White Paper

ExxonMobil

Compressor wash oil impact on process gas compressor efficiency and vibration

Michael J. Player, *Fluids Marketing Technical Support Advisor*
ExxonMobil Chemical Company

Yang Yang, *Fluids Marketing Technical Support Advisor*
ExxonMobil Chemical Company

Marie Conrad, *Fluids Americas Product Manager*
ExxonMobil Chemical Company

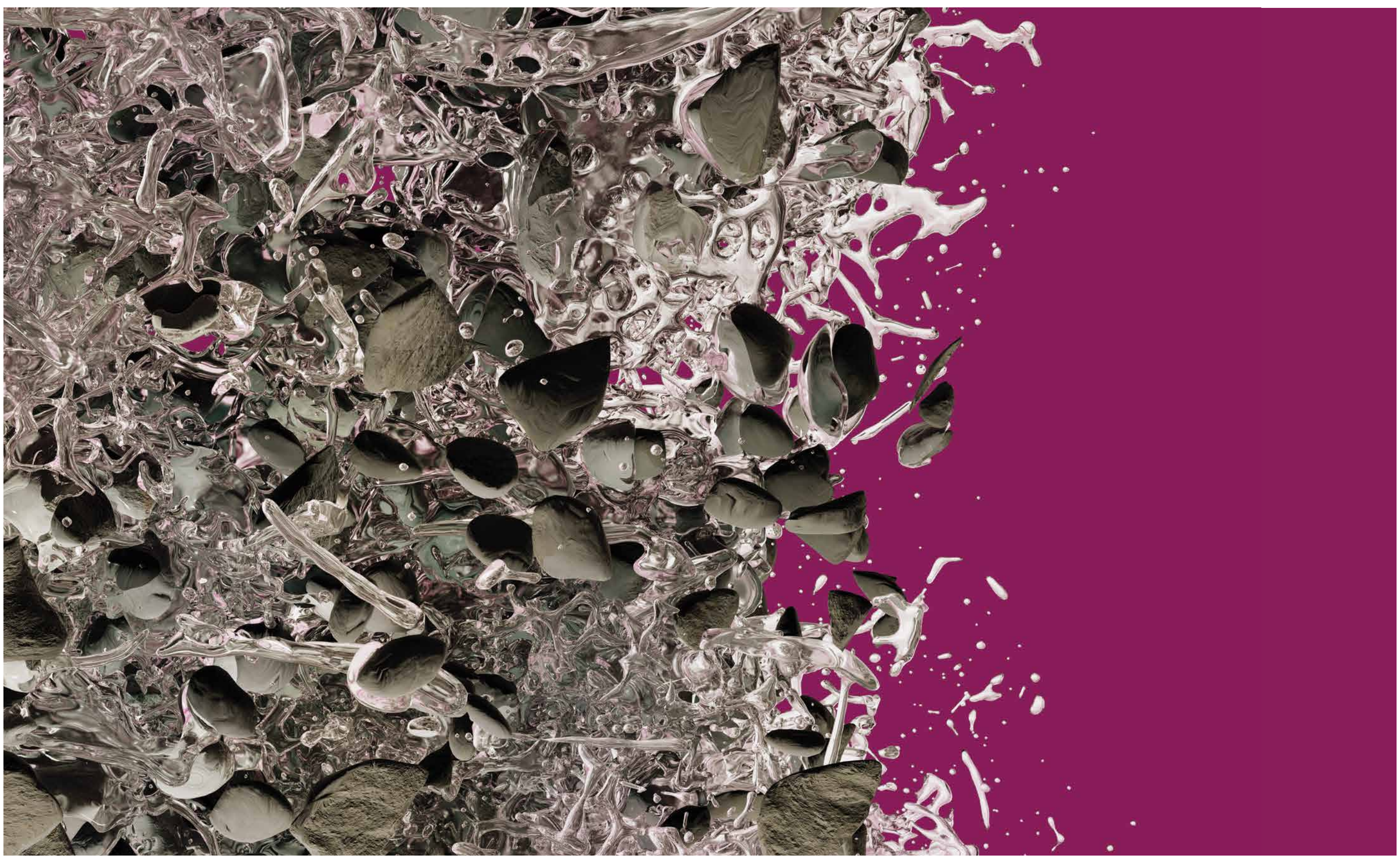
David Dutschmann, *Recovery Engineering Associate, Basic Chemicals*
ExxonMobil Chemical Company

