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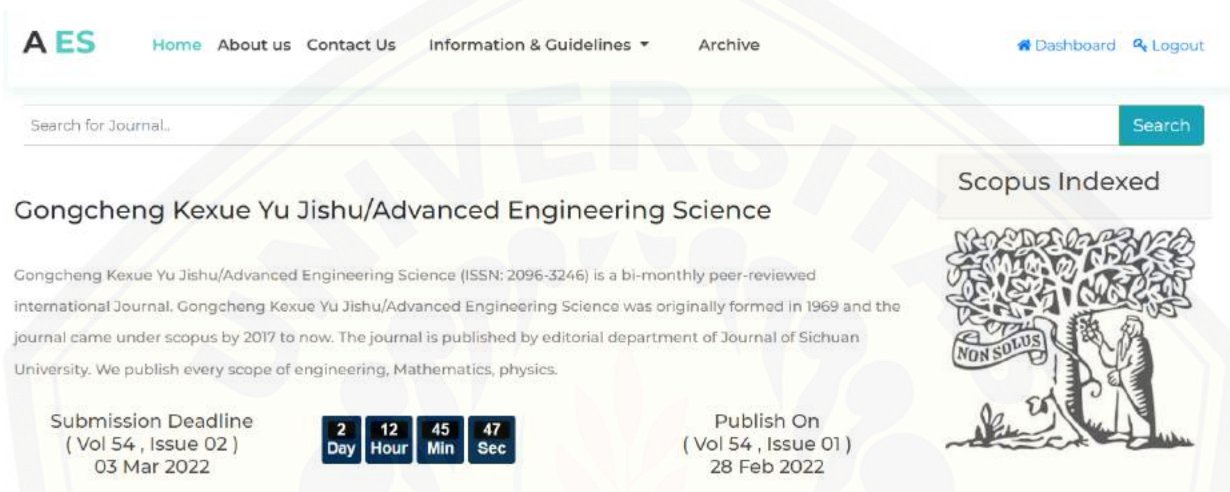

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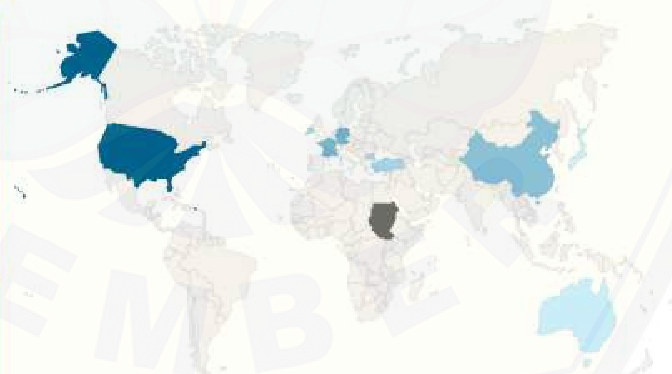

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Title : Metal Flower as Sustainable design that integrates Concentrated Solar Power with Street Squares in Egyptian neighbourhoods

Abstract : This study illustrates the fossil fuel crisis, which is now a major environmental threat. Currently, at 30% in 2021, the goal is to reach 85% by 2050. Concentrated solar power (CSP) is certainly a role for providing the majority of this sustainable power source while it is one of the most advanced inexhaustible power advances as well the vitality produced is transported from the world's sun-based belt to the populace focuses. As a result, the study's objectives are to create a new innovative design to improve the square's visual aspect by integrating concentrated solar power within the urban context, resulting in a square that looks good while also providing electric energy to the surrounding area. The research on Metal Flower Concentrated Solar Power (CSP) will provide enough energy to gradually replace non-renewable energy. This will be the first step toward a more environmentally friendly world. Photovoltaic is a different mechanism that uses mirrors to concentrate the Sun's light energy and reflect it into the focal point of the structure, where the warmth is collected and used to generate steam. The aim of this research is to integrate a concentrated solar power system into Egyptian streets using an innovative design that fits the Egyptian urban environment. The study revealed that installing CSP in street squares will generate an average of 900,000 kw annually and will save almost 135,000 Egyptian pounds annually. This nonstop energy generation can help in solving the energy problem facing developing countries..

