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THE EFFECT OF ANODIZING SOLUTION TYPE AGAINST THE COATING THICKNESS AND WEAR RATE OF ALUMINUM 6061

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ABSTRACT

Aluminum is metal that mild and has a fairly high mechanical strength. It is widely used in automotive industry, aircraft industry, but, aluminum has disadvantage which is low wear resistance. Development of methods for improving the wear rate can be conducted by using anodizing method. The study aimed to obtain accurate and detail information that needed to support the wear rate analysis results using anodizing solution of sulfuric acid and phosporic acid. The method used in this study was using experimental testing with variations of voltage and immersion time on solution type of sulfuric acid and phosporic acid. Analysis of the test results obtained from the thickness test, wear rate test and microstructure test by using Scanning Electron Microscopy (SEM). SEM was used to characterize the microstructure of coating on aluminium that resulted from anodizing process.SEM was conducted on specimen that had the lowest and the highest value of wear rate. According to the resultsobtained that voltage and time of anodizing affected the wear rate of aluminium 6061. The more time and voltage of anodizing, the lower the wear rate value, thus the wear resistance of aluminium improved 14 times higher than the wear resistance of base metal.

Keywords: anodizing solution, wear rate, voltage and time, anodizing aluminum

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1. INTRODUCTION

Material Aluminum has many advantages that are widely used in automotive industry, aircraft industry, manufacturing industry and household appliances [1,2]. Aluminum has high wear rate valuethus aluminum is not resistant to friction. To overcome this problem, a lot of researchs conducted by anodizing process [3]. The effect ofelectrolytes variation against the hardness of coating that resulted of anodizing process with nitric acid solution [4]. Anodizing hardness value is inversely proportional to the wear rate value of aluminum [5,6]. Based on the previous studies that conducted by several researchers, this study would observe the influence of solution type, voltage and anodizing time against the wear rate.

2. METHODS

2.1. Anodizing Process

The material used in this study was aluminum 6061 with dimension of 10 mm x 35 mm x 25 mm.

Anodizing process was conducted with three stages, which were:

1. Pretreatment consisting of
    a. Degreasing
    b. Etching
    c. Desmutting
2. Anodizing process
    Anodizing process performed with solution variation of 100% 1M Sulfuric acid (H_2SO_4), 100% 1M Phosphoric acid (H_3PO_4) at temperature that kept constantly at 500ºC, and on the anode side is connected to a slab of aluminum which would act as a negative pole of the power supply. Furthermore, the voltage setting with the variation of 15 V, 20 V, 25 V and 30 V. The next step was turning on the power supply and process variation anodizing that run for 10 minutes, 20 minutes and 30 minute.

Drying Drying is process of drying the specimen after anodizing process.

2.2. Wear Test

Material was tested its wear on the surface which was the anodizing results using worn equipment test by Ogoshi method, then weighing of the initial and final weight with the sliding distance of 117,75 m. Calculating the wear resistance was inversely proportional to the wear rate.

2.3. Morphology Test

Microstructure identification of oxide coatingwasconducted by using SEM, SEM could provi de a relatively low contrast at high magnification. In this study described the analysis result and characterization of the test by using SEM, the anodizing specimen which had the lowestand highest value of wear rate. This analysis was mainly aimed to obtain information on the extent of the SEM could be answered about the phenomenon of what was happening in the anodizing process.

3. RESULTS AND ANALYSIS

3.1. Wear Test

Table 1 The rate of wear of the results of anodizing with variation of time, voltage and solution type.

No.	Solution type	Voltage (V)	Immersion time (min)	Wear rate (m/g)
Base metal				0.000577155
1	100% 1M Sulfuric acid (H_2SO_4)	15	10	0.000064128
2			20	0.000058299
3			30	0.000058299
4		20	10	0.000134087
5			20	0.000040809
6			30	0.000081618
7		25	10	0.000075788
8			20	0.000460558
9			30	0.000134087
10		30	10	0.000058299

11			20	0.000064128
12			30	0.000256513
13	100% 1MPhosphoric acid (H_3PO_4)	15	10	0.000332302
14			20	0.000215705
15			30	0.000099107
16		20	10	0.000122427
17			20	0.000169066
19			30	0.000145746
20		25	10	0.000046639
21			20	0.000116597
22			30	0.000052469
23		30	10	0.000081618
24			20	0.000437239
25			30	0.000104937

