Jurnal Dinamika Vokasional Teknik Mesin
Vol. 10, No. 1, April 2025, pp. 60-70
https://journal.uny.ac.id/index.php/dynamika/issue/view/77644
ISSN: 2548-7590, DOI: 10.21831/dinamika.v10i1.77644

Enhancing Corrosion Resistance: A Comprehensive Study on Stainless Steel AISI 304

Farkha Nur Alifah[1], Vera Pangni Fahriani[1]
[1] University of Singaperbangsa Karawang

Article Info

Article history:

Received Sep 12, 2024
Revised Nov 22, 2024
Accepted Apr 24, 2024
Published Apr 30, 2024

Keywords:

AISI 304 stainless steel
Corrosion rate
Damage material
Metal corrosion
Corrosion resistance

ABSTRACT

The selection of metal as a construction material used for the industrial world is an important factor that is in accordance with industrial provisions. Corrosion is a factor that must be considered due to the corrosion impact of damage can cause losses in various aspects. AISI 304 stainless steel is one of the stainless steel materials that is resistant to corrosion so that it is widely used in several industries. The corrosion protection in AISI 304 stainless steel has to be carried out with the method of using corrosion inhibitors and protective coatings so that it can reduce damage and extend the life of the AISI 304 stainless steel metal material. Electrochemistry and weight loss methods are used in testing so that the corrosion rate of AISI 304 stainless steel material can be known in various temperature, salinity, and electrolyte solution. The results of temperature variations show that the corrosion rate decreases with increasing temperature and immersion time. The results showed that the higher salinity level of the water media produced the higher the corrosion rate. In the variation of electrolyte solution, the best corrosion resistance of AISI 304 stainless steel occurs in electrolyte solutions with low concentrations. In addition, the mechanical loading study indicates that the magnitude of the loading causes the corrosion rate to increase. In this case, to inhibit corrosion by considering temperature factors, water salinity media environment, chemical substances around the material, and mechanical loads, it is important to carry out corrosion protection in order to slow down the corrosion rate so that it is more effective in its application, minimize damage and loss and extend the life of the AISI 304 stainless steel metal material used

Corresponding Author:

Farkha Nur Alifah
University of Singaperbangsa Karawang
HS Ronggo Waluyo, Puseurjaya, Telukjambe timur, Karawang, West Java 41361
Email: farkhana015@gmail.com

INTRODUCTION

Corrosion cause damage to metal materials due to the interaction of chemicals from the environment with metal materials (Irawan et al., 2023). Corrosion is a chemical process caused by an electrochemical reaction between the "anode" and "cathode" which causes a redox reduction-oxidation reaction (Prayitno & Fikri, 2020). Metal is a material that is widely used than other materials because metal has the ability to conduct heat and electricity. In addition, the properties of metal are ductile and wear-resistant and have adequate strength (Chrisman & Priharyoto Bayuseno, 2014). Determining the quality of a product and the costs incurred are determined by the selection of the type of metal used which has a production system and certain superior properties (Perdana, 2017). Metal materials that are damaged by corrosion are a significant problem because chemical reactions occur with the environment, resulting in a decrease in metal quality (Kusumawati & Fahriani, 2024). Steel is one type of metal that is widely applied in industries such as stainless steel. Stainless steel is a type of steel that has resistance to corrosion containing at least 18% Cr and 8% alloying elements. According to the crystal structure, stainless steel is categorized into 5 types, namely austenitic, duplex, precipitation hardening, martensitic, and ferritic stainless steel. Austenitic stainless steel, steel that has very good corrosion resistance, is easy to weld, form and ferromagnetic. Stainless steel 304 is the most commonly used steel series for industry or non-industry (Novita et al., 2018). Austenitic stainless steel is an iron alloy with a face-centered cubic (FCC) structure and is referred to as the γ phase in the phase diagram, this is a single-phase alloy as a result of alloying elements whose addition stabilizes the γ phase from high temperatures to cryogenic conditions (Singh et al., 2018). Austenitic stainless steel is the most widely used for construction and machine tools whose production reaches 70% of all stainless steel, this steel is capable of maximum corrosion resistance in annealed conditions, where all carbon elements dissolve in the austenitic phase (Fitriani & Purwadaria, 2024). Compared to ferritic and martenistic, austenitic has better rust resistance (Ramadhan Cahya & Abdulah, 2019). Austenitic stainless steel 304 is a type of Fe-Cr-Ni alloy that is widely used because it has high corrosion and mechanical resistance (Nugroho et al., 2014 (Nugroho et al., 2014). Stainless steel 304 is the most commonly applied austenitic type because the combination of mechanical properties used has the best corrosion resistance (Setyowati et al., 2017). The oxide (chrome) layer that coats the surface of the steel makes stainless steel corrosion resistant even in corrosive environments (Umartono, 2012). According to (Aritonang & Fahri, 2006) construction needs that use 304 stainless steel need to pay attention to the temperature and acid in the area. This material is widely used in various fields such as chemistry, food processing, petrochemicals, and even pharmaceuticals (Fawaid et al., 2012). Stainless steel that has resistance to corrosion, but does not rule out the possibility of experiencing stress corrosion cracking, uniform, or even pitting (Novita et al., 2018). Corrosion occurs due to material interacting with corrosive environments and surrounding areas (Prayitno & Fikri, 2020). The use of metal materials certainly needs to consider the environment to plan a metal product. This is because alkaline and acidic environments have different uses of a material. There are several other factors that influence corrosion in addition to the acidity level of the environment such as environmental factors, temperature, and oxygen capacity in the environment (Sumarji, 2011). Due to the existence of various factors that affect the corrosion rate of AISI 304 stainless steel, a literature study was conducted to further determine the influence of other factors that can have a further effect on the corrosion rate of AISI 304 stainless steel.