Full article

Gongcheng Kexue Yu Jishu/Advanced Engineering Science Journal ID : AES-05-02-2022-118 Total View : 382

Title : Tensile Strength and Thermal Resistance Analysis of Polylactic Acid (PLA) and Cassava Starch with Cellulose Paper Sugarcane Bagasse as Filler

Abstract : At this time, the material made from plastic is widely used because it has strong and inexpensive properties. However, the amount of plastic waste is an environmental problem in every region. One way to overcome is to create environmentally friendly plastics that can decompose naturally. The purpose of this study was to prepare and investigate the tensile strength, thermal resistance and scanning electron microscopy (SEM) morphology observations of polylactic acid (PLA) and cassava starch (CS) with cellulose paper from sugarcane bagasse (CPSB) as filler. The fabrication process uses the solvent casting method with constant PLA and CS concentrations of 80% and 20% with variations in the CPSB mass fraction of 0.5%, 1%, 1.5%, and 2%. SEM observations showed that the mixture of PLA and CS had poor bonding due to the different hydrophobicity of the two materials. The content of CS causes agglomeration. The addition of CPSB reduces the tensile strength from 21.96 to 16.56 MPa and the modulus of elasticity from 96.75 to 74.90 MPa. The thermal resistance of the composite mixture increases with increasing CPSB load..

Full article

Gongcheng Kexue Yu Jishu/Advanced Engineering Science Journal ID : AES-30-01-2022-117 Total View : 374

Title : Study of Mild Steel Surface Integrity on Surface Grinding with Nyamplung (Calophyllum Inophyllum) Oil Cooling Media

Abstract : Applying cutting fluid in machining is a typical case, inevitable in grinding, cooling down the tool, prolonging tool life, and gaining a smoother surface. However, the petrol-based cutting fluid may harm the operator, and after being used, residue may damage the environment. This research attempts to reduce those harmful effects using petrol-based cutting fluid by applying a renewable and non-edible one made of Calophyllum Inophyllum, then studying the machined surface's surface integrity in the grinding process. It has compared the results with conventional cutting fluid, called dromus, in grinding of mild steel (St 37 and St 42). The research design used is Taguchi design used to design experiments, followed by optimization analysis. The surface integrity study concerned were (i) hardness alteration, (ii) surface roughness, and (iii) microstructure of the ground surface. So that conclusion is that the newly developed cutting fluid has a better effect in terms of minimum changing of hardness, smoother ground surface, affect changes in the shape of the microstructure denser, and more negligible when using nyamplung as cooling media..

Full article

Gongcheng Kexue Yu Jishu/Advanced Engineering Science Journal ID : AES-21-01-2022-114 Total View : 352

Title : Optimization of adhesive strength of chrome coating of SS400 using Taguchi method

Abstract : SS400 is structural steel, which is categorized within low carbon steel. It could not be hardened by heat treatment. In order to increase its properties, SS400 is enhanced with surface treatment and surface plating. Chrome is an element added as an alloy or as a coating to increase the corrosion resistance of steel. It also improved the surface appearance by shining the surface of the steel. This research aims to develop the surface properties of SS400 using chrome by electroplating. The quality of the surface improvement was evaluated by adhesive strength using a PosiTest AT-M Adhesion tester according to ASTM D4541 standard. There are three parameters with three-level each: i.e. voltage (3 volts, 6 volts, and 9 volts), temperature (45 °C, 50 °C, and 55 °C), and time (20 minutes, 25 minutes, and 30 minutes). Combination of parameters and levels according to the Taguchi orthogonal array L9(33) with thrice replication each. Minitab 18 was employed to analyze the S/N ratio and ANOVA. The results showed that the voltage, time, and temperature significantly contribute to the adhesiveness at the level of 51.18%, 39.7% and 7.25%, respectively. The maximum adhesiveness value of 22.11 MPa was achieved using a combination of the voltage of 9 volts, the temperature of 55 °C, and the time of 25 minutes..

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ISSN: 2096-3246
Volume 54, Issue 01, February, 2022

Optimization of adhesive strength of chrome coating of SS400 using Taguchi method

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Keywords:
electroplating, adhesive strength, Taguchi

ABSTRACT

SS400 is structural steel, which is categorized within low carbon steel. It could not be hardened by heat treatment. In order to increase its properties, SS400 is enhanced with surface treatment and surface plating. Chrome is an element added as an alloy or as a coating to increase the corrosion resistance of steel. It also improved the surface appearance by shining the surface of the steel. This research aims to develop the surface properties of SS400 using chrome by electroplating. The quality of the surface improvement was evaluated by adhesive strength using a PosiTest AT-M Adhesion tester according to ASTM D4541 standard. There are three parameters with three-level each: i.e. voltage (3 volts, 6 volts, and 9 volts), temperature (45 ℃, 50 ℃, and 55 ℃), and time (20 minutes, 25 minutes, and 30 minutes). Combination of parameters and levels according to the Taguchi orthogonal array L9(3^3) with thrice replication each. Minitab 18 was employed to analyze the S/N ratio and ANOVA. The results showed that the voltage, time, and temperature significantly contribute to the adhesiveness at the level of 51.18%, 39.7% and 7.25%, respectively. The maximum adhesiveness value of 22.11 MPa was achieved using a combination of the voltage of 9 volts, the temperature of 55 ℃, and the time of 25 minutes.

