The Effects of Environmental Materials on the Corrosion of Steel Nipples

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Abstract

This experiment was performed to find out how different environmental materials affected the corrosion of steel nipples. How do environmental materials in the environment affect the corrosion of steel nipples? If the environmental materials have more oxygen, then the steel nipples will have more corrosion. Since the environmental materials have different properties, they should affect how much the steel nipples corrodes. This project used four bins that each have a different environmental material including: snow salt, beach sand, all-purpose sand, and potting soil; water; and asphalt. In the bins are two nipples each that stay in the bins for a period of time to rust, which is then measured in grams. The potting soil saw the most change, then the beach sand and all-purpose sand, with the snow salt having the least amount of change. It was hypothesized that the more oxygen the environmental materials have, the heavier the nipples would be, which is true to this experiment since the materials with oxygen which are, the potting soil, beach sand, and all-purpose sand, are the environmental materials that made the nipple's weight increase the most.

Introduction

Purpose

This experiment will be performed to find out how different environmental materials affect the corrosion of steel nipples.

Problem

How do environmental materials in the environment affect the corrosion of steel nipples?

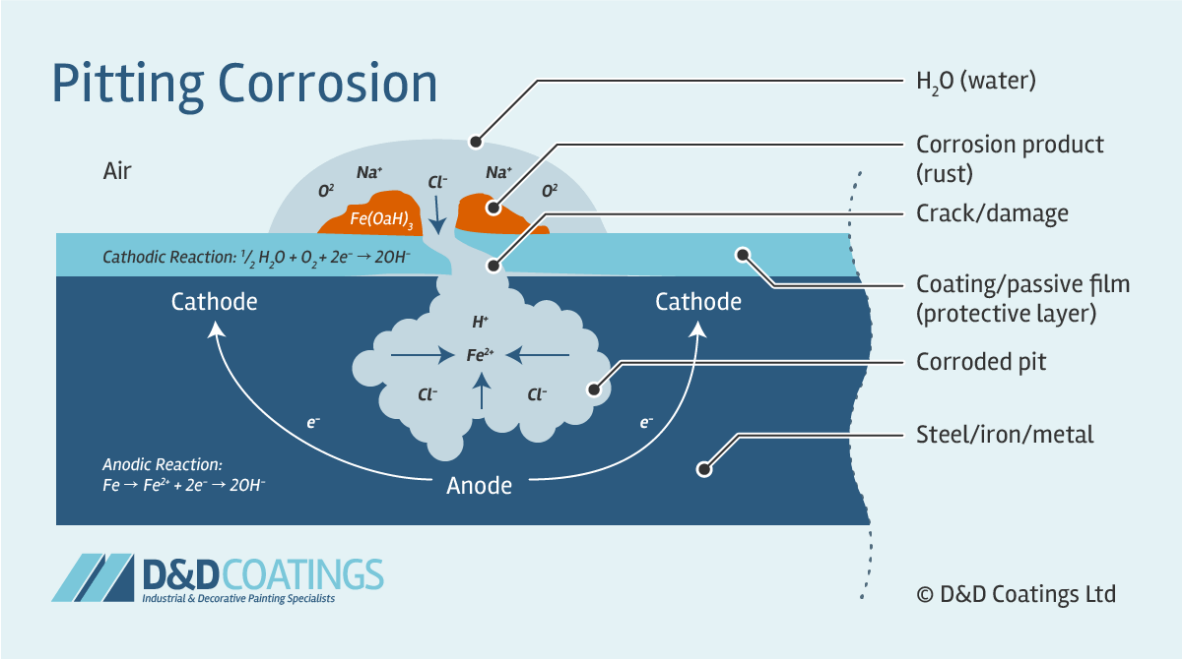
Hypothesis

If the environmental materials have more oxygen, then the steel nipples will have more corrosion. Since the environmental materials have different properties, they should affect how much the steel nipples corrodes.

Research

Steel is used in car parts that are exposed to environmental materials like the ones used in this project which are: snow salt, potting soil, all-purpose sand, and beach sand. They are exposed to these outside every year. This project is important to science because car parts are researched, but not always on how specific materials affect them. So, by doing this project, the data should show which environmental materials affect steel nipples the most, which will show which materials affect car parts the most. This is important because it could prevent car problems and then having to pay to fix the problems. This project will also show how time affects the corrosion of steel nipples with environmental materials.

For corrosion to form, both water (or moisture) and oxygen need to be present. According to BYJU'S, the chemical formula for iron, which is in steel, to rust is $Fe_2O_3.nH_2O$. Steel can corrode easier than other metals and depending on how much moisture and oxygen it is exposed to how much the steel corrodes can change. The more moisture, or water, and oxygen the steel is exposed to the more it will corrode.



