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The Effect of Mechanical and Electro-Chemical Treatment on the Corrosion Rate of Austenitic Stainless Steel

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ABSTRACT

The aim of this research is to determine the effect of grid blasting and electropolishing on the surface roughness and corrosion rate of AISI 304 stainless steel. In this research, AISI 304 will be treated using surface treatment grid blasting with various variations in blasting time which is then combined with electropolishing. The grit blasting times used in this research were 3, 5, and 7 minutes, and the type of sand used was alumina. Meanwhile, for electropolishing, H2SO4 is used. Before the grit blasting process is carried out, the material is polished using SiC paper no. 200 and then the surface roughness was measured to be 937 ± 10 μm. After this the electropolishing process is carried out using an H2SO4 solution. The surface roughness test results showed that the surface roughness decreased with grid blasting time. Likewise, the data obtained from the corrosion rate is where the corrosion rate also decreases with grid blasting time.

Keywords: *grid blasting, electropolishing, surafoce roughness, corrosion*

1. INTRODUCTION

In the advancement of the manufacturing industry, there are a number of innovations to improve the quality of the materials to be used. This development also creates new machining methods that are used to improve material characteristics according to existing needs and conditions. One attribute that is often observed is surface smoothness [1]. Surface roughness plays a significant role in various basic issues such as friction, deformation during contact, and the accuracy of the joint position between parts. Various techniques have been created to evaluate the surface finish, ranging from simple touch measuring tools to more sophisticated optical methods. In recent years, the emergence of digital computers that can be used for various purposes at high speed and vision systems has facilitated and increased flexibility in image analysis. Unlike stylus tools, computer vision systems have the advantage of not requiring direct contact and can measure the area of the surface instead of just measuring one line. Vision systems are considered an economical, efficient, and suitable solution for automation applications [2].

Stainless steel 304 material has been used in various industrial sectors [3]. In the construction and production sectors, the surface of stainless steel 304 has a very important role for various purposes. Corrosive environments require a flat surface so that dirt build-up that can cause corrosion cannot stick to the surface [4]. In the health sector, this material is used in food processing, beer making, catering services, and the chemical industry. In these applications, the surface needs to be cleaned every day. Stainless steel 304 is easy to clean because food residue, beer, and other chemicals do not easily stick to the surface, making the cleaning process simpler. The advantages of stainless steel 304 are also better than aluminium [5].

Grid blasting is a method of metal surface processing carried out by spraying sand using a predetermined pressure and speed [6, 7, 8]. The purpose of this process is to make the metal surface rougher, so that other coating materials can adhere well to the metal surface, are not easily removed, and are protected from corrosion. The impact of the sand causes plastic deformation on the surface of the material, so that the surface roughness also changes. The level of change in surface roughness is influenced by the size of the material, the speed of impact, the mechanical properties of the material, and the duration of impact. The grid blasting process is influenced by several factors, namely the type of abrasive material used, the air pressure applied, the shooting distance, the shooting angle, and the duration of the shooting. There are two types of grid blasting, namely dry grid blasting and wet grid blasting [9].

Electropolishing is a process of finishing the surface of an object electrochemically that produces a low surface roughness [10, 11]. The purpose of this process is to increase corrosion resistance without causing residual stress on the surface. The material to be polished is connected to the anode, while the cathode is connected to the plate, then inserted into the electrolyte and separated by the same amount. When the electric current works, it spreads on the surface of the material. Common electrolytes used are phosphoric acid or sulfuric acid, depending on the material to be used. Often, other materials are added to improve the characteristics of the material, such as glycerol or chromic acid. The electropolishing process is influenced by several factors, such as voltage, temperature of the electrolyte solution, and the duration used for electropolishing. Corrosion is generally considered one of the most common problems faced by metal structures during their operational life. Corrosion damage is a serious hazard to the integrity of infrastructure on land and at sea. Structural maintenance to limit or avoid corrosion damage is an important action in the United States and other countries around the world.

It is deemed essential to investigate the impact of the combination of mechanical and electrochemical treatment on the properties of stainless steel 304 in order to determine its impact on surface properties. The mechanical treatment was conducted through a grid blasting process, while the electro-chemical treatment was conducted through electropolishing with a sulfuric acid solution in this study. surface roughness and corrosion testing were implemented in this investigation to disclose the surface properties subsequent to treatment.

2. METHODOLOGY

Experiments are carried out on one or more variables that ultimately have an effect on other variables, and this study makes use of a real experimental approach. On the surface roughness of AISI 304 stainless steel material, the goal is to investigate the effect of grid blasting firing time and the kind of electropolishing solution, both of which have an influence on the rate of corrosion. The results of this study will include macroscopically and scanning electron microscopy (SEM) photo analysis, as well as information on the surface roughness of each test specimen.