Prepared for Presentation at the 2018 Spring National Meeting
Orlando, Florida, April 23-26, 2018

White Paper

Compressor wash oil impact on process gas compressor efficiency and vibration

Michael J. Player, *Fluids Marketing Technical Support Advisor - ExxonMobil Chemical Company*
Yang Yang, *Fluids Marketing Technical Support Advisor - ExxonMobil Chemical Company*
Marie Conrad, *Fluids Americas Product Manager - ExxonMobil Chemical Company*
David Dutschmann, *Recovery Engineering Associate, Basic Chemicals - ExxonMobil Chemical Company*



Abstract:

Organic fouling in process gas compressors (PGC) is an important issue that many olefin plants must manage. When fouling occurs, PGC efficiency drops and compressor vibration increases. Minimizing fouling is critical to limiting production losses and high maintenance costs in existing or new steam crackers. The introduction of lighter feed stocks from shale gas is expected to increase the probability of fouling in PGCs. There are numerous factors to consider when managing PGC organic fouling and resulting reliability issues. Compressor wash oil (CWO) plays a vital role in assuring and improving compressor reliability. In this paper, key wash oil properties, general operational concepts, and two cases relevant to PGC efficiency and vibration will be discussed.

Shale gas contribution

The dominance of ethane as a cracking feedstock for ethylene production has been growing and is expected to continue growing (Figures 1 and 2). This higher ethane consumption has translated to a greater need for compressor wash oils.

FIGURE 1

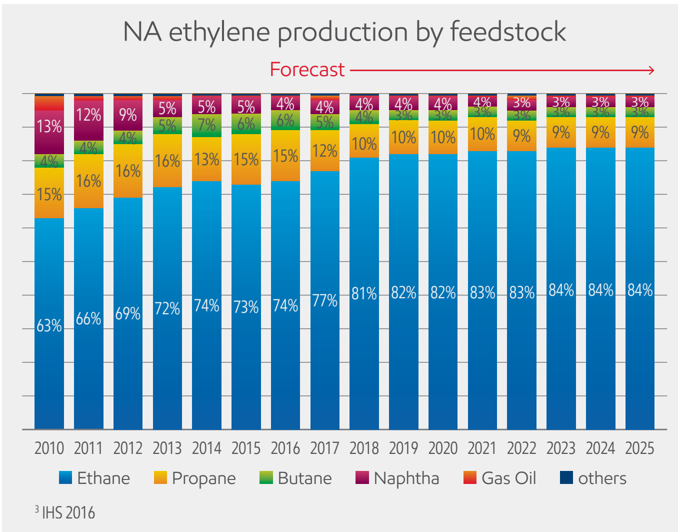
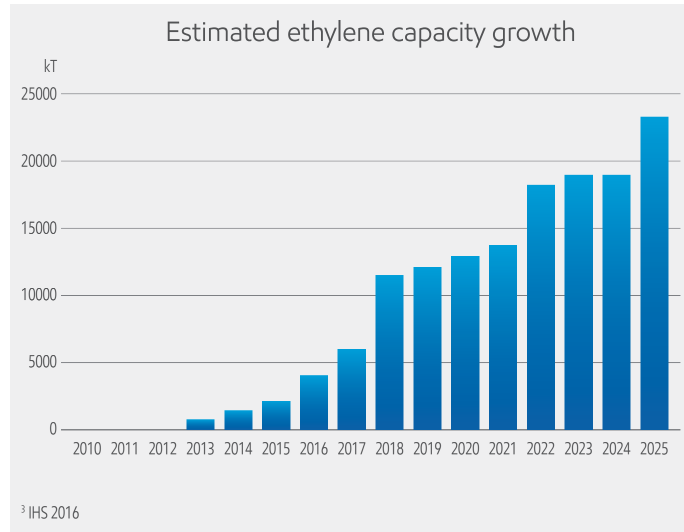