1. INTRODUCTION

The continuous use of metal equipment and direct interaction with the environment can reduce the mechanical properties of metals and can be corrosion [1], especially in low carbon steel that has relatively soft, rigid, cheap, and capable weld properties. It is often found in machine or construction components [1], [2]. One method to protect this steel from corrosion is by electroplating [3], [4]. In electroplating, the cathode deposition occurs due to the continuous transfer of ions using a stable electrical voltage. The ions attach and settle to form a surface layer on material or material. The deposition process occurs in the cathode due to the continuous transfer of ions using a stable electrical voltage. The ions attach and settle to form a surface layer on steel [5]. The benefits of the electroplating coating process can be applied at low temperatures and fast deposition rates and saved in metal coatings [6].

The adhesive strength (attachment of coatings or adhesiveness) on coated metals is one of the good references or quality of the coating process. The excellent coating has a high adhesive strength or the higher value specified in MPa or Psi. Every coating product needs to be tested for adhesiveness before use. Hard chrome thickness is 300 µm with a hardness of more than 600 VHN [7]. It is usually used for industrial tools that require high scratch and abrasion resistance [7]. In addition to decorative or appearance, chrome coating can improve the mechanical properties of the base metals [8]. The electroplating coating process result is influenced by many factors such as liquid concentration, temperature, time, pH, electrical voltage, current, electrode spacing, etc. [9], [10]. Other factors are the dirty surface, heterogeneity of the surface, and plating temperature [11]. Adhesive strength is one parameter which concerned by some researchers. It can be mechanically observed by PosiTest [4], [11], [12], scratch test following by SEM observations [6], [13], Ollard test [12], or bending test [14]. The authors found a different method to evaluate this parameter.

From PosiTest, the adhesive strength can be shown in numbers. In the previous research using AISI 1045 steel with chrome plating, the highest adhesive strength was 23.15 MPa. They used parameter variations of density, current, and time [11]. Another research on the electroplating of AISI 1030 with Zinc results in maximum adhesive strength of 15.595 MPa [4]. However, in the experiments, there was fluctuation result. Other researchers reported that the parameters' temperature got the most optimum results at 50 °C - 55 °C [15]. The testing method in these experiments was a bending test, and the best result was the layer that peeled off the least of the coated metal.

This research aims to determine the influence of three parameters (voltage, liquid temperature, and time) on the adhesive strength. Then, to find out the parameters combination which will result in the maximum adhesive strength.

2. Materials and Methods

2.1 Specimen

The material that will be electroplated is SS400 with the chemical composition and the main mechanical composition presented in Table 1. This steel is among low carbon steel [16].

Table 1 — Chemical composition and mechanical properties of SS400 [17]

P(%)	S(%)	Thick (mm)	Yield stress (MPa)	Tensile stress (MPa)	Elongation (%)
0≤0.05	0≤0.05	≤16	≤245	400-510	≥21

The dimension of the plate was 60 mm × 40 mm × 4 mm with a hole at the top middle to place a hook during the plating process, as shown in Fig.1. Before plating, the specimens were mechanically ground using sandpaper, then chemically soaked in HCl to remove rust. Then, the second soaking is in NaOH liquid to remove oils and impurities. Lastly, the specimens were rinsed using aquadest.

