

## LAMPIRAN I

### PENURUNAN RUMUS PERSAMAAN DASAR HUBUNGAN ANTARA RESISTANSI DAN WAKTU RENDAM

Dari persamaan hubungan resistansi dengan resistivitas

$$R = \rho_r \frac{L}{A}$$

karena luas adalah

$$\begin{aligned} A &= \pi R^2 \\ &= \pi D^2/4 \end{aligned}$$

maka

$$\begin{aligned} R &= \frac{4 \rho_r L}{\pi D^2} \\ D &= \left[ \frac{4 \rho_r L}{\pi R} \right]^{1/2} \end{aligned}$$

Berat yang hilang merupakan selisih berat awal dan akhir

$$\begin{aligned} \Delta m &= m_{\text{awal}} - m_{\text{akhir}} \\ &= \frac{\rho_d \pi L (D_{\text{aw}}^2 - D_{\text{ak}}^2)}{4} \\ &= \rho_d \rho_r L^2 (1/R_{\text{aw}} - 1/R_{\text{ak}}) \end{aligned}$$

Karena luas permukaan berubah selama korosi, berat yang hilang per satuan luas per satuan waktu (laju korosi) adalah

$$\frac{\Delta m}{A t} = \frac{\rho_d \pi L (D_{\text{aw}}^2 - D_{\text{ak}}^2)}{4 (\pi D L) t}$$

$$\begin{aligned}
&= \frac{\rho_d (D_{aw}^2 - D_{ak}^2)}{4 D t} \\
&= \frac{\rho_d (D_{aw} - D_{ak})}{2 t} \\
&= \frac{\rho_d \left[ \left( \frac{4 \rho_r L}{\pi R_{aw}} \right)^{1/2} - \left( \frac{4 \rho_r L}{\pi R_{ak}} \right)^{1/2} \right]}{2 t} \\
&= \frac{\rho_d \left( \frac{4 \rho_r L}{\pi R} \right)^{1/2} \left[ \left( \frac{1}{R_{aw}} \right)^{1/2} - \left( \frac{1}{R_{ak}} \right)^{1/2} \right]}{2 t} \\
&= \left( \frac{\rho_d}{t} \right) \left( \frac{\rho_r L}{\pi} \right)^{1/2} \left[ \left( \frac{1}{R_{aw}} \right)^{1/2} - \left( \frac{1}{R_{ak}} \right)^{1/2} \right] \\
(1/R_{ak})^{1/2} &= \frac{\left( \frac{\rho_d}{t} \right) \left( \frac{\rho_r L}{\pi} \right)^{1/2} \left( \frac{1}{R_{aw}} \right)^{1/2} - v}{\left( \frac{\rho_d}{t} \right) \left( \frac{\rho_r L}{\pi} \right)^{1/2}} \\
R^{-1/2} &= R_{aw}^{-1/2} - \frac{v}{\rho_d \left( \frac{\rho_r L}{\pi} \right)^{1/2}} t
\end{aligned}$$

dengan  $\rho_d$  adalah densitas logam,  $R_{aw}$  dan  $R_{ak}$  berturut-turut adalah resistansi awal dan akhir serta  $v$  sama dengan laju korosi ( $\Delta m/At$ ).

Dengan membuat grafik  $R^{-1/2}$  versus  $t$ , maka laju korosi dapat diketahui.

*Sm*

## LAMPIRAN II

### DATA PENGAMATAN LABORATORIUM

#### Lampiran II.1 Penentuan resistivitas.

Tabel II.1 Hubungan antara resistansi dan luas kawat.

Diameter (cm)	Luas (cm <sup>2</sup> )	1/luas	Resistansi ( )
0,3785	0,1125	8,8920	0,288
0,3269	0,0839	11,9133	0,4295
0,278	0,0607	16,4826	0,6094
0,0283	0,0445	22,4871	0,8798

## Lampiran II.2. Pengukuran resistansi kawat tembaga

Tabel 4.2. Resistansi kawat tembaga dalam larutan campuran HCl, HNO<sub>3</sub>, H<sub>2</sub>O dengan perbandingan volume 1:1:8.