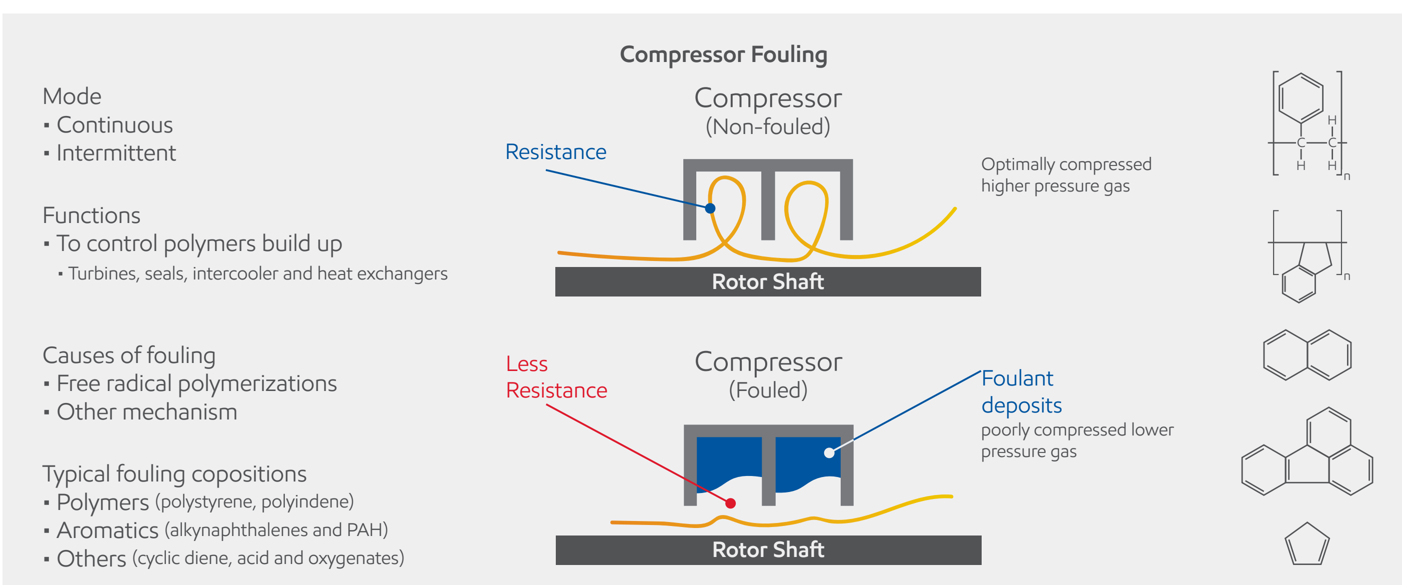
FIGURE 2



Wash oil necessity: why and how it works

Producing olefins by steam cracking or pyrolysis brings with it unwanted, reactive precursors. These precursors readily polymerize by a free radical or Diels Alder mechanisms and if left unchecked will rapidly decrease runtime for a PGC. Wash oil, whether continuously or intermittently injected, will help dissolve low molecular weight (MW) polymer and facilitate removal of its resistive buildup along the various compressor stages. There are other key characteristics for a wash oil that will be covered next.