METHOD

Literature study is used as a method of writing articles obtained from various sources related to the corrosion rate of 304 stainless steel. The data used are based on journals and studies that have been published and accessed online.

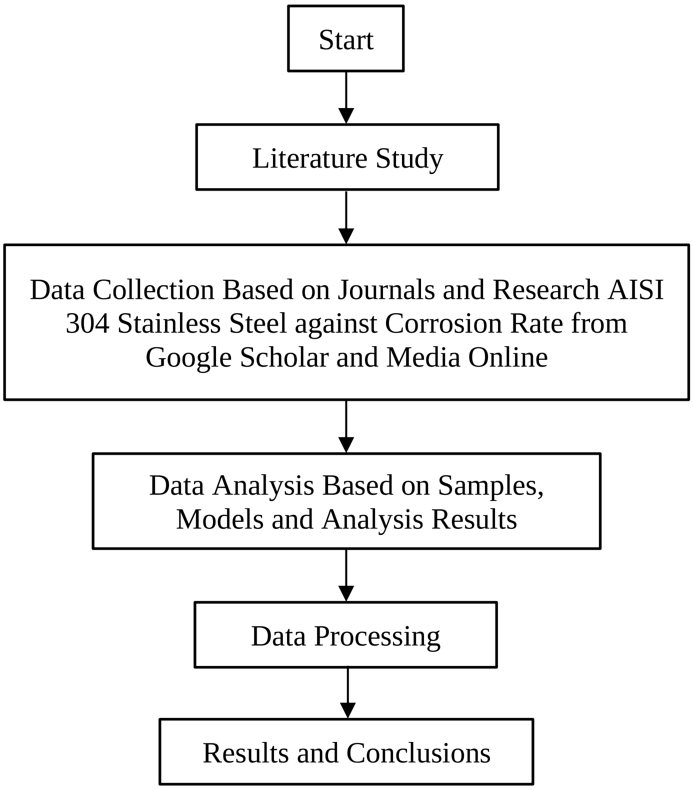

Figure 1. Flowchart Study Literature

The review method with a journal citation system based on samples, models and analysis results using Google Scholar online media keywords. The criteria for selecting journals in this journal review are national and international journals on AISI 304 stainless steel against corrosion rates by citing 22 journals of literature that are used as review materials and forming a journal review article with the theme of AISI 304 stainless steel studies on corrosion rate.