2.1 Material

A specimen of 304 stainless steel material with dimensions of 20 mm in length, 20 mm in width, and 3 mm in thickness is prepared for cutting. The chemical composition (%wt) of the 304 stainless steel specimen is as follows: Chromium 18.0-20.0 Carbon 0.08 Nickel ranges from 8.0 to 11.0. Manganese is 2.00%, silicon is 1.00, and phosphorus is 0.045%. Sulphur 0.030. The 94% H_2SO_4 was supplied by sigma Aldric.

2.2 Blasting and electropolishing procedure

A sandblast machine is employed in the grid blasting process, while a power supply machine is employed in the electropolishing process to furnish electricity to the anode and cathode. The blasting and electropolishing procedures are displayed in detail in Table 1 meanwhile the blasting variable is shown in Table 2.

Table 1. Research variable

Blasting time	3 minutes	5 minutes	7 minutes
Electrolyte	H_2SO_4	H_2SO_4	H_2SO_4

Table 2. Blasting variable

Variable	Notes
Grid Blasting Range	15 cm
Compressor Pressure	10 bar
Mesh Range	630-1000
Shooting Angle	90°

2.3 Surface roughness and corrosion measurement

The SJ-301 surface roughness tester was employed to conduct surface roughness testing on each specimen, with the tool calibration being performed. The data collection distance is 7 mm, and the test points are chosen at random. Surface roughness data is collected at three sample locations on each groove formed on the test specimen. Corrosion rate testing using Potentiostat/Galvanostat instrument Palmsens Corrosion rate test specimens.

3. RESULT AND DISCUSSION

3.1 Surface roughness

The average roughness value obtained after the lowest grid blasting and electropolishing operations at grid blasting times of 3, 5, and 7 minutes with the

H2SO4 electropolishing solution is depicted in Figure 1. The Ra roughness values are 0.681 µm, 0.621 µm, and 0.595 µm, respectively.

The graph above indicates a downward trend, indicating that the roughness of the material surface will decrease as the firing time during grid blasting increases. This is due to the fact that abrasive particles interact with the material surface more frequently as the firing time increases. The concentration of [H+] ions in the solution, the degree of ionization of the solution, and the class of electrolyte solution are all electrolyte factors that can affect the material. As the number of [H+] ions released increases, the number of electrons released also increases, thereby optimizing the electron reaction between the cathode and anode. Consequently, the material's surface roughness will decrease. The indentation will be reduced as the grid blasting duration and the solution's ability to conduct electricity during electropolishing increase. Demonstrates that the material's surface is becoming increasingly flat.

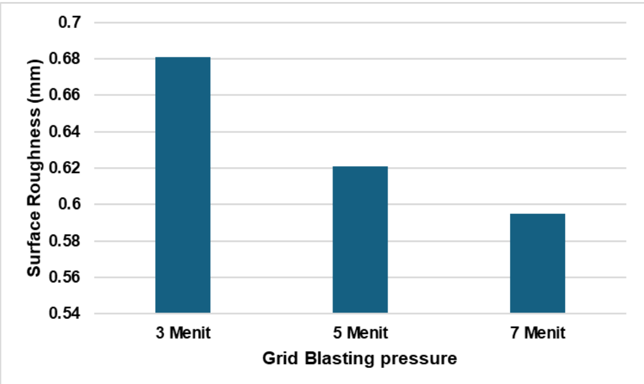

Figure 1. Surface roughness of treated 304 stainless steel

3.2 Corrosion observation

The corrosion rate values obtained after the grid blasting and electropolishing processes are depicted in Figure 2. The grid blasting process was conducted for 3, 5, and 7 minutes, and the electropolishing solution was a variety of H2SO4 solutions. The corrosion rate decreases as the grid blasting time increases. This demonstrates the significance of the grid blasting process in the corrosion resistance of AISI 304, despite the fact that an electropolishing process is performed at the conclusion of the surface treatment. The corrosion rate will decrease as the grid blasting time and the solution's ability to conduct electricity in the electropolishing process increase, as evidenced by the graph above with a declining trend. This is consistent with fundamental theory, as the surface roughness will decrease as the grid blasting time and the number of [H+] ions released during the electropolishing process increase. Consequently, the contact area between the corroded surfaces will be smaller, resulting in a lower corrosion rate.

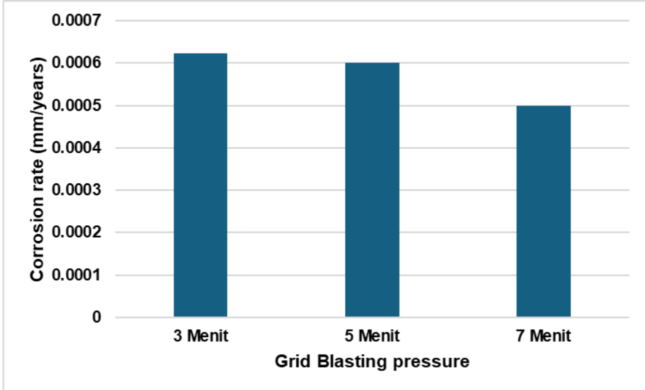

Figure 2. Corrosion rate of treated 304 stainless steel

3.3 SEM analysis of Stainless steel 304 after electropolishing

Figure 3 illustrates the surface observations of 304 stainless steel specimens that were subjected to the grid blasting and electropolishing process following corrosion. These observations were obtained using the SEM (scanning electron microscope) test apparatus.

