Taming Crude Behavior: Understanding production additives – Part 1

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By Mark D. Halloran

Since its earliest days, the oil industry has struggled to alter the composition and behavior of crude in ways that would allow for faster movement through the flow stream to the refinery. The advent of production additives, designed to perform very specific functions such as fluidification, pipeline drag reduction, demulsification, cleaning and recuperation, has led to great strides in operational efficiency. But the use of these helper chemicals has also, in many cases, presented a whole new set of challenges, including increased costs and adverse environmental impact.

In response to these challenges, a new class of production additives has emerged. With properties described as “anionic/non-ionic,” these additives are capable of becoming part of the crude’s chemistry and performing their intended functions, even at fluctuating temperatures and pressures. Coupled with the right additive plan, these new, “greener” solvents have the potential to address health, safety and environmental (HSE) issues while offering significant opportunities for productivity improvement.

While it’s impossible to historically pinpoint the inaugural use of production additives in the cutting of crude for commercial purposes, it is safe to say the partnership has been a very long and lasting one. In fact, some form of additive is likely to have played a role in every major processing milestone over the last 150 years. From James Young's first known distillation of kerosene in 1847 as a substitute for whale oil in lamps, to the operation of the first commercial U.S. oil well (Pennsylvania's Drake well) in 1859, there are many early indicators of a recognized need for solvents capable of wrestling crude oil into usable products for profit.

Additive Reasoning

As any modern oil industry professional from roughneck to refinery manager knows, handling heavy and extra-heavy crude can be an extremely difficult proposition. In its natural state, the substance is typically under tremendous pressure, and it is often just one part of a hot, roiling mixture of gases, saline water and other components.

To make matters worse, when the crude oil loses temperature in pipes, pipelines or tanks, its organic solvents evaporate, causing an increase in viscosity which presents serious extraction and transport issues. These are the fundamental drivers behind the development and consistent evolution of production additives, or "specialty chemicals," which have been engineered to target specific problems associated with crude oil. Some of these chemicals, for example, work to alter the thixotropic properties of the oil to achieve a lower kinematic viscosity (in a process known as fluidification). Still others are formulated to maintain a strict hydrophilic-lipophilic balance (demulsification). Any point at which the crude slows down is considered an area of "parasitic loss," and a good candidate for the chemical help that additives can offer.

The Solvent Remains the Same

In those early days of oil production, it was discovered that adding hexane-based solvents, such as naphtha, facilitated more successful, more profitable management of crude. These solvents, in their progression of chemistries and formulations, eventually became part of a specialty chemical additive methodology that encompassed five critical crude handling areas: production, flow stream delivery, refinery, environment and commercial product performance enhancement.

Aided by advances in research, computer technology, chemistry and engineering, the processes associated with finding, producing, delivering and refining crude oil have accelerated exponentially in the last few decades. Surprisingly, however, hexane has remained the principal base additive used during every stage, from fluidification of the crude oil mass, movement from the production well through the flow stream into storage tanks and tankers by sea/truck/rail to the refinery, to cutting wax/paraffin/asphaltene build-ups, dewatering and cleaning tanks and tankers.

The Hexane Compromise

Although many of the world's production facilities continue to use hexane-based naphtha for dilution and fluidification of crude oil with acceptable overall results, it is widely understood that the practice has inherent financial and environmental compromises. Among the most obvious of these is that naphtha evaporates, which means it leaves the crude oil with its original properties, but virtually disappears in the process. Large quantities of the solvent must be added during the process to offset evaporative losses that could compromise performance.

In addition, there's the indirect cost factor. Derived as precipitates of the refinery stack heating process used to convert crude to petroleum, naphtha and other hexane-based solvents actually begin their life as "free" assets, or by-products that just happen to work better as production additives than in almost any other viable commercial use. While this sounds serendipitous, the solvents must be captured at the refinery, bottled and shipped safely to a place of use at the extraction well, in pipelines or storage tanks. And the costs associated with these logistics can quickly add up.

HSE risks are another major concern with hexane solvents. They are highly flammable/explosive, and any exposure to them can represent a serious health hazard. They can cause skin burns, cancer and, due to their ability to bond at a cellular level, even birth defects. There have also been documented cases of naphtha shipments being rejected due to lead contamination.

