

Patents and Proprietary Technologies

High Tech Processes at Work ... Processes That Work for You!

PATENTS

HTC continues to innovate. It is said that if you're not moving ahead you're falling behind. At HTC we believe it is necessary to stay ahead of the curve. Shale oil production presents new process challenges and the need for better facility and component designs. Shale oil production conditions vary so dramatically that many older designs are inefficient or obsolete, and create the need for updated engineering and designs. Below is a listing of HTC's many patents, patents still pending, and HTC's proprietary technologies.

Complete SWD Plant Design (aka Pro-Fit®): The concept of a completely automated, highly efficient SWD Plant design is presented in this patent filed in the fourth quarter of 2104. Pro-Fit™ eliminates the single greatest problem in SWD plants by automating all oil skimming. It combines all the features and benefits of the various components which have distinguished HTC designs in the past, like the highly retentive buffer tanks and the Vaughan low-shear pumps so HTC's SWD Plants outperform all others. This patent is due for issuance in 2017.

Highly Retentive Automatically Skimmable Tank (aka Automatic Crude Oil Skimmer or "HRAST®"): Tanks can do more than store liquid; they can become efficient oil-water-solids separators too with the addition of simple retention time improvements. Skimming oil from enclosed storage tanks is normally time consuming and awkward. All too often circumstances overwhelm operators and tank overflow oil. This patent provides for improved retention time, added separation efficiency, and an automated skimming system with no internal moving parts. No human intervention is required! This patent should be issued in 2017.

The Original Skim Tank: The original Skim Tank was developed over many years of trial and error, R&D, experimentation. Conceived in its final form in the late 1980s US Patent Number 5,073,266 and Canadian Patent Number 2,053,326 were granted in the early 1990s. These Original Skim Tanks were developed to replace all Gunbarrels and Wash Tanks in high water cut applications where Gunbarrels and Wash Tanks fail

miserably. Both of these patents are now expired and the technology is in the public domain available for free use by anyone. HTC continues to provide support and detailed designs for this marvelous technology.

KOTREAT® Combination Pressure Vessel: This is a unique vessel designed to separate bulk “free” water from oil, and then to dehydrate the oil by removing remnant water, all in a single pressure vessel. It is truly the marriage of a free water knockout (AKA FWKO) and a horizontal heater treater. By building both into one vessel installation costs are reduced by 50%. These were tested in 2015 and proved to perform as expected. Both water quality and oil quality were exceptional. This unique vessel is patent pending. The patent should issue in 2017 or 2018.

****Horizontal 3-Phase High Pressure Separator (aka EF312HHPS):** The EF312HHPS is covered by Patent 8,470,080, purchased from HTC by Worthington Industry in mid-2014. This vessel was specifically designed for unusually high IP new well flowing conditions typical of those in the NE Eagle Ford Shale Oil Production area where slug rates exceed the capacity of more conventional designs. This vessel has been successfully tested to perform without carryover at rates up to 9,000 BOPD with up to 30 MMSCFD of simultaneous gas flow and up to 1,500 BWPD simultaneous water flow. The design is suitable for both shale oil and conventional production processing.

****Horizontal Heated Separator (Heater Treater, aka EF416HHS):** The EF416HHS is covered by Patent 8,465,372, purchased from HTC by Worthington Industries in mid-2014. The vessel was specifically designed to separate and dehydrate large volumes of medium and high gravity crude oil at high temperatures and pressures with slug flow rates of 2.5 times the nominal design rate without impacting effluent oil, water, or gas quality. The vessel has been successfully tested to perform without carryover. The design is suitable for both shale oil and conventional production processing.

Lease Portable Oil Dehydrator (aka L-POD®): Off-spec oil is successfully processed through this patented system. Patent Number 9,157,035 B1 is both a method and apparatus patent covering this amazing technology applied to resolve difficult emulsions inherent in off-spec oil. This patent was granted in the fall of 2015 in a cooperative effort with Red Stag Energy LLC. For more information contact Gary Johnson, CEO of Red Stag Energy LLC at 918-630-1616.

***60 Degree Cone Bottom De-Sanding Tank:** The de-sanding is modified in this patent application using a 60 degree cone bottom to positively collect the solids, which are pumped out of the cone frequently to avoid

confined space entry, often necessary in the cleaning process of flat bottom De-Sanding Tank (see below), the patent for which was purchased from HTC by KBK in 2014. This new patent application was filed in the third quarter of 2014 by its owner KBK, naming HTC's owner as the primary inventor. It should be issued in 2017.

