WHY MEASURE SALT IN CRUDE OIL ? DEVELOPMENT OF AN INNOVATIVE HANDHELD INSTRUMENT THAT HELPS MEASURE SALT CONTENT ANYWHERE, ANYTIME

A common material used in machinery and pipes is iron. Iron has many different advantages over other metals, like having high compressive strength, easy to machine with and the ability to form different types of cast irons and steels when mixed with different compounds.

For these reasons iron is commonly used in machinery, engines and pipes, but it has one weakness which is it is susceptible to corrosion/rusting [10]. For rust to occur, oxygen and water must be present. When the iron molecule comes in contact with water, the iron atom losses an electron causing it to ionize, leading the iron to react with the water to make ferrous hydroxide compounds or rust. The way salt helps accelerate this process, is through the formation of an electrolyte solution, which can conduct electrons much easier ultimately aiding to proliferate the initial process of the ionization of iron [1]. It is therefore important to consider areas where the iron is susceptible to rusting, leading to expensive repair costs. In the oil industry there are strict rules about the salt and water concentration in crude oil when it is being transported [3]. The reasoning for this is that water and salt can emulsify into the crude oil and when it comes in contact with any steel, the salt and water mixture can cause the steel to rust. In 2020, the United States averaged 18.12 million barrels per day of petroleum used [2]. That amount of petroleum has to be refined daily. When crude oil is pumped from the ground it will contain a mixture of gases, water, dirt and chloride salts and other minerals. There are strict regulations on the transport of oil and salts in the crude oil. If the salts and water are not removed at an early stage, it will cause corrosion of the refinery, scale formation and catalyst deactivation [3].

This could lead to having to stop the refinery for a certain period of time as parts are being replaced, which can turn costly over time. Sometimes corrosion could happen in the transport pipes, which can lead to an oil spill, like the Refugio Beach Oil Spill in 2015 near Santa Barbara California [9]. This spill caused around 383,000 liters of crude oil to spill into the ocean. This was a direct result of the pipe walls rusting down to 1.5mm and the pipe bursting open from the amount of oil being pumped through it [8].

Crude oil is made from the remains of aquatic animals from millions of years ago. As time passed by sand, rocks and silt piled up on top of the remains causing pressure to build up. Heat from the earth and the rising pressure caused the remains to turn into hydrocarbons which can be refined into gasoline, jet fuel, lubricants, etc. [4]. Through that water and salt can emulsify into the crude oil. Since the salt and water mixture can cause any steel to rust, it is important to remove as much of the salt and water before the crude oil gets transported to the refinery. A safe concentration of salt is considered to be less than one pound of salt per thousand barrels (PTB) which is the minimum amount of salt allowed to be transported in steel pipes [5]. In most cases, the salt and water get removed at the location in which it is pumped out of the ground. The process of removing the salt and water from crude oil is known as crude oil desalting. There are two versions of this process, the one- and two-step desalting process. Each process requires a chemical demulsifier agent to help in

Figure 1: When exposed to the elements and not properly maintained, iron pipes can corrode away leading to having to replace the pipes.

breaking up the emulsions and a freshwater stream are mixed with the crude oil and sent into a series of electrostatic separators (the amount is determined by the number of steps).

Depending on what process that is chosen to be used, the one-step desalting process has the ability to remove around 90% of the salt and water in the crude oil, while the two-step process can remove up to 99% of the mixture. When running the electrostatic separator, the voltage that must be used is approximately 12,000 to 35,000 volts [3]. All of this compounds the cost to produce the final refined oil product. This is not accounting for other minerals, gasses and debris that can be dissolved and mixed with the crude oil that must be removed before the crude oil can be processed.

To test the crude oil for the amount of salt it has dissolved into it, there is an American Standardized Testing Method (ASTM) that is used to test for salt concentration. The test is denoted as the ASTM D3230 Standard Test Method for Salts in Crude Oil (Electrometric Method). The test method is designed to test for the approximate concentration of chloride salts in the ranges of 0 – 500 mg/Kg or 0 – 150 PTB in crude oil. The test consists of a sample of crude oil that has been homogenized and two electrodes placed into the sample. A voltage applied to the electrodes which results in a current to flow through the sample and the current that flows through the sample is measured. To find the amount of salt in the sample, there are calibration curves which have the current that flows through the sample versus the chloride concentration of existing mixtures.

