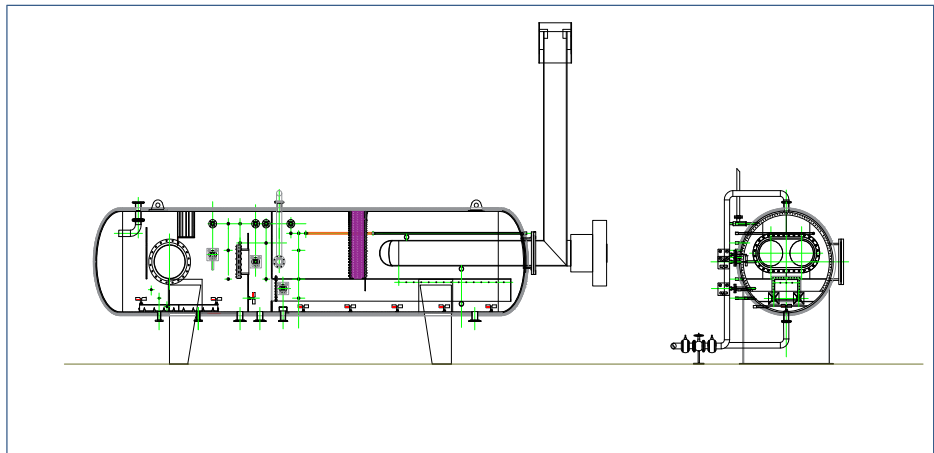


***KOTREAT[®] VERSUS CONVENTIONAL
HEATER TREATERS
A COMPARISON REPORT***



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EXECUTIVE SUMMARY

This report highlights the differences between this producer's previously used mal-performing treater and a new 21st century design from Breakthrough Engenuity.

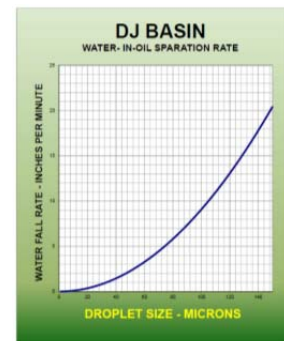
In May of 2016 the Facilities Engineering Group of a major producer in Colorado's DJ Basin commissioned Breakthrough Engenuity to design a new and efficient horizontal heater treater to replace their mal-performing treaters. The driving force in this project was the fact that their existing treaters failed to reliably produce crude oil with less than the 0.5% BS&W pipeline specification. When this specification is not met the producer pays a high BS&W penalty. The penalty was costing this producer every month, with oil prices down, and they sought an immediate solution.

Breakthrough Engenuity specializes in the design of highly efficient oilfield process equipment, and produced the design this producer needed.

THE PHYSICS OF SEPARATION

The physics of separation was established over 157 ago in Stokes' Law. Stokes' Law was therefore used to determine the velocity of fluid separation in client's DJ Basin applications.

The results can be seen in the Stokes' Law graph at the right. Graphs like this were used to determine the proper size of the heater treater for this client's applications.



COMPARING THE EXISTING AND NEW HEATER TREATERS

The existing heater treater was designed and fabricated by a remote vessel manufacturer. To give the reader a comparison of the differences between that treater and the new KOTREAT® treater design we created the following comparison chart.