***DFSD® Inlet Fluid Conditioning Tank:** This is a De-sanding, Flow Splitting, and De-Gassing Tank patent application purchased from HTC by KBK late in 2014, and was immediately licensed back to HTC for HTC's continued use. It is an oilfield waste water pre-conditioning system. This patent issued late in 2015. This vessel is used in oilfield process facilities to first remove solids, then to separate any gas and air from the incoming liquids, and finally to uniformly divide the outlet flow into two or more equal more streams to reduce velocities and enhance separation. This is accomplished without moving parts or flow-splitting automation in a way that has been successfully applied in oilfield equipment for decades. The uniform division of the outlet flow streams reduces the velocity of each to downstream storage and process vessels, adding retention time and separation efficiency. The de-sanding, or solids removal system is designed to remove 120 micron solids and larger. Improvements have been made by HTC in cooperation with KBK to enhance performance, and more are on the way.

***HWSB®:** The "*Hydrodynamic Water Skimming Breakthrough*" is covered by several patents and pending patents which were purchased from HTC by KBK late in 2014. This IP was immediately licensed back to HTC for HTC's continued use. Patent 8,496,740 was issued for a cold weather version on July 30, 2013. This version has an internal water leg making it freeze resistant and suitable for all cold weather applications. A fourth patent has been filed for and is pending. It was filed to include an automatic sand/solids removal system used to preclude the necessity for confined space entry using NOV's TORE® technology. A fifth patent has been filed to update the design of record, reflecting a process design with other features requested by some clients. This and "*The Original Skim Tank*" (see above) are standards of the industry for high water cut oil –water separation applications.

Condensate Separation and Collection System (aka MorOil™): The MorOil™ System is in the patent pending status. Filed early in 2012, this patent application passed all tests for prior art, and expected to be issued in 2016. The MorOil™ System is a wellhead rich gas condensation and separation system designed to condense C5+ fractions from rich gas streams, separate them in the liquid phase, and to provide a conduit to local crude oil storage facilities to enhance both oil gravity and volume, thus adding a new revenue stream while minimizing well site air pollution. Every 10°F of temperature reduction produces another 50% recovery of the C5+ fractions, maximizing lease based BOPD equivalency.

The High Efficiency Gunbarrel/Wash Tank (aka HEGB™): The HEGB™ is a long-overdue replacement for the API Gunbarrel. It is 5-15 times more efficient at resolving more and difficult emulsion from larger streams in small tanks. Because its hydraulic efficiency is so high compared to any other system, it is very forgiving during upsets, resolving tighter emulsions in smaller footprint with less heat and fewer chemicals. The HEGB™ is truly a 21st century breakthrough system. Its patent pending status is due to mature into a patent in 2017.

**These patents were sold by HTC to KBK Industries in August, 2014 in HTC's effort to 1) perpetuate the technology, 2) to increase client exposure to these marvelous technologies through KBK's broader client base, and 3) to increase the technical credibility of KBK. This IP was immediately licensed back to HTC for HTC's continued use. More and more SWD Plant owners and oil producers Use this IP each year in their plants to improve oil recovery, cash flow, and reduce disposal well plugging.*

***These patents were sold by HTC to Worthington Industries in August, 2014. Worthington manufactures this IP for all clients in an effort to spread the value of these marvelous technologies, and to grow the awareness of this IP to a broader client base, adding technical credibility to Worthington Industries Oilfield Division, and better separation performance for its clients.*

OTHER PROPRIETARY TECHNOLOGIES

Many technologies have been developed over time, which individually add to process performance. HTC makes a concerted effort to keep up with these technologies, and where appropriate, offer them to its client base. Some of these are listed below.

SAND PANS: Sand removal from tank and vessel bottoms has been a serious concern since sand production from producing wells was first experienced. Producing from unconsolidated sandstone reservoirs had long-since been an issue, but was mostly dealt with through the use of pre-packed liners to keep the sand in the reservoir. As waterflooding became popular in the 1950s more and more solids were produced. Then, during and after the 1960s, as the US oil industry moved offshore and into international waters, sand produced with oilfield fluids became commonplace, driving the industry to develop means to deal with it. One of the more common methods was the use of "sand pans". These are structures placed on the vessel or tank bottom which by design provide for the horizontal sweeping flow of solids into a confined space where fluid flow is accelerated and sand particles remain entrained in the rapidly flowing associated fluids for removal from the tank or vessel. This IP is used whenever solids are light and "fluffy", or slurried and flowable.

OIL STORAGE TANK EMULSION RESOLUTION: When oil storage tanks are full it's time to sell the oil. In many cases, however, the oil is "off spec" and either must be further processed or sold at a substantial discount. In order to resolve this issue HTC developed a proprietary design which incorporates electric immersion heaters and a single side-wall tank mixer. When an oil tank is full of off spec oil it is transferred to the "Emulsion Resolution Tank" (ERT™) for final treatment. The ERT™ takes the place of a hot oil truck, eliminates wait time, and gives the facility operator an immediate "tool" to resolve and sell off spec oil at the normal WTI price without ANY discount. In most applications the ERT™ pays for itself in the first six months.

