The Effect of Quenching and Nickel-Chrome Electroplating with Variations of Voltage and Time of Coating Againts Value of Hardness on Brass

T. Endramawan[1][a], A. Sifa[1][b], D. Suwandi[1][c] and B. Laksono Jaelane[2]

[1]*Design Manufacturing, Politeknik Negeri Indramayu, Jl. Lohbener Lama no.08, Indramayu, Indonesia*

[2]*Department of Mechanical Engineering, Politeknik Negeri Indramayu, Jl. Lohbener Lama no.08, Indramayu, Indonesia*

Keywords: Brass, Heat Treatment, Electroplating, Nickel-Chrome.

Abstract: Brass is a mixture of copper and zinc. Brass is very easy to shape into various shapes, brass is mostly used for ship applications, one of which is the propeller, the propeller is usually damaged in the form of corrosion or hit by a hard object so that it bends or breaks at the tip of the propeller leaf. The electroplating process is one of the metal coating methods. The coating method is influenced by several parameters including: current strength, electrode distance, current distribution, coating time, concentration level of the electrolyte solution and others. The process of heat treatment (Hardening) is a process carried out to increase the hardness of the material. Hardening at a temperature of 650ºC for 6 hours with the highest hardness value obtained by water quenching media of 101.78 HV (12, 67%) with a base material hardness of 90.34 HV. The results of the Vickers hardness test after the nickel-chrome electroplating process with a voltage variation of 1.5, 3, and 4.5 volts and a time of 5, 10, and 15 minutes, with a loading of 100 gf indentation time of 10 seconds with the highest hardness value obtained at a voltage of 4 ,5 volts and 15 minutes of 254.82 HV for nickel and 261.95 HV for nickel and 261.95 HV. The results of the thickness test after the nickel-chrome electroplating process based on the results of the Vickers test with the highest hardness value on nickel obtained a thickness of 70.90833 m and chrome at 99.5483 m. with a loading of 100 gf indentation time of 10 seconds with the highest hardness value obtained at a voltage of 4.5 volts and a time of 15 minutes of 254.82 HV for nickel and chrome of 261.95 HV of 261.95 HV. The results of the thickness test after the nickel-chrome electroplating process based on the results of the Vickers test with the highest hardness value on nickel obtained a thickness of 70.90833 m and chrome at 99.5483 m. with a loading of 100 gf indentation time of 10 seconds with the highest hardness value obtained at a voltage of 4.5 volts and a time of 15 minutes of 254.82 HV for nickel and chrome of 261.95 HV of 261.95 HV. The results of the thickness test after the nickel-chrome electroplating process based on the results of the Vickers test with the highest hardness value on nickel obtained a thickness of 70.90833 µm and chrome at 99.5483 µm.

1 INTRODUCTION

In line with the development of the industrial revolution 4.0 and advances in science and technology, the use of metals cannot be separated from human life. The development of technology that is increasingly rapidly affecting the lifestyle of humans has resulted in almost all equipment around us being made of metal. The Ministry of Industry is concentrating on developing the domestic brass-based industry to make it more competitive. One of the strategic efforts is to encourage the production of this sector through the use of recycling raw materials of brass or copper from the remnants of household appliances or projects that are no longer used. The development of the brass industry will contribute to the performance of the national metal industry. In 2017, the metal industry recorded a growth of 5, 87% or above the economic growth which reached 5.07%. Currently, the growth of the base metal industry is

[a] https://orcid.org/0000-0002-5605-680X
[b] https://orcid.org/0000-0001-9565-9884
[c] https://orcid.org/0000-0001-6816-1570

Endramawan, T., Sifa, A., Suwandi, D. and Jaelane, B.
The Effect of Quenching and Nickel-Chrome Electroplating with Variations of Voltage and Time of Coating Againts Value of Hardness on Brass.
DOI: 10.5220/0011711500003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 56-61
ISBN: 978-989-758-619-4; ISSN: 2975-8246

still supported by the iron, steel, aluminum, nickel, copper and tin sectors (kemenperin.go.id).