COMPARISON CHART

| Comparison Description Between Existing Treater and the New DHJ624HHT | EXISTING TREATER | KOTREAT TREATER |
|---|-----------------------------|----------------------------|
| <i>This treater can treat all inlet fluids at IP rates to produce pipeline quality oil</i> | NO | YES |
| <i>This treater separates most free water prior to heating the inlet oil and emulsion</i> | NO | X |
| <i>This treater can produce pipeline quality oil at IP conditions</i> | NO | YES |
| <i>This treater has adequate gas retention time and degassing space</i> | NO | YES |
| <i>This treater has a gas-liquids demister</i> | NO | YES |
| <i>This treater exposes the firetube exclusively to the oil phase</i> | NO | YES |
| <i>This treater has a dedicated free water separation section</i> | NO | YES |
| <i>This treater is designed with 100% removable internals</i> | NO | YES |
| <i>This treater has a dedicated oil distribution system to assure uniform oil heating</i> | NO | YES |
| <i>This treater uses ANSI Raised Face firetube flanges to assure leak-free operations</i> | NO | YES |
| <i>This treater uses a spiral wound ANSI-style firetube gasket to assure a 100% seal</i> | NO | YES |
| <i>This treater has a dedicated sand removal system to prevent internal accumulations</i> | NO | YES |
| <i>This treater has fluid flow redistribution baffles to assure maximum retention time</i> | NO | YES |
| <i>This treater has adequate oil separation cross sectional area and quiescence</i> | NO | YES |
| <i>This treater can be 100% internally coated to minimize long term corrosion</i> | NO | YES |
| <i>This treater is designed with internal anodes (cathodic protection) to stop corrosion</i> | NO | YES |
| <i>This treater has a firetube sized based on a maximum of 8,000 BTU/Hour-sq. foot</i> | NO | YES |
| <i>This treater has an internal fuel gas preheat line to eliminate NGLs in the fuel</i> | NO | YES |
| <i>This treater has a low level ESD safety switch to prevent firetube failures</i> | NO | YES |
| <i>This treater has a high temperature thermostat to prevent firetube over-firing/failure</i> | NO | YES |
| <i>The firetube on this treater can be stamped with the ASME Code stamp</i> | NO | YES |
| <i>This treater is currently designed for either 150 PSIG MAWP or 275 PSIG MAWP</i> | NO | YES |
| <i>This treater is designed to be insulated</i> | NO | YES |
| <i>This treater has all instruments closeted to fit inside an insulated controls house</i> | NO | YES |
| <i>This treater is designed specifically for this client's DJ Basin process conditions</i> | NO | YES |
| <i>This treater uses an anti-downdraft stack head to minimize the effects of wind</i> | NO | YES |
| <i>This treater uses a multiple mitered firetube return bend</i> | YES | YES |
| <i>This treater can be operated in either steady-state or with snap acting controls</i> | YES | YES |
| <i>This treater is an ASME Code stamped vessel</i> | YES | YES |
| <i>This treater is has a lower purchase price</i> | YES | NO |

From the above we see that the KOTREAT® compares quite favorably to the existing treater, and will consistently meet this client's primary goal of providing this client with pipeline quality crude. Its additional cost saving benefits includes:

- 1. Minimizing this client's sand related operating difficulties and related downtime costs.*
- 2. Minimize this client's firetube failures and related downtime, lost production, fire hazard, and environment cleanup costs.*
- 3. Minimize this client fuel operating costs through the pre-separation of all free water.*
- 4. Minimize corrosion related downtime, inspection, and repair costs through the use of internal coatings combined with cathodic protection.*



5. Minimize winter time freezing issues through the use of 1) vessel insulation, and 2) an insulated instrument enclosure.
6. Minimize firetube downtime and replacement costs by eliminating firetube failures from over designed flux rates, low vessel liquid levels, over-firing due to thermostat failures, and water exposure related scaling and corrosion.

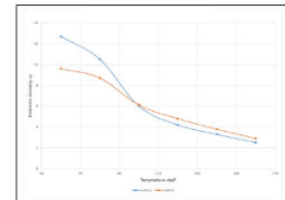
The KOTREAT® comes at a price, but the advantages pay out the price difference in a FEW weeks, making the KOTREAT® a much more cost effective heater treater by a wide margin.