RESULTS AND DISCUSSION

Effect of Temperature Variation on the Heat Treatment Process of AISI 304 Steel on Corrosion Rate

Research (Perdana, 2017) used the AISI 304 steel heat treatment method and corrosion testing. AISI 304 steel measuring 75 mm x 75 mm x 5 mm was heat treated by varying the time, AISI 304 steel specimens were heated for 30 minutes at various temperatures (600 °C, 700 °C, 800 °C, and 900 °C) and cooled in water. During this process, treatment using variations in temperature is required, namely specimen 2 at a temperature of 600 °C, specimen 3 at a temperature of 700 °C, specimen 4 at a temperature of 800 °C, and specimen 5 at a temperature of 900 °C. The four specimens were carried outfor 30 minutes with water as a cooling medium. While specimen 1 was not heat treated. Metallography observations were carried out so that the microstructure of the initial specimen (non-heat treatment), after heat treatment, and after corrosion testing was carried out was obtained. The test was carried out by dipping the corrosion model that had been heat treated. Then the weight measurement after the corrosion of the specimen was dipped into a sulfuric acid solution (H_2SO_4) for 24 hours. After that, the specimen was cleaned and weighed to measure the weight before and after the corrosion test. The weight measurement of the specimen was measured before and after the corrosion test to determine the corrosionrate that occurred. The data obtained from the weight measurement and metallography observations wereanalyzed to determine the *heat treatment process* on the corrosion rate of AISI 304 steel which was affected by temperature variations.

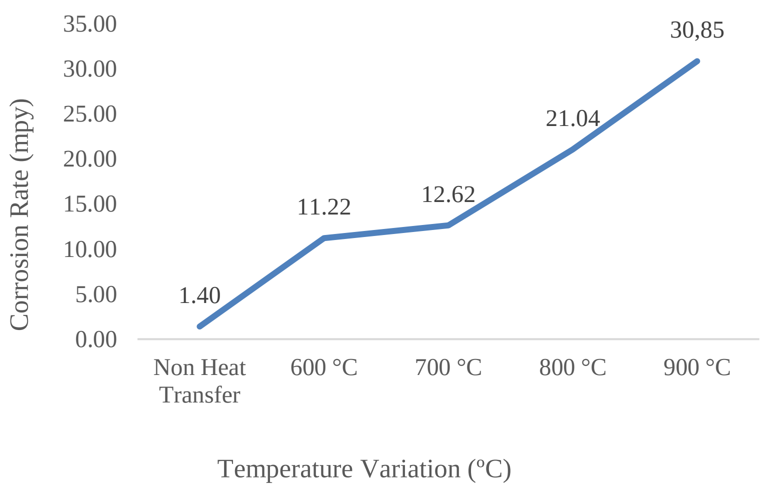

Figure 2. The Effect of Temperature Variation on The Heat Treatment Process of AISI 304 Steel on Corrosion Rate

The results obtained has an effect of temperature variation during *heat treatment* on the corrosion rate of AISI 304 steel. The higher the *heat treatment temperature*, the higher the corrosion rate. This is evidenced by the increase in the corrosion rate from 11.2208931 mpy at a temperature of 600 ºC to 30.8574559 mpy at a temperature of 900 ºC. AISI 304 steel specimens thatwere not *heat treated* resulted in a slower corrosion rate (1.40261163 mpy) than those that were *heat treated.* Therefore, the corrosion rate is faster and higher when the temperature is getting hotter. The microstructure also changes with temperature variations indicating changes in material properties due to heat treatment. Based on research (Sumarji, 2011) temperature is one of the factors that influence the corrosion process, in his research which varied the temperature of 30 °C, 50 °C, 70 °C at each different pH level with different HCl solutions, the corrosion process was carried out for 7 x 24 hours, the corrosion rate that occurs is higher as the temperature increases, this occurs because of the difference in pH, the increase in acidity levels (pH decreases), so that the corrosion that occurs is greater. Temperature can increase the energy in a system so that it will affect the rate of corrosion that occurs. This is because the higher the temperature in stainless steel, the particles that make up the elements, both from the solution and from the metal, move faster. With this faster movement, the possibility of ions from the solution and ions from the metal meeting to react is also faster. So that the reaction rate that occurs is also faster. However, in the research (Sukmana, 2007) variation sensitized temperatures in H_2SO_4 affected the corrosion rate of AISI 304 stainless steel that occurred. at a heating time of 4 hours with different temperature variations and different soaking times, at a temperature of 500 °C the average corrosion rate was 2.76 mm/y, at a temperature of 670 °C the average corrosion rate that occurred was 1.58 mm/y, and at a temperature of 840 °C the average corrosion rate was 0.9 mm/y, the higher the temperature the smaller the corrosion rate that occurred. This is also similar to the research results (Mulya, 2019) of AISI 304 Stainless steel specimens which were tested for corrosion rate in sulfuric acid without heat treatment and which were given heat treatment at temperatures of 480 °C, 650 °C, 820 °C, with a holding time of 2 hours and different immersion times, the corrosion rate decreased with increasing temperature and immersion time. This may be due to the differences in soaking time. So it can be concluded that temperature variations without any difference in immersion time experience an increase in the corrosion rate along with the increase in temperature, but if there is a difference in immersion time, the corrosion rate that occurs becomes smaller along with the increase in temperature.

