# Dissolution Of Ferrous Into Molten Of Aluminum-Copper:A Proposed Dissolution Rate Constant

*by* Joko Riyono FTI

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# Dissolution Of Ferrous Into Molten Of Aluminum-Copper:A Proposed Dissolution Rate Constant

Dody Prayitno[1, a)], E. Shintadewi J.[2], Rosalina Tjandrawinata[3], Joko Riyono[1]

[1)] *Department of Mechanical Engineering, Faculty of Industrial Engineering, Universitas Trisakti*
*Jalan Kyai Tapa No 1, Jakarta 11440, Indonesia*
[2)]*Department of Electrical, Faculty of Industrial Engineering, Universitas Trisakti*
*Jalan Kyai Tapa No 1, Jakarta 11440, Indonesia*
[3)]*Faculty of Dentistry, Universitas Trisakti*
*Jalan Kyai Tapa No 1, Jakarta 11440, Indonesia*

[a)] Corresponding author: dodyprayitno@trisakti.ac.id

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**Abstract** – In the previous research, a surgical blade was immersing into a molten aluminum-copper alloy and then destroy. A conventional corrosion rate equation is not used directly to predict a need time for the surgical blade to destroy. A corrosion rate constant should be corrected to become a dissolution rate constant. The aim of research is to propose a dissolution rate constant. Method. The molten of aluminum-copper was melted at 750 ºC for 30 minutes. The samples were 4 steel-cutters. Next the sample was weighed firstly. Second, the half part of sample was immersed into molten aluminum-copper alloy for a certain time (10; 20; 30 and 60 minutes). Next the sample was pull out and a sticked aluminum was removed from the sample surface. Finally, the sample was weighed again. The thickness of sample was measured. The experimental results. The thickness of steel-cutter becomes thinner with increasing the dipping time. The K (dissolution rate constant) is 2.34.

## INTRODUCTION

The dissolution of ferrous alloy into molten a non-ferrous alloy is an interesting field to study [1, 2, 3, 4, 5, 6]. In the previous research, a surgical blade was immersing into a molten aluminum-copper alloy and then destroy as shown in Figure 1 [7, 8, 9]. A conventional corrosion rate equation is not applied directly to predict a need time for the surgical blade to destroy. A corrosion rate constant should be corrected to become a dissolution rate constant.

Immersing into molten metal alloy reduces the diameter of sample. Increasing dipping time increase rectifying diameter of sample as shown in Figure 2. [10]. Corrosion is defined as the destructive and unintentional attack of a metal; it is electrochemical and ordinarily begins at the surface [10, 11]. A rate of corrosion is the speed at which any given metal deteriorates in a specific environment (examples: water and sea water) [12].

(a) Before

(b) after

**FIGURE 1**. a surgical blade was immersed into a aluminum-copper alloy

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**FIGURE 2**. Relation between rectified diameter and dipping time (● ○ ● —Fe-3Ni, ▲ Δ ▲ ˜-˜Fe2C, ■ □ ■---- Fe-3C). is distributed in Al bath homogeneously. [2]

The Corrosion rate equation is shown in Equation (1)

$$CR = (W.K) / (\rho.A.t) \quad (1)$$

Where:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *CR* | : | corrosion rate | ρ | : | density | *K* | : | constant of corrosion rate |
| *W* | : | weight | *A* | : | area | *t* | : | time |

In order to predict a need time for the surgical blade to destroy the Equation (1) is used after the corrosion rate constant should be corrected to become a dissolution rate constant. The aim of research is to propose a dissolution rate constant.

## METHOD

Figure 3 shows the research flowchart, an copper wire is weight for 40 gram and an aluminum is for 60 gram. The alloy is melted by a heating furnace. Then the Al-Cu Alloy molten was mixed by a stick at 800 $^0$C and then hold for 30 minutes. Then the molten was ready. Second step the samples (4 steel-cutters) were washed, dried and then weighted. Next the half of length of each sample was immersed into the molten aluminum-copper alloy for a certain time (10; 20; 30 and 60 minutes). Then the furnace door was closed. Next the dipped sample was picked out. the sample surface was cleaned from a sticked metal. The thickness, width and length of dipped area were measured. Next each sample was reweighted. Finally, some calculation was done to find a dissolution rate constant.

**FIGURE 3**. Research Flowchart



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## RESULTS AND DISCUSSION

In this research, a half of length of sample was immersed into the molten of Aluminum-copper alloy with certain times. There was a thin metal (aluminum-copper alloy) stick on the surface. But it is easy to remove. (Figure 4). The dipping area of sample is location of dimension measuring (thickness, width and length).

**FIGURE 4** The initial sample (a). A thin sticked metal is removed from the sample (b). The sample (dipping area) was ready to thickness measuring (c)

Table 1 shows the results of thickness measuring. Table 2 shows the weight of the steel-cutter sample before (Wo) and after (W1) dipping into the molten aluminum-copper alloy. Table 3 shows the result of calculated dipping area.

