DEVELOPMENT OF A UNIQUE ACCELERATED IRON CORROSION TEST (AICT) TO STUDY CORROSION TENDENCIES IN A WIDE RANGE OF FUELS

In 2016, it was recorded that there are around 115 million motor vehicles on the roads in America [1]. That year the U.S. daily consumption of gasoline was 19.6 million barrels per day [2]. There is much importance in sustaining the infrastructure that supplies the needed petroleum products. Major problems in the infrastructure could have major implications economically, environmentally and/or legally. One such problem that is especially prominent is the process of rusting which can lead to the entire system to shut down. When rust starts to form on iron structures, that may weaken any iron structure which could lead to major failures in the infrastructure. For example, iron pipes that start to rust creates a weakness in the structure of the pipe which could cause the pipe to burst open. The economic and environmental impact is massive. In recent months, there was an oil spill in the shorelines of Huntington Beach, Orange County California. It is predicted that around 25,000 gallons of crude oil was spilled into the ocean [4]. Currently that event is still under investigation on why the crude oil leaked into the ocean.

When the crude oil is pumped out of the ground it contains a mixture of different minerals and chemicals that have to be filtered out [3]. Some of those minerals and chemical are corrosive to iron. When iron starts to rust, the iron oxide compounds can dissolve into petroleum products and contaminate any further processes. Before any process is then conducted, the corrosive chemicals that have dissolved into the petroleum products has to be filtered out. That is another cost that has to be implemented into the cost of final product. As time passes, the chemicals that have dissolved into the petroleum products could cause the iron to rust, leading to the weaking of the iron structure which can lead to oil spills and/or other major damages that could shut down any processes, ultimately resulting in massive economic losses and legal implications.

The recent oil spill in Huntington Beach is not the biggest oil spill that has happened from rusted pipes. A much larger oil spill occurred in 2015 of the coasts of Santa Barbara in California. The cause of this oil spill was from the pipes that were used to transport the crude oil, which corroded away to the point where the pipe ended up breaking. This resulted in over 140,000 gallons of crude oil to be spilled into the ocean [5,6].

Figure 1: Image of workers cleaning up Refugio Beach after the pipe busted open

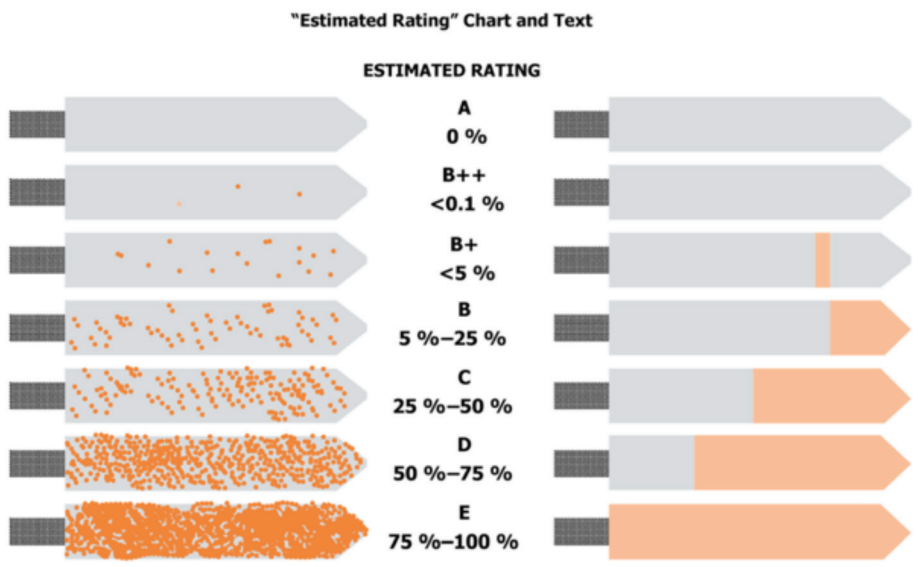

Figure 2: "Estimated Rating" Chart and Text for amount of rust forming associated rust grading

This spill resulted in major environmental and economic damage for the local area. Also, the owners of the pipeline, Plains All American Pipeline, in June of 2021, reached a settlement of 22 million dollars with the Department of Justice (DOJ) that had to be paid for the restoration of the Santa Barbara beach [10]. Since the pipes they were using had corroded away, one thing that could have been done to prevent this was to run tests on the crude oil for the amount of water that has emulsified into it. Water and oxygen must be present in a mixer for rust to form. When water is in contact with the surface or iron, the iron atom will oxidize and either react with the water or oxygen and form iron oxides. A common form of rust is iron (III) oxide, largely termed as rust [7]. Rust is known for weaking iron, if formed in pipes, where the petroleum product is under pressure as it is being transported, and it could directly cause the pipe to burst. Rust does not only effect pipes, but it could also affect storage containers and anything else that it comes in contact with. When the water is either not detected in time or the rust is not found early enough and treated in time, it could lead to massive economic, environmental, and legal problems.

