

Effects of Corrosion Rate AZ31 in a Solution of SBF (Simulated Body Fluid)

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Abstract - The current use of AZ31 in biomedical implants continues to be developed. The effect of SBF (Simulated Body Fluid) solution in AZ31 corrosion tests has not been widely used on AZ31 material which has been subjected to heat treatment, immersion test and weight loss as a reference for observing the effect of SBF on AZ31 material. Pitting corrosion can be clearly seen on the AZ31 surface. The corrosion rate can be minimized at 250°C treatment, held for 2 hours at 2.263 mm / y. Treatment 200°C was held for 1 hour and had the smallest weight loss of 0.1216 gr.

Keywords: AZ31; Corrosion Rate; Heat Treatment; Simulated Body Fluid; Weight Loss.

I. INTRODUCTION

These highly biodegradable materials continue to evolve to avoid a second operation to remove non-degraded materials [1]. Magnesium is commonly used in biomedical fields, where the body makes it easier to degrade. Magnesium alloys have recently been developed to serve as non-toxic, degradable bone implants [2].

The better mechanical properties of pure Mg are one of the choices for AZ31 as a biomedical material. Aluminum and zinc as a mixture of magnesium with low levels that can be accepted by the body [3]. Elemental Manganese in Magnesium can strengthen corrosion resistance [4]. It aims to identify the level of degradation in magnesium alloys used as implant materials. The corrosion rate of Magnesium alloys can be affected by the treatment given. Heat treatment on AZ31 material will affect the corrosion rate [5].

Several previous studies have described the use of AZ31 in experimentally to test the corrosion rate using a solution that resembles a liquid in the body, the type of electrolyte solution used is SBF, Bovine Serum, Ringer's solution and others [6]. The use of a solution suitable for human body fluid is intended to determine the rate of reaction in the body by following the conditions in the body with a temperature of around 36-38°C [7]. The purpose of this paper is to determine the effect of SBF solution on treated and non-treated AZ31

material. The testing process uses different weight loss and immersion time methods [8].

1.1 Materials and methods

AZ31 Magnesium Rod Bar with a diameter of 15 mm has a composition of 2.33% Al, 0.953% Zn, 0.262% Mn, and Mg balance. Cutting specimens using EDM with dimensions of 3 mm thick. The treatments prepared for the corrosion process include non-treatment, heat treatment 200°C holding time 1 hour, and heat treatment 250°C holding time 2 hours with initial weight weighed using an analytical balance.

Table 1: Initial Weight

SPECIMEN	INITIAL WEIGHT (gr)
NON HEAT TREATMENT	
A1	1,1604
A2	1,3596
A3	1,5189
HEAT TREATMENT 200°C HOLDING TIME 1 HOURS	
B1	1,0373
B2	1,0254
B3	0,9802
HEAT TREATMENT 250°C HOLDING TIME 2 HOURS	
C1	1,0488
C2	1,0497
C3	1,0354

1.2 Preparation SBF

SBF was made in the physical metallurgical laboratory of Diponegoro University with the composition in Table 2. The stirring process was carried out at room temperature conditions. The acidity level in SBF follows the pH in a healthy body condition. The addition of HCl is gradually done to reduce the pH to neutral (6.8 - 7.2) [8].

Table 2: The chemical composition of the SBF solution

No	Chemical Material	amount
1	NaCl	7.996 gr
2	NaHCO ₃	0.350 gr
3	KCl	0.224 gr
4	K ₂ HPO ₄ .3H ₂ O	0.228 gr
5	MgCl ₂ .6H ₂ O	0.305 gr
6	HCl 1 M	40 mL
7	CaCl ₂ .2H ₂ O	0.278 gr
8	Na ₂ SO ₄	0.071 gr
9	(HOCH ₂) ₃ CNH ₂	6.057 gr

1.3 Corrosion Test

The immersion process is carried out in a container with circulated SBF assisted by a pump. The test was carried out in SBF conditions at a temperature of 36 - 37°C. The process was observed for 1334 hours and every 168 hours the rinsing and weighing process was carried out to determine the weight loss of AZ31 specimens. The post immersion cleaning formula (rinsing process) is shown in Table 3. Corrosion rate calculations in equation (1) refer to ASTM G 1.

$$CR = \frac{K \times W}{A \times T \times D} \quad (1)$$

Table 3: Chemical cleaning removal

Solution	Time	Temperature
150 g chromium trioxide (CrO ₃)	1 min	Boiling
10 g silver chromate (Ag ₂ CrO ₄)		
Reagent water to make 1000 mL		

III. RESULTS AND DISCUSSIONS

3.1 Visual Examination

Figure 1 shows the magnesium condition after immersing AZ31 for 1334 hours in SBF solution. In Figure (1), it can be seen that there is pitting corrosion that makes a hole look like a well, different from the 200°C treatment condition, the holding time of 1 hour shows that the corrosion process does not cause minimal degradation. The AZ31 non-treatment condition shows that the corrosion process occurs very large which can be seen in Figure (1).