**TABLE 1**. Thickness of Sample (mm)

| No | Initial sample | Dipping time (minutes) | | | | |
|---|---|---|---|---|---|---|
| | | 10' | 20' | 30' | 60' | |
| Average thickness | 0.50 mm | 0.381 mm | 0.345 mm | 0.271 mm | 0.214 mm | |
| Thickness loss | 0 | 0.119 mm | 0.155 mm | 0.229 mm | 0.286 mm | |

**TABLE 2.** Weight of sample before (Wo) and After (W1) dipping into molten

| Dipping time | | W0 | W1 | Mass Loss |
|---|---|---|---|---|
| Minutes | (second) | (g) | (g) | (g) |
| 10 | 600 | 6,500 | 5,710 | 0,79 |
| 20 | 1200 | 6,503 | 5,388 | 1,115 |
| 30 | 1800 | 6,500 | 5,246 | 1,254 |
| 60 | 3600 | 6,476 | 4,671 | 1,805 |

**TABLE 3.** Mass Loss/Dipping Area

| Dipping time | | Mass Loss | Dipping area | Mass loss/dipping area |
|---|---|---|---|---|
| (Minutes) | (Second) | (g) | ($mm^2$) | ($g/mm^2$) |
| 10 | 600 | 0,79 | 1914 | 0,00041 |
| 20 | 1200 | 1,115 | 1809,6 | 0,00062 |
| 30 | 1800 | 1,254 | 1660,8 | 0,00076 |
| 60 | 3600 | 1,805 | 1557 | 0,0012 |



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The data in Table 1 are plot in a graphic as Figure 5. Based on the Figure 5 it can be shown that increasing in the dipping time reduce the thickness. For example, dipping times from 0 to 3600 second reduces the thickness from 0,5 mm to 0,21 mm. It is a proof that the sample dissolve into the molten. Phenomena of dissolution steel cutter into molten like as phenomena of "corrosion".

**FIGURE 5.** Relationship between dipping time and thickness

The dissolution rate equation can be analog with the corrosion rate equation [1] as follows:

$$DR = (W_1 . K_1) / (\rho . A_1 . T_1) \quad (2)$$

Where:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $DR$ | : | Dissolution rate (mm/second) | $K_1$ | : | Constant of dissolution rate | $A_1$ | : | Dipping area ($mm^2$) |
| $W_1$ | : | Mass loss (g) | $\rho$ | : | density of ferrous ($g/mm^3$) | $t_1$ | : | Dipping time (second) |

The equation (2) can be rewritten as

$$DR = \left(\left(W_1 / A_1\right) / t\right) \times (K_1 / \rho) \quad (3)$$

The dissolution rate constant can be calculated as an equation (4)

$$(K_1 / \rho) = DR \ / \ \left(\left(W_1 / A_1\right) / t\right) \quad (4)$$

The value of Dissolution Rate ($DR$) can be found as an equation (5).

$$DR = (\text{Thickness loss / Dipping Time}) \quad (5)$$

The value "$((W_1/A_1)/t)$" is shown as an equation (6).

$$((W_1/A_1)/t) = ((\Delta \text{ mass loss/area})/ \text{ dipping time} \quad (6)$$

## Finding dissolution rate value (*DR*)

The thickness loss increases with increasing dipping time as shown in Table 1 and Figure 6. The equation (7) is a linear regression for relationship between thickness loss with dipping time

**FIGURE6.** Relationship between dipping time and thickness loss

$$y = 6.10^{-5}\, x + 0{,}0976 \quad (7)$$

where $y$ = thickness loss (mm)



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$x$ = dipping time (sec)

According to equation (7), the ratio of (thickness loss/dipping time) is nearly to $6.10^{-5}$ mm/sec. Thus the dissolution rate value (DR) (equation (5)) can be wrote as:

$$DR \approx 6.10^{-5} \text{ mm/second} \quad (8)$$

## Finding Ratio of ((Δ mass loss/area)/Δ dipping time)

Based on Table 2 and Table 3, a graph ((Δ mass loss/area) versus dipping time) is made and shown in Fig. 7. Their relationship is illustrated by equation (9).

**FIGURE 7.** Relationship between dipping time and mass loss/area

$$y = 2.\ 10^{-7}\ x + 0.0003 \quad (9)$$

where
y is ratio of mass loss with area or ($W_1/A_1$) and $x$ is time (t).

Based on equation (9) it is found that

$$((W_1/A_1)/t) \approx 2.10^{-7} \text{ (g / (mm}^2\text{.second))} \quad (10)$$

## Finding Dissolution Rate constant ($K_1$)

The equation (4) can be written since the equation (8) and the equation (10) are substituted

$$(K_1/\rho) = (6.10^{-5}) / (2.10^{-7}). \quad (11)$$

Since $\rho = 7.8\ 10^{-3}$ (gram/mm$^3$), the equation (11) becomes

$$K_1 = (6.10^{-5} \times 7.8\ 10^{-3}) / (2\ 10^{-7}) \quad (12)$$

$$K_1 = 2.34 \quad (13)$$

## CONCLUSIONS

The conclusion are as follows:
1. Since the steel cutter was immersed into molten aluminum-copper, the thickness of steel cutter becomes thinner.
2. Increasing the dipping time reduced the thickness of steel cutter.
3. $DR = (W_1.\ K_1.) / (\rho.\ A_1.\ t_1)$

Where:

| | | | | | |
|---|---|---|---|---|---|
| $DR$ | : | Dissolution rate (mm/second) | $\rho$ | : | density of sample (gram/mm$^3$) |
| $W1$ | : | Mass loss (gram) | $A_1$ | : | Dipping area (mm$^2$) |
| $K_1$ | : | Constant of dissolution rate =2.34 | $t_1$ | : | Dipping time (second) |



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