IMPROVING HEATER TREATER DEHYDRATION EFFICIENCY WITH PERFORMAX[R]

BILL CALKIN AND BILL BALL

C-E NATCO

ABSTRACT

Separating water produced in conjunction with crude oil has been an ever increasing problem since Drake's first well. As refinery capabilities grew more complex and pipeline companies became more aware of the problems associated with water, their demands to lower the water content of oil expanded to those we know today. The process equipment arm of the petroleum industry has always reacted to these needs with ever growing efficiency. This paper reviews past efforts and introduces one of the latest advancements in crude oil dewatering, documents its state-of-the-art applied technology, and reports its resultant efficencies.

INTRODUCTION

The removal of produced water from crude oil has been a problem since the first discovery well was drilled in Titusville. Efforts too numerous to recount have been made, but few have succeeded. One that has become the industry's standard is the heater treater. First introducted in 1934 by the founder of C-E Natco, J. P. Walker, the vertical heater treater became the yardstick against which all other methods of crude oil dehydration were measured. To handle the tougher and tougher problems of water-in-oil emulsions internal baffling was added to the basic design to crossflow both oil and emulsion through the water, or heating phase, and through the oil, or coalescing phase. This was later refined with excelsior for the resolution of the toughest emulsions. As design emphasis shifted toward the more efficient horizontal treaters the application of excelsior came with it. Many proposed substitutes for excelsior were tried but none proved to be as cost effective . . . until C-E Natco's Performax process developed. The Performax utilizes a matrix of angular surfaces through which produced fluids flow. The torturous flowpaths are adjusted to accomplish maximized coalescence. This results in a degree of separation efficiency here-to-fore unknown in field dehydration.

HISTORY OF CRUDE OIL TREATING

In the earliest days of crude oil production it was thought that time alone was the controlling factor in removing water and sedimentary contaminants from oil. To accommodate this separation, oil was produced into large earthen ponds or tanks. As the water gravitated to the bottom of these tanks and ponds oil quality improved to the degree that it could be sold.

As the demand for crude oil increased the requirement for oil quality became more apparent. At the same time the concentrations of water and sediments increased in aging fields. As fields developed to maturity and beyond, wells produced more and more water with less and less oil. Gushers were controlled by valving, but as water and oil flowed at increasing velocities through the restriction of the reservoir and through rod pumps or chokes stable emulsions were observed in much greater volumes. Time alone would not remove the contaminants from this crude. Huge amounts of this new waste product were stockpiled in open pits and typically burned to make room for more. But, as the nation and the industry matured into the industrial revolution it became more and more apparent that a large quantity of oil could be recovered from this waste, and importantly that the waste volume itself could be drastically reduced, by the simple application of then state-of-the-art technology. This was the World War I era. The nation and industry geared up like never before. Oil previously contained in earthen ponds was now stored in tanks . . . some fitted with steam boilers to heat the crude oil. Heating the crude made it less viscous, thinner and allowed the heavier contaminates to sink through it almost without resistance. Heat also had the effect of resolving to a large degree the emulsions which created these large amounts of here-to-fore wastes.

TECHNOLOGY ADVANCEMENTS

The roaring twentys spawned efforts to develop better methods of doing everything . . . including producing, treating, transporting and refining the crude oil now redirected from a war related economy to the industrialization of America. Growth was everywhere. Advancements were being made on every front. And the oil industry was making the transition from an unbounded speculation to a sound and stable business. Energy, it seemed, would become a necessary commodity regardless of other factors, economic or political. During the thirties, strides of enormous impact were made. Many of todays industry leaders were founded and grew when the depression was stiffling other industries. It was early in this era that two very significant concepts came to fruition. They were 1) the successful application of what we generally call today vertical heater treaters and 2) emulsion breaking chemicals. By the close of the thirties it was accepted that the proper application of vertical heater treaters and emulsion breakers could reduce the quantity of waste crude oil emulsions to almost nothing. It was observed that heating crude in a pressurized vessel designed for condensation of lighter fractions conserved large quantities of oil previously lost to atmosphere by vaporization of these same light ends in unpressured tanks. Vertical heater treaters became a standard of the oil producing industry.

