Energy Company Saves $6M USD with a Performance Engineering Digital Twin

aspentech | Case Study

$6M

USD in savings

CHALLENGE

Frequent amine unit failures at a gas plant in South America were affecting gas sales volumes. Though engineers ruled out mechanical problems, they struggled to find the root cause of the problem.

SOLUTION

Using Aspen Exchanger Design & Rating™ to simulate the reboiler circuit and regenerating column and Aspen HYSYS® to model column hydraulics revealed hydraulic instability in the thermosiphon system for the entire range of operating conditions, from minimum flow to maximum capacity. The model showed engineers they could correct the problem by modifying the thermosiphon piping circuit.

BENEFITS

Troubleshooting and correcting the hydraulic instability improves operations so the company can:

- avoid unplanned shutdowns and save an estimated $6 million USD per year
- prevent damage to the column and related equipment
- maintain integrity of the solvent
- eliminate the risk of export market non-compliance penalties

The customer is one of South America's main energy suppliers and a major operator of gas fields.

Fighting Frequent Unplanned Shutdowns at a Gas Plant

One facility in South America has two amine units of 30 and 18 MMPCD, respectively, for a total processing capacity of 130 MMPCD in a dew point type gas plant. The 30 MMPCD unit presented high corrosion rates and tube puncturing in the reboiler of the regeneration section, contaminating solvent with hot oil. During the first quarter of 2020, the unit required shutdowns for at least three days every four weeks to recover the solvent and repair or block the tubes. This reduced the reboiler thermal capacity, and the company was considering procuring a new reboiler. In addition, lower gas sales volumes meant the company could incur in penalties for non-compliance with export markets.

Though engineers determined mechanical problems weren't creating the tube punctures, they couldn't find the root cause of the problem. Operating with such frequent unplanned shutdowns wasn't sustainable.

Troubleshooting with a Digital Twin

To identify the problem, staff worked with the AspenTech support team to create a model of the amine unit and thermosiphon circuit in Aspen HYSYS and Aspen EDR. The model incorporated detailed geometry and piping arrays and was calibrated against plant data. It helped calculate the circulating flow rates in the thermosiphon system.

The models demonstrated that while the column was operating normally and far from flooding and weeping conditions, the actual problem was occurring in the thermosiphon circuit. Engineers observed that piping and sizing were causing unstable operations and a very low level of liquid at the bottom of the tower and the reboiler, generating excessive surface heating in the tubes and exposure to acid gas corrosion.

Thermosiphon Piping

Piping Reference Points	ft	Pressure Points	psi	°F	Quality
Height of liquid in column	13.7927	Liquid level in column	24.7		
Height of heat transfer region inlet	5.958	Inlet to exchanger	27.98	243.59	
Height of heat transfer region outlet	8.5622	Inlet to heated section	27.42		
Height of column return line	16.3747	Boiling boundary position	27.42		
		Outlet of heated section	24.38	243.91	0.12
		Exit of outlet piping	24.7	243.91	0.12

Pressure changes (-loss/+gain)	psi	Inlet Circuit	Exchanger	Outlet Circuit
Frictional		-0.04	-2.54	-0.37
Gravitational		3.32	-0.55	-0.39
Momentum		0		0
Flashing			-0.02	
Nozzles			-0.16	
Unaccounted		0		0.76
Total		3.28	-3.28	0

Thermosiphon Stability Unstable — two-phase instability possible

Figure 1. Pressure losses Aspen EDR estimated before modifications

Thermosiphons / Kettles / Knockback Condenser

Thermosiphons	
Thermosiphon stability	Unstable — two-phase instability possible
Kutateladze Number in axial nozzle (should be > 3.2)	**3.15**
Circuit DeltaP ratio (Outet/Inlet)	**82.062**
Vertical tube side thermosiphons	
Flow reversal criterion — top of the tubes (should be > 0.5)	
Flooding criterion — top of the tubes (should > 1.0)	
Fraction of tube length before boiling starts	

Figure 2. Instability analysis before modifications

Thermosiphon Piping

Piping Reference Points	ft	Pressure Points	psi	°F	Quality
Height of liquid in column	11.8	Liquid level in column	26.7		
Height of heat transfer region inlet	5.3445	Inlet to exchanger	28.72	247.84	
Height of heat transfer region outlet	9.1778	Inlet to heated section	27.88		
Height of column return line	16.378	Boiling boundary position	27.88		
		Outlet of heated section	27.72	249.54	0.11
		Exit of outlet piping	26.7	248.37	0.11

Pressure changes (-loss/+gain)	psi	Inlet Circuit	Exchanger	Outlet Circuit
Frictional		-0.71	-0.15	-0.51
Gravitational		2.73	-0.82	-0.07
Momentum		0		0
Flashing			0	
Nozzles			-0.48	
Unaccounted		0		0.01
Total		2.02	-1.45	-0.57

Thermosiphons Stability Stable — Circuit DeltaP ratio (Outlet/Inlet) < critical ratio of 2.

Figure 3. Pressure losses estimated by Aspen EDR after modifications

Thermosiphons / Kettles / Knockback Condenser

Thermosiphons

Thermosiphon stability	Unstable — DeltaP ratio (Outlet/Inlet) < critical ratio of 2
Kutateladze Number in axial nozzle (should be > 3.2)	**5.88**
Circuit DeltaP ratio (Outet/Inlet)	**1.627**
Vertical tube side thermosiphons	
Flow reversal criterion — top of the tubes (should be > 0.5)	
Flooding criterion — top of the tubes (should > 1.0)	
Fraction of tube length before boiling starts	

Figure 4. Instability analysis after modifications

To correct the problem, the company decided to change pipe diameters and implement a valve in the outlet pipe from the tower in the thermosiphon circuit. Using Aspen EDR, engineers evaluated the impact of reducing the return line diameter as well as other updates in internal and nozzle diameters. They were able to identify and implement changes that eliminated the instability.

While stopping the amine unit for a week during the COVID-19 pandemic initially seemed risky, AspenTech's Performance Engineering solutions provided company leaders confidence in their decision. The software provided rigorous and iterative simulations to help engineers understand and accurately model the thermosyphon circuit. In particular, the Aspen EDR model provided guidance the team needed to make informed decisions and implement these modifications in the plant (Figures 3 and 4).

Eliminating Shutdowns and Improving Operations

Three months after carrying out the modifications, the impact is highly visible. There have not been tube punctures or unplanned shutdowns in the amine unit due to contaminated solvent, and plant data confirms that instability has been controlled.

The customer's team has observed a range of operational improvements, including:

- Tower bottom liquid level significantly increased
- Reboiler tubes remain flooded
- Column shows normal oscillating behavior
- No continuous puncturing of reboiler tubes

By preventing unplanned shutdowns, the customer eliminates potential sales gas reductions, ensuring compliance with delivery agreements, and achieves an estimated savings of $6 million USD per year. Additional savings come from preventing damage to the column and related equipment, as well as maintaining integrity of the solvent. With this revamp, unit uptime is extended to approximately 18 more months. The modifications also contributed to an improvement on unit turn down and increased operations flexibility.

Technology That Loves Complexity

About Aspen Technology

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