FLUID QUALITY MANAGEMENT AND OPTIMIZATION OF NGL TREATING

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ABSTRACT

Liquid-Liquid Separations are a critical part of the efficient operation of many hydrocarbon processing operations. Ineffective emulsion separation can cause foaming, fouling, equipment reliability issues and process downtime. In amine treating of liquid hydrocarbons (NGL, LPG etc.), amine emulsification into the hydrocarbon is a common challenge. This is particularly acute in those NGL treating systems where amine is injected into a static mixer followed by a coalescer. Any amine carryover to the LPG affects downstream units (molecular sieve beds, caustic treaters etc.). If the downstream unit is a molecular sieve bed, the bed cycle length will decline faster than if no amine were present. The efficient removal of emulsified amine carryover has the practical benefit of improving the bed cycle length decline. This, in turn, means molecular sieve beds can remain in service for longer periods of time. Transcend Solutions will present a case study of the effect of improved liquid-liquid separation on molecular sieve bed operation including a discussion of the impact on operating cost.

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Introduction

Liquid-Liquid Separations are a critical part of the efficient operation of many hydrocarbon processing operations. Ineffective liquid-liquid separation can cause emulsified dispersed phases to be carried downstream and to cause foaming, fouling, equipment reliability issues and process shutdown. In midstream and downstream treatment of liquid hydrocarbons, liquid-liquid separations are found in amine treating of NGL or LPG, caustic treating of LPG, condensate stabilization units, sour water strippers, and other units.

In amine treating of liquid hydrocarbons (NGL, LPG etc.), amine emulsification into the hydrocarbon is a common challenge. This challenge is observed both in the amine-continuous column-based treaters and the NGL-continuous static-mixer-coalescer based treaters – however, it is particularly acute in the NGL-continuous treaters because those are specifically designed around high energy dispersion of the amine into the NGL. This amine carryover affects downstream units (molecular sieve beds, caustic treaters etc.). If the downstream unit is a molecular sieve bed, the bed cycle length will decline faster than if no amine were present. The efficient removal of emulsified amine carryover has the practical benefit of reducing the rate of decline of bed cycle length. This, in turn, means molecular sieve beds can remain in service for longer periods of time. Water washing the hydrocarbon stream to recover amine would help but requires a capital expense. Transcend Solutions will present a case study of the effect of improved liquid-liquid separation (in the absence of a water wash) on molecular sieve bed operation including a discussion of the impact on operating cost.

Background

A static mixer followed by a high efficiency coalescer can be an attractive approach for NGL treatment with amine, particularly when the acid gas can be removed in one or two theoretical stages. The practical advantage of this approach is that the vessel sizes can be much smaller, resulting in a tremendous capital cost benefit.

An NGL fractionator treated the Y-grade NGL with DEA through a mixer-coalescer arrangement [1] for CO_2 removal. Following the amine treatment, the Y-grade NGL was dehydrated with molecular-sieve beds and then sent to a fractionation train. There were two molecular sieve beds in a conventional 2 x 100% configuration. The molecular-sieve beds, when new, required regeneration after approximately 96 hours of operation. Subsequent cycles typically evidenced shorter cycle lengths. The regeneration of the bed typically required 24 hours. As the bed aged in service, the loading cycles declined from 96-hours at a consistent rate. Typically, once the loading cycle length fell below 36 hours, the bed was replaced, and the time for bed cycle lengths to decline from 96-hours to 36-hours was approximately 8 – 10 months. Bed replacement often affected plant throughput. The bed changes were typically staggered to allow for the bed replacement to occur with limited throughput impact. The fractionator was interested in evaluating an upgrade of their existing coalescing elements to determine if molecular sieve bed performance could be improved, particularly since the plant was operating at only 20-35% of the design capacity for throughput.

Theory

The amine treating of a hydrocarbon liquid can result in discontinuous phase amine carryover that will contact the molecular sieve bed. The amine can be in the form of free, dispersed, emulsified, in addition to dissolved amine. The hypothesis is that free, emulsified, and dispersed amine in the NGL wets out on the surface of molecular sieve particles and then cokes during regeneration. This coking results in the loss of adsorption sites, which results in a reduction of bed cycle length and ultimately reduces bed lifetime. In the absence of a water-wash, the hydrocarbon stream is still expected to contain dissolved amine, which may also be expected to affect the molecular sieve bed performance.

Eliminating the free, dispersed, and emulsified amine requires high efficiency coalescing. High efficiency coalescing requires media that is compatible with the streams, and is able to capture and grow the discontinuous phase droplets to be large enough to separate within the available settling zone within the coalescing vessel. If the bulk NGL flow rate is increased over design capacity, the velocity within the media increases. The increased flow rate also results in a reduced residence time in the coalescer vessel itself. The combination of these factors can result in both amine carry-over and NGL under-carry.