For these reasons, naphtha and other low-cost/no-cost hexane-based solvents can actually end up being the most expensive fractions of the distillate. This is especially true in light of the fact that such a high dosage (between 10 and 20% of the crude mix on average) must be added to get the job done.

Taming Crude Behavior: Understanding production additives – Part 2

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"Incorporating" Options
Oil industry professionals have traditionally had to accept the trade-offs associated with the use of hexane-based additives. This is largely because the few available alternatives, built on naturally-occurring organic chemicals, condensates (diluted bitumen) and a variety of polymers, didn't offer a universally acceptable cost/performance balance.

More recently, however, chemists have applied new formulation techniques to introduce a class of additives with "anionic and nonionic" properties. Makers of these chemicals say they represent huge performance leaps over hexane solvents and other alternatives, and that they can be purchased at lower costs and used in much lower quantities.

These new additives, broadly classified as "incorporative/non-evaporative," use a generic base as a vehicle to transport the anionic and nonionic active agents responsible for reducing the kinematic viscosity of the crude oil for fluidification and drag reduction purposes. These agents apply the science of polarity transformation, which allows them to physically act between the molecules in the crude and rearrange the force of attraction between each to achieve better cohesion. This causes the compact mass of the crude oil with a low API degree to become more fluid and capable of flowing through ducts and pipelines with less turbulence and drag.

The viscosity-reducing components of the additive's active agents are also hydrocarbons, so they don't affect the physical properties of substances in the processes of refining or refined products. For example, in the distillation towers, the compounds of each fraction are separating depending on their temperature, recovering in each fraction of the distillate the part that corresponds by its evaporation point.

The most notable feature of these new additives is that they don't evaporate. Their composition allows them to incorporate into the crude oil, assuming its properties while performing the function for which they have been engineered, even as the temperature and pressure of the crude oil declines. Unlike the hexanes, these incorporative additives do not require re-heating or increased pressure in the flow stream. They effectively reduce drag and turbulence, and they are used in very small dosages (0.1% to 0.5% by volume treated as compared with 10% to 20% by volume treated for traditional hexane solvents like naphtha).

In addition, because the new additives incorporate into the crude oil mass, they do not represent a separate environmental threat apart from the crude oil itself, as hexanes do. There is no residual contamination if the additives are released into the environment separate from the crude. And while they are not considered bio-degradable, manufacturers say the additives aren't harmful to humans or the environment if they are handled in accordance with practices outlined on their MSDS sheets.

Another area in which the new incorporative additives differ from traditional solvents is the unique "building block" method by which they are formulated. This allows users to customize and add features, such as increased fluidification and drag reduction, and even mix in additives to aid in wax/paraffin separation, asphaltene inhibiting, breaking of the crude oil-water emulsion, cleaning, recovery of crude oil, elimination of incrustations and bacteria, foam prevention, sulfhidric acid reduction, crude oil remediation and performance improvement for the end user.

Technology, Applied

Two common oilfield areas that stand to benefit directly from incorporative additive technology are production wells (upstream) and storage tanks (midstream). In the production well, the new additives can help fluidify the crude via molecular dispersion without altering its original composition. This, in turn, can help address the problems associated with clogged or inactive wells, and/or interruptions in production. Results of additive use in such applications can be faster movement of the crude, a reduction in pressure and better pump traction, all without the potential for adverse environmental impact inherent to hexane-based additives.

In storage tank cleaning applications, the incorporative additives can help recuperate a much larger quantity of the crude that would normally be retained in the tank due to viscosity. Since the additives have a high flashpoint (above 170° C in some formulations as compared with around 44° C for naphtha), they can also greatly reduce the risk of explosion due to static electricity.

Taming Crude Behavior: Understanding production additives – Part 3

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By PennEnergy Editorial Staff
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Keen to Commercialize
Enrique Muñoz Pinilla, CEO of Los Angeles-based Oil Flux Americas, LLC, (www.oilfluxamericas.com) says his company's suite of 15 incorporative oil additives became commercially available in mid-2014, after several years of focused research, development and testing. He adds that the decision to create the new formulations was fueled by what he calls "an unprecedented demand for alternatives to the economic and environmental perils of hexane-based solvents."