World War II seemed to spawn technology in all facets of industry. Organic chemistry matured from an abstract art to an applied science. Plastics were born. Some of the technologies of other industries found a home in ours. One new technology was secondary recovery waterflooding. This boon to the industry brought back old fields to new heights of production, but not without a price. One of the problems caused by waterflooding was a new breed of emulsions, more difficult to resolve. New technologies also took the industry into old producing areas with renewed vigor. In the Rocky Mountain states the requirements for oil quality were stiffened and then stiffened again until they were a full order of magnitude more stringent than West Coast Standards. These changes brought an increased burden on the existing technology of process equipment manufacturers and greatly increased the cost of production. This burden was reduced with the first broadened application of wood excelsior as a coalescing media, and later with the successful development of the first horizontal heater treater. Wood excelsior fitted into the coalescing area of the vertical heater treater collected and coalesced the tiny water droplets which would have migrated through the unit without it. This high resolution of difficult emulsions via wood excelsior became standard practice in the Rockies as well as other areas and is still used today. Because wood excelsior bears a distinct resemblance to baled hay, it became known as hay and the compartment of the vertical heater treater it was installed in became known as the hay section. Hay was and is used successfully in vertical and horizontal treaters coast-to-coast to help resolve difficult emulsions. But hay had its problems too. It plugged rapidly. It only worked if wetted with water first. It had to be replaced, often three or four times a year ... and while the hay was not expensive the labor to remove and replace it so often was. Yet, even with all the effort to find a suitable substitute, wood excelsior remained the only viable material for improving heater treater dehydration efficiency through the fifties, sixties and into the seventies.

PERFORMAX DEVELOPMENT

By the early 1970's the advancement of coalescing research had been permiated with space-age technologies. One such technology was the application of an inclined folded matrix of a plastic material. Successful in other industries, all varieties, shapes and types were evaluated in C-E Natco's Research Laboratories. Development was augmented with field testing so that by the mid-seventies the best material, design, construction and configurations were determined and offered to the petroleum industry. Acceptance was slow at first as the only plastics used in steel process vessels here-to-fore had been heavy wall fiberglass . . . and reluctantly in many cases, where steel was preferred. The very idea of installing plastic corrugations in an oil field steel process vessel was difficult to get past initially. But as it was tried by the daring first few and proven successful beyond all expectations the word spread. Success stories were developed over and over again. The product name "Performax[R]", an acronym for performance maximization and mispronounced during the first few years, became the byword of an industry in the need of ways to improve its efficiency on all fronts.

The first of these fronts was water clarification. Removing oily wastes from produced water had become a major concern as environmental considerations came to the forefront of our consciousness. One success for Performax^R led to another. Continuing R&D efforts at C-E Natco expanded Performax^R to applications in gas demisting and crude oil dehydration.

Performax^R is now replacing wood excelsior (hay) in the Rocky Mountain states in vertical and horizontal heater treaters alike. Not surprisingly it's doing a better job. Its small, light single-piece construction makes it easy to install and easy to remove. It is disposable, of course, but unlike hay can economically be cleaned and reused. This adds to its economic justification and helps minimize both the costs of labor to replace it since it prolongs the in-service life, and can eliminate altogether the normal costs of hay disposal.

PERFORMAX THEORY AND APPLICATION

The Performax^R matrix creates a torturous path for any fluids traversing its breadth, be they oil and water, liquids and gasses or gasses and mists. This torturous horizontal path allows for maximized surface area impingement of the droplets or particles in the discontinuous phase during horizontal flow. Unique in its design, Performax^R is constructed with interconnecting vertical passageways so as coalescence occurs, horizontal flow can result in vertical migration. This unique design feature accounts for the distinct phase separation which occurs within the body of the matrix and impacts the traditional Stokes velocity parameters significantly.