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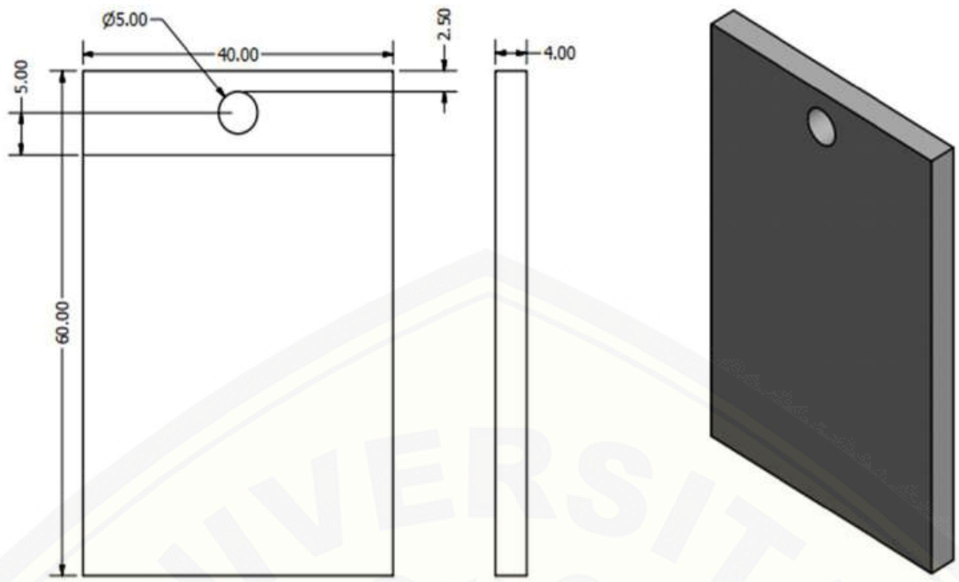

Fig. 1 — Dimension of the specimen.

Three parameters were varied with three levels each as the independent variables, as shown in Table 2. Those chosen variables and levels were based on the preliminary studies by the authors. While, the controlled parameters were electrode distance of 50 mm, electric current of 5 A, and dipped anode of 50 mm.

Table 2 — Independent variables

Code	Factor	Level 1	Level 2	Level 3
A	Temp (^{o}C)	45	50	55
B	Time (min)	20	25	30
C	Voltage (V)	3	6	9

2.2 Electroplating Processes

Each independent variable will be varied according to the Orthogonal Array matrix L9(33) in the Taguchi method. In this research, the anode (chrome) used is solid metal and uses a hard chrome electrolyte liquid. After the parameters have been set, the coating process is carried out. Electroplating tools will be displayed in Figure 2 below:

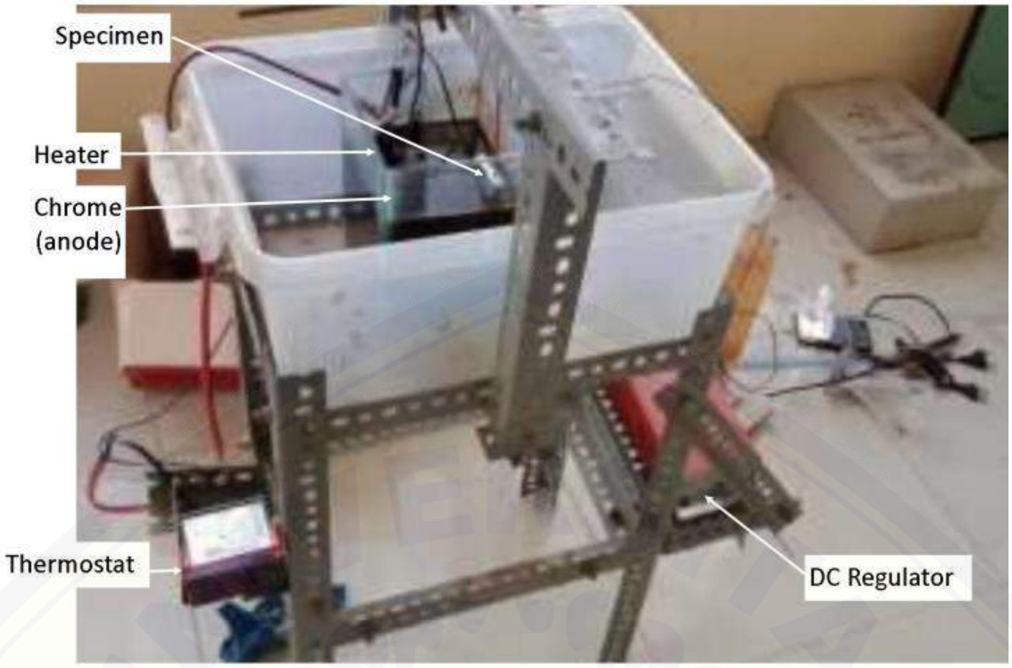

Fig.2 - Electroplating equipment

2.3 Test

The adhesive strength test using PosiTest is suggested by some previous and current researchers, either for metals [18], [19] and non-metals coating [20], [21]. The typical tester's appearance and its main components are presented in the following Fig 3. The PosiTest apparatus used has accuracy of 0.01 MPa and in accordance with ASTM D4541 standard.