While the steel nipples are in the bins they will be exposed to 20 ounces of water and oxygen. When snow salt comes into contact with water, it dissolves by combining with the water, whereas the potting soil repels water. All purpose sand is mostly used in the home, while beach sand comes in contact with water often and the water makes the sand wet and moist. All of these materials will react differently to the water, so they also will affect the corrosion on the steel nipples differently.

Materials and Methods

Variables

- Independent Variable: The Environmental Material that is in the bin
    - Trial 1: Snow Salt
    - Trial 2: Potting Soil
    - Trial 3: All-Purpose Sand
    - Trial 4: Beach Sand
- Dependent Variable: The weight of the steel nipple after it corrodes (in grams)
- Control Group: I am not going to have a control group because the weather always changes
- Constants (Controlled Variables):
    - The amount of water in each bin (16oz)
    - The asphalt in each bin (1 cup)
    - The amount of steel nipples being put into each bin (2 nipples)
    - The time the steel nipples are in the bins for

Materials:

1. Notebook with pencil or phone to record data
2. Weight Scale
3. Camera (IPhone 12)
4. Four, 45 ounce bins with lids
5. 8 steel nipples
6. 80 ounces of water
7. 5 cups of asphalt
8. 300 grams of snow salt
9. 200 grams of potting soil
10. 300 grams of all-purpose sand
11. 300 grams of beach sand
12. 1 or 2 paper towels, paper plate, or napkin
13. Measuring tools, ½ cup and 1 cup

Procedure:

1. Measure the weight of all the nipples and calculate the average of the nipples and record it in your notebook.
2. Set up all four bins by removing the lid, separating them, labeling them 1, 2, 3, and 4, and setting them out on a table.
3. Label all of the nipples 1, 2, 3, etc., until the last one which should be labeled 8.
4. Pour 1 kilogram of asphalt into each bin.

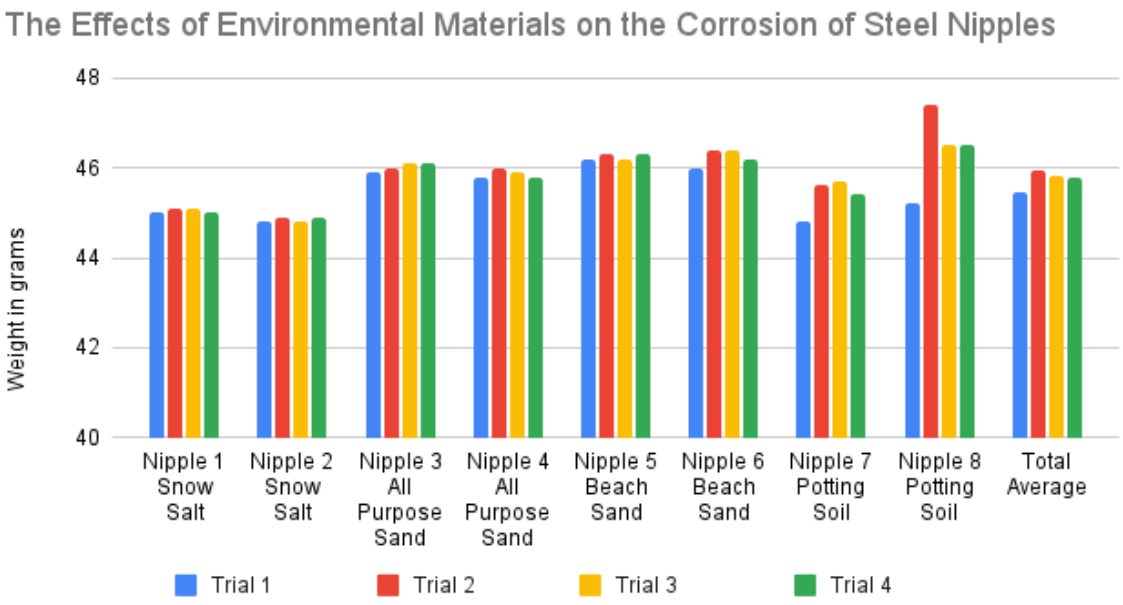
5. Compress the asphalt in each bin by pushing down on it with your hand all around; the asphalt should be slightly packed.
6. Pour 0.3 kilograms of snow salt into bin #1.
7. Fill the bin with 16 ounces of water.
8. Repeat step 6, but with the all-purpose sand (bin #3) and beach sand (bin #4), and put 0.2 kilograms of potting soil into bin #2.
9. Repeat step 7 for bins 2, 3, and 4.
10. Ask for help with dropping two nipples into each bin, then record the starting time that you dropped the nipples into each bin.
11. To keep findings organized, use a paper towel and write the numbers 1, 2, 3, and 4 for the bins. Make sure that the number markings are spaced apart sufficiently.
12. For each trial, after approximately 1 week for each, ask for help and take all of the nipples out of the bins at the same time and place them on the paper towel with identifying number markers, and let the nipples dry for an hour.
13. After an hour, thoroughly dry-off each of the nipples and remove any environmental materials on them; you may need to remove materials from the center or inside of the nipples.
14. Measure the weight of each nipple and record it in a notebook, indicating which nipples came from which bin with the labels 1 to 8 for each of the nipples.
15. Subtract the original weight of each nipple from the new weight of the nipples to identify the change in weight.
16. To collect more data for additional trials, put the nipples back in the bins and repeat steps 10-15.

