SEPARATION TECHNOLOGY AND ITS BENEFITS IN THE OILFIELD

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ABSTRACT

The use of various separator designs, internals, and/or internal configurations can significantly enhance separation. The use of centrifugal inlet devices, in some cases, has been shown to increase vessel throughput up to eight hundred percent. Also, internal baffling and various coalescing media, including matrix plate coalescing sections and serpentine vanes, can improve the separator efficiency by eliminating short-circuiting and reducing foam. Inlet devices and vessel intemals are often used in retrofit applications to de-bottleneck facilities or simply improve performance using existing equipment. Furthermore, centrifugal separation may be utilized in vertical recycling separators and horizontal, in-line recycling separators. These separators utilize tangential inlets or fixed vanes to generate centrifugal force and push the heavier liquid droplets to the vessel wall, scrubbing the gas. These technologies can be used as either 'stand alone' units or may be combined into a complete system that utilizes highly engineered solutions.

PAPER

In oil and gas separation, there are a number of devices and configurations available to improve separation over the performance that a bare vessel would provide. The most basic is vessel orientation, whether the vessel is placed in a horizontal or a vertical fashion. More advanced would be the use of basic internals. Among these basic internals are mist extractors, coalescing media, vortex breakers, and sand jetting systems. Last, there are the most engineered internals / configurations available. Examples of advanced internals / configurations are centrifugal inlet devices and recycling separators.

The most basic decision in separator design is the vessel orientation, whether it is vertically oriented or horizontally oriented. Vertical vessels, such as vertical, cross-flow separators, are often deployed in higher gas-to-oil ratio applications, or in areas where vessel footprint is an issue. However, vertical vessels are not commonly recommended for heavy or foamy crude oils. Horizontal vessels, such as a horizontal, longitudinal-flow separator, offer increased foam handling, as well as a larger gas/liquid interface for improved liquid degassing. Horizontal vessels also offer the most flexibility in vessel design and internal arrangement.

Basic separator internals serve to greatly increase the separator performance over a 'gutless' vessel for both minimal cost and minimal effort. Wire mesh mist extractors utilize impingement and coalescence to achieve gas/liquid separation. Wire mesh is most often used in vertical vessels. Vane-type mist extractors also serve to improve gas/liquid separation. They achieve this by utilizing a tortuous path, which creates an inertial separation mechanism. Vane-type mist eliminators may be installed in both horizontal and vertical vessels. Also, coalescing media, such as Performax®, serve to improve liquid / liquid coalescence. Coalescing media also serve to improve foam and help to control the flow within a vessel. Perforated baffles are also used to control the flow within a vessel. Furthermore, vortex breakers serve to eliminate both gas carry-under and liquid carry-over as well as to stop re-entrainment of separated liquid phases. Vortex breakers accomplish this by eliminating the creation of potentially detrimental vortexes of the individual liquid and gas outlets. They help to eliminate 'short-circuiting' in a vessel, which helps to ensure that the actual liquid retention time is close to the calculated retention time. Lastly, sand jets are often used where solids production occurs. Sand jets are used to intermittently sweep the bottom of a vessel to ensure that the outlets and drains remain unclogged, and to ensure that the entire vessel may be used for separation. These basic elements, alone or in combination, are often used successfully in basic separator design.

In the most advanced types of separation devices / configurations, centrifugal force is often applied. This can be done utilizing either vane sections, which apply a spin to the flow, or tangential entry into the vessel or device. Centrifugal force may be used in conjunction with other separation mechanisms for removing oil mist from gas. A vortex tube cluster may be installed in an otherwise conventional separator. Each vertical vortex tube in the cluster handles a portion of the flowing stream, performing primary separation of entrained mist by means of centrifugal force. The vortex tube device is followed by a disengagement space where any droplets of oil that have been caught and coalesced, but carried through, will rapidly settle. A mist extractor, such as a vane-type mist extractor, may be installed in the disengagement space. This

use of centrifugal force combined with gravity or impingement devices can be used in crude oil separators or gas scrubbers to complete the design.
In applying centrifugal force to separation, the separator size is determined by the flow capacity, among other factors. However, the amount of separating force that can be generated at a given rotational velocity decreases as the separator diameter increases. The result is that larger, higher-capacity, centrifugal monotube units are less efficient than smaller diameter units for removing small, entrained mist droplets. To overcome this, another means of applying centrifugal force to de-mist the gas is a multi-tubular cyclone separator in which the flow stream is processed through a bank of parallel cyclone tubes, each tube taking a fraction of the flow. Each tube is kept small in diameter to maintain high separation efficiency.

