use of dynamic simulation, if there were operational or process control alternatives that would allow the execution of current pigging operations to continue without production trips.

A holistic dynamic model was created that encompassed the oil gathering network, the processing facilities and the flare network, thus covering the equipment from the choke valves in the wells to the flare tips. A model of the multiphase trunklines in the gathering network (built in Schlumberger's OLGA) was combined with a model of the CPF and the flare network (built in Aspentech's Aspen HYSYS Dynamics). The link and the interchange of data between the two software systems was achieved using IFLOW technology. Working in this way, the holistic model was capable of capturing the interactions between pipeline transients and processing facility transients, particularly the pressure wave created by the pigging operation and the operation of the high-pressure separator and the flare header.

The holistic model was successfully used to test, analyse and suggest process control alternatives, operational changes and other options which should avoid trip conditions, and consequent plant and production shutdown, while keeping the safe integrity of the whole asset.

Methodology

In this study, the OLGA dynamic multiphase flow simulator models time-dependent behaviours within the transfer lines from wells to the CPF. The Aspen HYSYS Dynamic simulator models time-dependent thermodynamic behaviours and allows easy application of the CPF's control narratives. The link between both simulators allows the analysis of the dynamic interaction between the transfer lines and the process facilities.

A process diagram of the CPF and its HP-LP flare system is shown in Figure 1 including all major equipment. The model covers 6 HP separators with 6 PSVs, 6 ESDs valves, a raw gas compressor unit, connection and HP headers and pressure transmitters. Control narratives have been implemented as well. Models were validated against the H&M balance for normal operation which includes a continuous flaring from HP separator. Figure 2 represents the project simulation model used to complete the study. Multiphase flow trunklines were modelled in OLGA from the choke valves to the HP separator Inlet. IFLOW software developed by the company allows the transmission of pressure, flow and composition data between the two software applications.

Pressure build-up during pigging operations

During a pigging operation on a trunkline, the liquid slugs reached the HP separator and disturbed the pressure behaviour of the facility. The model was used to reproduce the disturbance in the CPF and monitor flare header behaviour. A simulation run was performed keeping the three trains of the facility producing at normal operation while a pig was launched across Train A's trunkline. The resulting velocity for the pig was 8 m/s.

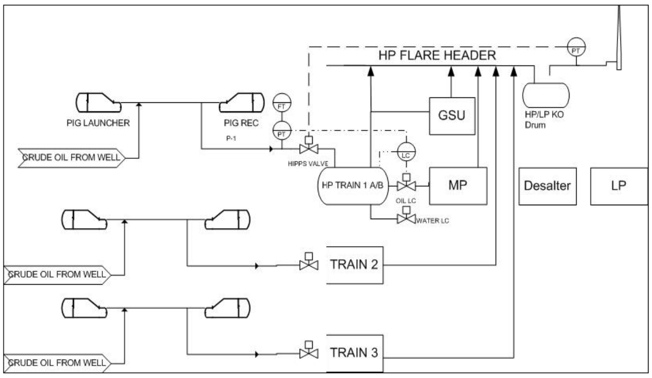

Figure 1. *CPF Plant and HP flare system process scheme.*

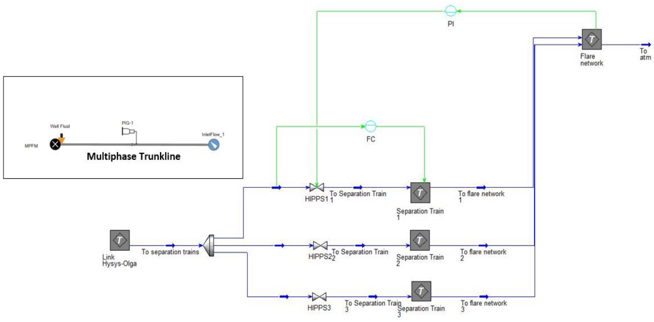

Figure 2. *Modelling approach and methodology.*

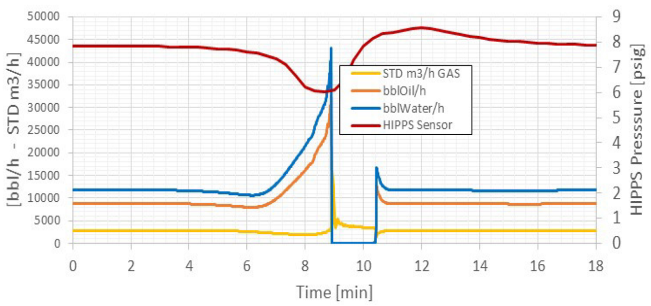

Figure 3. *Gas (yellow), oil (orange) and water (blue) flowrates at the end of the pipeline during normal operation pigging.*

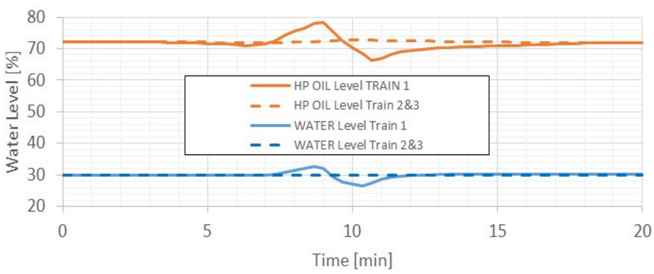

Figure 4. *Oil and water level at HP separators during pigging operation.*

Figure 3 shows the gas, oil and water flow rates at the HP separator inlet.

