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Case Study

Stripped Sour Water

Background

All oil products originate from unprocessed crude oil. After the crude has been extracted through drilling, there are multiple steps to process and treat the crude oil into many usable products. One of the first steps is desalting, which will remove contaminants, such as salts and suspended solids that will affect the product quality and process equipment operation. The next stage is to separate the crude oil into various fractions and is commonly done with distillation. Distillation is a process that utilizes a compound's individual boiling point for separation. In this case, the number of carbons in a compound will determine the boiling point. The feed material is heated and enters the bottom of a distillation column. As the vapors rise up the column, the temperature decreases and cause the vapors to condense into liquid at their corresponding boiling temperatures at a certain height. A bubble cap distillation unit has caps on the trays of the column and allows vapor to continue up the column through the cap to each tray. When a compound cools down below its boiling point at a certain height in the column, it will condense into a liquid and will be collected on the tray below, while allowing the lighter compounds to travel up the column to eventually cool to its boiling point and be collected in the same manner. As the number of carbons in the compound decreases, it is more volatile, so the lighter oils, naphtha, gasoline and are collected towards the top of the column and the heavier oils, lubricating and coker, can be found towards the bottom with kerosene, diesel, and others in the middle of the column. After the crude oil has been separated, additional separation, processing, and refining will be performed for final products.

Heavier oils are defined by their large number of carbon atoms and molecular weight. These heavier fractions can be broken down into smaller fractions such as gasoline. Large molecular weight compounds are broken down by a process known as cracking. This can be achieved by different methods. Thermal cracking is achieved by applying heat to the material to break the compounds into smaller molecular weight compounds. For fluid catalytic cracking and hydrocracking, a catalyst is used to speed up the process and break double carbon bonds to break down the heavy oils. Different catalyst and operating temperatures will yield different products. The product can then be distilled to separate the newly created fractions. There are also other methods of cracking that apply heat or steam, but all cracking methods perform the same job of breaking down the material to obtain a new product. Fractions can also be combined to form heavier fractions. Chemical reactions can rearrange the fractions to form new products. All of these processes are used due to the varying composition of crude oil and are used to meet the demand for the final products.

Hydrotreating is a process that is used to remove contaminants like sulfur and nitrogen. Not only do these contaminants affect product quality and equipment operation, burning them is an environmental hazard and the removal from fuel is required by government regulations. Removing these contaminants will increase the product quality, reduce pollution, and some can be sold as a byproduct. Fractions from the distillation column can be finished products or can go through further processing. Depending on the crude oil grade and product demand, the fractions can go through coking, isomerization, hydrotreating, cracking, alkylation, reforming, stripping or any combination of the above or other steps not mentioned to obtain the desired final product.

Through many of these steps, wastewater streams are generated with contaminants that were removed. Wastewater that contains sulfide from the processes is referred to as 'sour water.' This wastewater can contain other contaminants such as, phenols, ammonia, carbon dioxide, traces of metals and other compounds. There are a variety of sources of sour water such as the processes discussed above and many of the other operations that are involved in the refining process. Some by products are removed from the water through a process called stripping. The sour water is an example that uses stripping. The process begins with the sour water entering the top of a tower with steam entering the bottom. As the steam and water contact counter currently, dissolved compounds can be removed into the steam. Hydrogen Sulfide and ammonia are stripped by the steam and collected as a by product or for disposal. This may require a two step stripping process due to the difference in solubility of ammonia and hydrogen sulfide. The residual water with the hydrogen sulfide and ammonia removed is referred to as stripped sour water and is sent for wastewater treatment for reuse in the process or sewer disposal.

Objective

Selenium is a nonmetal that is an important trace nutrient that is an essential part for enzymes that affect cell function. Only a small daily amount is required and is toxic in large amounts. Recent government regulations are continually becoming stricter on selenium disposal due to the environmental impact. One particular concern is when wastewater accumulates in wetlands; birds will build up levels of selenium at toxic levels causing egg shell deformation and birth defects. Selenium sources have been traced and stripped sour water has been identified as one source. The Clean Water Act has set limits on selenium at a maximum of 0.005 ppm. One problem for refineries is finding a reliable treatment method to obtain consistent results to meet regulations.

Solution

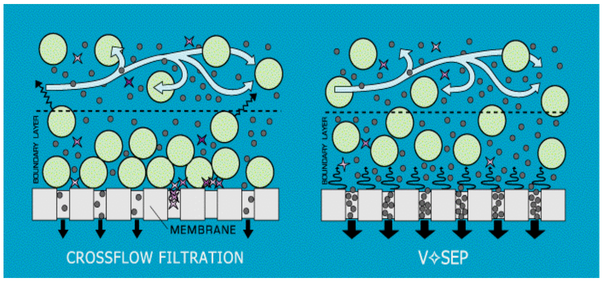
Advanced membrane technology has allowed refineries to consistently meet the discharge requirements with V*SEP (Vibrating Shear Enhanced Process). The vibration component adds a shear force to the surface of the membrane, which will reduce or even eliminate surface fouling. This will yield high flux and consistent quality permeate. An additional benefit to having clean water for reuse is the discharge volume reduction of waste for disposal, hence, reduced water and disposal costs. The design is elegant and performs clean separation in a single pass and requires no chemical treatment.

