EPC-EqTech- an innovative turnkey solution to process spent caustic in the Oil&Gas industry

M. Pastur[1], C. Pastor[1], O. Arumí[1], B. Lefevbre[2], V. Almirall[2], S. Arca[3], E. Senol[3], B. Alkcan[3], O. Sahin[3], C. Castro-Barros[1], J. Tobella[1]

[1]Cetaqua, Cornellà de Llobregat, Carretera d'Esplugues 75, 08940, Spain
[2]AQUATEC, Proyectos para el sector del agua, S.A.U, Passeig Zona Franca 48, 08038, Barcelona, Spain
[3]Tüpras Güney Mah Petrol Cad. No:25 41790. Köfrez/ Kocaeli, Turkey
Keywords: Spent caustic; Petrochemical ; Electrochemical technology; Electro-peroxicoagulation.
Presenting author email: m.pastur@cetaqua.com

Abstract: Spent caustic from petrochemical industries is a complex concoction of various pollutants, not only making it a threat to the environment, but also very difficult to treat using conventional treatment processes. EPC-EqTech create a novel solution capable of processing spent caustic at low-cost and within regulatory parameters. A prototype (1 m^3/h) based on a pre-peroxidation followed by Electro-peroxicoagulation (EPC) unit will be operated 12 months to demonstrate a cost-effective spent caustic processing solution for the Oil&Gas sector that minimises environmental impact and enables refineries to meet ever tightening regulations. The prototype will be in the oil refinery company Tüpras, located in Turkey.

Introduction

In the petrochemical industry, alkaline washing processes for oil product desulphurisation purposes result in spent alkaline solutions, known as spent caustic or sour water, which contains a very high Chemical Oxygen Demand (COD) levels and several other hazardous contaminants such as sulphides, mercaptans, sodium salts, etc. Due to these contaminants in refinery spent caustic, these wastewaters are difficult to treat and very harmful and toxic to the environment. Consequently, spent caustic wastewater treatments can be both challenging and expensive.

Today, the global Oil&gas industry spends ~3.5 bn€ p.a. to process spent caustic - making it a critical challenge[1]. However, due to regulatory tightening designed to reduce environmental impacts, costs are now climbing further. Beyond cost implications, the regulations mean that for many operators across the globe, disposal of spent caustic is almost impossible as there are fewer local approved disposal facilities. As a result, large stockpiles of this hazardous waste are now accumulating at refineries with no means of disposal.

These complex wastewaters are difficult to treat using conventional processes. Traditionally, various spent caustic disposal techniques were adopted for disposal of spent caustics such as: deep well injection, biological treatment with careful dosage, incineration, wet air oxidation or disposal off-site. Many of these traditional spent caustic treatment processes have proven to be unattractive due to key issues: (i) difficult operation; (ii) significantly cost prohibitive; (iii) damaging to the environment (i.e. toxic volatile organic compounds, air contamination and soluble mobile organics) and/or (iv) inability to treat extremely hazardous materials meaning they do not meet regulations [2].

Since 2016 Cetaqua and Aquatec have been collaborating in development of an innovative solution: "EPC-EqTech" – a plant that combines three electrochemical technologies to create a novel solution capable of processing spent caustic at low-cost and within regulatory parameters.
EPC-EqTech technology demonstration is within FTI-H2020 project that focuses on the adaptation of the EPC technology for suitability with spent caustic, the novel materials selection required for reactors and other equipment and, the adaptation to the layout design; process configuration and combination of processes to achieve optimal processing capability.

This present study, based on the EPC-EqTech project, is focus on the demonstrative site in Tüpras, a large oil refinery company, and the bench-scale trials and design of a cost-effective spent caustic processing solution for the Oil&Gas sector that minimises environmental impact and enables refineries to meet ever tightening regulations.

Material and Methods

A semi-industrial prototype able to treat up to 1 m^3/h, which is under construction, will be operated 12 months to demonstrate a cost-effective spent caustic processing solution for the Oil&Gas sector that minimises environmental impact and enables refineries to meet ever tightening regulations. The prototype will be in the oil refinery company Tüpras, located in Turkey.

The stream selected for treatment has a high COD - range of 60-85 g/L - an average pH of 11.5 ± 0.2, a conductivity of 223 ± 0.5 mS/cm, and highly odorous reduced sulphur compounds, such as sulphides (average concentration of 3 ± 0.5 g/L) and mercaptans, as well as corrosive organic species.

Results and Conclusions

During the laboratory phase, the key goals of the project were achieved by degrading more than 80% of COD and 100% of the sulphides. Removal efficiencies and costs seemed to be better compared with other techniques used for eliminating spent caustic. There have also been identified other benefits such as treatment on site, eliminating the need for transport, possibility of roving units to be used by the same client at different sites, etc. In addition, the technology is modular, so reactors and pumps can be added and can be scaled up for different customer size.

To ensure safe operation from the point of view of health and safety has been optimized the gas treatment ventilation and the cooling requirements. The main reaction tank has been equipped with a chimney and a fan for forced air introduction to allow ventilation of the pilot area. The ventilation will allow the dilution and dispersion of hydrogen generated during the process. It will also ensure, a better dispersion (1) of door's during normal operation and (2) of hydrogen sulphide in case of uncontrolled acid pH events.

The reaction that occurs when oxidizing and breaking the organic matter chains is exothermic. To prevent the temperature from rising to dangerous limits and decreasing the efficiency of the process it is necessary to have a cooling system. Based on theoretical calculations and laboratory tests, it has been determined that two parallel heat exchangers are needed. The cooling system will allow to dissipate the energy generated during the reaction and maintain the temperature of the spent caustic stream at about 30-35ºC.

On the other hand, the toxicity of the treated caustic soda has been studied, as it is intended to be discharged upstream of the biological treatment plant. Through respirometry trials, it has been concluded that the optimal option is to adjust the pH of the treated spent caustic to 10.5-11 and discharge it upstream to biological treatment at a flow rate of 1 m^3/h. With these conditions there will be no impact to the biomass of the biological reactor.

Once the pilot of the EPC process has been constructed, commissioning will be performed. At this point the system will be operating at design conditions. Finally, 12-months of commercial trials at Tüpraş technically will validate the processing capability of the plant and the materials capability to withstand spent caustic. As an output a case study of results will be produced that will be used to prove the capability and commercial benefit potential of EPC-EqTech to our stakeholders.

References

1. Siemens Energy I-WS. Water Recycling Efficiency In Ethylene Spent Caustic Treatment, Part I: Cost. Water Online. https://www.wateronline.com/doc/water-recycling-efficiency-in-ethylene-spent-caustic-treatment-part-i-cost-0001. Published 2018.
2. Seyedin S, Hassanzadeganroudsari M. Evaluation of the Different Methods of Spent Caustic Treatment. Int J Adv Res Sci Eng Technol. 2018;5(2):5275-5283.