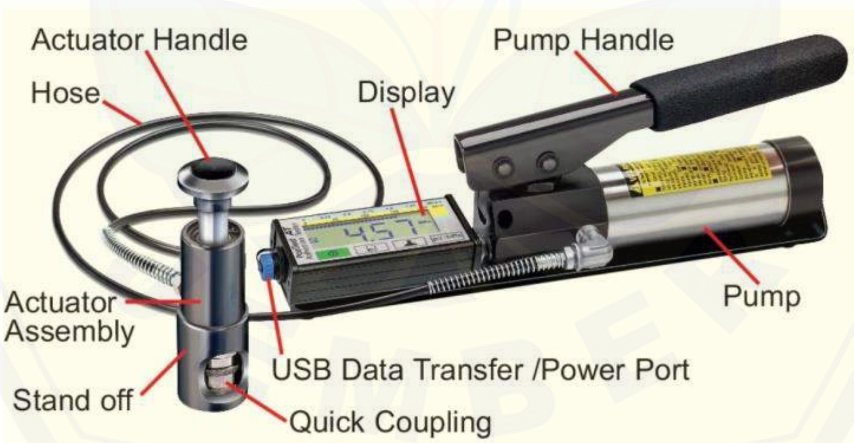

Fig. 3 — A typical PosiTest equipment and the main components [22].

2.4 Test Results and Data Analysis

The analysis process is carried out using the Taguchi Method to improve the quality of products and processes. The goal of the Taguchi method is to make a robust product against noise. Therefore Taguchi method is called Robust Design [23]. This method only takes a few experiments to find the conditions of parameters and materials, which will provide the best results to reduce the cost of the experiment [24].

3. Results

The micro structure was observed using a digital microscope to ensure that plating has worked on the base

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metal. A sample of it is presented in the following Fig. 4. It is clear that the chrome layer has been deposited at the base metal at a thickness of about 45.5µm.

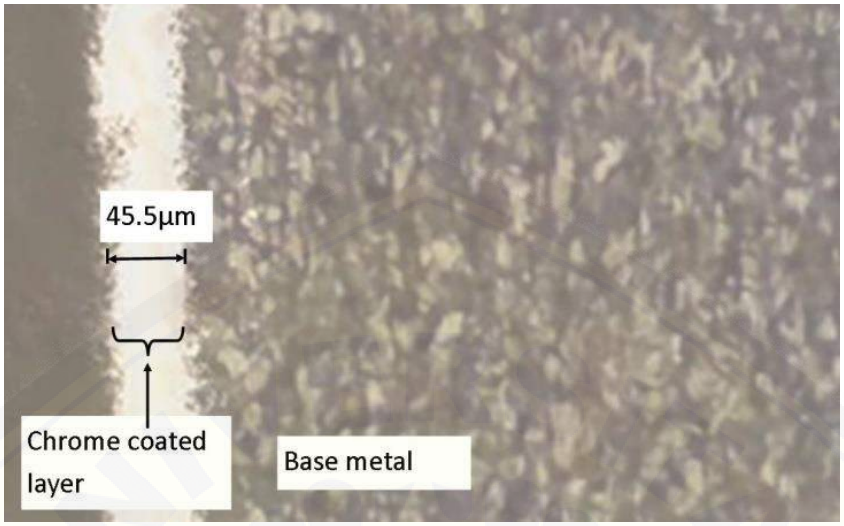

Fig. 4 — Microstructure of the coated layer on the base metal

The test was conducted using a 20 mm diameter dolly affixed to the surface of the test specimen using epoxy glue and left for approximately 24 hours until it thoroughly dried. After the glue dries, clean the remaining bond beyond the dolly. Figure 5 shows one of the test specimens after testing.

Fig. 5 — Post-test photos of specimens. According to the design experiment, they are arrayed with an enlarged image of the 1st one.

Polishing may affect the validity of the adhesiveness test results. Coating specimens are dark because there is no final polishing process (finishing). It was let after electroplating to avoid damage the coated layer.

3.1 Adhesiveness Value Data

The overall adhesiveness or adhesiveness value of the test results using the pull-off method is displayed in Table 2. From Table 2, combination nine on first replication of 22.32 MPa is the highest adhesiveness value, and the combination one on first replication of 20.69 MPa is the lowest. The highest average of the adhesiveness value is combination 9 of 22.11 MPa. The total average adhesiveness value in this experiment is 21.59 MPa.

3.2 Calculation of S/N Ratio Value

The calculation of S/N ratio is used to find out the influence of the modified parameters (signal/S) in compare the uncontrolled ones (noise/N) on the results of the experiment. The higher value of the S/N ratio means the controlled variables more dominant in influence the result than the uncontrolled ones. In this research, the highest adhesiveness value is the optimum, so the more significant, the better the method. The calculation of the overall S/N ratio is displayed in Table 2 of the 9th column. The most significant S/N ratio is in combination nine at 26.89 and the smallest at 26.39 in combination 1.