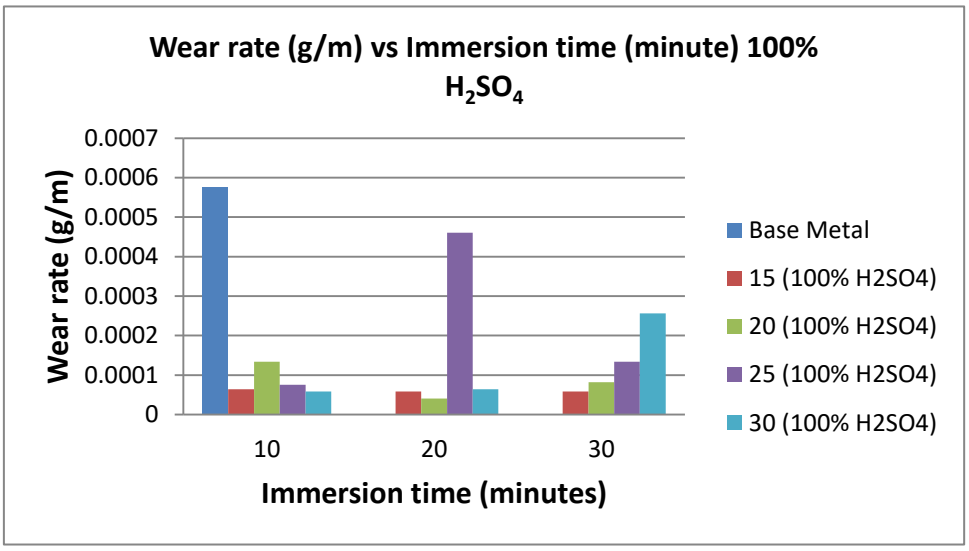


Figure 1 Wear rateof anodizing result on Al 6061 with variation of immersion time for 10 minutes, 20 minutes and 30 minutes at voltage variation of 15 V, 20 V, 25 V and 30 V with solution of 100% H_2SO_4.

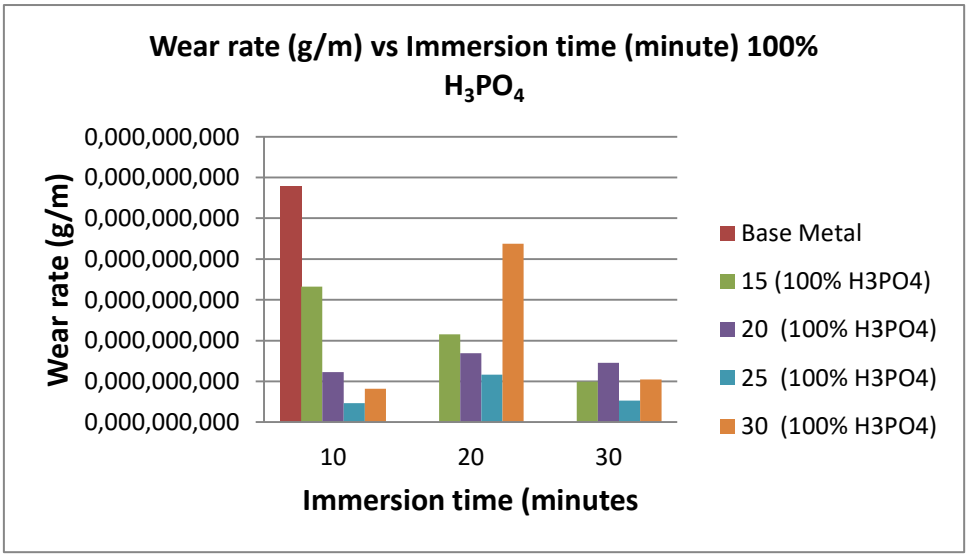


Figure 2 Wear rate of anodizing result on Al 6061 with variation of immersion time for 10 minutes, 20 minutes and 30 minutes at voltage variation of 15 V, 20 V, 25 V and 30 V with solution of 100% H_3PO_4

