Case study

Oil & Gas analysis

Billions saved by using detailed blowdown analysis in the design of a high pressure gas plant

A multi-national Oil & Gas operator performed a preliminary blowdown analysis on a high pressure gas plant that indicated a requirement for 80% of the plant to be constructed from expensive stainless steel. To minimise the requirement for stainless steel construction, the operator commissioned PSE to determine the minimum metal temperatures in the process equipment and piping during system depressurisation. The resulting optimised design decreased the stainless steel construction requirement from 80% of the facility to just 30%, with total project savings of up to $1.8bn.

Pre-FEED analysis predicts extensive material embrittlement risks

As with many Oil & Gas facilities, the minimum metal temperatures experienced by this high pressure gas plant are observed during highly transient depressurisation operations ("blowdown"). Analysis in Pre-FEED was performed using a conventional methodology where the entire blowdown segment was represented as an aggregated, idealised volume. Depressurisation was simulated with an equilibrium-based utility. This simple analysis showed that extremely low metal temperatures could be expected in nearly all parts of the processing facility. Violations were predicted even when depressurisation was initiated from typical operating conditions. To avoid material embrittlement, large vessels and piping would require expensive stainless steel construction for approximately 80% of the facility; this was considered to have significant impact on the feasibility of the investment. Detailed information, such as which pipes and equipment items were subjected to low temperatures (and the coincident pressure), was unavailable because of the simplistic methodology used.

The operator and asset owner wanted to substantially reduce capital spend whilst maintaining critical safety standards. They needed detailed information about the location and severity of the worst case minimum metal temperatures in process equipment and piping. The operator contracted PSE to (i) perform a rigorous blowdown analysis of the proposed facility and (ii) to optimise the plant design by collaborating with their engineering teams at the FEED and Detailed Design stages.

PSE Oil & Gas collaborates with design engineering team

To accurately assess potential low temperature risks, PSE created a detailed geometric model in gFLARE for each isolatable blowdown segment. gFLARE models calculated depressurisation times as well as accurate fluid and metal temperatures in all process equipment and piping. The system model incorporated design information such as

- system geometry – pipe and vessel dimensions, wall thickness and materials of construction
- system elevation – points where liquid may accumulate, drainage
- the number and location of blowdown valves / ROs for each isolatable segment

- variable feed gas composition

PSE worked with the design engineering teams using a collaborative approach to understand the system's operational requirements. The team explored the design space by assessing 'what-if' scenarios including the impact of design changes and variable process conditions.

Dynamic, distributed analysis pinpoints areas of real concern

PSE's detailed analysis predicted much more accurate metal temperatures than the preliminary study and identified specific locations of concern using a geometric model representation. Key results included:

- When depressurisation was initiated from typical operating conditions, metal temperatures below the lower design temperature of Low Temperature Carbon Steel (LTCS) were not predicted in any of the blowdown segments
- When depressurisation was initiated from ambient conditions, low temperature violations were predicted in all but one segment, but crucially, these areas were generally restricted to low points and process vessels coming into contact with liquid and at the outlet lines of process equipment in contact with gas
- Variable feed gas composition impacted metal temperatures by as much as 35°C.

Having identified specific locations of concern, PSE collaborated with the operator to develop targeted solutions addressing all predicted issues whilst minimising capital expense. Savings were achieved by optimising material selection and other critical design specifications including wall thickness, line schedules, blowdown valve locations and blowdown rates.

This is illustrated in Figures 1 and 2 for the Feed gas KO drum, where low temperature violations were seen at the bottom head wall which is in contact with liquid, and line 4, where low temperature violations were seen in metal wall in contact with gas. In each figure, the red dotted line denotes the lower design temperature of LTCS.

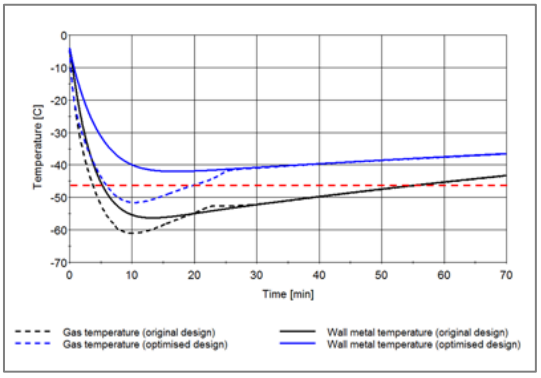

Fig. 1 Feed gas KO drum temperatures

Optimisation of design specifications allowed the selection of LTCS for the feed gas KO drum.

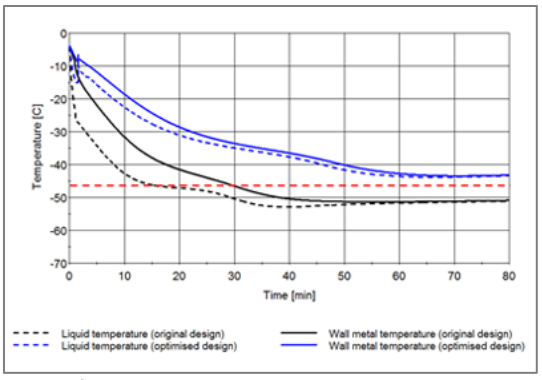

Fig. 2 Line 4 temperatures

Optimisation of design specifications and system topology allowed the selection of LTCS for line 4.

Stainless steel construction drops from 80% to 30%, saving $1.8bn

If the design team relied on conventional single aggregated methodology for blowdown system analysis, then 80% of the facility would need to be constructed from stainless steel. By using a detailed blowdown methodology throughout the design cycle, only 30% of the facility is being constructed from stainless steel - saving the operator up to $1.8bn through reduced material costs.