There are a number of options for selenium removal. A digester utilizes biological and chemical reactions to break down compounds and consume oxygen. This method has proven to remove selenium but due to its narrow operating conditions, unreliable results, and immense size, there is no practicality in installing a digester for a refinery. Another proven method of selenium removal is copper co-precipitation. By manipulating the waste water with chemical additions to cause precipitation of selenium under specific conditions, certain oxidation states of selenium will precipitate out, which can then be separated from the water. This can require a lot of maintenance and is unreliable for regulation requirements due to the unpredictable amounts of specific selenium oxidation states in the feed. Conventional membrane filtration is able to filter and concentrate the selenium in stripped sour water. A micro filtration membrane is the first step which will remove suspended solids in the feed, which can foul the tighter membranes. Numerous steps and chemical additions for pH adjusting, precipitating, removing hardness and other steps for removing any possible fouling agent that a conventional cross flow membrane cannot tolerate is required before moving into the final membrane that will remove selenium. These membranes may seem inexpensive, but the hidden cost of the multiply required pretreatment equipment and chemicals accumulates into a much more expensive treatment system.

When comparing all the possible treatment methods, V*SEP stands out with its simplicity, reliability, and economical benefits. Conventional membranes are limited in their abilities. Particles can become lodged in the membrane pores causing fouling. This will cause reduced flow and permeate recovery as well as more frequent cleanings. A laminar boundary layer will form at the surface of the membrane resulting in a formation of a barrier that restricts permeate flow. By applying a shear force to the surface of the membrane to disrupt the boundary, these problems can be decreased or even eliminated.

Selenium Removal Systems	Operating Costs	Space Requirement	Residence Time	Capital Costs	Reliability	Feed Variation Tolerance
V*SEP	Low	Low	Low	Low	High	High
Conventional Membranes	Moderate	Moderate	Low	High	Moderate	Low
Copper Co-Precipitation	High	High	High	High	Low	None
Digester	High	Very High	High	High	Low	None

The V*SEP is a cross flow membrane that is able to produce economical flow rates and reliability with fouling resistance due to the vibrations. The membrane vibrates at a 3/4" displacement at 55Hz. The vibration keeps the turbulent flow at the surface of the membrane allowing large molecules to continue movement away from the surface, avoiding fouling and allowing the smaller particles to pass through the membrane.



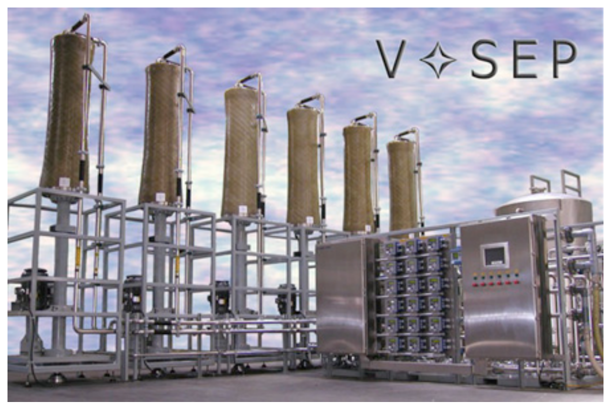
The system is compact and space efficient. V*SEP comes in a variety of sizes to accommodate different process sizes and the number of units required is calculated based on total process flow. Being a modular system, the ability to add additional machines is simple. Filter packs can be changed and different membranes can be used on the same machine for a variety of applications. This unique system has many advantages over conventional membranes and also other technologies for the same application. V*SEP can process much higher concentrations of feed. In many cases, the feed can come from a variety sources and can vary in composition. The V*SEP is designed to handle this variation in feed quality without sacrificing product quality.

Process Conditions

New Logic has installed a VSEP system to treat stripped sour water at a major refinery in the United States. The process requires very low levels of Selenium and uses a Reverse Osmosis membrane, that has a sodium chloride rejection of 99.5%. This system is capable of producing an extremely high percentage of the volume as clean permeate from the dirty feed. The treated water can be reused in the process or sewered. High recovery can be achieved in a VSEP system by using multiple stages of filtration in series. The membrane can tolerate temperatures up to 60°C-70°C and a pH range of 2.5-11. The system is automated and cleanings are implemented according to performance standards. With low maintenance, low energy consumption, and the ability to accommodate variation in feed and operating conditions, V*SEP is a reliable and economical option for refineries and is currently in use and exceeding expectations.

Summary

Each application that comes to New Logic goes through rigorous tests and each system conditions are customized. The process begins with an initial feasibility test using lab scale V*SEP machines. An important characteristic of V*SEP is that just about any membrane on the market can be cut and inserted into the V*SEP to meet desired filtration needs. A variety of membranes are tested based on the application and the best membrane continues to test different variables including pressure, temperature, pH, %recovery, and others. Further testing is completed onsite with pilot machines. New Logic works with a wide range of applications from food products, pulp and paper, all types of wastewater to even hog manure and works to meet each individual application's objectives.



Contact a New Logic representative to develop an economic analysis and justification for the VSEP in your system. For additional information and potential application of this technology to your process, visit New Logic's Website @ www.vsep.com or contact:

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