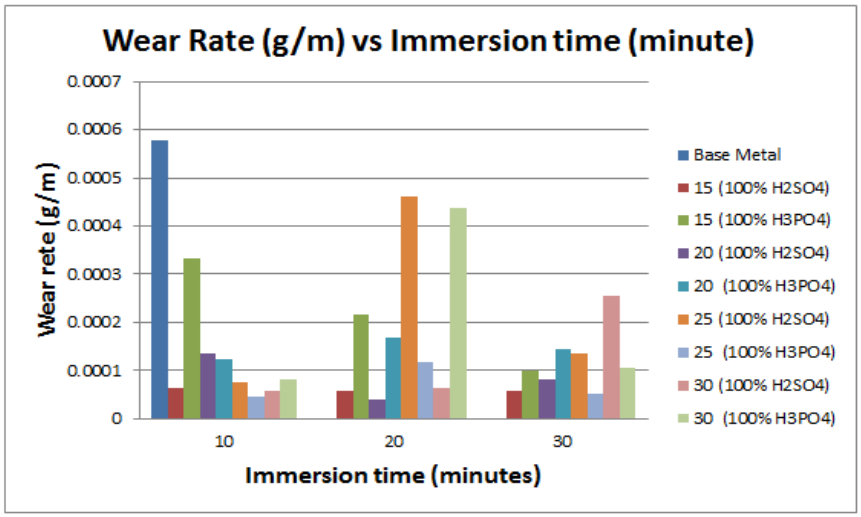


Figure 3 Wear rate of anodizing result on Al 6061 that using solution of 100% H_2SO_4 versus 100% H_3PO_4 with variations in immersion time for 10 minutes, 20 minutes and 30 minutes at voltage variation of 15 V, 20 V, 25 V and 30 V.

Table 2 The rate of thickness of the results of anodizing with variation of time, voltage and solution type.

Solution type	Voltage (V)	Immersion time (minutes)	Thickness (µm)			Rate of thickness (µm)	Wear rate (g/m)
			1	2	3		
100% 1M Sulfuric acid (H2SO4)	15 (100% H2SO4)	10	10,8	10,8	10,8	10.8	0.0000641284
		20	9,5	9,5	9,5	9.5	0.0000582985
		30	5,4	5,4	5,4	5.4	0.0000582985
	20 (100% H2SO4)	10	10,8	10,8	10,8	10.8	0.0001340866
		20	13,6	9,5	13,6	12.2	0.0000408090
		30	8,1	8,1	8,1	8.1	0.0000816179
	25 (100% H2SO4)	10	13,6	13,6	13,6	13.6	0.0000757881
		20	8,1	8,1	8,1	8.1	0.0004605583
		30	6,7	6,7	6,7	6.7	0.0001340866
	30 (100% H2SO4)	10	6,7	6,7	6,7	6.7	0.0000582985
		20	8,1	8,1	8,1	8.1	0.0000641284
		30	6,7	5,4	6,7	5.8	0.0002565135
100% 1M Phosphoric acid (H3PO4)	15 (100% H3PO4)	10	10,8	10,8	10,8	10.8	0.0003323015
		20	9,5	9,5	9,5	9.5	0.0002157045
		30	13,6	12,2	13,6	13.1	0.0000991075
	20 (100% H3PO4)	10	10.8	10,8	10,8	10.8	0.0001224269
		20	10,8	9,5	10,8	10.3	0.0001690657
		30	12,2	12,2	12,2	12.2	0.0001457463
	25 (100% H3PO4)	10	10,8	9,5	10,8	10.3	0.0000466388
		20	10,8	12,2	12,2	11.7	0.0001165970
		30	9,5	10,8	9,5	9	0.0000524687
	30 (100% H3PO4)	10	10,8	12,2	9,5	10.8	0.0000816179
		20	8,1	8,1	8,1	8.1	0.0004372389
		30	5,4	5,4	5,4	5.4	0.0001049373