Results

Table

The Effects of Environmental Materials on the Corrosion of Steel Nipples				
Steel Nipple and Environmental Material	Weight in grams			
	Trial 1 Days: 0	Trial 2 Days: 8	Trial 3 Days: 19	Trial 4 Days: 27
Nipple 1 Snow Salt	45	45.1	45.1	45
Nipple 2 Snow Salt	44.8	44.9	44.8	44.9
Nipple 3 All Purpose Sand	45.9	46	46.1	46.1
Nipple 4 All Purpose Sand	45.8	46	45.9	45.8
Nipple 5 Beach Sand	46.2	46.3	46.2	46.3
Nipple 6 Beach Sand	46	46.4	46.4	46.2
Nipple 7 Potting Soil	44.8	45.6	45.7	45.4
Nipple 8 Potting Soil	45.2	47.4	46.5	46.5
Total Average	45.4625	45.9625	45.8375	45.775

Graph



Analysis

As the time that the nipples were in the bins increased, for most of the nipples their weight also increased. This means that the oxygen molecules in the nipples increased, making the weight of the nipples also increase. While most of the nipple's weight increased, there were two that had the same starting and ending weight, but changed throughout the trials. Overall, each of the nipples stayed in generally the same numbers range with 0-0.2 difference. For example the 4th nipple, which was in all-purpose sand, started at 45.8 and ended at 45.8, but during the second trial increased to 46 and 45.9 during the third trial. The nipple that increased the most was the 7th nipple which was in potting soil. The weight at the first trial started at 44.8 and ended with 45.4; and during the second trial increased to 45.6 and 45.7 during the third trial. Using the averages, the weight of the nipples did increase by 0.3125 grams.

Discussion

Conclusion

If the environmental materials have more oxygen, then the steel nipples will have more corrosion. Since the environmental materials have different properties, they should affect how much the steel nipples corrode. Snow salt is magnesium chloride, which doesn't have any oxygen in it, and for that reason the first nipple had no change in its weight and the second nipple had a 0.1 grams change. All purpose sand and beach sand has a chemical formula of SiO2, which shows that both sands have oxygen in them. This explains why the third nipple had a 0.2 grams change and why the fifth and sixth nipples increased by 0.1 grams and 0.2 grams. Since soil is 25% air, the nipples that were in those bins increased by 0.6 grams and 1.3 grams, which shows that the weight of the nipples did increase even if some of the weight added was due to excess soil stuck to the nipples.

Since the chemical formula for steel to rust is $Fe_2O_3.nH_2O$, which has oxygen, how much oxygen the environmental materials have affects how much the steel is going to rust. In addition to oxygen, steel also needs water, which was present in the bins throughout the experiment. The weight in the nipples increased because there were more oxygen molecules from the environmental materials present because that is what happens to steel before it starts to corrode. Since all purpose sand, beach sand, and potting soil all have oxygen in them, the nipples that were in those bins experienced the most change. The nipples in the snow salt always had very little change in the weight because snow salt doesn't have any oxygen in it, but still had the change since some oxygen was present in the bins.

Application

My project relates to real world problems because it shows how environmental materials affect the corrosion of steel nipples. These environmental materials are used and found outside, which can come into contact with someone's car constantly. If the beach sand, snow salt, and all-purpose sand come into contact with the steel in the car, while the car is wet, the steel will rust. This means that eventually, the steel could corrode. While most steel in cars now has protection against rusting, there are many other outdoor items that have steel which could rust including steel fences, signposts, and mailbox posts, all of which could eventually corrode if they come into contact with the environmental materials included in this experiment.