Performax^R is a variable, with the variables adjusted in design based on anticipated or predicted operating conditions. It's matrix spacings are variable as are the angles of the flutes and materials of construction. Each is key and must not be taken for granted. For instance, a matrix spacing of 1/4" may result in a high degree of efficiency improvement for the short term, but if solids like paraffin iron sulfide, scales or silts exist it is predictable that close spacing will result in rapid matrix plugging. This negatively affects operating costs and must be avoided. A thorough understanding of the system is necessary in deciding how and where to apply Performax^R. It would not be wise, for instance, to select a material of construction suited for 120° F maximum temperature in a system where 140° F temperatures may occur due to high process temperatures. Care taken to select the correct variable in the beginning will result in a long term cost effective improvement in treater efficiency.

In order to document the comparative effectiveness of Performax^R the Rocky Mountain area was selected for initial field testing as this is almost always the toughest place to process and because oil quality requirements of 0.3% BS&W are much tighter than in the warmer areas. Case 1 is a typical location in North East Wyoming. Tables 1 and 2 report the efficiency improvements. As the tables reflect, the results were very encouraging and retrofitting of existing treaters is continuing in these areas. Additional field studies were made in North Dakota on medium to high gravity crude, East Texas on heavy 9° API fireflood crude, and California on 13° API asphaltic steam flood related crude. This work was all done in horizontal and vertical treaters typical of the local design and is reported in Cases 2, 3 and 4.

CONCLUSION

In conclusion we see that the process of removing water from produced crude oil has come a long way from Drake's first well to the present. Because this is an industry always searching for a better way, always seeking greater efficiency, the search for ways to improve heater treater efficiency has continued from the early depression years and is likely to proceed well into the future. Basic lessons were learned early on. Settling time aided by the addition of heat to decrease the viscosity, chemicals to break through the emulsion shell, baffling to alter the direction of flow, and wood excelsior to coalesce the smallest water droplets, proved their values in the evolution of the heater treater. Finally the adaption of state-of-the-art plastic technology to the subject of separation saw the birth of a matrix plate coalescer for heater treaters. This event was captured by the PERFORMAX® process, the latest improvement in heater treater efficiency.

ACKNOWLEDGEMENTS

The authors wish to express their thanks to C-E Natco for the privilege of publishing this paper.

Case I - North East Wyoming

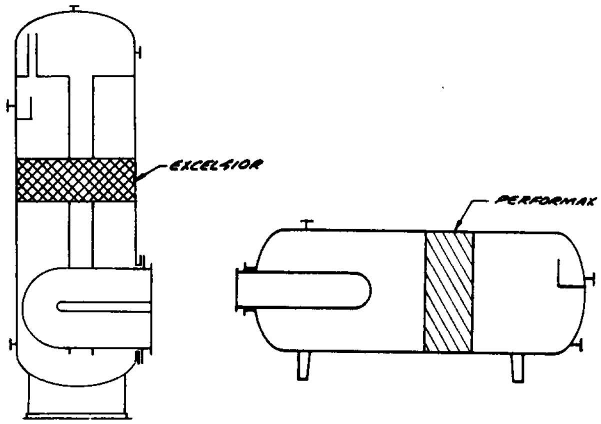

Table 1
Previous Operating Conditions

Equipment: 8' x 27-1/2' x 50#
Conventional Vertical Treater
Oil Rate: 650 bpd, 29° API
Water Rate: 800 bpd
Inlet Temp: 107° F
Fuel: Propane

Problem

Operating Temp: 145°
Dirty Water for Disposal
High Fuel Costs
Approximately $22,000 per year
Oil Outlet Cut 0.2%
and at times more which was diverted to bad oil tank

Table 2
Solution

Installed: 6' x 20' x 50# Horizontal Performax[R] Treater
Oil Rate: 650 bpd, 29° API
Water Rate: 800 bpd
Inlet Temp: 107° F

Results

Lowered Operating Temp to 115° F
Clean Injection Water
Savings on Fuel Costs
$15,000 - $18,000 per year
Oil Outlet Cut: Nil to 0.1%