Table 2. Experimental data on adhesive strength (adhesiveness)

Combinations	Control Factor			Adhesiveness value (MPa)			Average	S/N Ratio
	Voltage	Temp	Time	Rep.I	Rep.II	Rep.III		
1	2	3	4	5	6	7	8	9
1	3	45	20	***20.69***	21.03	20.88	20.87	26.39
2	3	50	25	21.98	21.49	21.21	21.56	26.67
3	3	55	30	21.80	20.77	21.47	21.35	26.59
4	6	45	25	22.27	21.51	21.83	21.87	26.80
5	6	50	30	22.00	21.57	21.55	21.71	26.73
6	6	55	20	21.63	22.01	21.19	21.61	26.69
7	9	45	30	21.91	22.17	20.93	21.67	26.72
8	9	50	20	21.90	21.18	21.56	21.55	26.67
9	9	55	25	**22.32**	21.96	22.04	**22.11**	26.89
Total Average							21.59	26.68

3.3 Optimum Value of Combination and Variation

The average values at each level of the electroplating process adhesiveness control factor i.e. voltage, liquid temperature and time are shown in Fig. 6.

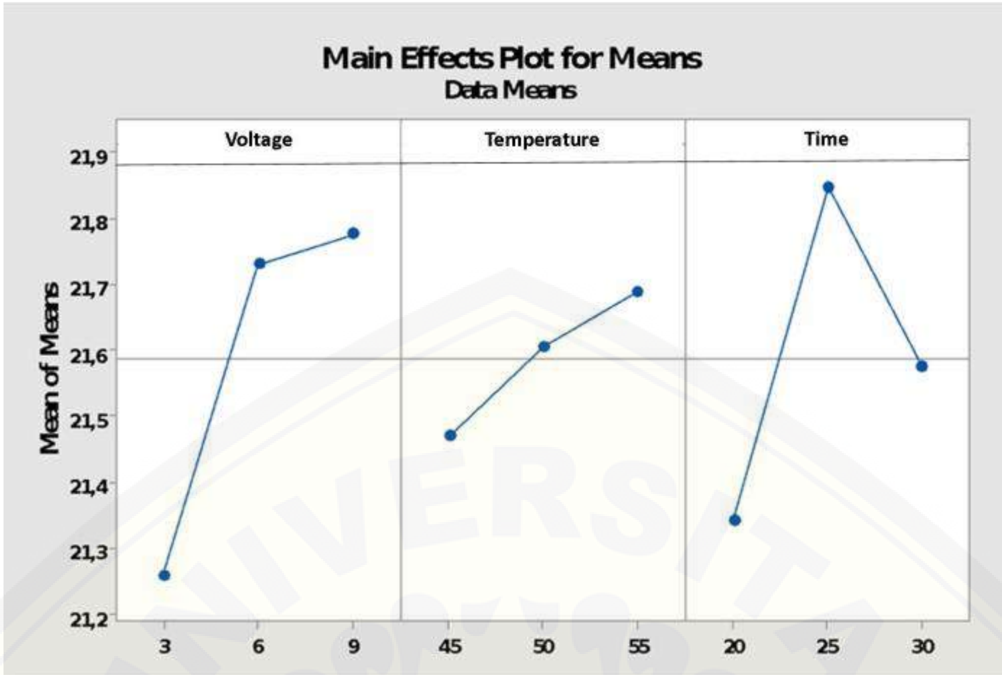

Fig. 6 — Plot average adhesiveness values of each variable and level

From Fig. 6, the highest average value shows the most optimum parameter level of each variable so that it can be determined the best combination of levels. The combination of levels at the most optimum parameters is shown in Table 3.

Table 3. Combination of parameters which results in maximum adhesiveness

Symbol	Parameter	Level	Value
A	Voltage (Volt)	3	9
B	Temp (^{o}C)	3	55
C	Time (min)	2	25

3.4 Analysis of Variance, F-Test, and Percent of Contribution

Analysis of variance (ANOVA) determines the significance level and percent contribution of independent parameters to output parameters. Table 4 provides ANOVA calculations with the help of Minitab 18 software.