RETENTION TIME IMPROVEMENT: Most oilfield tanks are installed simply for storage. However, having the associated storage volume presents an opportunity to use them for more than simple storage. A simple and low cost addition to tanks designed to add retention time for better separation of oil, water and solids can increase retention time and separation by a factor of 10 or more! Since most tanks have no internals, the fluids flow through them in the path of least resistance, from the inlet to the outlet. A 90° elbow properly placed at the inlet can defeat the shot flow path and increase the retention time. Tracer surveys routinely show short-circuit flow from inlets to outlets in a few seconds or minutes. These rapid flow equate to less than 3% of the tank volume, effectively wasting 97% of the tank. The 90° elbow, properly installed, increases the nominal retention time, increasing flow throughout at least 30% of the tank. The added retention time increases the separation of oil and solids. The cost is so small as to be considered almost inconsequential compared to the cost of the tank, or the overall facility. We call this proprietary IP the "RTI Nozzle". It's something every facility engineer should incorporate as often as possible.

AUTOMATION SOFTWARE FOR SWD PLANTS: PRO-FIT® OS was designed by Keystone Controls to completely self-manage ANY SWD Plant. All offloading is controlled to prevent tank overflows or unusually high surge rates that might exceed the plant design. As tank levels rise offloading lanes are sequenced off. Where pipelines and trucks feed water into a SWD both rates are controlled, normally with a priority to the pipeline inlet stream. As tank levels go up and down, pumping rates are managed to maximize plant throughput. Since continuous injection into the disposal well(s) extends well life and maintains more constant injectivity, disposal pumping rates are also managed to minimize the start-stop cycles now known to reduce well life. Where automatic skimming is a part of the installation, Pro-Fit® OS automatically controls the tank levels and skimming functions to move all separated oil directly to oil storage for ultimate oil-water separation in a static environment where separation occurs best. SWD owner report that their chief complaint is oil spills from tank overflow events. PRO-FIT® OS prevents these events, eliminating owners' chief complaint.

DEMISTING SYSTEMS: For decades pressure vessel manufacturers have used ever simpler versions of wire mesh pads as mist extractors. While wire mesh is known to effectively demist gas streams, it can rapidly collect solids and plug. Gas plant operators routinely report finding chunks of wire mesh in their inlet filter separators; plugged mesh pads displaced from upstream separators! New wire mesh pads have been found to be quite effective, particularly when placed vertically where gas and entrained mist flows horizontally through them, but, as they plug with the likes of paraffin, iron sulfide, and/or other solids, the pressure drop across the pads increases until they are hydraulically ripped from their cages and displaced down the gas line, only to be captured in a downstream gas processing plant. One sure solution is the use of vertical parallel plates. These plates are often formed into a "chevron-like" pattern, sometimes referred to as a "serpentine" flow path. When these plates are assembled into demisters they are often referred to as "vanes". The parallel configuration of the plates of vanes forces gas flowing between them to change direction several times. As the lighter gas changes directions the heavier liquids tend to impinge on the vane surface, thereby separating from the gas stream. Vane spacing can be reduced to capture finer mist droplets, or expanded to be self-cleaning in the presence of waxy paraffin and/or iron sulfide. These vane packs can also be used to assist in oil-water separation when they are extended through the gas phase in a horizontal separator, and down through the oil layer as well. When oil and emulsified water droplets, often 30-150 microns in size, pass through the vane section the heavier water droplets impinge onto the plates while the lighter oil travels through the torturous path. Water droplets grow in size and rain downward off of the plates into the water layer below. At HTC we strongly believe in the merits of serpentine vanes since they are so much effective throughout the life of any separator. We refer to these as 'Serpentine Vane Packs', or SVP™s.

COALESCING SYSTEMS TO ENHANCE SEPARATION: As mentioned above, serpentine vanes can cost effectively aid in the separation of liquids from gas and water from oil. An even more efficient system is called "corrugated plates", sometimes referred to as "matrix plates". When assembled, these are sections of corrugated plates where the corrugations are no longer perpendicular to the flow path as in the serpentine vane packs, but are bent at 30° from vertical with every other plate inverted so the first is angled downward, the second upward, the third downward, the fourth upward, and so-on. Where fluid flow in serpentine vanes is left-right-left, flow through a matrix plate section is both left and right and up and down, repeated over and over again. This three dimensional change in direction further enhances plate impingement and separation. The separation efficiency is so high in fact that these sections will eventually collect enough material to plug, necessitating replacement. However, their cost is low enough that this is palatable to most users. These are excellent final fluid quality "polishers", often reducing water in crude oils to below the pipeline quality specification, and oil in water to below 30 ppmv. At HTC we refer to these as Matrix Plate Coalescers, or MPC™.