Analysis of Corrosion Rate of AISI 304 Stainless Steel Based on Differences in Water Media

(Irawan et al., 2023) Conducted a study using the *weight loss method* in the ASTM G31-72 standard. 304 stainless steel specimens measuring 40 mm x 40 mm x 4 mm were immersed in several media, namely seawater, brackish water, and ponds. A total of 27 specimens were used for testing for a period of 1-4 weeks. In addition, an additional 2 specimens were used for testing for 1 & 2 hours. After testing, the test results were compared by looking at the size of the specimen using a caliper so that the correct dimensions could be ascertained. After that, the scale and dirt on the test material were cleaned using polish or others. Three types of immersion media were prepared, pond water, salinity of 14% for brackish water and 32% for seawater. Before immersion in a corrosive solution, it is necessary to weigh each specimen to determine its initial weight so that it can be used as an initial reference. Specimen immersion is carried out by immersing each specimen in the solution for a predetermined time. After immersion, the weight of each specimen is reweighed so that the difference in the initial and final weight of the specimen after testing can be known. Thus, the level of corrosion in each test material can be known. The corrosion rate can be calculated using the formula:

$$Cr = \frac{K.W}{\rho.A.T}$$

Where:

Cr (mpy) = corrosion rate (mm/y)
K = constant (3.45 x 10^6)
W = weight lost due to corrosion (gr)
ρ = density of metal (gr/cm^3)
A = surface area immersed (cm^2)
T = soaking time (hours)

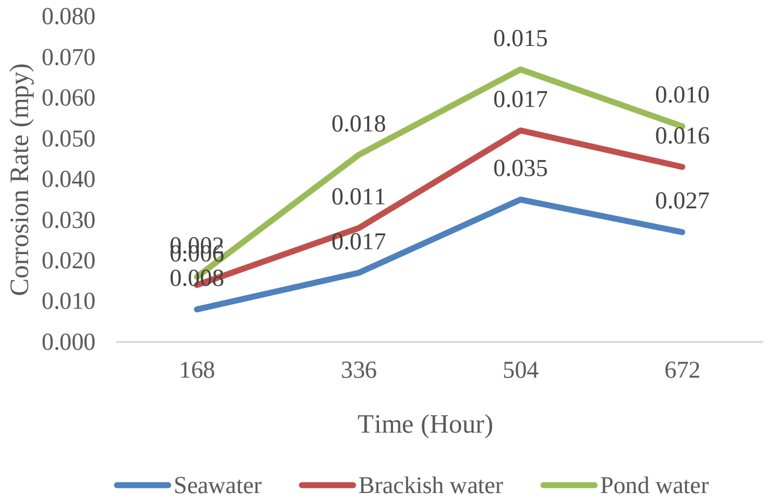

Figure 3. The Effect of Differences Water Media of AISI 304 Steel on Corrosion Rate