Table 4. ANOVA Results independent variable of steel SS400 electroplated

Independent Variable	**DK**	**SS**	**MS**	**F_{count}**
Voltage	2	0.490965	0.245483	115
Temp	2	0.073232	0.036616	17.15
Time	2	0.38241	0.191205	89.58
Residual	2	0.004269	0.002135	

Total	8	0.950877	

To find out the significance level of each parameter, the value of the F-count is compared to the F-table value. When the F-count value is greater than the F-table, the parameter significantly influences the output. In this research, the value of the F-table used is 5.14. Therefore, all of the F-count of three parameters is larger than F-table. That means all three parameters have a significant influence on the output. This result can be observed in Figure 6. When one of the parameter levels is changed, adhesiveness will undergo significant changes. While the percent contribution of each parameter is shown in Table 5 as follows:

Table 5. Percent contribution of each independent parameter

Code	Independent Variable	SS'	P (%)
X	Volt	0.486695	51.18
Y	Temp	0.068962	7.25
Z	Time	0.37814	39.76
R	Residual		1.81
Total			**100%**

Percent contribution indicates how much influence the parameter has on the response or output with a percentage value. If the percentage of residual error contribution is less than fifteen percent (<15%), then no influential parameters were ignored in designing the research. However, suppose the percentage of residual error contribution is more than fifteen percent (>15%) [23]. In that case, it is suspected that there are influential parameters in the electroplating process but neglected in the research. In this research, the residual error value was 1.81%, which means that no factors were overlooked (not included) in the experimental design. It can be seen in Table 5, that the influenced parameters in order are voltage (51.18%), time (39.76%), temperature (7.25%).

4. Discussions

4.1 Voltage

Voltage is one of the essential factors in the electrical coating because the presence of an electrical voltage (potential difference) between electrodes causes the ions in the system to move towards the electrode. The voltage influence graph is shown in the following Fig. 7.

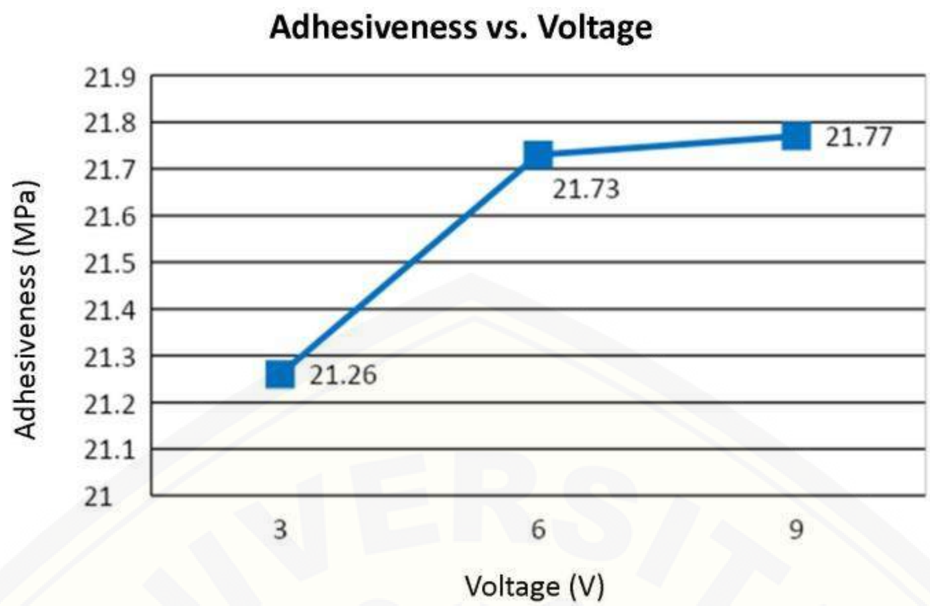

Fig. 7 — Graph of the effect of voltage on the adhesiveness

In this research, the voltage became the most influential factor with a percent contribution of 51.18 percent and level 3 being the most optimum at 9 volts. The high voltage difference will cause the energy to oxygenate electrons from the anode to the cathode to be more significant. These results align with previous research [25], which explained that the value of layer thickness and bending strength would increase when the voltage is raised. The adhesive strength will be higher with the more ions attached to the cathode surface. In an electrocoagulation process, which is a contra process to electroplating, increasing the increasing voltage would increase the rate of metal removal [26].