PROCESS CONDITIONS

The design process conditions for the KOTREAT® are identified here:

| | |
|------------|--|
| BOPD: | 1,500 @ 60°F minimum inlet temperature |
| BWPD: | 3,500 @ 60°F minimum inlet temperature |
| MMSCFD: | 5.0 |
| OP. TEMP.: | 120-160°F |
| SOLIDS: | <10 PPMV |
| PARAFFIN: | Yes, 30-40% by volume, cloud point $\pm 110^{\circ}\text{F}$ |
| MAX BS&W: | 0.5% |

Crude oil viscosity was a key contributing factor to the development of the KOTREAT®, so this client provided the crude oil viscosity curves are shown again.



THE KOTREAT® DESIGN

The client reported the several key areas where the existing treater fails to perform. The KOTREAT® overcomes those process deficiencies. They are:

1. Heating was a key problem in the existing treater because its design forced the unit to heat both the oil and the water. Since heating water requires 2.33 times as much heat input, removing the free water lowers the heat requirement needed to dehydrate the crude. So, we added a “free” water knock out/separation section to the basic treater design to remove all freely separable water, significantly reducing the process fluid heating requirements.
2. Frac sand had become a serious problem for this client. The proppant used in fracking was being produced back in large quantities, particularly during the first several months after IP. We incorporated a dedicated sand collection and removal system to keep the

- new KOTREAT® treater from filling with sand and suffering from sand-related mal-performance issues experienced with the existing treaters.*
- 3. The existing treater was designed with the gas outlet adjacent to the production inlet, allowing little or no appreciable time for gas-liquids separation. We added a dedicated gas-liquids separation section that takes fullest advantage of all of the available gas-phase space in the newly added free water knockout section, and uses the most current proven serpentine vane demisting technology to demist the gas, moving all separated liquids back into the liquid phases of the treater rather than carrying them over in the gas outlet line. Oil carryover costs the producing industry millions of dollars each year, and the degassing/demisting design feature in the new KOTREAT® eliminates these losses.*
 - 4. The existing treater used an over-rated firetube and the treater design forced the firetube to attempt to heat all incoming water and oil. Overrating firetubes translates to excessive heat stress and results in premature firetube failures. By removing the free water in the KOTREAT® design we reduced the heat demand by over 200%, and by sizing the firetube for the ideal 8,000 BTU/hour flux we assured its long life. Furthermore, we designed an oil distribution system to assure that all oil is distributed uniformly across the entire cross section of the firetube to create uniform the heat transfer needed to assure the uniform viscosity lowering of the crude needed to completely dehydrate the crude.*
 - 5. The fluid dynamics of the existing treater were determined to be a serious contributor to the poor crude oil dehydration results. The multi-compartmented design of the existing treaters routed oil over the top of the oil layer, precluding dehydration at anything but the lowest flow rates. The new KOTREAT® was based on ideal fluid dynamics to assure repeatable and uniform fluid flows and ideal fluid separation characteristics.*
 - 6. The existing treaters had been internally coated, but were never fitted with adequate cathodic protection. The new KOTREAT® design incorporates sacrificial anodes in each water wetted area to assure corrosion mitigation.*
 - 7. The existing treater was designed for the use of a weighted float ball for the control of the oil-water interface. It is often difficult and time consuming to properly weight such a float so it sinks in oil and floats in water, and such devices often fail as the linkage becomes clogged or corroded, creating the need for additional mechanical leverage which does not exist in this type of controller. This sort of interface control became effectively obsolete by about 1960 when the development of the torque tube and balanced beam displacer-type interface controllers took all of the guesswork out of interface detection and control. The KOTREAT® treater incorporates the balanced beam interface controllers throughout.*

CONCLUSION

The new KOTREAT® treater is a free water knockout and heater treater forged into a single vessel. It is designed to meet or exceed all of any client's low pressure (up to 285 PSIG) process requirements wherever daily produced water volumes are equal to or exceed oil volumes. The fact that it is a single vessel instead of the traditional two vessel approach means the client prepares on site instead of two, transports one vessel instead of two, sets one vessel with one set of instruments, valves and controls, instead of two, and operates a single vessel instead of two!