Case II - Williston Basin North Dakota

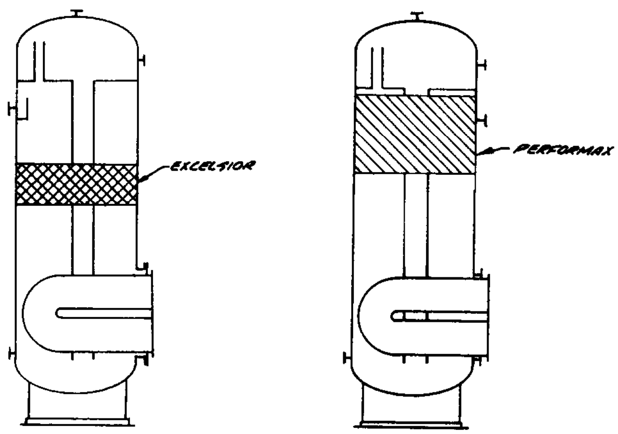

Table 3
Previous Operating Conditions

Equipment: 6' x 20' x 50#
Conventional Vertical Treater
Oil Rate: 212 bpd
Water Rate: 70 bpd
Inlet Temp: 64° F
Chemical Usage: 1 qt per 100 BO
Fuel: Natural gas

Problem

Operating Temp: 125°
High chemical usage
High treating temps
High fuel cost at approximately $5,875 per year

Table 4
Solution

Installed: 6' x 20' x 50#
Vertical Performax[R] Treater
Oil Rate: 212 bpd
Water Rate: 90 bpd
Inlet Temp: 64° F

Results

Lowered operating temp to 115° F resulting in lower fuel costs
Cut chemical usage to less than 1/2 qt per day
Cut fuel from 4700 scf/day to 1500 sct/day
Fuel savings based on $3.50 Mscf approximately $4,000 per year

Case III - East Texas Fireflood

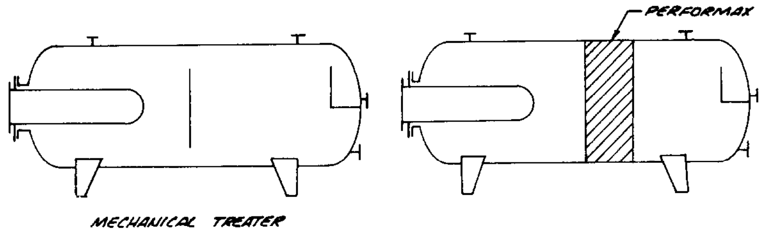

Table 5
Previous Operating Conditions

Equipment: 8' x 25' x 50#
Mechanincal Treater
Oil Rate: 2000 bpd
9° API blended to 22° API
Water Rate: 250 - 300 bpd
Inlet Temp: 110° F

Problem

High Operating Temp: 170°-190° F
High oil outlet
BS&W cuts: 0.3 to 0.6%

Table 6
Solution

Installed: 6' x 20' Horizontal
Performax[R] Treater
Oil Rate: 2000 bpd
9° API blended to 22° API
Water Rate: 250 - 300 bpd
Inlet Temp: 110° F

Results

Lowered operating temp to 165°-170° F
Oil Outlet cuts down to 0.1% to 0.2% BS&W
Resulting in a more saleable product

Case IV - South California

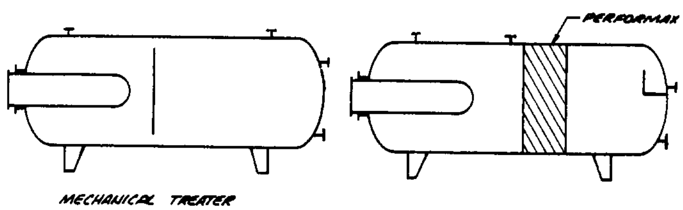

Table 7
Previous Operating Conditions

Equipment: 10' x 60' Mechanical
Horizontal Treater
60% Emulsion
13° API Crude
Inlet Temp: 150° - 160° F

Problem

Capacity of unit: 2500 bopd
1700 bwpd
Operating Temp: 210° F
Oil Outlet Cut: 1.5% BS&W

Table 8
Solution

Installed: 10' x 60' Horizontal
Performax[R] Treater
60% emulsion
13° API Crude
Inlet Temp: 150° - 160° F

Results

Capacity of unit: 4300 bopd
3000 bwpd
Operating Temp: 200° F
Oil Outlet Cut: 1.0% BS&W