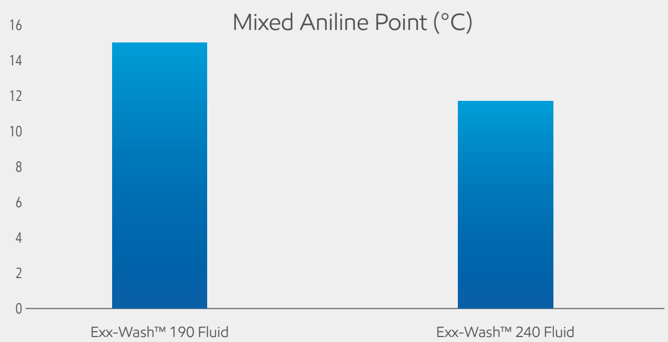
FIGURE 3



Wash oil quality is important

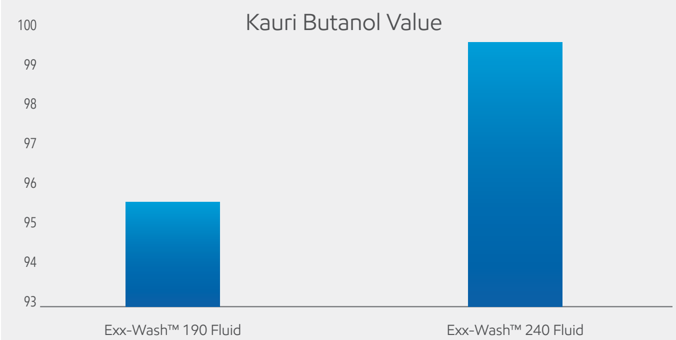
Using Wash oil should not contribute to compressor complications with regard to quality. Quality wash oil is essentially defined by three pillars: solvency, purity and volatility. Strong wash oil solvency promotes effective foulant removal which is its primary function. Kauri-Butanol (KB) and Mixed Aniline Point values measure solvency power:

FIGURE 4



Property	Exx-Wash™ 190 Fluid	Exx-Wash™ 240 Fluid	Unit	Tested Method
Mixed Aniline Point in C	14.8	14.8	C	ASTM D611-A
Mixed Aniline Point in F	58.6	53.6	F	ASTM D611-A

FIGURE 5



Property	Exx-Wash™ 190 Fluid	Exx-Wash™ 240 Fluid	Unit	Tested Method
Kauri-Butanol Value	95.5	99.5	-	ASTM D1133

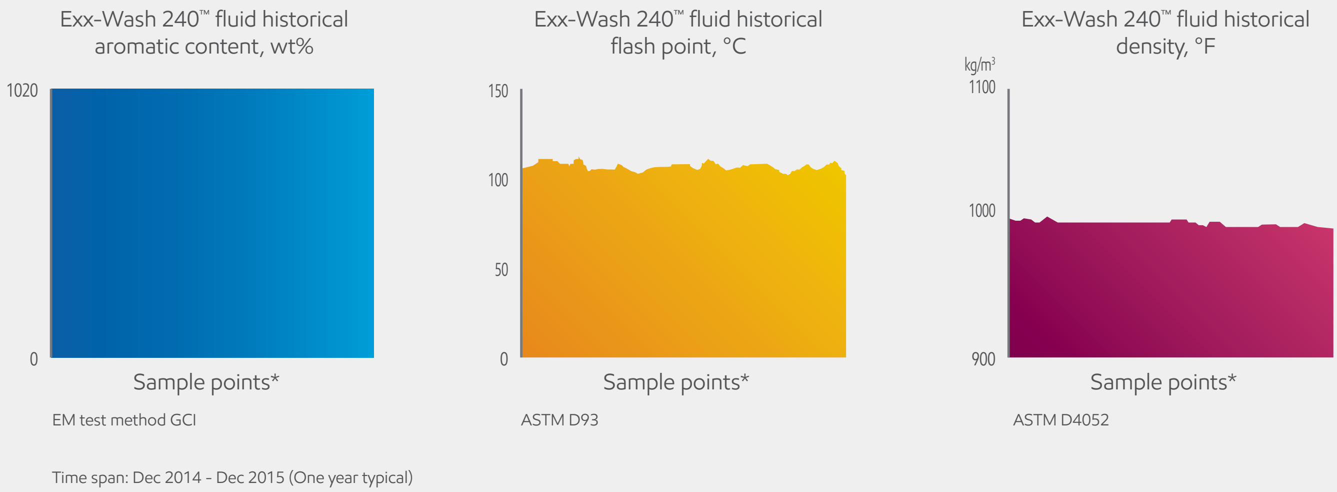
Impurities consist of a number of important items such as gum, organic chloride, sediment, sulfur, and olefin content (defined by Bromine number). Gum content needs to be low so that it does not provide a platform for additional foulants to build upon. Organic sulfur and chlorides contribute to corrosion which will weaken compressor internals and lead to foulant formation. Sulfur and chloride can aid crosslinking which enhance polymer growth which impedes solvation. The effect of sediments is akin to sand blasting the compressor train. Some sediments like rust will provide a boost to foulant formation. Low trace metals content should not be discounted either. Key spot property data provided in table below:

TABLE 1

Property	Fluid 190[1]	Fluid 240[2]	Unit	Tested Method
Total organic chloride	0.3	<0.3	ppm	UOP 779
Sediment and water	<0.01	<0.01	vol%	ASTM 2709
Total sulfur	<3	<3	wppm	ASTM D2622
Bromine number	1.3	0.8	gBr2/100g	ASTM D1159
Washed gum content	<0.5	<0.5	mg/hml	ASTM D381
Cloud point	-10	-14	°C	ASTM D2500

High cloud point indicates the presence of heavy wax, asphaltenes and other polymer contributions.
Consistency in a wash oil is an often overlooked and under-valued property. There can be significant variation in key properties, say aromatic content for example. Some wash oils can have wide ranges for key properties. This inconsistency can lead to more adjustments and consumption to keep the process running smoothly and efficiently.

FIGURE 6: Property consistency



One might believe that the heavier wash oil is the better it will be from a volatility stand point. In theory that would be case, but oils with final boiling points (FBP) greater than 300 °C can introduce heavier molecules that are more prone to forming deposits and contain more polycyclic aromatic hydrocarbons (PAH). These heavier molecules can contribute to deposits which can be more difficult to remove.

A comparison of wash oils in Table 2 below highlights several key quality items that have been discussed- aromatic content and volatility. The aromatic content of the competitive materials is significantly lower than wash Fluid 240. Not only is the distillation range wider, the FBPs are also above 300 °C. Wider cut wash oils will likely have more inconsistency.

TABLE 2

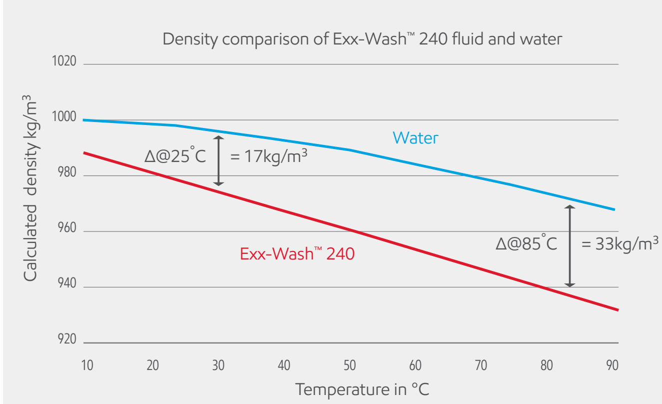
Property	Fluid 240[2]	Similar product	Catalytic lite heating oil*	Unit	Tested Method	Benefist
Aromatic content	>99	82	78.	wt% vol%**	GC1 (EM) ASTM D1319	▪ Better solvency to remove the foulants
Flash point	102	82	72	°C	ASTM D93A	▪ Safety handling
Initial boiling point	229	204	162	°C	ASTM D86	▪ Narrower distillation range ensures higher quality consistency ▪ Higher IBP reduces carry-over
50% distillation point	243	246	274	°C	ASTM D86	
Final boiling point	285	316	351	°C	ASTM D86	
Specific gravity @60°F	0.99	0.96	0.95	-	ASTM D4052	

* Data for single sample only **Vol% assumed based on published data

Water-oil separation

Water washes can be a concern for several reasons when using wash oils. Having emulsions or foam forming in a PGC is undesirable as it will drive efficiency and pressures down. The compressor will need to work harder to maintain throughput. A wash oil must provide good separation from water under operating conditions. With increasing temperature the density difference between water and Fluid 240 provides a margin of safety against forming emulsified material, as illustrated by Figure 7.