The effects of the pig in the flowrate appear after four minutes. At such time a smooth decrease of the flowrates could be noted. The liquid slug reaches the HP train after nine minutes. Afterwards, there is a period where no liquid is arriving because the pipeline volume must be filled again. Finally, flow rates return to normal at 11 minutes.

The red curve in Figure 3 represents the pressure at the HIPPS sensor. Pressure at normal operation is 7.86 psig. As the gas flowrate from the Train HP separator decreases during the pigging operation, pressure also decreases to 6.00 psigs. However, when the liquid slug reaches the separator, the gas and pressure build-up to 8.5 psigs. At 12 minutes, the pressure rises to a point where it is very close to the HIPPS set point fixed at 9 psig. In short, the slug reached the separator nine minutes after the pig was launched and the pressure built up at the flare header occurred three minutes later. Pig velocity, length and diameter of the trunkline line and flare header could have a significant impact in this time. Dynamic simulation is a powerful feature for determining the time responses.

Figure 4 shows the oil and water level at the HP separators. The continuous line corresponds to the pigged Train HP Separator while the discontinuous line shows the level for the other two trains.

It can be observed that the level of the pigged line HP separator increases from 72% to 78% but the controller action is able to recover the level. Similarly, the water level increases from 30% to 33%.

Pressure build-up mitigation

From Figure 3 it can be concluded that pigging without reducing the oil production of the CPF reaches 8.5 psig at the flare header. Just 0.5 psi under the trip of the facility by the HIPPS. Some methods to increase the difference between the flare pressure peak value and the HIPPS set pressure at 9 psigs are investigated in this section. The first method suggests a modification of the control philosophy. In fact, overriding the liquid level control action mitigates the pressure build-up keeping the flare header pressure at its normal operational value. Alternatively, pigging at lower velocities reduces the flare header pressure and therefore increases the difference with respect to the HIPPS sensor. However, this method involves a reduction in production during the trunkline pigging operation.

Control philosophy override

In order to mitigate extreme pressure build-up at the flare header, pressure and flow transmitters could be placed at the inlet of the HP separators. By overriding the automatic action of the HP separator controllers of the pigged trunkline, it is possible to reduce the pressure build-up. When the process valve of the inlet flow indicator is higher than 350 tph, the HP oil level control valve opens to 40% and the HP water level control valve opens to 30%.

The continuous brown line in Figure 5 represents the oil levels under normal control action, while the continuous green line demonstrates the oil level of the pigged HP separator with the overridden action. The oil level falls because the overridden action opened the valve from 35% to 40%, as shown by the dotted green line. Once the pig disturbance disappears, the control recovers its automatic action, the valve closes, and the separator recovers its normal operation level. The discontinuous brown line represents the other two trains. It can be concluded, therefore, that the overridden action does not disturb the normal production of the other two trains.

In Figure 6, the continuous blue line represents the water level under the normal control action and the continuous green line demonstrates the water level of the pigged HP separator with the overridden action. The water level falls because the overridden action opens the valve from

20% to 30%, as shown by the dotted green line. The discontinuous blue line indicates the level of the other two separators. Similarly to the oil level, it can be concluded that the overridden action does not disturb the normal production of the other two trains.

Both Figures 5 and 6 allow comparison of the override actions against the auto control action. Figure 5 shows that the overridden oil control valve is not opening as much as the auto control action, while Figure 6 shows that the overridden water control valve does open significantly more than the control action. In fact, the liquid slugs reaching the HP separator are mainly formed by water. Therefore, the overridden action over the water level control gives more room to accommodate the slugs. As a consequence, there is more space for the gas reaching the HP separator and the pressure build-up at the flare header is avoided.

It can be observed in Figure 7 that the pressure peak, casued by the pigging operation at the HIPPS, disappears. Pressure at the flare header falls up to 6 psigs under normal control action. But it falls up to 4.5 psigs under the overridden action because of the available room at the HP separator. In such conditions, the pressure is always lower than the 7.8 psig of normal operation.

Pigging velocity

Maintaining the production of the tree trains while a pig operation is performed in one of the trunklines is possible, but has the drawback of having a high pig velocity (the pig moves at the velocity of the liquid phase). Alternatively, it is possible to reduce the production of the pigged train and use the pig at lower velocities. Reducing the production means a reduction of the amount of gas sent to the flare. As a consequence, the pressure at the flare header is reduced because of the smaller volume of gas.

A sensitivity analysis has been performed to study the pressure at the HIPPS sensor during pigging operations as a function of the pig velocity. Figure 8 shows the pressure build-up against the pig velocity.