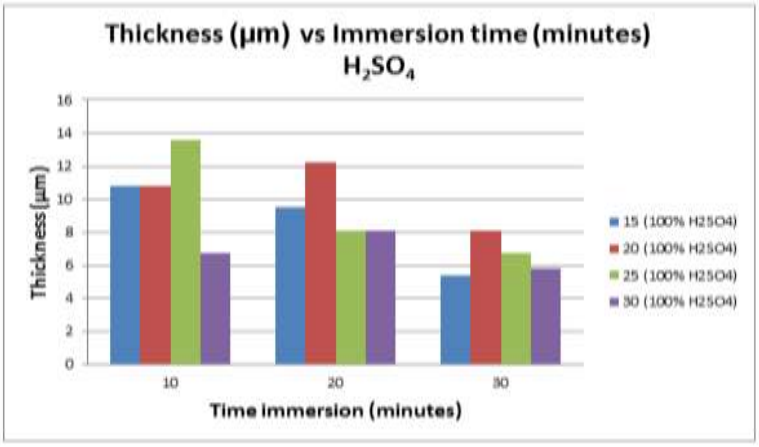


Figure 4 Thicknessrate of anodizing result on Al 6061 versus time immersionwith variation of voltage of 15 V, 20 V, 25 V and 30 V with a solution of 100% H_2SO_4.

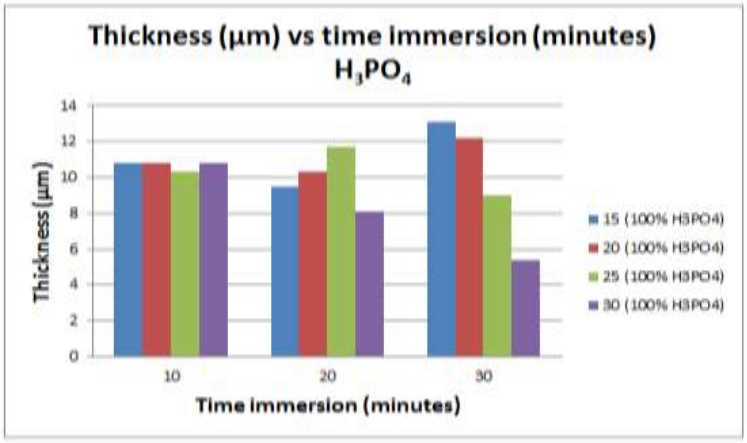


Figure 5 Thickness rate of anodizing result on Al 6061 versus time immersionwith variation of voltage of 15 V, 20 V, 25 V and 30 V with a solution of 100% H_3PO_4.

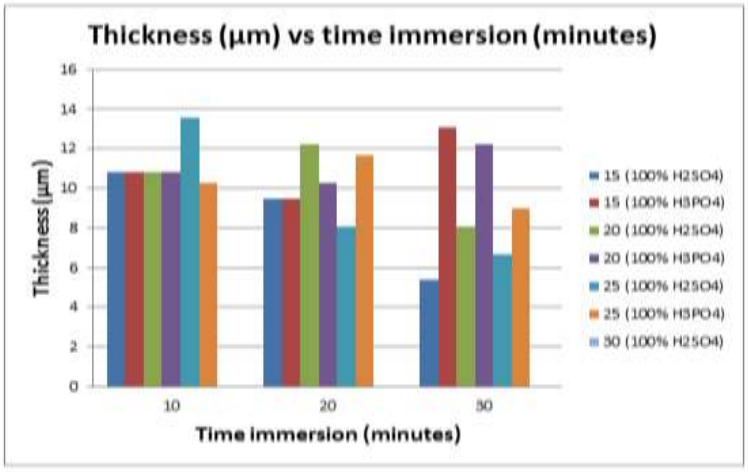


Figure 6 Thickness rate of anodizing result on Al 6061 versus time immersionusing solution of 100% H_2SO_4versus 100% H_3PO_4 with variation of voltage variation of 15 V, 20 V, 25 V and 30 V.