The results obtained for the corrosion rate in seawater media, the highest corrosion rate is 0.0356634 mmpy while the lowest is 0.0088931 mmpy. In brackish water media, the highest corrosion rate is 0.021972 mmpy while the lowest is 0.006096 mmpy. In pond water media, the highest corrosion rate is 0.018247 mmpy while the lowest is 0.002459 mmpy. The salinity level of water affects the corrosion rate. Media with higher salinity (seawater) shows a higher corrosion rate compared to media with lower salinity (brackish water and pond water). In this case, the higher the salinity of the water, the greater the corrosion rate, the lower the salinity of the water, the lower the corrosion rate. Research (Iskandar et al., 2020) which analyzed the corrosion rate in various river environments used as SS 304 media, the river media used with different salinity levels include the Progo river with a salinity of 498-527 mg/L, the Gudang Senjata river with a salinity of 624-1340 mg/L and the Banger river with a salinity of 752-970 mg/L with different variations in soaking time (720 hours, 1140 hours, 2160 hours). The results of the study showed that the highest corrosion rate was found in the Gudang Senjata river at 0,179 mpy with the highest salinity level and the lowest immersion time, and the lowest corrosion rate was found in the Progo river at 0,074 mpy with the lowest salinity level and the highest immersion time, the higher the immersion time, the smaller the corrosion rate that occurs, but the higher the salinity level of river water, the higher the corrosion rate that occurs, so in this case and in various different water media, the salinity level of the water contained is a factor that greatly affects the corrosion rate of Aisi 304 stainless steel.

Corrosion Analysis of AISI 304 Stainless Steel in Various Electrolyte Solutions

In the study (Hamidah et al., 2018) the method used was *scanning electron microscope analysis. (SEM)* with *energy dispersive x-ray spectroscopy (EDS)* for corrosion rate testing on AISI 304 steel. Potassium hydroxide (KOH), sodium hydroxide (NaOH), and sodium chloride (NaCl) with concentrations of 0.27 to 0.53 M at a temperature of 25 °C were used as electrolyte solutions. All chemicals were of technical grade and used without further purification. AISI 304 stainless steel samples were cut into thin plates with dimensions of 20 mm in length, 10 mm in width, and 1.50 mm in thickness. The weight loss test method was used to measure the corrosion rate on the mass loss method parameters based on previous studies. Then, microstructure and composition analysis were carried out using SEM tests to characterize the microstructure and type of corrosion of AISI 304 before and after corrosion. The results of the corrosion rate study of all samples showed a parabolic curve, and most samples began to experience corrosion from the beginning of immersion. Differences in the type and concentration of electrolytes experience different mechanisms in the corrosion phenomenon, resulting in different corrosion rates. The best corrosion resistance of AISI 304 stainless steel after being observed occurred in electrolyte solutions with low concentrations affecting the rate of corrosion that occurred decreased. The average corrosion rate from the test results was around 0.0051530 mpy which was below 1 mpy. In a study (Abdelfatah et al., 2022) that analyzed variations in NaCl and H_2SO_4 electrolyte solutions with concentrations of 0.5 to 1 M at a temperature of 25 °C against time differences. The results of the corrosion rate study on NaCl samples showed a parabolic corrosion resistance curve, the lowest corrosion rate in electrolyte solutions with low concentrations, while in H_2SO_4 samples along with increasing concentration the corrosion rate increases, increasing NaCl molarity has an impact on increasing the potential for pitting. The corrosion rate of H_2SO_4 with a concentration of 0.5 M is 2.314 mm/yr, the corrosion rate of H_2SO_4 with a concentration of 1 M is 17.740 mm/yr, the corrosion rate of NaCl with a concentration of 0.5 M is 0.035 mm/yr, the corrosion rate of NaCl with a concentration of 1 M is 0.021 mm/yr, in NaCl the corrosion rate is below 1 mm/yr. The corrosion rate of SS 304 in H_2SO_4 is higher than in NaCl, this is because H2SO4 is more aggressive than NaCl due to its acidity. In this case, the concentration of the electrolyte solution has an influence on the rate of corrosion that occurs.