"The oil industry is being pressured as never before from both regulatory and profit perspectives, due to what author Allen Brooks describes as the 'capital cost/commodity price/investor return trifecta,'" says Muñoz. "And although new engineering and mechanical technology is helping to find and squeeze more out of the crude that's being discovered and extracted, there are still a great many 'pinch points' in the crude oil production and flow stream process where speed and efficiency are being hampered because additive technology just hasn't kept up. With the anionic/non-ionic formulations becoming available, I believe that's about to change. The industry is beginning to recognize that the crude it already has in the production lines is cheaper than the crude it hasn't extracted yet."

Muñoz adds that this shift in mindset has been underscored by Berkshire Hathaway's recent purchase of Lubrizol and Phillips 66 specialty chemical additive business – a move that complements its earlier purchase of Burlington Northern Santa Fe Railway's rail tanker business. BNSF uses large amounts of specialty chemical additives for cleaning and flow stream fluidification to keep its immense fleet of crude oil rail cars running.

The "pinch points" Muñoz references are very specific areas of the production process in which the crude's resistance to easy, uninterrupted flow can pose serious profitability roadblocks. See table 1. for a detailed description of these areas and information about how incorporative additives are being used to overcome the roadblocks.

Table 1. Common production "pinch points" and corresponding uses of incorporative additives.

Area of use	"Incorporative" Product Function	Description
Extraction/Pipeline Transportation	Fluidifier	Added to crude oil in wells or pipelines. For fluidification of the mass .
Extraction/Pipeline Transportation	Fluidifier & Demulsifier	Added to crude oil in wells or pipelines. For fluidification of the mass, and as demulsifier
Extraction/Pipeline Transportation	Tailored Fluidifier	Added to crude oil in wells or pipelines. For fluidification of the mass. Customized according to the characteristics of the crude oil (characteristics such as the composition of paraffins, asphaltenes, naphthalenes, total acidity, H^2O, sediments, sulfur, the API degree and the water cut in the crude oil.
Extraction/Pipeline Transportation	Fluidifier & Paraffin Separator	Added to crude oil in wells or pipelines. For fluidification of the mass that contains paraffins
Extraction/Pipeline Transportation	Fluidifier & Asphaltene Inhibitor	Added to crude oil in wells or pipelines. For fluidification of the mass that contains asphaltenes
Ponds	Crude Recuperation From Pits	Total crude oil recuperation from Ponds/Pits
Flow Stations/Refineries	Demulsifier	Demulsifier that separates the water of the "water/crude oil" emulsion. For the elimination of water in flow stations. It can be applied in refineries if the water content is still over the admissible 2%
Flow Stations/Refineries	Anti-embedment	When added to the crude oil that comes from the wells, it leaves no incrustations coming from the water in the crude oil (very high in dissolved salts), protecting all types of pipes.
Flow Stations/Refineries	Bactericide	When added to the crude oil, it eliminates the bacteria produced by the water. It can also be applied to refineries when necessary.
Flow Stations/Refineries	Corrosion Inhibitor	When added to the crude oil coming from the wells, it protects the pipes from corrosion caused by the water.
Flow Stations/Refineries	Anti-foam	Only necessary when foam is produced. For the cleaning of all types of tanks.
Flow Stations/Refineries	Sequestering	When added to crude oil, it decreases the reaction of the sulfhidric acid (H^2S) to form sulphuric acid (H^2SO^4).
Refineries, Tanks/Tankers	Cleaning	For cleaning all types of tanks & tankers with residues, whether they come from crude oil or any derivate, fuel, gas-oil, etc. For cleaning of crude oil spills in the marine environment.
Tanks/Tankers	Performance Additive	To be added only to fuel oil. It stabilizes the fuel oil preventing a separation of water, causing a stable micro-emulsion and helping to avoid cutoffs of the combustion. Improves the atomization of carburant in the injectors. Eliminates residual lumps in fuel oil tanks, reducing the possibility of the plugging of filters and injectors.
Tanks/Tankers	Performance Additive	To be added only to gas or oil. It stabilizes the gas oil ensuring that there is no separation of water, causing a stable micro-emulsion and helping to avoid cutoffs of the combustion. Also prevents the growth of algae and the formation of mucilage in tanks (commonly called "gas-oil snot").