Since the vessel itself is fixed, and the number of cartridge elements that are used in the vessel is fixed, the primary degrees of freedom center around the media technology and element design. Both degrees of freedom ultimately impact the droplet size that is created. The impact of droplet size on settling velocity can be seen by reviewing the Stokes' settling velocity equation, where settling velocity increases with the square of droplet diameters, e.g., increasing a droplet from 2-µm to 2 mm results in a droplet settling velocity increase of 1,000,000 x.

$$V = \frac{(\rho_1 - \rho_2) g d^2}{18\mu}$$

Performance Evaluation

The design parameters for the installation are summarized in Table 1.

Table 1 – Design Parameters for the Liquid-Liquid Separator Installation

Parameter	Value
Continuous Fluid	Y-grade NGL
Design Flow rate	2200 gpm (75,000 bpd)
Line Size	10 in
ANSI Flange Rating	300#
Corrosion Allowance	1/8 in
Change-out DP	10-15 psid
Existing Vessel	85 elements (72" OD)

Data was gathered prior to the installation of upgraded elements. Figure 1 illustrates the bed cycle lengths. As noted previously, the bed cycle length is the duration that the molecular-sieve bed remains online before needing regeneration. As can be seen, there is a consistent decline in the bed cycle length over time. The "A" and "B" designates the two beds on a given train, so that 1A and 1B are sister molecular sieves, 2A and 2B, and so on. The cycle length data was captured on Bed 2B and 3A over their entire life. The 2800 – 3000 hours of bed life corresponds to approximately twice the calendar duration, as each train has two beds. The resulting 5,600 - 6,000 hours between bed replacement is approximately 240-250 days (or around 8 months). The beds are also estimated to experience approximately 50 cycles.

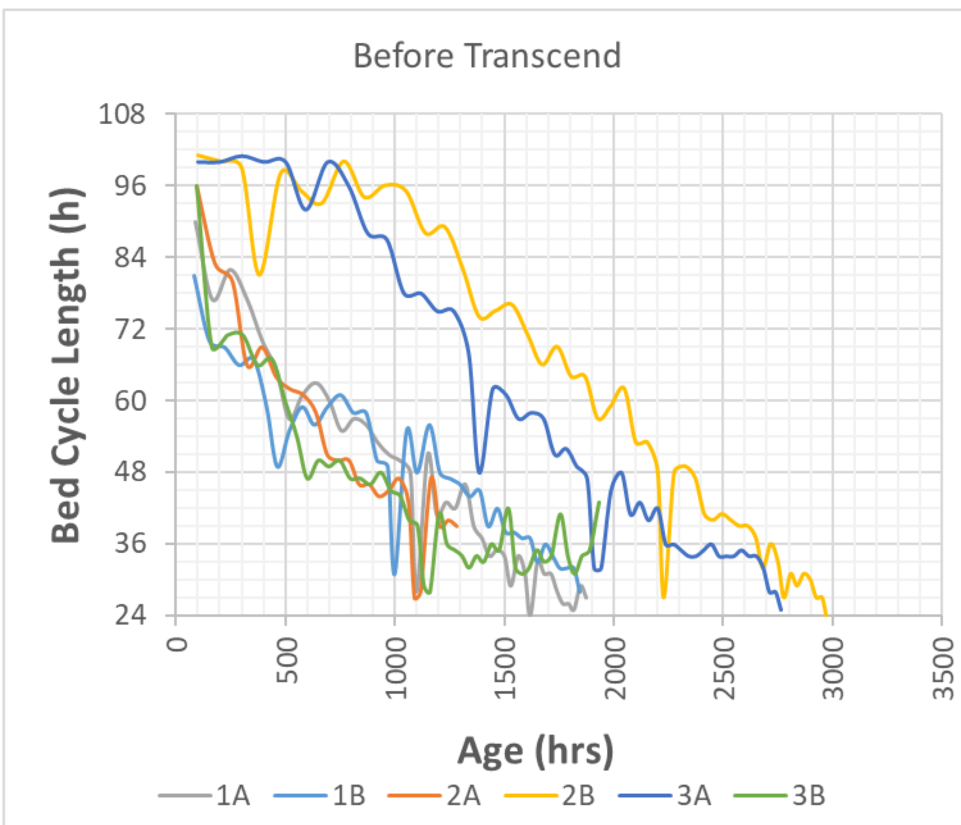

Figure 1 – Bed Cycle length with conventional separators

Figure 2 shows the bed cycle length trends for the same trains. Some of the beds were upgraded before they reached the 24-hour cycle length limit that impelled bed replacement. In all cases, the trend lines are clear and distinctly different from the trends before the upgrade. The plant reports that bed replacement frequency increased from approximately 8-months to 18 – 24 months. A clearer picture of the life extension is expected once a bed is in operation for its entire life with Transcend technology on the liquid-liquid separators feeding it. This is approximately equivalent to surviving 250 regeneration cycles. Note that the various trains were upgraded to Transcend at various points in their life, and in all cases, the downward trend of bed cycle length was arrested, and bed cycle lengths stabilized.