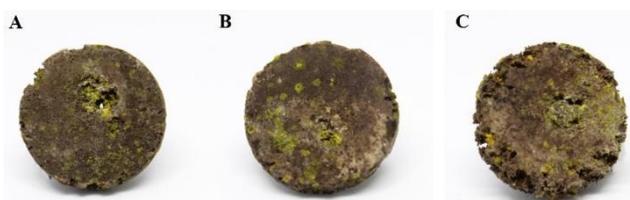


Figure 1: Magnesium condition immersion 1334 jam (A) 250°C holding time 2 hours, (B) 200°C holding time 1 hour, (C) Non Treatment

Figure 1 Shows that the difference between heats treated and untreated is very significant the visible pitting corrosion. Figure 1.C without heat treatment shows pitting corrosion which is very clear, it can be seen that almost all specimens experience pitting corrosion. The results of the specimen immersion visually show the effect of decreasing the corrosion rate by heat treatment of magnesium.

3.2 Weight loss

The process of weighing specimens is carried out using an analytical balance tool at the Mechanical Engineering Metallurgical Laboratory of Diponegoro University. Before weighing the specimens are rinsed using a chemical rust cleaning solution listed in table 2 with reference to ASTM G3 [9].

Figure 2 shows the relationship between weight loss and immersion time in the SBF solution. The resulting AZ31 non-treatment weight loss material continued to experience a significant increase for 1176 hours. The last 168 hours of weight lost didn't increase that much.

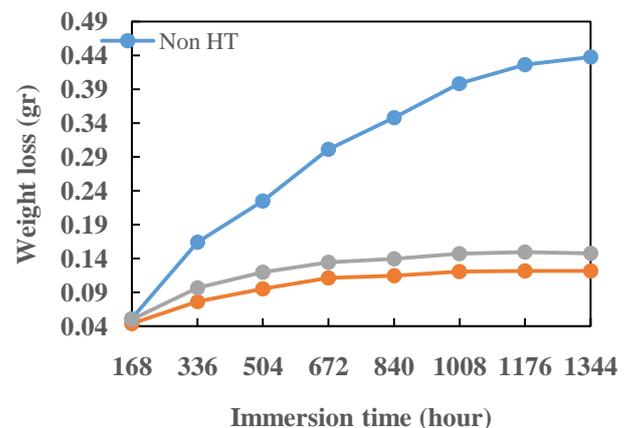


Figure 2: Weight loss due to the effects of heat treatment

Meanwhile, for materials that are heat treated, the resulting graph is not as significant as non-treated. The results of weight loss, 250°C treatment, 2 hours holding time has a relatively small increase. However, the results of the immersion from 1176 hours to 1344 hours decreased from 0.1494 gr to 1.473 gr.

The lowest degradation was obtained at AZ31 with a heat treatment of 200°C holding time of 1 hour. In the immersion process from 1176 hours to 1344 hours there was no reduction in the load and it remained 0.1216 gr.

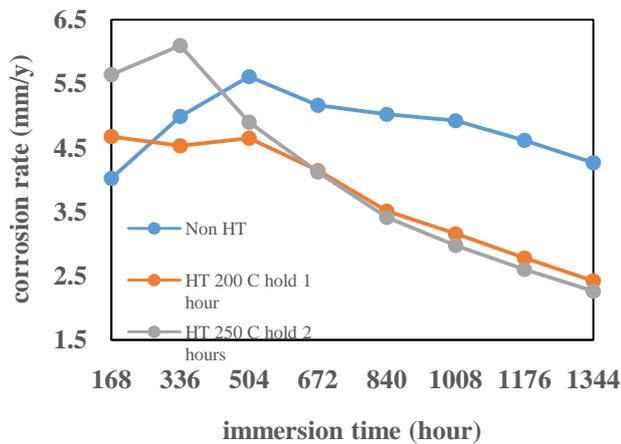


Figure 3: Corrosion rate due to heat treatment effect

Figure 3 shows the corrosion rate relationship with the immersion process in the SBF solution. Non-treated materials from 168 - 504 h experienced an increase in the corrosion rate and decreased to 1344 h. The decrease in corrosion rate is relatively small at 672-1008 h. Similar to the material for the heat treatment of 250°C, the holding time of 2 h occurred an increase in the corrosion rate at the beginning of the immersion process. After the immersion process was more than 336 h, the corrosion rate decreased to 2,263 mm / y at 1344 h.

Unlike the others, the heat treatment material at 200°C, the holding time of 1 h at the beginning of immersion, experienced instability in its corrosion rate. The increase occurred in immersion 336 - 504 h from 4,529 mm / y to 4,647 mm / y. The corrosion rate has decreased again after more than 505 h.

3.3 Discussion

Heat treatment affects the microstructure character of AZ31 causing weight loss and corrosion rate to be different from that of the non-treated ones [10]. Pitting corrosion that occurs due to localized corrosion and uniform attack causes the surface at the 250°C treatment, holding time of 2 hours to create holes in the material. The presence of chloride in the simulated body fluid exacerbates the pitting corrosion that occurs [11], [12]. The increase in corrosion rate is also triggered by the presence of chlorine in SBF at the first 504 hours as shown in Figure 2. The rapid increase in corrosion rate also causes a large weight loss at non treated material.

IV. CONCLUSION

Further research is expected to develop treatments for magnesium that can improve the physical properties of magnesium. Heat treatment given the smallest corrosion rate

at the heat treatment 250°C holding time 2 hours with an immersion period of 1344 hours of 2.263 mm / y. The lowest result of weight loss at 200°C treatment 1 h holding time of 0.1216 gr. The results of this study can be concluded that the heat treatment of magnesium affects the physical strength of the AZ31 magnesium material.

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