Part Of The Plan

Oil Flux Americas, like the handful of other production additive manufacturers currently offering incorporative technology, believes the formulations are "next-generation alternatives" to hexanes, condensates, polymers or natural plant products, and that they will ultimately help professionals tasked with managing crude wring more profit out of their processes. But Muñoz warns that any chemical – incorporative or evaporative – should be part of a carefully considered plan. He says he encourages prospective customers to take these simple steps before finalizing their own additive strategy:

Step 1.) Identify the physical problem area, problem actor and problem result. For example:

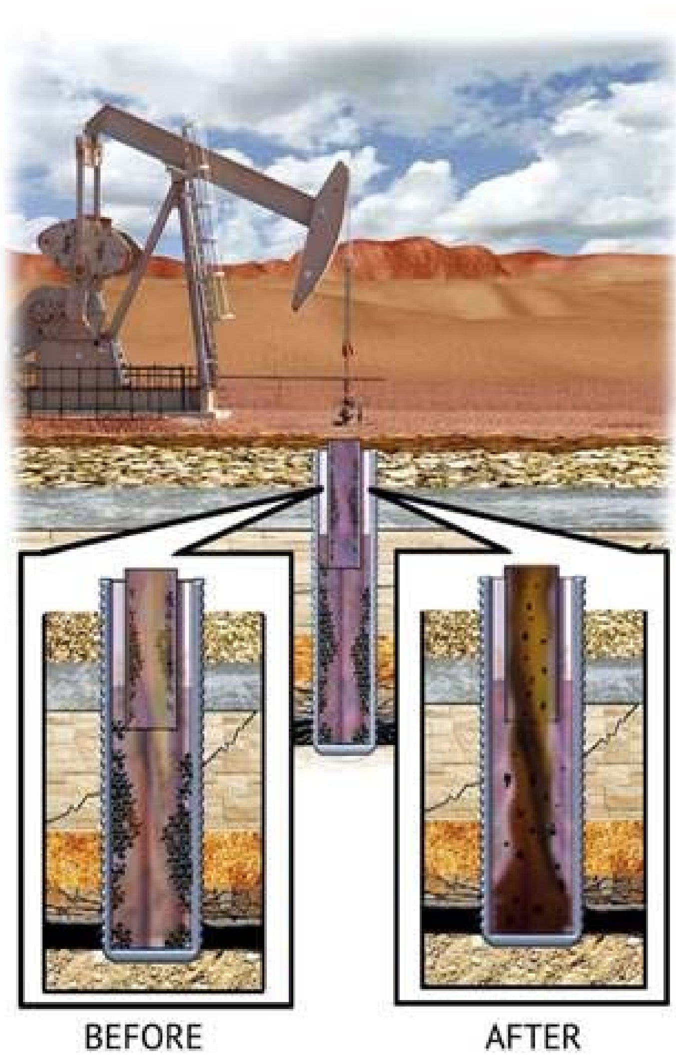
i. Problem area: production well clogging due to loss of fluid flow. Problem actor: wax/paraffin/asphaltene. Problem result: causing increased costs due to increased pressure and heating required.
ii. Reduced flow and possible environmental blow out/spills causing increased costs and HSE problems.
iii. Flow stream dewatering to eliminate increased costs due to pumping more fluids than necessary, or reduced flow and possible environmental blow-out.
iv. Flow stream cleaning causing increased costs and HSE problems.
v. New HSE regulatory issues creating new problem areas, actors and results.

Step 2.) Involve operational, financial and HSE executives to list the physical problem area, problem actor and problem result, then list available solution costs as well as operational and HSE consequences.

Step 3.) Secure lab tests to ensure efficacy.

Step 4.) Create a comparative analysis of cost vs. efficacy vs. undesirable outcomes that might result from using and/or not using one solution vs. another.

“Such analysis is crucial if you’re hoping to arrive at a plan that gets you the most from each additive you choose,” Muñoz says. “Your plan might consist of a mix of traditional and new (incorporative/non-evaporative) additive technologies, or it might rely completely on just one type. But you won’t really know what’s going to be most effective until you do the legwork.”



The typical state of an oil well in which no production additives have been used during the extraction phase. Buildup of asphaltene and paraffin in the bore and on the head impede the efficient flow of crude. Right, the same well bore and head as treated with new incorporative/non-evaporative production additives, which can offer improved performance over traditional hexane-based solvents without HSE concerns.

An illustration of how water in a flow station without production additive remains mixed with the crude, causing process slowdowns. Right, the same flow station treated with a low dosage (0.1% to 0.5% by volume) of an incorporative/non-evaporative demulsifying additive that reduces the emulsified water content of the crude to meet refinery standards.
Images courtesy of OilFlux Americas, LLC. www.oilfluxamericas.com