Brass is a metal that is a mixture of copper (Cu) and zinc (Zn). Copper is the main component of brass. Brass is usually classified as an alloy of copper and zinc. The color of brass varies from dark reddish brown to light silvery yellow depending on the amount of zinc (Zn) content. Zinc affects the color of the brass more. Brass is stronger and harder than copper, but not as strong or as hard as steel. Brass is very easy to form into a variety of shapes, is a good conductor of heat, and is generally resistant to corrosion from salt water. Because of these properties, brass is mostly used to make pipes, tubes, screws, radiators, musical instruments, marine applications, and cartridge casings for firearms. (Tata Surdia, 1996).

Most ship propellers are also made of brass and aluminum alloy, both of which have their own advantages and disadvantages. The propellers on fishing boats are rarely damaged in the form of fractures caused by the work of the propellers. Damage experienced by fishing boat propellers is generally due to corrosion or bending of the leaf tips on the fishing boat propellers.(Mad & Ellyawan, 2006).

Corrosion process is an event of damage or decrease in the quality of a metal material caused by a reaction to environmental conditions and at the place where the metal is used (AR Hakim, 2012). What is meant by environmental influences and places of use can be in the form of air or sunlight, dew, fresh water, sea water, river water, ground water, lime water, and rocky sandy soil. Corrosion of metals can also be interpreted as the reverse reaction of metal refining. This corrosion itself can lead to a decrease in the quality of the metal, resulting in the metal becoming weak and damaged quickly. Corrosion or rust is a form of metal degradation due to electrochemical reactions with the environment that are directly related to open air or often referred to as corrosion. Almost all corrosion products are caused by the atmospheric environment. This is because in general, metals are always in contact with open air where humidity and pollutant content can affect metal corrosion. Atmospheric corrosion is strongly influenced by topographic and climatic conditions of the environment, factors such as temperature, humidity and chemical content in the air or water greatly determine the corrosion rate. One of the prevention and protection against corrosion is by electroplating nickel-chrome plating. factors such as temperature, humidity and chemical content in the air or water greatly determine the corrosion rate. One of the prevention and protection against corrosion is by electroplating nickel-chrome plating. factors such as temperature, humidity and chemical content in the air or water greatly determine the corrosion rate. One of the prevention and protection against corrosion is by electroplating nickel-chrome plating.

The electroplating process is one method of metal plating. The electroplating process is often called electrodeposition, which is a process of deposition of protective metal on top of another metal by means of electrolysis. The metal electroplating process is basically carried out with the aim of preventing the corrosion process that attacks the steel surface. Currently, the electroplating method is very popular because of its brilliant appearance, uniform distribution of coating material throughout, not easy to corrode and durable. The metals used as coatings are copper, nickel, chromium, zinc, gold, silver, brass and others (Kaban et al, 2010). In metalworking technology, the electroplating process is a metal finishing process. Simply, Electroplating can be interpreted as a metal plating process using the help of an electric current and certain chemical compounds to transfer the coating metal particles to the material to be coated. In chrome plating, currently there are two kinds of chrome plating that can be done, namely decorative chrome plating.

The electroplating coating method is influenced by several influential parameters and needs to be considered in order to obtain good coating results including: current strength, electrode distance, current distribution, plating time, agitation, concentration level of the electrolyte solution and others (Adnyani and Triadi, 2009: 77).

From the explanation above, the urgency of this research is important to carry out, the aim is to increase the hardness, physical and mechanical resistance of the material to corrosion and to coat the material so that it can be oxidized so as to increase the life of the brass alloy. The method used is to treat the brass material, this treatment includes a direct heat treatment (hardening) process and coating the material with the nickel-chrome electroplating method. This research was carried out on brass material for experimentation and testing, with the title taken in making scientific papers, namely "The Effect of Quenching Media and Nickel-Chrome Electroplating with Variations in Voltage and Plating Time on Hardness Values in Brass"

2 RESEARCH METHODS

2.1 Materials

The specimen material used in this study was brass were brass that had been cut beforehand with a cutting saw that shown at Figure 1.