3.2. The Effect of Anodizing Solution

According to the Table 1 and Figure 1 that showed anodizing result using solution media of 100% H_2SO_4indicated the highest wear rate at immersion time for 20 minutes at voltage of 25 V with value of 0.000460558 g/m while the lowest wear rate obtained at the immersion time for 20 minutes at voltage of 20 V and yielded the value of 0.000040809 g/m, compared with the wear rate of base metal that had a value of 0.000577155 g/m which able to lower the wear rate 14 times lower. While on Table 1 and Figure 2 showed the anodizing result by using solution of 100% H_3PO_4 indicated the highest wear rate at immersion time for 20 minutes at voltage of 30 V with value of 0.000437239 g/m, while the lowest wear rate value obtained on treatment with immersion time for 10 minutes at voltage of 25 V with a value of 0.000046639 g/m, if this result was compared with base metal that had wear rate value of 0.000577155 g/m, the anodizing process by using 100% $H_3PO_4$was able to reduce the wear rate 12 times. Thus, the use of anodizing media of 100% $H_2SO_4$was more effective than 100% H_3PO_4which was able to reduce the wear rate value by 14 times, thus the wear resistance increased (Fig. 3).

3.3. The Effect of Anodizing Time and Anodizing Voltage

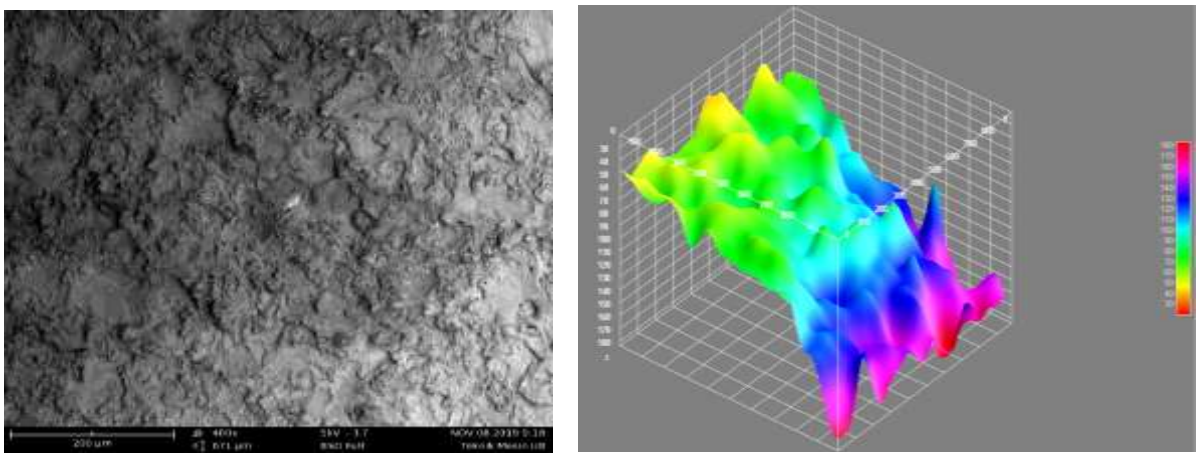
According to Table 1 and Figure 3 showed that the highest wear rate was obtained at immersion time variation of 20 minutesby using solution media of 100% H_2SO_4at a voltage of 25 V with the value 0.000460558 g/m while the lowest wear rate obtained at immersion time of 20 minutes at a voltage of 20 V with a value of 0.000040809 g/m, compared with the wear rate of base metal that had a value of 0.000577155 g/m, this variation was able to lower the wear rate by 14 times, thus the use of effective immersion timefor media of 100% H_2SO_4 was 20 minutes at voltage of 20 V. Table 1 and Figure 3 also showed the anodizing result by using solution media of 100% H_3PO_4. The highest wear rate was obtained at immersion time variation of 20 minutes at a voltage of 30 V that had a value of 0.000437239 g/m, while the lowest wear rate value obtained at variation of immersion time for 10 minutes at a voltage of 25 V that had a value of 0.000046639 g/m. If this result was compared with the base metal that had wear rate value of 0.000577155 g/m on anodizing process that used solution media of 100% H_3PO_4, it was able to reduce the wear rate by 12 times, thus the use of effective immersion timefor solution media of 100% $H_3PO_4$was 10 minutes at voltage of 25 V.

3.4. The Effect of Coating Thickness

According to Table 2 and Figure 4 that showed the anodizing result. The highest wear rate was obtained at anodizing process that using 100% H_2SO_4had the value of 0.000460558 g/m with a coat thickness of 8.1 (μm), while the lowest wear rate obtained value of 0.000040809 g/m with a coat thickness of 12.2 (μm). Table 2 and Figure 5 also showed the highest wear rate that resulted from anodizing process by using 100% $H_3PO_4$with the value of 0.000437239 g/m with a coat thickness of 8.1 (μm), while the lowest wear rate value was 0.000046639 g/m with a coat thickness of 10.3 (μm). Thus, the coat thicknesses that resulted form anodizing process affected the wear rate that occurred, the higher the value of coat thicknesses, the lower the wear rate [6]. Thus, the base metal produced high wear rate value because there was no coat on the aluminum surface (Figure 6).