A vortex tube cluster, such as a NATCO Porta-Test Revolution®, generates relatively high g-forces to quickly de-gas the oil phase. This allows the use of a shorter oil retention time. Degassing is so rapid and thorough that foam is minimized or eliminated. Without the vortex tube cluster, foam can occupy a considerable volume in the separator. The use of a vortex tube cluster often allows foam volume to be ignored as a sizing consideration. Thus for high capacity crude oil separators (which are the ones most limited by foam) the vortex cluster can significantly reduce the required vessel liquid and foam hold-up volume, size, weight and cost. An inlet vortex tube cluster is a separator internal device that can be part of the original separator design, or may be retrofitted into existing separators in order to increase vessel throughput. Incoming process fluids are accelerated in the manifold to a desired velocity. Each tube peels off a portion of that stream, which enters the tube tangentially, generating rotational flow. Within each tube the swirling fluids create a high g-force for separation of gas and liquid. The gas accumulates in the center forming a gas core, and exits through an orifice in the top of the tube, and out into the separator gas phase. Liquids are slung to the tube wall where they migrate downward as a continuous sheet. They exit the tube through a peripheral gap in the tube wall at the bottom, and flow out into the separator liquid bath, in which the bottoms of the tubes are submerged.

In a vertical, centrifugal separator, the fluid often enters the vessel tangentially. This tangential entry, along with the kinetic energy of the incoming fluid provides the driving force for centrifugal separation. Primary separation occurs when the liquid droplets are forced to the wall due to centrifugal force. The gas is then drawn out the top of the vessel, and the liquid level is controlled as in a typical separator. A centrifugal, recycling separator, such as the NATCO PortaTest Whirlyscrub VO, takes this process a step further to enhance separation. As the incoming gas progresses down and into the center of the vessel, it encounters a vortex plate. The vortex plate, which has a hole in the middle of it that connects to the recycle line, redirects the flow of the gas upwards into a vortex finder tube. In this tube, secondary scrubbing occurs as the gas accelerates and spins upwards, towards the outlet. The liquid recovered in the vortex finder tube is carried upwards by the departing gas stream and drawn off through a gap near the top of the tube. This gap is connected to the vortex plate in the vessel by an external pipe. A low-pressure area due to the velocity of the rotating gas above the vortex plate pulls the recycle stream out through the gap. The liquid drops are then returned back into the separator through the recycle line where they then fall into the liquid handling section of the vessel.

A multi-tube cyclone in-line separator, such as a NATCO/PortaTest Whirlyscrub I®, causes a wet gas flow stream to be divided between a number of cyclone-tubes. As the gas stream enters a tube it encounters a spin-generator. The spin-generator is a stationary device consisting of a hollow core and a radial arrangement of curved blades that divert the gas stream into a rotating flow pattern. In the tube downstream of the spin-generator liquid is separated from the gas by being slung out against the tube wall by centrifugal force. Near the tail end of each tube the liquid film encounters a peripheral gap in the tube wall. This gap allows the liquid to be pulled out of the tube, into the annular space around the tubes, where it falls to the bottom and it is discharged under liquid level control. The de-misted gas stream continues through the tube and then recombines with that of the other tubes. To coerce the liquid to exit through the tube-wall gap, a slipstream of gas is withdrawn through the gap. The slipstream is induced to exit through the gap by maintaining a lower pressure in the outer annular space than that inside the tubes. This is done by constructing a duct between the annular space and the hollow core pieces of all the spin-generators. The tails of these hollow cores are, in turn, open to the low pressure of the newly generated gas vortices. A gas slipstream of about 5% is thus recycled out of the tubes to pull liquid out. This slipstream returns back to the spin-generator and out its tail end, where it joins the main gas stream.

The GLCCO (Gas-Liquid Cylindrical Cyclone) is a very simple and inexpensive centrifugal separation device. Rough separation is achieved under low 'g' conditions, the swirl being generated by the sloped tangential inlet. The slope provides for stratified flow and helps keep the level down during small slug occurrence. The GLCC® is a completely gutless vessel which also helps to add to its ease of operation. It is often used for bulk separation in conjunction with well testing. In a well testing case, the streams are temporarily separated, measured and analyzed, then re-combined. With this arrangement no level control is necessary, as the levels are maintained by the height at which the levels are recombined.