Figure 1: Brass specimen.

2.2 Heat Treatment

The heat treatment carried out in this study is uses Bench Furnace Type BF02, where in general the heat treatment consists of heat treatment and quenching with water and oil. In the heat treatment process, the test object is heated from a temperature of 650°C for 6 hours (ASM Metal Handbook V.4 – Heat Treating), then the test object is quenched with water and oil media after.

2.3 Pre-Treatment Process

Before doing the electroplating proses the spesimen will be mechanical and chemical cleaning, first proses is the mechanical cleaning process is carried out by sanding which aims to remove dirt attached to the surface of the brass specimen. This sanding process uses 240 CW to 2000 CW sandpaper. After that we continiue to the chemical cleaning process, this cleaning is carried out by washing the specimens using sodium carbonate (NaOH) and H2SO4. The concentration used in this process (50 gr/liter), 5% H2SO4 and distilled water for rinsing.

2.4 Electroplating Nickel Proses

Furthermore, in this process the specimen is immersed in a plastic bath containing a nickel solution that has been mixed with distilled water with varying concentrations of the solution as shown in Table 2 of nickel chemicals solution (Nickel Plating Handbook, Nickel Institute 2014). In this electroplating process, the brass specimen is in the conductor as the cathode (-) and the coating is at the anode (+). Furthermore, the anode and cathode distances are set for 5 cm and the power supply electric current is regulated before the specimen is immersed with a current of 5 amperes, voltage variations of 1.5 volts, 3 volts, and 4.5 volts and immersion time of 5 minutes, 10 minutes, 15 minutes and the temperature of the solution. ± 40 °C. After the nickel electroplating process is complete, the specimen will be rinsed first to neutralize it.

Table 1: Nickel Chemical Solution.

No.	Material Name	Concentration
1	Nickel Sulfate	250 gr/l
2	Nickel Chloride	70 gr/l
3	Boric acid	45 gr/l
4	Brightener	1 cc/l
5	Carrier	2 cc/l

2.5 Electroplating Chrome Proses

Furthermore, in this chrome electroplating process, the specimen is immersed in a plastic bath containing a chrome solution that has been mixed with distilled water, with variations in the concentration of the solution as shown in table 3.4 of the chemical chrome solution. In this electroplating process, the brass specimen is in the conductor as the cathode (-) and the coating is at the anode (+). Furthermore, the distance of the anode and cathode is adjusted as long as 5 cm and the electric current of the power supply is regulated before the specimen is immersed with a current of 5 amperes, a voltage variation of 3 volts and an immersion time of 1 minute and a solution temperature of ± 40 °C. After the nickel electroplating process is complete, the specimen will be rinsed first to neutralize it.

Table 2: Chrome Chemical Solution.

No.	Material Name	Concentration
1	Chrome Acid	200 gr/l
2	Sulfuric acid	0.85 cc/l
3	Catalyst	4 gr/l

2.6 Testing

The method used to collect the test data is the vickers hardness testing is carried out at the Mechanical Engineering Laboratory of the Indramayu State Polytechnic using the Innovatest Verzus 700AS type.

The macro Vickers hardness testing process is carried out through 3 data proses, the testing in this hardness test uses an indenter load of 5 kg with a holding time of 15 seconds, aiming to determine the hardness value of the KTM 25 base, after hardening and aging material.

Vickers microhardness testing aims to test the hardness of the anodizing layer, this test was carried out at the Mechanical Engineering Laboratory of the Indramayu State Polytechnic using a microhardness tester type FM-810. This test uses an indenter load of 100 gf with a holding time of 10 seconds.