An inflection point can be observed around 7 m/s. Decreasing the pig velocity reduced the production of the pigged trunkline to 50% normal production, which also reduces the flare header pressure.

Sequential pigging

Sequential pigging was also studied as another alternative to reduce flare header pressure build-up. A pig with a lower diameter (95% of the total diameter) was launched first to remove some of the liquid, and then a larger pig was launched. Therefore, two peaks were expected but with a lower surge volume. While the first peak was 8.0 psig, the second was 8.4 psig, and consequently this option did not mitigate the pressure build-up.

Conclusions

The holistic model has been successfully used to test, analyse and suggest process control alternatives, operational changes and other options which should avoid trip conditions, and consequent plant and production shutdown, while keeping the safe integrity of the whole asset.

The study shows that pigging produces a large water slug. Therefore, by manipulating the water control level of the pigged train HP separators, the pressure peak at the HIPPS sensor could be significantly reduced. The measurement of a process variable at the trunkline, such as the flow rate or the pressure sensors at the inlet of the HP separator, could also solve the problem. However, this could also be achieved by leaving the water level controller in manual during such operation. Alternatively, turning down the production of the pigged train to 50% of the normal operation also leads to a significant reduction of the flare header pressure and prevents the facility from having a production trip during the pigging operation.

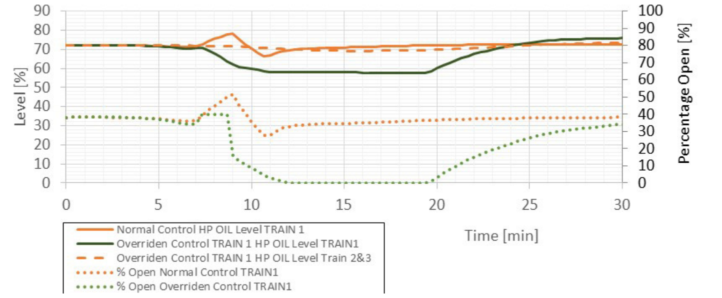

Figure 5. *Level at the HP Separator during pigging with modified control logic.*

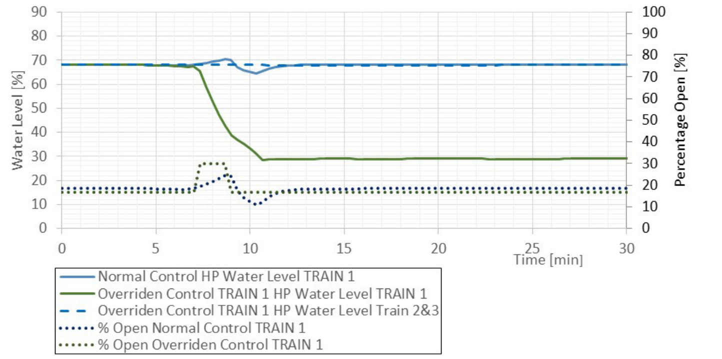

Figure 6. *Water level at the HP separator during pigging with modified control logic.*

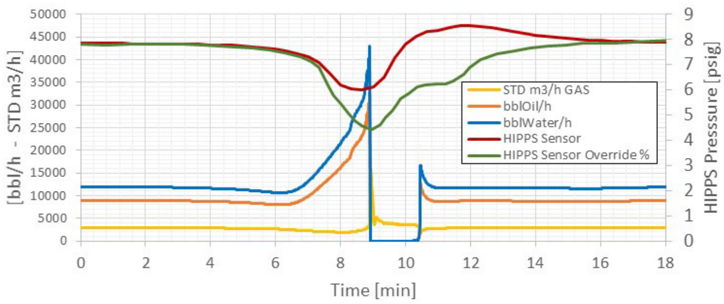

Figure 7. *Gas (yellow), oil (brown) and water (blue) flow rates at the HP separator inlet and the pressure at the OPPS sensor PI-011A/B/C during pigging under overridden control action (green) and the auto control action (red).*

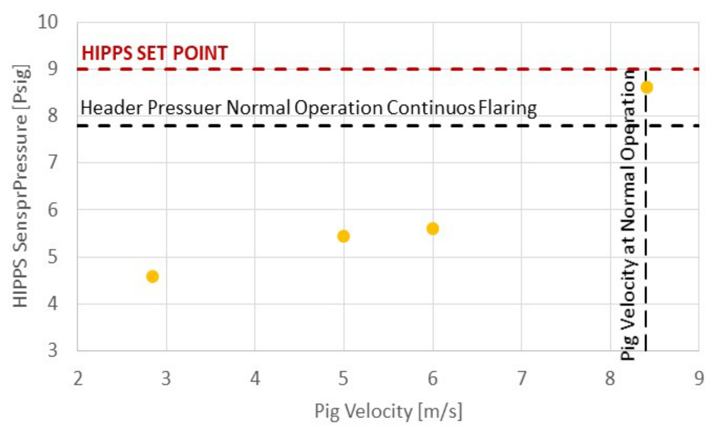

Figure 8. *Sensitivity study of pressure at the HIPPS Sensor as a function of the Pig velocity.*