Recommendations

If I were to redo this project, I would use larger bins so that the measurements of the snow salt, potting soil, beach sand, and all-purpose sand would be all the same. Since the bins weren't that large, I could only add 200 grams of potting soil to bin #2, while the other bins held 300 grams of each of the other environmental materials. If I were to extend this project, I would use more environmental materials and/or use a variety of metals used in cars instead of just steel. A mistake

that I made during the second trial was that I didn’t clean out all of the extra material around the inside of the nipple. While I did remove most of it, some material remained on the inside of the nipple, which I fixed by removing all of it for the other trials.

Acknowledgments

Thank you to Dr. LaBanca for helping me come up with my project. Thank you to Mr. Neuhausel for letting me borrow a weight scale and talking to me about my project. Thank you to Mrs. Locke who encouraged me and kept me on track. Thank you to my friend, Hannah, who looked over all my documents. Thank you to Torrco for selling me the steel nipples and encouraging my project. Lastly, thank you to my parents who supported me and encouraged me throughout the entire Science Fair process.

References/Annotated Bibliography

Ali, Nurdin, and Mohamad Ali Fulazzaky. (2020). The empirical prediction of weight change and corrosion rate of low-carbon steel. *Heliyon*, *6*(9), e05050. https://doi.org/10.1016/j.heliyon.2020.e05050.

This source explains what happens to low-carbon steel buildings during the process of corrosion as it is affected by sodium chloride. This source also explains how common environmental materials surrounding the steel can affect the metal, especially when combined with high levels of sodium chloride. Lastly, this project shows how my project could be expanded. This source is trustworthy because it is an academic science journal that reports scientific research.

General Data Protection Regulation (GDPR) Guidelines BYJU'S. (2021, March 22). BYJU'S. https://byjus.com/chemistry/rusting-iron-prevention/

This source explains what rust is, how it happens, and how to prevent it. In addition, this source also shows the chemistry behind the rusting of iron. It explains that certain materials would make iron, which is in steel, rust easier and why rust is undesirable. This connects to my project because I am seeing if there are environmental materials that will make steel rust faster, to eventually corrode, and why we don't want this to happen. This source is trustworthy because it is a technology-based educational company that provides learning programs for grades preK-12, and it focuses on helping students and teachers.

Corrosion Protection for Car Parts and Safety. (2017, February 8). Automotive IQ. Retrieved on January 11, 2022, from https://www.automotive-iq.com/car-body-and-materials/articles/corrosion-protection-car-parts-and-safety

This source explains how corrosion has become an issue for companies because it has caused them to recall products. It also explains the problems that corrosion causes and how it forms. It also provides some solutions to help prevent corrosion. For example, it states how water and salt cause metal to corrode, which is a big problem for the auto industry. This article helps me with my project because it explains how corrosion is a problem for cars and auto parts, which is something that I am trying to show in my project. This source is credible because the people publishing articles on this site are experts in this field. Also, this site is trusted by many other credible sources.

Science Fair Meeting with Dr. LaBanca. (2021, October 28). [Video]. Audio Recording. https://drive.google.com/file/d/19b3n0q_tUnH_FDtrfgA7xqSoRkV9RoAw/view?usp=sharing

During my meeting with Dr. LaBanca, we talked about what I wanted to do with science fair and what I was interested in studying. I explained to Dr. LaBanca that I wanted to test and measure rust, but after talking about my original project I learned that some of the testing I had planned on doing wouldn't work. As we started to explore ideas, we came up with a new project that involved testing the corrosion that iron nails produce in certain environments. This is important because it is how I developed the project that I am doing

for science fair. Dr. LaBanca is a credible source because he has worked with kids for Science Fair for many years.

What is Pitting Corrosion? (2019, May 26). D&D Coatings. https://www.ddcoatings.co.uk/2276/what-is-pitting-corrosion

This source explains what pitting corrosion is and how it happens. In addition, this source also explains different where pitting corrosion could take place and what happens to the metal as pitting corrosion occurs. Furthermore, this source includes many helpful diagrams for the different types of pitting corrosion. This source connects to my project because it gives an in-depth explanation of what corrosion is, which is something I need to understand for my project. This source is credible because D&D Coatings is an industrial painting specialist that provides many services with an entire team of experienced professionals, including a health and safety contractor.

"Why Do We Put Salt on Icy Sidewalks in the Winter?" Scientific American, 26 Dec. 2005, www.scientificamerican.com/article/why-do-we-put-salt-on-icy/#.

This source explains what snow salt is and how it works. It also explains why it is useful and how different temperatures affect it. This source connects to my project because snow salt was one of the environmental materials that I used so this provided me with a better understanding of what snow salt was. Finally, this source is credible because Scientific American is an academic science journal, which has been publishing scientific articles since 1845.