Microstructure Photo Testing this test is carried out to see the thickness of the coating resulting from the anodizing process. The tool used in this test is the Olympus BX3M with 20x optical magnification.

3 RESULTS AND DISCUSSION

3.1 Hardness Test Results

From the results of the heat treatment research, in the hardening process with water and oil quenching media directly with a hardening temperature of 650ºC with a holding time of 6 hours, then the quenching process with water and oil, obtained hardness results as shown in Figure 2.

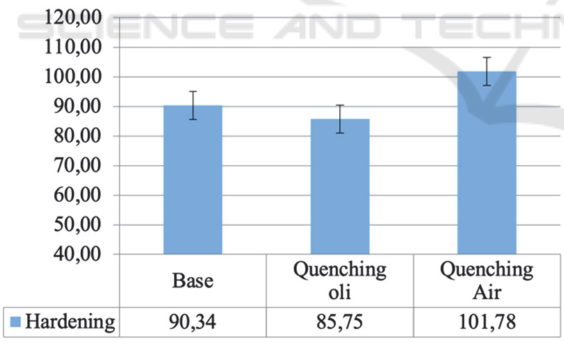

Figure 2: Graph of Hardness Value After Heat Treatment.

The results of this study are similar to those carried out (Cahyono, 2018) where the highest hardness in his research was obtained in water quenching rather than using oil and open air quenching, and in his research showed that quenching using oil can reduce the hardness of brass materials.

From the results of the nickel electroplating process with a voltage variation of 1.5, 3 and 4.5 volts with a time variation of 5, 10 and 15 minutes, the results of the surface hardness of the coating can be seen in Figure 3.

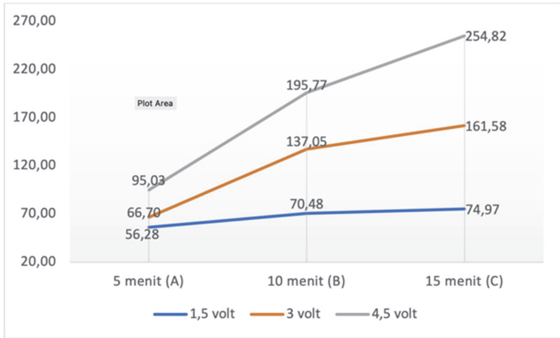

Figure 3: Graph Coating Hardness Value Chart Nickel Against Time.

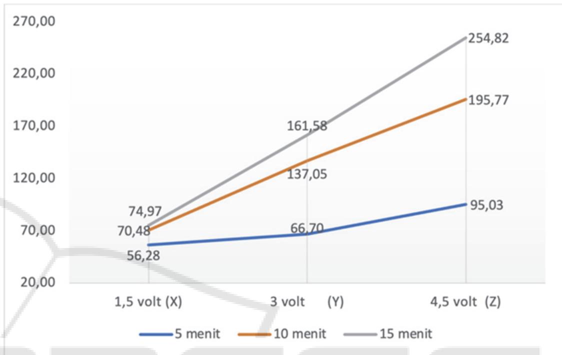

Figure 4: Graph Coating Hardness Value Chart Nickel Against Voltage.

Based on the graph above, it can be seen that the value of hardness is increasing which shows that each voltage and the coating time, the value of hardness will increase. This is similar to research (Sumpena, & Wardoyo, 2020) and (Tahu, Maliwemu, & Limbong, 2015) where the highest layer hardness value is obtained at each increase that occurs as the coating time and voltage increases.

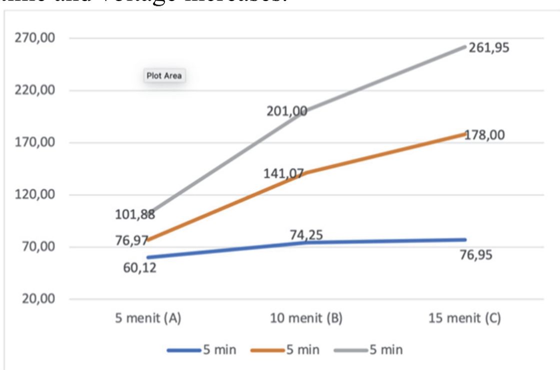

Figure 5: Graph Coating Hardness Value Chart Chrome Against Voltage.