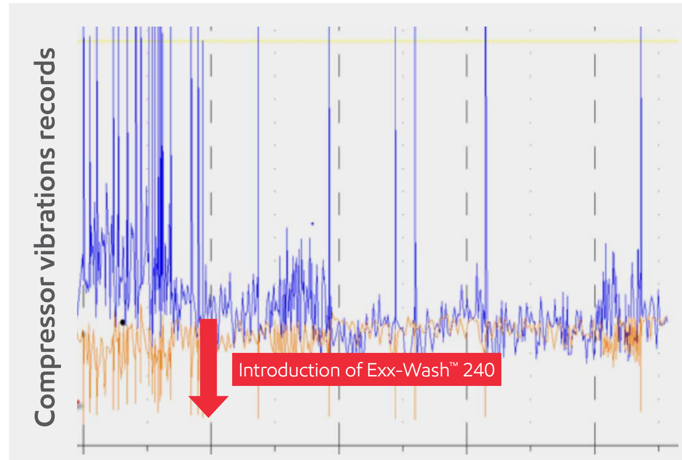
FIGURE 7: Wash oil/water density comparison



Wash oil and compressor vibration

Excluding mechanical compressor issues, vibration will increase as foulant continues to deposit on rotors and impellers which lead to imbalances as well as build- up in the stator blades and casing areas. Sudden releases of polymer deposits will hasten mechanical wear and or failure. Injecting wash oil will lower vibration and soften the impact of polymer deposits within the compressor internals.

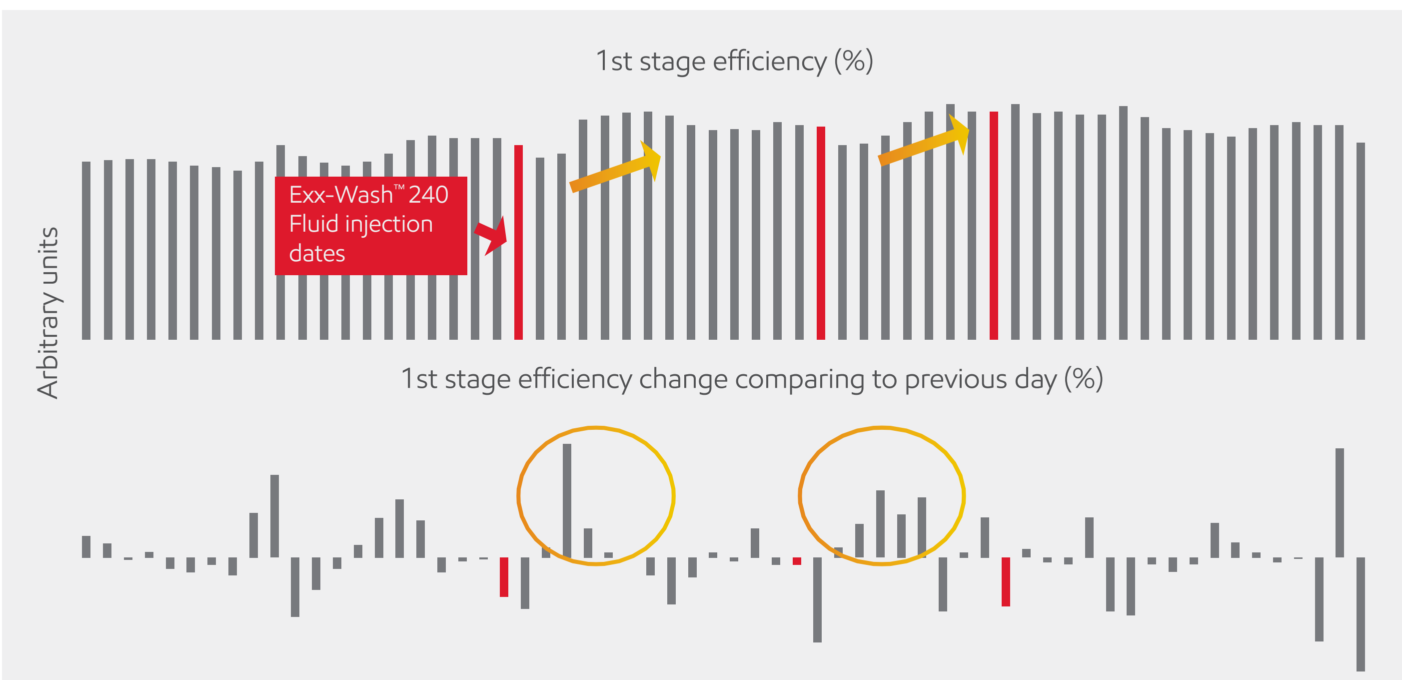
FIGURE 8: Vibrational decrease with wash oil use