The Effect of Corrosive Environment and Mechanical Load on Corrosion Behavior of AISI-304 Stainless Steel Material

The study conducted (Islami et al., 2021) used the loading method (C-ring) to test the effect of mechanical load on corrosion in AISI 304 stainless steel. One of the triggers of corrosion is a corrosive environment and mechanical load from materials under tension. This method was chosen because it is appropriate for small-scale testing. The specimen was immersed in NaCl to assume an artificial seawater environment. The steel soaked in 3.5% NaCl as a corrosive environment so that the corrosion that occurs during specimen testing can be studied with three different loads for each specimen and three other specimens without immersion as control data for 240 hours. Mechanical load is applied to the specimen using the (C-ring) method according to the ASTM G-38 standard, then electrochemical corrosion measurements are carried out using the polarization method. The mechanical loads used are different so that the correlation of polarization behavior caused by mechanical loads can be studied in more depth. The parameters considered during the analysis are Icorr, which affects changes in corrosion rate. The results obtained that the stress on the AISI 304 material affects the corrosion rate so that the faster the polarization rate occurs due to the higher stress. Thus, causing a high number of corrosion areas. Mechanical loads have a consistent effect which causes stress corrosion cracking with a maximum value of the corrosion rate of 4,662 mm / yr at a load of 868,380 N while in specimens without mechanical loads 3,975 mm / yr . The corrosion rate increases with longer immersion times. Specimens soaked for 240 hours showed an increase in the corrosion rate compared to specimens that were not soaked. The use of 3.5% NaCl solution as a corrosive environment can affect electrochemical behavior and increase the corrosion rate. The overall corrosion rate is not affected by mechanical loads, but can affect the corrosionrate under certain conditions such as stress corrosion cracking (SCC). Research conducted (Saputra et al., 2021) on AISI 304 stress corrosion cracking using loading variations (3 KN, 4 KN and 5 KN) on a compression machine with a capacity of 250 KN ASTM C-39 and seawater media, pipe-shaped specimens were cut into 9 pieces with the same width of 2 cm, then the side of the pipe was cut into a C shape, then the sample was given a load using a compression machine with a capacity of 250 KN ASTM C-39 with load variations of 3 KN, 4 KN and 5 KN. After the sample was pressed, note the reduction in distance on the C-shaped sample, then the sample was given bolts so that the sample remained in position when the load was applied. Before the immersion stage, the specimen was weighed without bolts to determine the initial weight, then the specimen was dipped in seawater media with time variations of 5 days, 10 days, and 15 days.

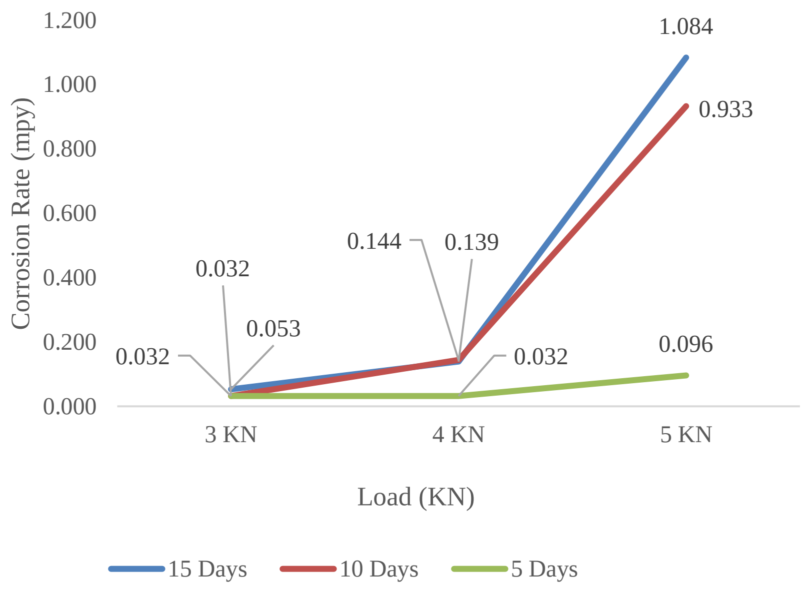

Figure 4. The Effect of Differences Load of AISI 304 Steel on Corrosion Rate for Each Immersion Time

The smallest corrosion rate was at a load of 3 KN and the largest corrosion rate was at a load of 5 KN. The magnitude of the load given affects the rate of corrosion that occurs. Increasing the load from 3 KN, 4 KN and 5 KN causes the corrosion rate to also increase. So that the loading and the length of immersion time given to the AISI 304 material greatly determine the speed of the corrosion rate that occurs.

