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Compact Electrostatic Separation Process

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Abstract

Crude oils from mature fields are routinely associated with high water cuts and high operating costs. High water cuts increase the process heat requirements, chemical requirements, overall vessel volumes, equipment footprints and weights. If a significant quantity of water can be removed at lower temperatures, the subsequent production equipment size, weight and cost can be reduced or eliminated. A method to accomplish this ambitious separation goal is being developed by NATCO.

This separation process includes a compact treatment vessel that combines electrostatic coalescence and separation in either a series or parallel process. The vessel design permits both capacity expansions as well as performance improvement by the addition of more coalescing / separating stages. The overall oil-water separation process includes a series of processing steps for:

- 1) Free gas removal
- 2) Preliminary free-water separation
- 3) Electrostatic water coalescence
- 4) Oil dehydration, and
- 5) Separated water treatment.

This paper will concentrate on steps 3 and 4 of this 5-part scheme.

In laboratory equipment using a pipe vessel, NATCO has processed up to 3000 bfpd/ft² of fluids and achieved an 85 - 95% water removal from oil streams containing as much as 40% water. This compact separation technology has the potential to be applied to either surface or subsea facilities. Using this compact electrostatic separation technology in a subsea environment can provide huge process and economic advantages in deep water applications.

Introduction

Weight and space are at a premium in the offshore environment. The compact electrostatic separator combines several advantages to work well offshore. The separator vessel is “pipe size”; therefore it has a small footprint and weight. In addition the operation is simple with minimal and conventional controls.

Description of Electrostatic Technologies Evaluated

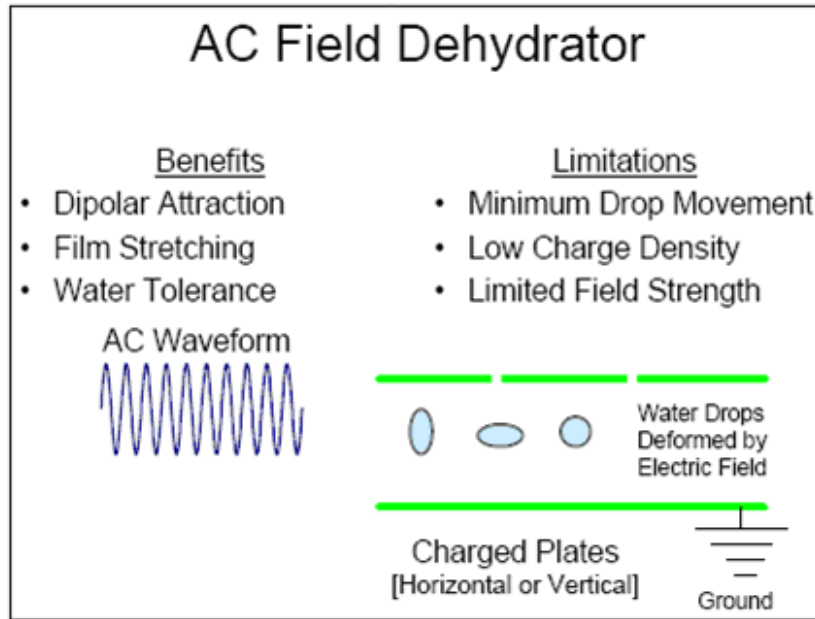
Alternating Current (AC)

Alternating Current (AC) is an older Electrostatic Dehydration technology. The AC process used here applies an alternating electric field at 60 Hz. The voltage can be varied to optimize the emulsion oscillation, which causes the water droplets to deform and accelerates their coalescence. See Figure 1.

Bimodal AC

Bimodal AC is a newer technology that utilizes a higher AC carrier frequency. The potential is modulated between lower and higher voltages at a slower frequency. This additional modulation facilitates additional drop coalescence.