From the results of the chrome electroplating (3 volt, 5 ampere) againts nickel process with a voltage variation of 1.5, 3 and 4.5 volts with a time variation of 5, 10 and 15 minutes, the results of the surface hardness of the coating can be seen in Figure 5.

Based on the graph above, it can be seen that the value of hardness is increasing which shows that each voltage and the coating time of nickel variations, the value of hardness will increase. This is similar to research (Sumpena & Wardoyo, 2020) and(Tahu, Maliwemu, & Limbong, 2015) where the highest layer hardness value is obtained at each increase that occurs as the coating time and voltage increases.

3.2 Electroplating Nickel-Chrome Coating Thickness Test Results

From the results of the hardness test that has been carried out, the highest layer hardness value of the electroplating process is obtained at 4.5 volt and 15 minutes of coating time. Then the specimen is tested for thickness, where the thickness test results are obtained as follows:

Table 3: Electroplating Nickel Layer Thickness Values.

.	Layer Thickness	Average
1	76.82	70.90833
2	69,80	
3	70.23	
4	73.26	
5	62.38	
6	72.96	

Table 4: Electroplating Chrome Layer Thickness Values.

No.	Layer Thickness	Average
1	95.69	99.5483
2	100.79	
3	91.88	
4	90.04	
5	117.37	
6	101.52	

For more details where the measurement is located taken from the process of testing the thickness of the electroplating layer with a time of 15 minutes and 4.5 volt can be seen in the following figure:

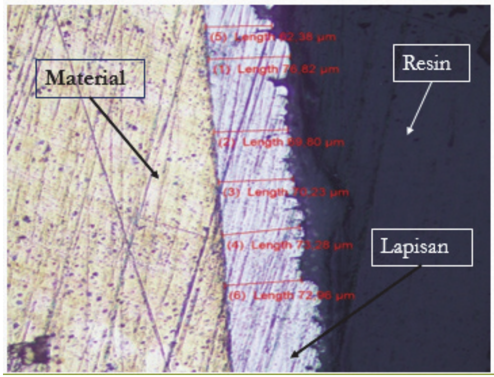

Figure 6: Electroplating Nickel Layer Microstructure (Measurement Position).

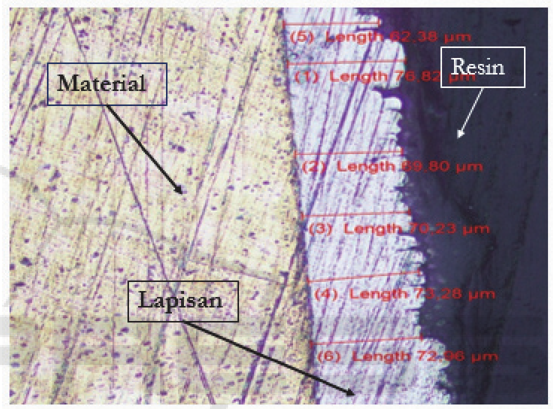

Figure 7: Electroplating Chrome Layer Microstructure (Measurement Position).

Based on the table data above, the lowest thickness value is at point 5, which is62.38 µm, and the highest thickness is obtained at point 1 which is 76.82 µm. While the value of the average thickness obtained from the results of the electroplating process with a voltage of 4.5 volts and a time of 15 minutes is70.90833 µm in nickel coating.
Based on the table data above, the lowest thickness value is at point 4, which is90.04 µm, and the highest thickness is obtained at point 5 which is117.37 µm. While the value of the average thickness obtained from the results of the electroplating process with a voltage of 4.5 volts and a time of 15 minutes is 99.5483 µm in chrome coating.