CONCLUSION

From the literature review that has been conducted on AISI 304 stainless steel on corrosion rate, it can be concluded that there are several factors that affect the corrosion behavior of AISI 304 stainless steel such as heat treatment temperature factors, water salinity environmental factors, electrolyte solution composition factors, and mechanical load factors. The effect of high heat treatment temperatures will affect the high corrosion rate that occurs, while those that do not undergo heat treatment tend to have a lower corrosion rate. The water media environment with a high salinity level has an impact on accelerating the corrosion rate when compared to low salinity levels which will slow down the corrosion rate. In the difference in electrolyte solution and concentration, the corrosion rate decreases in electrolyte solutions with low concentrations. And in mechanical loads, it affects the presence of stress corrosion cracking with a corrosion rate value at a higher load, the corrosion rate that occurs is greater, while if there is no mechanical load, the corrosion rate is lower. In this case, for the selection of AISI 304 stainless steel material to inhibit corrosion, it is important to carry out corrosion protection by considering the most influential factors such as temperature, water salinity media environment, chemicalsaround the material, and mechanical loads in order to slow down the corrosion rate so that it is more effective in its application, minimize damage and loss and extend the life of the AISI 304 stainless steel metal material used.

REFERENCES

Abdelfatah, A., Raslan, A. M., & Mohamed, L. Z. (2022). Corrosion Characteristics of 304 Stainless Steel in Sodium Chloride and Sulfuric Acid Solutions. *International Journal of Electrochemcal Science*, *17*(4), 220417. https://doi.org/10.20964/2022.04.29

Aritonang, M, O ., & Fahri, I. (2006). Effect of Nitric Acid on the Corrosion Rate of Austenitic Stainless Steel 304 for Construction Purposes. *Menara: Journal of Civil Engineering* , *1* (1), 10. https://doi.org/10.21009/jmenara.v1i1.7832

Burhanuddin, I. S. & Y. (2007). The Effect Of Sensitization Temperature On Stress Corrosion Cracking Of Stainless Steel AISI 304 in Sulphate Acid Environment. *Jurrnal Teknik-Universitas Lampung*, *14*, 0854–2139.

Chrisman, *, & Priharyoto Bayuseno, A. (2014). Stress Corrosion Cracking Analysis of Austenitic Stainless Steel (Aisi 304) Using U-Bend Method in Corrosive Media Hcl 1M. *Journal of Mechanical Engineering S-1* , *2* (1), 110–118.

Fawaid, M., Ismail, R., & Nugroho, S. (2012). Proceedings of the 3rd SNST 2012 Faculty of Engineering

Wahid Hasyim University Semarang Characteristics of AISI 304 as Friction Welding Material.*Characteristics of Aisi 304 as Friction Welding Material* , 5.

Fitriani, F., & Purwadaria, S. (2024). Anodic Polarization Behavior of AISI 304 Stainless Steel in Dilute Sulfuric Acid Solution: A Preliminary Study for Stress Corrosion Cracking Testing. *AME (Aplikasi Mekanika Dan Energi): Scientific Journal of Mechanical Engineering*, *10* (1), 1–7. https://doi.org/10.32832/ame.v10i1.383

Hamidah, I. D. A., Solehudin, A., Setiawan, A., Hamdani, A., Hidayat, M. A. S., Adityawarman, F., Khoirunnisa, F., & Nandiyanto, A. B. D. (2018). Corrosion study of AISI 304 on KOH, NaOH, and NaCl solution as an electrode on electrolysis process. *Journal of Engineering Science and Technology*, *13*(5), 1345–1351.