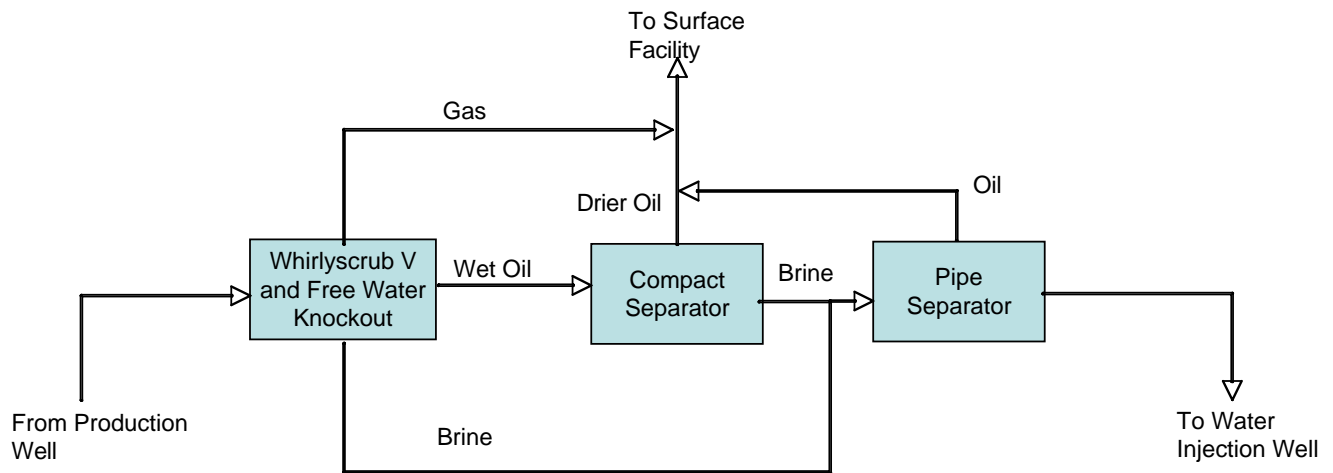
Figure 1



Compact Separator Process

One of the potential uses of the compact separator process is subsea as an initial separator prior to lifting. This process consists of three components working together as shown in Figure 2. The first component is an initial stream conditioner. In order for the electrostatics to function, the stream entering the compact separator should be oil continuous and degassed. Both of these could be accomplished by use of a small free water knockout, FWKO, with a degasser like a recycling separator, i.e. Whirlyscrub V. The wet degassed oil then goes to the compact separator where the water is coalesced and separated. The drier oil from the compact separator is combined with the gas from the Whirlyscrub V and lifted to the surface. The water from the FWKO and compact separator could be cleaned prior to reinjection with a simple pipe separator. The combination of these three elements would be a relatively small simple package with a minimum number of moving parts.

Figure 2



Compact Separator Configurations

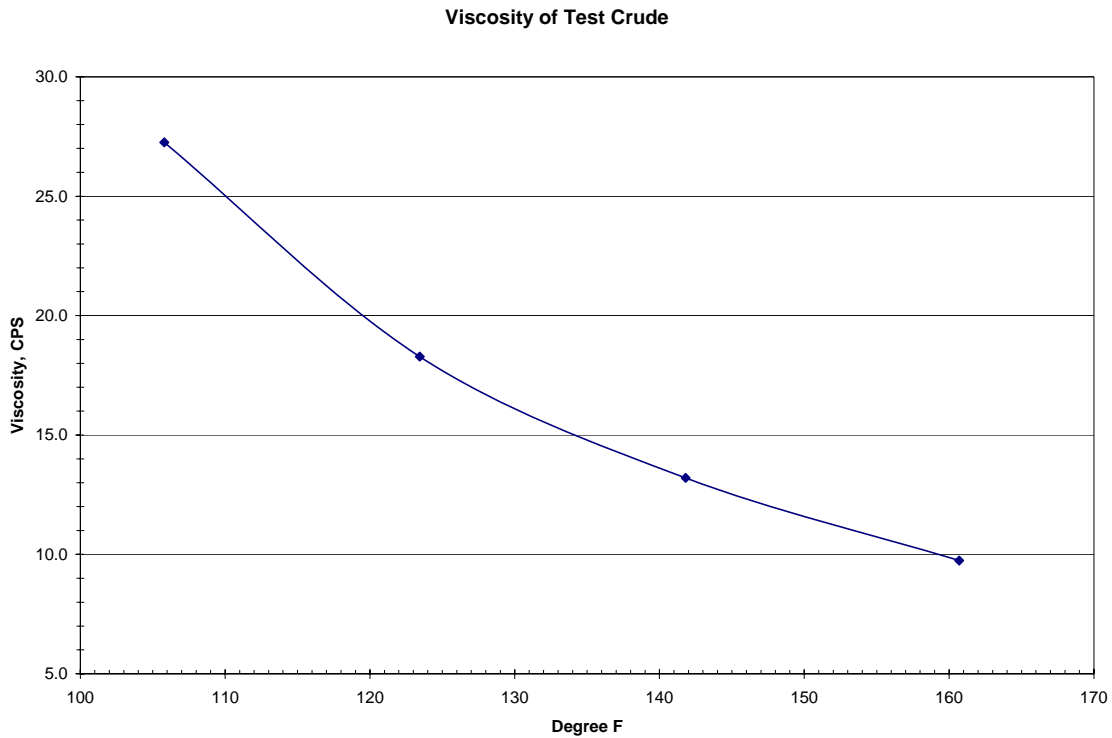
The compact separator can be configured several ways. This flexibility is in part possible because the vessels are in pipe dimensions. The compact separator can be configured in series to produce drier oil or in parallel to increase capacity. The configuration also can be varied to increase water quality.