When storing gasoline products for extended periods of time, there is a chance that there is some water that got mixed in or emulsified into the gasoline. To test how the presence of water will corrode iron in gasoline, gasoline products, diesel and diesel products, the American Standard Test Methods (ASTM) can be utilized. One type of test that can be performed is the ASTM D7548 Standard Test Method for Determination of Acceleration Iron Corrosion in Petroleum Products. Water can sometimes be mixed into petroleum products and could lead to the storage tanks to rust or the transportation pipelines to rust. Thus, the test can simulate the long-term effects of how water can affect iron when mixed into oil. The assessment can also be used to evaluate the anti-rust properties of the material as it is either being proceeded

or transported. Often, in the petroleum product may be mixed with a corrosion inhibitor and the test can be used evaluate the effectiveness of the corrosion inhibitor.

ASTM D7548 is conducted with an iron test-rod which is put in a sample of the test material at 37.8˚C and is then mixed with 5 mL of type three or better reagent water. In order to heat the mixture, the test is conducted on a stirring hotplate with a speed of 900 ± 100 rotations per minute (RPM). In preparation, the iron rod must be cleaned with acetone and a grinding and polishing apparatus with a C-100 abrasive cloth which is used to clean off any rust and then to form circular grooves and polish off the test rod to get rid of any rust that has been left from previous tests. Before doing the test, it is important to clean the test jar and magnetic stirring bar so that it does not have a thin film of rust on it. If either the jar or the stirring rod has thin film of rust on it, use 15% hydrochloric acid to clean off any rust. With preparation completed, it is now possible to start the test. To start off the test, there should be a jar cover which would allow for the mounting of the iron rod. With that part of the assembly put together, 50 mL of the test sample should be poured into the jar with the magnetic stirring rod placed into the jar shortly after. The entire assembly is submerged into a water bath which is at a temperature between 37˚C to 39˚C with an initial speed of 100 RPM. Once the sample has hit the target temperature between 37˚C to 39˚C, using a syringe, inject the type III reagent water into the sample and take note of the time. As time passes, increase the RPM of the magnetic stirring bar to 900 RPM. Once the total test time has hit the one-hour mark after the addition of the water into the sample, it is now possible to remove the assembly. Remove the iron rod and within five minutes inspect with the help of magnifying glass with 2x magnification and take note of the results. The result of the test is based on a rating chart in the ASTM testing documentation called the "ASTM Iron Corrosion Rating".

The rating goes from a scale from A to E, where a score of A means that there was no rust that was seen on the iron rod. A score of D or higher means that 50% or more of surface area of the iron rod is covered by rust. A detailed image of the amount of rust on the surface of the iron rode means what percentage of its surface is covered and what rating that should be given to the sample that was tested [8]. Once the entire test has been completed, it is possible to properly dispose of the chemicals that were used to conduct the test.

Figure 3: Image of the K30260 Determination of Accelerated Iron Corrosion in Petroleum Products

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Gleb Khlebutin and **Blerim Gashi** are part of a thriving internship program at Koehler Instrument company and are students of chemical engineering at State University of New York, Stony Brook, where Dr. Shah currently heads the External advisory board of directors.

One instrument that can perform the test is the K30260 manufactured by the Koehler Instrument Co. The instrument comes with the ability to perform four tests at a time. Also, the instrument comes with a five-inch touch screen with soft keys for accessible user experience. The unit comes with all the specification to perform the test with the temperature and RPM with the accordance of the ASTM method [9]. When ordering the instrument, it comes with the four temperature probes, four test jars with the necessary caps, the test rods and the magnetic string rods. The instrument also comes with a list of optional accessories which are a polishing chuck, driver motor and a silicone carbide abrasive cloth. More information about everything that instrument comes with can be found through the company's website.

There is much importance in understanding how the properties of fuel interacts with rust formation on iron surfaces. Knowing that water can always emulsify into fuel and cause any exposed iron to rust could lead to massive consequences if left untreated. Rusting could lead to pipes to burst open similar to the 2015 incident in California. Another event that could happen is that key parts of the oil refinery process or storage tanks will have to be shut down to remove/fix all the iron that has been corroding away which can be costly in the long term if not treated earlier. The ASTM method mentioned, is a way to help understand what the anti-rusting properties of the fuel that is being tested. This method uses an iron rod to that submerged in a fuel water mixer and mixed solidly for a given amount of time. The amount of rust that is left on the iron rod could be used to help understand how well that all the chemicals that have been mixed into the fuel can help prevent the iron from rusting. An instrument that can be used to perform the ASTM test is the K30260 from the Koehler Instrument Co. The instrument comes with all the necessary tools and information to perform the test to the highest accuracy possible.

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Figures

Figure 1: Hong, Jae C., Wagner, L., "Pipeline Company Indicted Over 2015", National Public Radio. May 2016, https://www.npr.org/sections/thetwo-way/2016/05/17/478388898/pipeline-company-indicted-over-2015-california-oil-spill

Figure 2: Figure 1 ASTM Iron Corrosion Rating Chart, "Standard Test Method for Determination of Accelerated Iron Corrosion in Petroleum Products", ASTM, Designation D7548-16a.

Figure 3: "K30260 Determination of Accelerated Iron Corrosion in Petroleum Products", Koehler Instrument Co.

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