3.5. SEM Test

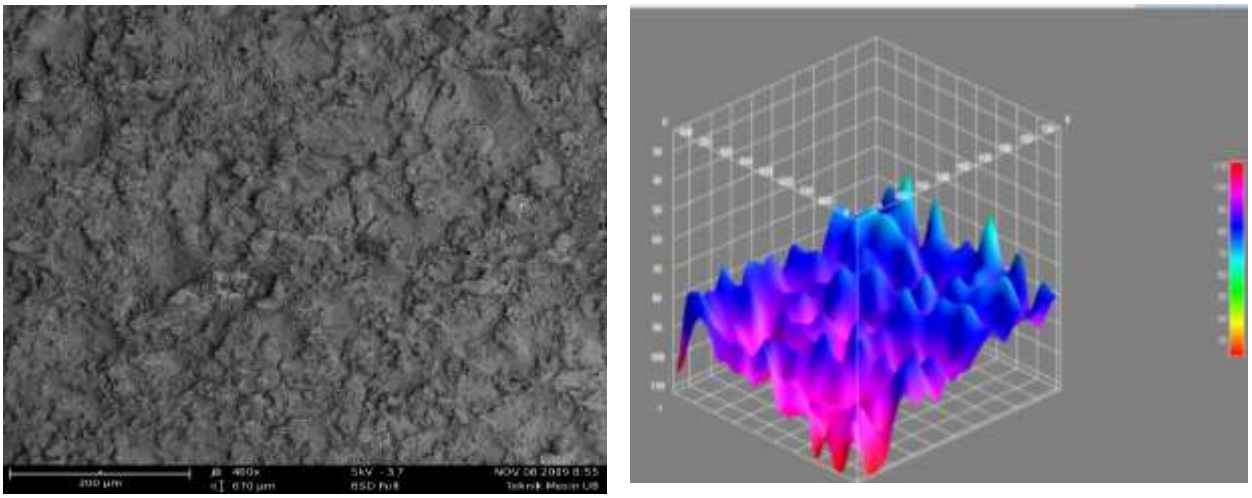
Microstructure test using SEM on anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes and voltage of 20 V was showed in Fig. 7.



(a) (b)

Figure 7(a). SEM image on anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes and voltage of 20 V. (b). 3D Simulation of SEM image resultusing Software Image

According to SEM image (Figure 7 (a)) showed that the coating density of anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes with voltage of 20 V had higher density. The thickness could be obtained using 3D software Image with the value of 180 (the altitude) in the z-axis (Figure 7 (b). This caused the wear rate results on anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes with a voltage of 20 V was lower.



(a) (b)

Figure 8 (a). SEM image on anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes and voltage of 25 V. (b). 3D Simulation of SEM image resultusing Software Image

According to SEM image (Figure 8 (a)) showed that the coating density of anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes with voltage of 25 V had lower density. The thickness could be obtained using 3D software Image with the value of 110 (the altitude) in the z-axis (Figure 8 (b). This caused the wear rate results on anodized Al 6061 using H_2SO_4 solution with immersion time for 20 minutes with a voltage of 25 V was higher. In sulfuric acid, metals are more reactive and easily corroded [7]. Likewise, the non-ferrous alloys are recative in nitric acid [8].

4. CONCLUSION

Wear rate of anodizing resulton on immersion time for 20 at voltage of 20 V with 100% H_2SO_4 produced a wear rate of 0.000040809 g/m was lower compared with wear rate of base metal which was 0.000577155 g/m. It could be concluded that the longer the anodizing time, decreased the wear rate, thus the wear resistance increased 14 times higher than the base metal.

The hgher anodizing voltage, the higher wear resistance (14 times higher).

The thicker the coatings produced, the lower wear rate (14 times lower).

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Note: The responsible translator for the English language is Pungky Eka Setyawan, Indonesia