Maintaining efficiency

Polytropic efficiency computation provides an assessment of compressor performance. The efficiency plots below show positive impact from wash Fluid 240 injection relative to the previous period.
Over time the intermittent injections of Fluid 240 facilitate in keeping overall throughput higher and energy consumption lower.

FIGURE 9: Efficiencies before and after wash oil use



Operational guidance

Wash oil can be implemented in an intermittent or continuous fashion. Generally speaking, high volume periodic rinses at typical levels 1-3% can be performed. Although lower in material cost, there is more risk with periodic washes due to polymer building up and if large chunks of polymer shift and suddenly break free resulting in severe vibrations. Continuous wash oil injection at 0.1-0.3% levels offer the prospect of keeping compressor internals "slick" so that foulant does not become stationary and surfaces are more resistant to other forms of attack from corrosive impurities. Of course this treatment mode is more expensive, but maximizing run time on the compressor without having to completely shut down and open the casing has immense appeal. ExxonMobil ran compressors for over ten years without having to throttle down and remove casings.

Measuring PGC vitals such as pressures, effects of feed swings, temperatures, flow rates, and wash injections frequency, is paramount when a treatment regimen is deployed. Monitoring these parameters permits better assessment of expected compressor design efficiency in addition to computing pressure drop limits within the system. Higher temperatures can dramatically fuel foulant formation, so keen attention must be given to intercooler and quench tower vitals to keep heat removal optimal. Knock-out drum content and trace (ppm), low levels of either oxygen or peroxides intrusion must be avoided since they readily promote radical polymerization.

Conclusion

Keeping a compressor running smoothly and efficiently requires careful consideration of foulant management. Wash oil use is an effective means of mitigating deleterious effects of organic foulant formation and accumulation within a PGC, particularly in the era of light cracking feeds where probability for fouling is higher. Wash oil quality is important because impurities and lack consistency can complicate compressor operation. Evaluating key PGC parameters when using wash oil is necessary to achieve best results.

References:

1. Fluid 190 is Exx-Wash™ 190 Fluid
2. Fluid 240 is Exx-Wash 240 Fluid
3. Similar product information available on request
4. Snider, Sheri "Ethylene Plant Cracker Gas Compressor Fouling" AIChE Spring National Meeting, April 2006
5. Yang, Yang; Harrison, Megan; Dutschmann, David "Compressor Wash Oil Supply in a light Feedslate Environment", AIChe Spring Meeting, April 2016
6. "World Analysis – Ethylene." November 2015. IHS Chemical. 2016 Edition
7. Snider, Sheri "Olefins plant cracker gas compression fouling" April 2007
8. HP Special Report: "A chemist's perspective on organic fouling in ethylene operations" Hydrocarbon Processing, June 2014

Permission to publish:

ExxonMobil
Energy lives here™