When conducting the test, it is important to use xylene and alcohols to clean the used instruments and conduct the experiment. The test must be conducted in a 100 mL beaker which has been cleaned with xylene or an alcohol. To start off the test, 10 mL of crude oil is mixed with 65 mL of xylene. The rest of the beaker is filled up with an alcohol solvent which is comprised with 63 volumes of butanol and 37 volumes of absolute methyl alcohol. Also, if mixing large amounts of this mixture, add 3 mL of water to that mixture. Once all the liquids have been mixed in the beaker and the mixture was allowed to sit for a few minutes, the electrodes can be placed into solution and the instrument used to conduct the test can proceed with measuring the current that flows through the mixture. To calculate the amount of salt in the solution, use the measured salt concentration from the calibration table in either g/m^3 or in PTB and use the following equations based on the units of the calibration table:

$$Salt\ Concentration, {}^{mg}/_{kg} = \frac{1000X}{d} = \frac{2853Y}{d}$$

The terms X and Y are the salt concentration in g/m^3 and PTB. The resulting test has a repeatability and reproducibility when ran correct of one case in twenty [6].

An Instrument that is capable to run the ASTM D3230 test is the K23060 Salt in Crude test from the Koehler Instrument Co. The instrument not only is able to conduct the ASTM D3230 test, but it is able to measure the temperature of the sample and the pH of the same sample while conducting the ASTM test. This instrument also has the ability to run off a LiPo battery and store twelve different test results. Some instruments that are also able to conduct the test requires the use of calibration curves. The instrument can automatically calculate the concentration of salt using the conductivity values and the temperature of the sample. Additionally, the instrument allows for self-calibration to account for any changes without having to re-enter the temperature curves. The TFT-LCD display on the unit has the ability to show all of the results as well as the battery level, date and time [7].

When pumping out crude oil from the ground, the importance of knowing what chemicals that will come with the raw

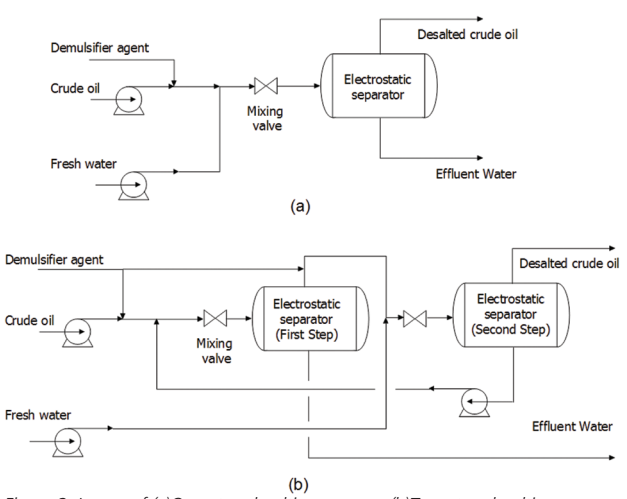

Figure 2: Image of (a)One-step desalting process. (b)Two-step desalting process

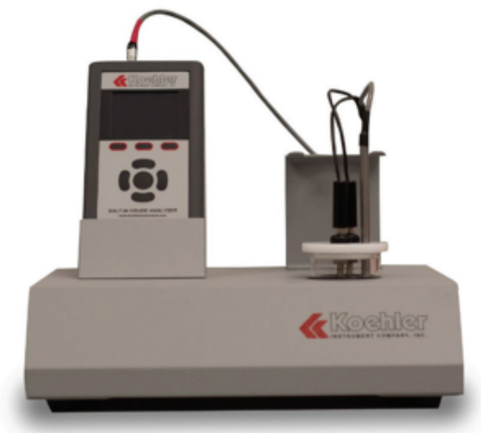

Figure 3: Image of the K23060 Salt in Crude Apparatus with K23060-8 Stand

material is more than important to know. Chemicals like chlorine salts dissolved in water in the crude oil can damage the expensive equipment used in the refining process by corroding pipes and with the ability to have scales form and deactivate any catalysts used in the refinery [3]. There are many processes that can remove the salt and water in the crude oil before it makes its way to the refinery. These processes can get expensive and add to the final cost of the oil that was refined. Understanding all of the chemical properties of the crude oil before it gets used can help predict the best way to refine it with the most cost-effective method. Tests like the ASTM D3230 can help gain an understanding of the salt concentration of the crude oil. This will help preserve the life span of all the gear by letting engineers know that the crude oil has a high salt concentration, so they can set up a desalter on the oil field. Instruments like the K23060 from the Koehler Instrument Co. can perform this test as well as provide many different important chemical properties of the crude oil. Measuring testing can undoubtedly save profits and time in the long run as preemptive knowledge of the crude oil salt concentration allows for proper utilization of desalination methods in the effort to prevent equipment corrosion [3].

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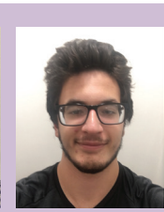
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