As the water-oil mixture enters the separator it is subjected to the electrostatic field which coalesce the water droplets. The largest water droplets separate out and flow concurrently with the oil until the water leg, where they exit. The small water droplets continue with the oil and encounter the second electrode and are coalesced again and allowed to separate.

Table 1

Characteristics of Crude and Brine		
Property	Value	Temperatue
API	24	60 F
Conductive	20 nS	68.5 F
Interfacial Tension	5.1 dynes/cm	71.6 F
Brine	50,000 ppm NaCl	NA

Figure 3



NATCO Compact Separator Performance

The physical properties of the oil and brine are listed in Table 1. Inlet water cut varied from about 25 to 40 % and did not have an effect on the oil outlet quality as long as water was not allowed to build up in the water outlet leg. With no voltage applied to the electrodes the inlet and outlet oils water were the same. One of the principle parameter in the separation of water form oil is the viscosity, Figure 3, of the oil. The improved removal of water from oil with increase in temperature, decreased viscosity, is shown in Figure 4. Increased temperature will result in either an increase in the capacity of the electrostatic separator or in the performance of the separator.

Figure 4

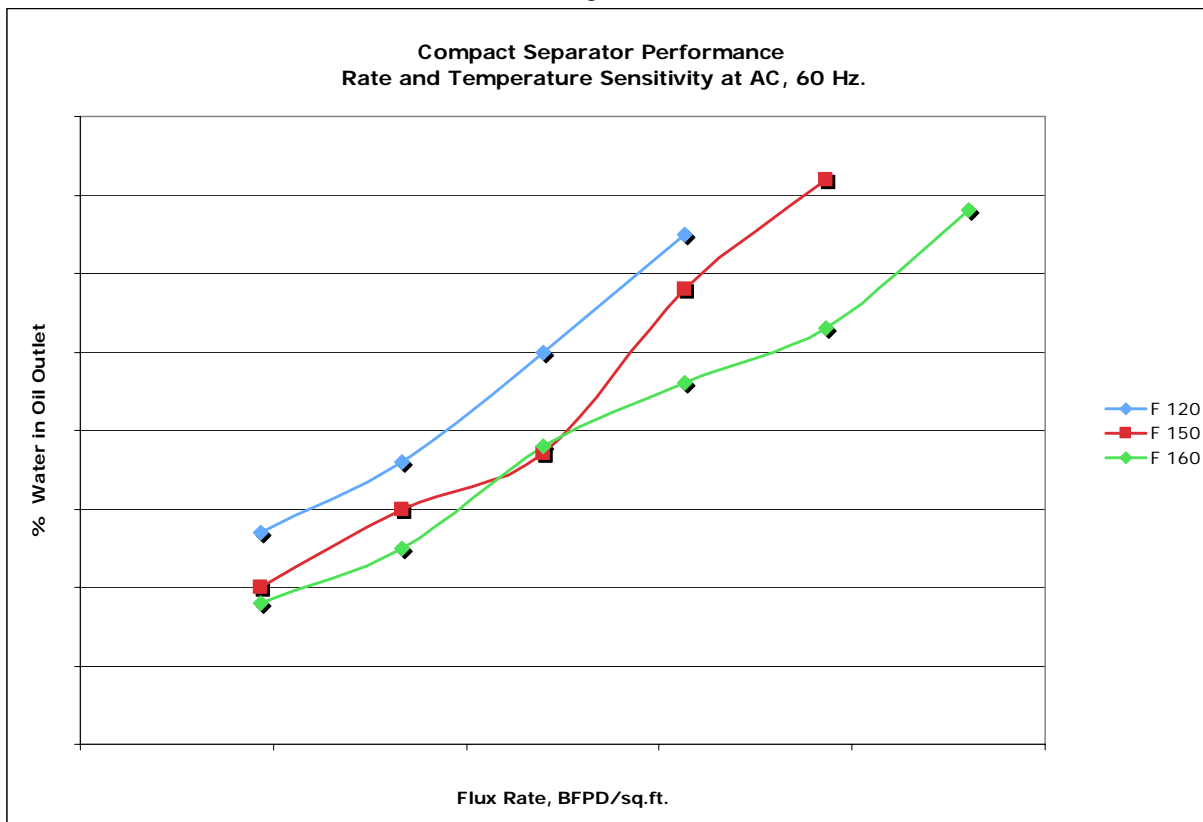


Figure 5

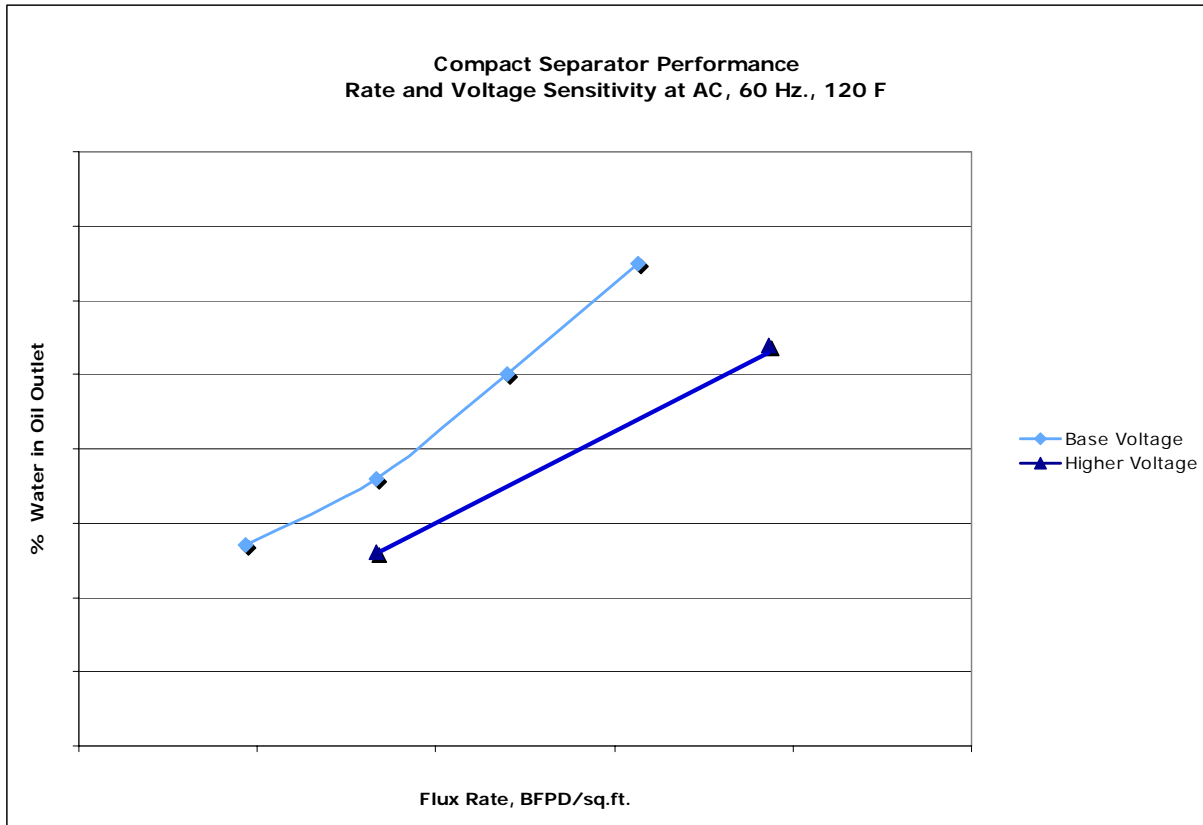
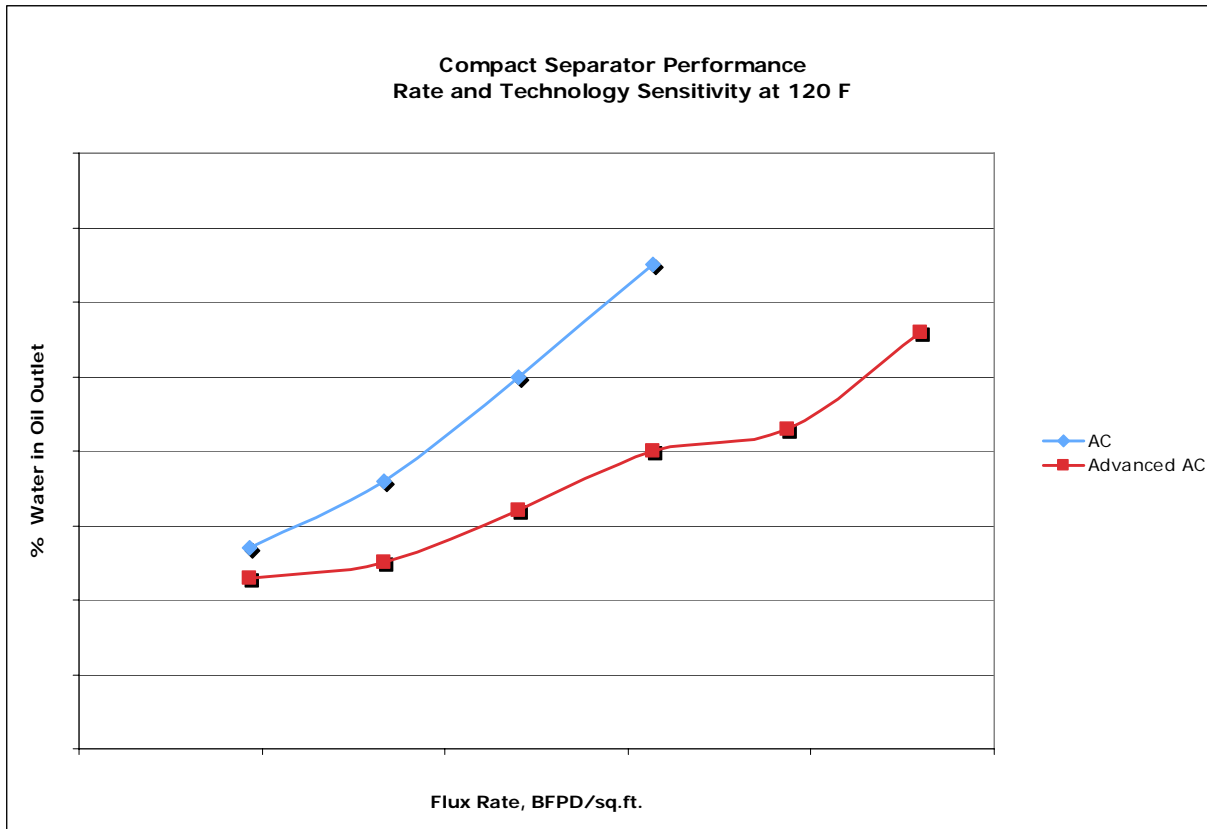


Figure 6



Increasing the applied AC voltage from a base voltage to a higher voltage improves recovery, Figure 5. This is a result of increasing the energy available for deforming the water droplets. A 20% increase in voltage has been shown to produce a 30% improvement in performance. This improvement is either in increased capacity or improved performance. An alternative to higher voltage is voltage modulation. A modulated voltage field is another method of increasing the energy available for use in coalescence. Figure 6 compares AC at 60 Hz and base voltage with Bimodal AC at higher frequency and modulating voltages. The improved capacity or performance is as much as 40%.

Conclusions

The high operating flux in the compact electrostatic separator allows the use of pipe size vessels. The pipe design can be easily placed subsea, permits optimization of the performance and represents the smallest possible footprint. The separator can be arranged in series for either higher degree of separation or redundancy of capability or in parallel for increased capacity. The current design has permitted up to 95% of the wellhead water to be removed in a subsea electrostatic separator.

The planned development steps include further investigations into the following areas:

- Scale –up to larger capacity sizes.
- Increased vessel flux.
- Improved performance at high inlet water cuts.
- Improve electrostatics for better water recovery.
- Evaluation of degassing and dewatering techniques.
- Evaluation of de-oiling techniques for the produced water.