Irawan, H., Ali, M. I., & Kanaka, W. (2023). Analysis of Corrosion Rate of SS-Aisi 304 Steel in Seawater, Brackish Water, and Pond Water Media on Automatic Fish Feed Machine Frame. *National Seminaron Applied Science and Technology XI 2023 Adhi Tama Institute of Technology Surabaya* , 1–6.

Iskandar, N., Nugroho, S., & Krisna, I. (2020). Analysis of Corrosion Rate in River Environment on 304 Stainless Steel Pipe Material and Galvanized Pipe in Semarang City. *Rotasi*, *22*(4), 266–271. https://ejournal.undip.ac.id/index.php/rotasi/article/view/33378

Islami, N., Ihsan, M., Hafli, T., Putra, R., & Muhammad, M. (2021). The Effect of Corrosive Environment and Mechanical Load on Corrosion Behavior of AISI-304 Stainless Steel Material. *Malikussaleh Journal of Mechanical Science and Technology* , *5* (2), 28. https://doi.org/10.29103/mjmst.v5i2.6025

Kusumawati, E. D., & Fahriani, V. P. (2024). Study of Low Carbon Steel on Corrosion Rate. *Sprocket Journal of Mechanical Engineering* , *5* (2), 59–65. https://doi.org/10.36655/sprocket.v5i2.1265

Mulya, F. F., (2019). *Stress Corrosion Cracking Analysis on Stainless Steel (Aisi 304) Given Heat Treatment with Temperature Variations*. *Aisi 304*, 1–77.

Novita, S., Ginting, E., & Astuti, W. (2018). Analysis of Corrosion Rate and Hardness on Stainless Steel 304 and Nickel Laterite Steel with Variation of Ni Content (0, 3, and 10%) in Corrosive Medium. *JOURNAL of Physics Theory and Application* , *6* (1), 21–32.

Nugroho, AW, Suwanda, T., & Irwanto, F. (2014). *Mechanical Properties and Microstructure of AISI 304 Austenitic Stainless Steel Friction Welded Joint* . *17* (1), 83–90.

Saputra, E., & Hastuti, K. (2021). *STRESS CORROSION CRACKING OF AISI 304 WITH VARIATION OF WEIGHT USING OCEAN ' S WATER AS MEDIA*. *4*(01), 7–13. https://doi.org/10.25299/rem.2021.vol4(01).4948

Perdana, D. (2017). Effect of Temperature Variation in the Heat Treatment Process of Aisi 304 Steel on Corrosion Rate. *Teknika: Engineering and Sains Journal* , *1* (1), 67. https://doi.org/10.51804/tesj.v1i1.70.67-72

Prayitno, D., & Fikri, I. A. (2020). The Effect of Gtaw Welding Current Strength on the Corrosion Rate of Low Carbon Steel. *Serial Metrics of Technology and Science* , *1* (1), 31–36.

Ramadhan Cahya, M., & Abdulah, A. (2019). Analysis of Grain Boundary Corrosion Occurrence Due to Gtaw Welding Process on Austenitic Stainless Steel Aisi a304 Material. *Jurnal Teknologika*.

Setyowati, VA, Wahyu, DE, Widodo, R., & Surabaya, T. (2017). Analysis of Tensile Strength and Xrd Characteristics of Stainless Steel Materials with Different Carbon Contents. *National Seminar on Applied Science and Technology V* , 57–62.

Singh, R., Sachan, D., Verma, R., Goel, S., Jayaganthan, R., & Kumar, A. (2018). Mechanical behavior of 304 Austenitic stainless steel processed by cryogenic rolling. *Materials Today: Proceedings*, *5*(9), 16880–16886. https://doi.org/10.1016/j.matpr.2018.04.090

Sumarji. (2011). Comparative Study of Corrosion Resistance of Stainless Steel Type SS 304 and SS 201 Using Cyclic U-Bend Test Method with Variations in Temperature and Ph. *ROTOR Journal* , *4* (1), 1–8.

Umartono, A. S. (2012). Effect of Cold Working on Austenitic Stainless Steel Type 304. *Journal of Science and Applied Engineering* , *1* (1), 65–86.