The picture indicates that the corrosion is general corrosion, with the corrosion characteristics uniformly distributed across the specimen's surface. Stainless steel typically does not corrode uniformly, as is the case with carbon steel and alloy steel. Nevertheless, the passive layer may be uniformly attacked in certain corrosive fluids, contingent upon the concentration and temperature of the fluid. Uniform corrosion is the process by which oxygen reacts with a material, resulting in corrosion on its surface. Typically, uniform corrosion is observed in materials with a high degree of homogeneity and a fine particle size. This is consistent with the theoretical foundation, which posits that electropolishing treatment can reduce the material's roughness and increase its homogeneity. Therefore, the material is more susceptible to homogeneous corrosion than to pitting corrosion.

The picture indicates that the corrosion is general corrosion, with the corrosion characteristics uniformly distributed across the specimen's surface. A relatively uniform reduction in thickness over the surface of the corroded material is referred to as general corrosion or uniform corrosion. The anodic and cathodic processes that occur on the metal surface are uniformly distributed and occur on materials with a high homogeneity and fine grain size, which is why uniform corrosion occurs. Stainless steel does not corrode uniformly, as opposed to carbon steel and alloy steel. Nevertheless, the passive layer can be uniformly attacked by certain corrosive fluids, contingent upon the concentration and temperature of the fluid. Electropolishing treatment can smooth the material's roughness and increase its homogeneity, rendering it more susceptible to uniform corrosion than pitting corrosion.

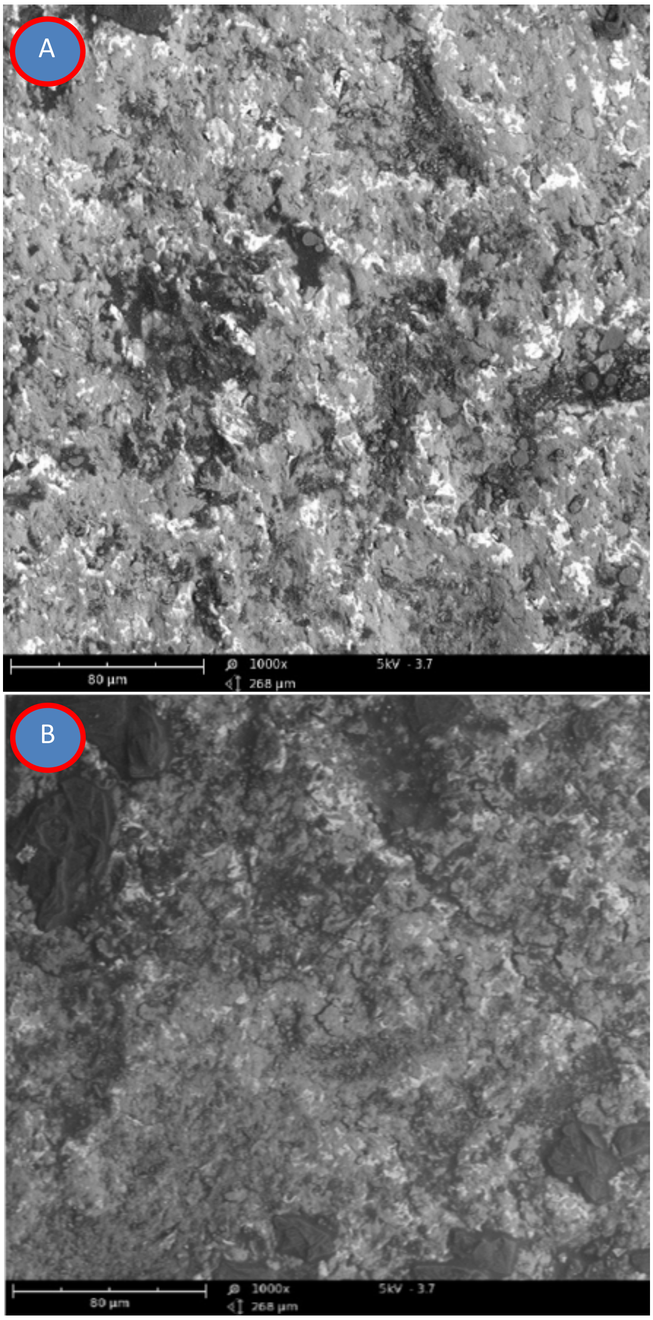

Figure 3. SEM image of corroded 304 stainless-steel: (a) 3 minutes electropolishing, (b) 7 minutes electropolishing

4. CONCLUSION

According to the findings of the research conducted, the surface roughness level will decrease as the grid blasting firing duration increases and the solution's ability to conduct electricity during the electropolishing process improves. This reduces the rate of corrosion by decreasing the contact area between corroded surfaces.

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