4 CONCLUSION

Vickers hardness test results with a loading of 5 kg indentation time 15 seconds after the heat treatment (Hardening) process that is gradually starting from a temperature of 350oC to 650oC for 6 hours with oil quenching media decreasing the hardness value by 85.75 HV (5.08%) and water quenching experienced a significant increase of 12.67% with a hardness value of 101.78 HV compared to the hardness of the base material 90.34 HV, it can be concluded that the highest hardness value was obtained using water media.

The results of the Vickers hardness test after the nickel-chrome electroplating process with a voltage variation of 1.5 volts, 3 volts, and 4.5 volts and a time of 5 minutes, 10 minutes, and 15 minutes, with a loading of 100 gf indentation time of 10 seconds increased the hardness value. with increasing stress and time on the coating, the variation of the increase in at a voltage of 4.5 volts with a time of 15 minutes with the highest hardness value for nickel of 254.82 HV and chrome of 261.95 HV. The increase in voltage and time in the nickel-chrome electroplating coating affects increase in the hardness of the coating.

The results of the thickness test after the nickel-chrome electroplating process of 4.5 volts and 15 minutes based on the results of the Vickers test with the highest hardness value on nickel obtained a thickness of 70.90833 µm and on chrome the thickness is 99.5483 µm.

ACKNOWLEDGEMENTS

The author would like to thank the Ministry of Research and Technology, Indramayu State Polytechnic and the Department of Mechanical Engineering, Indramayu State Polytechnic.

REFERENCES

https://kemenperin.go.id/artikel/18999/Tingkatkan-Efisiensi,-Industri-Kuningan-Manfaatkan-Bahan-Baku-Daur-Ulang.

Surdia, Tata. 1996. Teknik Pengecoran Logam, Edisi ke-2, Cetakan ke-7, PT. Pradnya Paramita, Jakarta.

Mad, Y., & Ellyawan, A. (2006). Studi Kasus Laju Korosi Baling-Baling Perahu Nelayan. Jurnal Teknologi Academia Ista, 43.

Hakim, AR. 2012. Analisa Korosi Atmosfer pada material Baja Karbon Sedang di Kota Semarang. Semarang. Universitas Diponegoro.

Kaban, Hadir, dkk. 2010. Menguji kekuatan bahan 6 ubtract 6 ating pelapisan nikel pada 6 ubtract besi dengan uji impak. Jurnal Penelitian Sains Vol. 13 No 3B. September 2010.

Adnyani, I.A.S., dan Triadi A.A.A., (2009). Pengaruh Kuat Dan Distribusi Arus Terhadap Ketebalan dan Kekerasan Lapisan Krom Pada Stoneware Dan Earthenware. Mataram: Jurusan Teknik Elektro Fakultas Teknik, Universitas Mataram.

ASM International Metals Handbook Volume 4 – Heat Treating

Nickel Plating Handbook, Nickel Institute 2014.

Cahyono, I., 2018. Analisa Hasil Pengecoran (Cu, Zn) Dengan Variasi Media Pendinginan (Air Sumur, Oli SAE 40 Dan Udara) Menggunakan Cetakan Pasir CO2, Fakultas Teknik Univeritas Muhammadiyah.

Sumpena, Wardoyo, 2020. Analisa Kuat Arus Listrik dan Waktu Electroplating Nickel-Chrome terhadap Kekerasan dan Ketebalan Lapisan Permukaan Baja Karbon Rendah. Jurnal Engine Vol. 4, No.2, 2020 : 96-102.

Tahu, F., Maliwemu, E. U., 7 Limbong, i.S. (2015). Pengaruh Tegangan Listrik dan Waktu Terhadap Mikro Pelapisan Nikel-Krom Pada Produk Pengecoran Alumunium Bekas (Scrap), Jurnal Teknik Mesin UNDANA.