4.2 Temperature

Temperature is a factor that affects the active movement of ions in the electrolyte liquid so that it can cause ions to settle faster at the cathode. The temperature influence chart will be shown in Fig. 8 as follows:

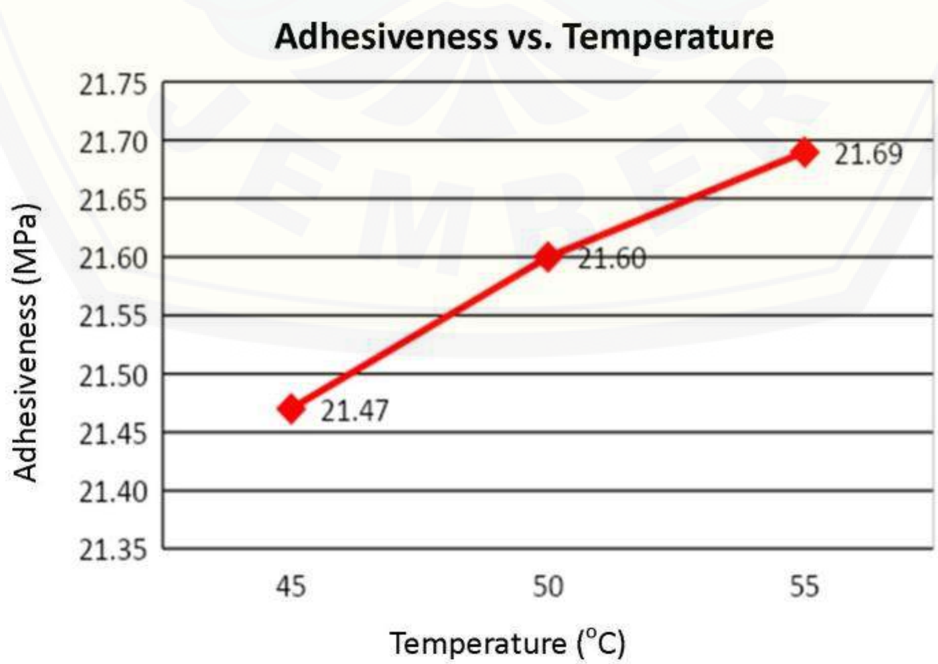

Fig. 8 — Graph of the influence of temperature on adhesiveness

The results of each parameter level show that the adhesive strength will be higher with the increase in temperature. In this research, the temperature of the liquid had a percent contribution of 7.25 percent and level 3 of 55ºC became the most optimum because at high temperatures, soluble power increased and the breakdown of metal salts accelerated, increasing the mobility of metal ions to be deposited and reducing the H2 elements entering the layer. This result also supports previous research [15], which obtained the best adhesiveness results at temperature 50-55 ºC and performed bending test.

4.3 Time

The timing of electroplating coating will impact the quantity of the final result of coating the metal or the product to be coated [25], [27]. The time influence chart will be displayed in Fig. 9 below.

Fig. 9 — Influence of time on the adhesiveness

The most optimum time parameter level is at level 2, which is 25 minutes with a percent contribution of 39.76%. This research showed that the longer the time does not make the value of adhesiveness higher. Within 30 minutes, adhesiveness tends to decrease. The longer coating time can increase the resistance so that the potential difference needed to reduce the ions will increase and decrease the conductivity of the electrolyte liquid [28]. The increase in resistance and decreased conductivity can be caused by the electrolyte liquid repeatedly producing more impurities.

This result aligns with previous research [4], which states that increasing time electroplating would decrease the adhesiveness strength AISI 1020 in Zn electroplating.

5. Conclusion

The following conclusions were obtained based on the analysis and processing of data using the Taguchi method and Minitab 18 software, and the following findings were obtained. First, the greater the electrical voltage, the greater the adhesiveness value. Because the voltage is getting higher, the ion energy to bind is getting bigger, and the bond becomes more robust. In this research, a contribution percentage is 51.18 % at level 3 is 9 volts.

ISSN: 2096-3246
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Second, the higher the temperature of the liquid provides the increase in the value of adhesiveness. This is because the ions' movement increases so fast that many are deposited in the steel to be coated. In this research, the temperature has a percent contribution of 7.25% and the most optimum at level 3 is 55 ºC.

Third, at the coating process time, the longer electroplating time is not necessarily the increasing value of adhesiveness. At level 3 (30 minutes), adhesiveness decreases. Because the longer electroplating process causes the liquid to become dirty and increases the resistance, the ions are less attached. In this research, time had a percent contribution of 39.76 percent with a level of 2 which is 25 minutes.

Fourth, the combination of parameters to get the most optimum adhesiveness value is at a voltage of 9 volts, a temperature of 55 ºC and a coating processing time of 25 minutes.

6. Acknowledgement
The author thanked the CV. Cipta Agung, Surabaya, Indonesia especially to Mr. Larasanto and Mr. Munandar who have shared knowledge, accompanying and providing facilities to carry out adhesive testing. In this article, each author has a commensurate contribution.

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