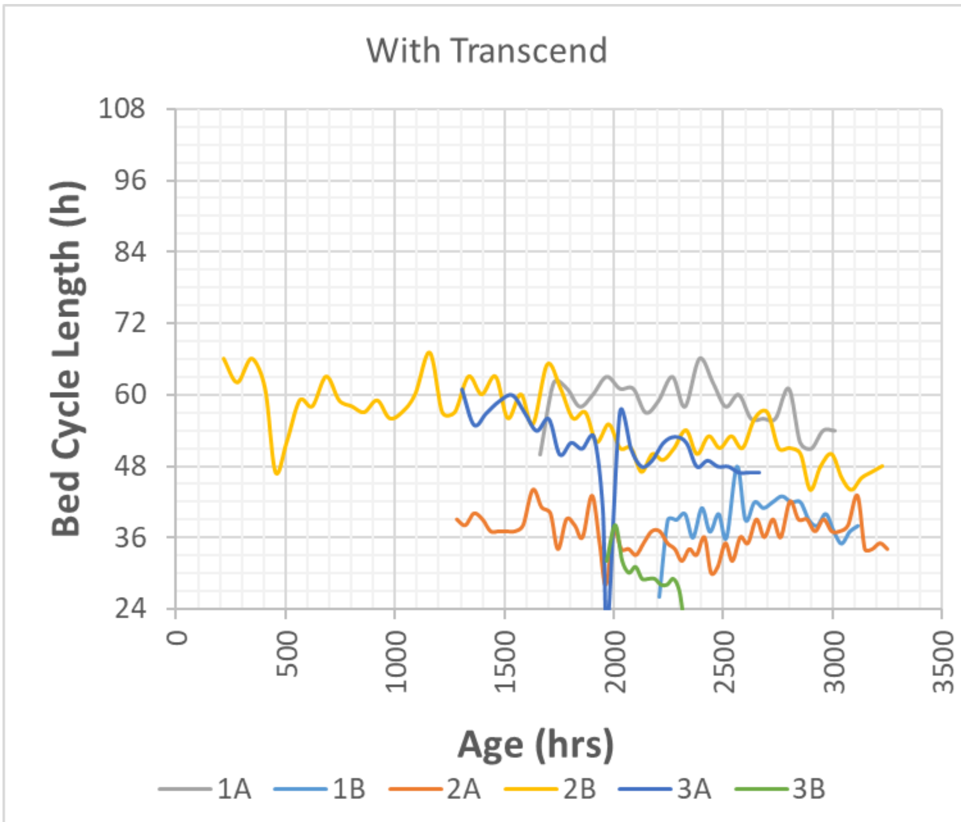

Figure 2 – Bed Cycle length trends after Transcend Upgrade

The operating economics are summarized in Table 2. The math is easy to follow. We consider both the cost of replacing the elements and the cost of labor associated with this process.

Table *2* – Economics for the Upgraded Liquid-Liquid Separator Installation

	Conventional Design	Upgrade Case1	Upgrade Case 2
Molecular Sieve Bed Cost	$250,000	$250,000	$250,000
Number of Beds per train	2	2	2
Bed Run Life	8-mo	18-mo	24-mo
Annual Molecular Sieve Costs	$750,000	$333,333	$250,000

Number of Trains	5	5	5
Total Molecular Sieve Cost / Yr	$3,750,000	$1,666,665	$1,250,000
Annual Savings	-	$2,083,000	$2,500,000
Cost of Upgrade	-	$0	$0
Payback Period		Immediate	Immediate

As can be seen, the upgrade did not have a capital cost and the upgraded elements had a cost substantially like the then-current element. The annualized savings per train was $400,000 – 500,000 ***not including any throughput benefits from replacing molecular sieve beds one third as frequently.***

These benefits to the molecular sieve run lengths were realized ***without adding a water wash***. This implies that molecular sieve bed cycle lengths are dramatically impacted by the presence of free, dispersed, and emulsified amine. Furthermore, it is possible that an added extension to molecular-sieve run life may be possible by adding a water wash, since molecular-sieve beds are expected to survive 500 cycles or more.

Summary

The upgrade of the coalescer vessels was demonstrated to impact molecular sieve cycle lengths across multiple trains. It is important to note that in this case, no modification was made to the vessels, and the only upgrade pertained to the element and media technology within the element. The upgrade allowed for

(a) Confirming the hypothesis that reducing free, emulsified, and dispersed amine carryover with proper media and high efficiency design was critical to the shortening of molecular sieve bed cycle lengths.
(b) Achieving improved fluid quality without increased operating cost

The significant reduction in operating cost impact was achieved by the use of high efficiency media, in an extended surface area configuration, to maximize droplet sizes and therefore take advantage of available settling zones allows for the upgrade of a variety of conventional coalescers to improve downstream performance.

References

1. Bullin, J., Polasek, J., and Rogers, J. (1995). Design considerations for Sweetening LPGs with Amines. 74th Annual Gas Processors Association Meeting, San Antonio, Texas.