The KOTREAT® uses single burner firetube which is properly sized for the required heat release and is designed to heat 100% of the oil from IP to the final days of the well(s). It removes ALL free water to minimize firetube size and fuel usage. The firetube flanges are special ANSI pattern raised face oval flanges with ANSI spiral wound oval gaskets which eliminate the all-too-common firetube gasket leak common to all flat face firetube flanges historically used in previously fabricated heater treaters, thus avoiding any fire-related issues. The KOTREAT® is insulated externally to prevent heat transfer through the vessel shell, conserving fuel while assuring complete crude oil dehydration in both summer and winter months, even in the coldest climates! The instruments and related piping are enclosed in an insulated housing that provides a winterized enclosure for all instruments. The exposed area vessel insulation provides for limited wasted heat and provides a level of freeze protection as well, assuring this client that the vessel and instruments will remain warm enough to function 24/7, summer and winter.

*By addressing each of these issues all clients can rest assured that **the new patent pending KOTREAT® treater will outperform others while exceeding the client's process and operating expectations.***

ABOUT BREAKTHROUGH ENGENUITY AND ITS OWNER/INVENTOR



Bill Ball is the founder and owner of Breakthrough Engenuity LLC. He has a distinguished history of oilfield separation system designs, and a comprehensive list of related patents. Bill's hands-on oilfield experience and career portfolio make him one of the industry's leading separation authorities today. After his university studies he launched his career in a 1,000,000 b/d waterflood operation where he was responsible for the evaluation and performance improvement of all surface facilities. He joined NACE and SPE. He spent most of his work days crawling through the process equipment of the day, making improvements wherever possible.

This hands-on experience was the foundation Bill needed to improve, develop, and advance the technologies necessary to improve process equipment efficiencies across the board. In the early years Bill learned what works, and what doesn't! In the decades since his accumulated separation knowledge and experience led to his ten patents, each of which speaks for itself.

The result is a unique approach; one where, “Engineering meets ingenuity!”

Bill’s efforts continue to innovate improvements like the patent pending combination free water knockout- heater treater in one vessel. It’s called “KOTREAT®”. Each new KOTREAT® eliminates the time and expense of installing two more traditional and separate vessels; the FWKO followed by a heater treater, combining the two vessels into one. Through this unique approach and the use of more efficient internals, KOTREAT® has become another industry game changer.

Another example of our ingenious innovation is the MorOil™ system. MorOil™ is a patent pending system designed to condense the valuable C4+ hydrocarbon liquids from produced natural gas streams to generate a larger produced oil stream with added cash flow without the need for compression or chilling.

Still another is the L-POD®, a skidded reject oil treating system for producers and pipeline stations where processing reject or “off-spec” crude is necessary to get full WTI crude prices without off-spec penalties!

These are just a few of Breakthrough Engenuity’s unique oil industry contributions.

Today, Breakthrough Engenuity is one of the industry’s leading low-cost engineering and vessel design firms. We specialize developing designs for the industry’s most efficient high and low pressure, two and three-phase heated and unheated separators, as well as providing general engineering services geared to specialty subjects like:

- *Optimized tank battery design.*
- *Natural gas handling to optimize income and liquids recovery.*
- *Correct and proper line sizing avoiding turbulence, erosion-corrosion, and eliminating the mixing energies that can create severe emulsion issues.*
- *Specialty vessel internals designed to maximize separation performance.*
- *Recommendations for the optimized application of oilfield chemicals to reduce cost and improve performance.*
- *3D modelling to avoid costly facility installation delays.*

Now, more than ever, Breakthrough Engenuity can be found in every sector of the oil and gas industry, adding cash flow to operators and efficiency to their operations.

We’re a full service engineering firm. We pledge to meet and exceed every client expectation. Call us at 918-231-9698 any time!