$t_{\text{rendam}}$ (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ )	$(1/R)^{1/2}$ ( ) <sup>1/2</sup>
0	44,2	0,29467	1,8421
15	44,2	0,29467	1,8421
30	44,3	0,29530	1,8401
45	44,6	0,29730	1,8339
60	43,9	0,29267	1,8485
75	43,9	0,29267	1,8485
90	44,3	0,29530	1,8401
105	44,4	0,29600	1,8380
120	44,6	0,2973	1,8339
135	44,2	0,29467	1,8421
150	44,4	0,29600	1,8380
165	44,3	0,2953	1,8401
180	44,5	0,2967	1,8361
195	44,7	0,2980	1,8319
210	44,4	0,2960	1,8380
225	44,5	0,2967	1,8361
240	44,6	0,2973	1,8339

$$\rho_d = 4,741517 \text{ gr/cm}^3, I = 150 \text{ mA}$$

Tabel 4.3. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 1:2:8$

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ )	$(1/R)^{1/2}$ ( ) <sup>1/2</sup>
0	42,9	0,2860	1,8699
15	42,8	0,2853	1,8721
30	43,2	0,2880	1,8634
45	43,5	0,2900	1,8570
60	43,6	0,2907	1,8548
75	44,1	0,2940	1,8443
90	46,1	0,3073	1,8038
105	40,1	0,2670	1,9341
120	43,8	0,2920	1,8506
135	43,6	0,2907	1,8648
150	44,4	0,2960	1,8380
165	44,8	0,2987	1,8298
180	43,9	0,2927	1,8485
195	44,5	0,2967	1,8356
210	45,0	0,3000	1,8257
225	44,8	0,2987	1,8298
240	44,9	0,2993	1,8278

$$\rho_d = 4,75866 \text{ gr/cm}^3, I = 150 \text{ mA}$$

Tabel 4.4. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 1:3:8$

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ )	$(1/R)^{1/2}$ ( ) <sup>1/2</sup>
0	44,7	0,2980	1,8319
15	44,9	0,2993	1,8278
30	44,8	0,3053	1,8097
45	47,1	0,3140	1,7846
60	52,3	0,3487	1,6935
75	50,6	0,3373	1,7217
90	51,6	0,3440	1,7050
105	52,2	0,3480	1,6951
120	55,0	0,3667	1,6514
135	58,6	0,3907	1,5999
150	57,4	0,3827	1,6166
165	59,1	0,3990	1,5931
180	61,3	0,4087	1,5643
195	60,6	0,4040	1,5733
210	63,5	0,4233	1,5369
225	61,2	0,4080	1,5656
240	66,9	0,4460	1,4974

$$\rho_d = 4,75519 \text{ gr/cm}^3, I = 150 \text{ mA}$$

Tabel 4.5. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 2:1:8$ .

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ )	$(1/R)^{1/2}$ ( ) <sup>1/2</sup>
0	43,8	0,2920	1,8506
15	43,7	0,2913	1,8527
30	43,9	0,2927	1,8485
45	43,9	0,29270	1,8485
60	43,8	0,3487	1,8506
75	44,9	0,2727	1,8278
90	44,1	0,2940	1,8443
105	44,0	0,2933	1,8464
120	44,3	0,2953	1,8401
135	44,2	0,2947	1,8422
150	44,4	0,2960	1,8380
165	44,2	0,2947	1,8422
180	44,5	0,2967	1,8360
195	44,7	0,2980	1,8319
210	44,5	0,2967	1,8360
225	44,5	0,2967	1,8360
240	44,5	0,2967	1,8360

$$\rho_d = 4,8621 \text{ gr/cm}^3, I = 150 \text{ mA}$$

Tabel 4.6. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 3:1:8$

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ ) $10^1$	$(1/R)^{1/2}$ ( ) $^{1/2}$
0	44,5	2,967	1,8360
15	44,5	2,967	1,8360
30	44,4	2,960	1,8380
45	44,4	2,960	1,8380
60	44,5	2,967	1,8360
75	44,7	2,980	1,8319
90	44,6	2,973	1,8339
105	44,7	2,980	1,8319
120	44,9	2,993	1,8278
135	44,8	2,987	1,8298
150	44,8	2,987	1,8298
165	44,9	2,993	1,8278
180	45,0	3,000	1,8357
195	44,9	2,993	1,8278
210	45,2	3,013	1,8217
225	45,2	3,013	1,8217
240	45,4	3,027	1,8177

$$\rho_d = 4,7710 \text{ gr/cm}^3, I = 150 \text{ mA}$$



Tabel 4.7. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 2:3:8$ .

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ ) $10^4$	$(1/R)^{1/2}$ ( ) $^{1/2}$
0	45,5	3,033	1,8157
15	45,9	3,060	1,8078
30	46,2	3,080	1,8019
45	46,9	3,127	1,7884
60	47,7	3,180	1,7733
75	48,2	3,213	1,7641
90	50,3	3,353	1,7269
105	47,6	3,173	1,7752
120	50,0	3,333	1,7321
135	49,0	3,267	1,7496
150	53,9	3,593	1,6682
165	54,6	3,640	1,6575
180	53,9	3,593	1,6682
195	54,8	3,653	1,6545
210	57,1	3,807	1,6208
225	58,1	3,873	1,6068
240	58,9	3,927	1,5958

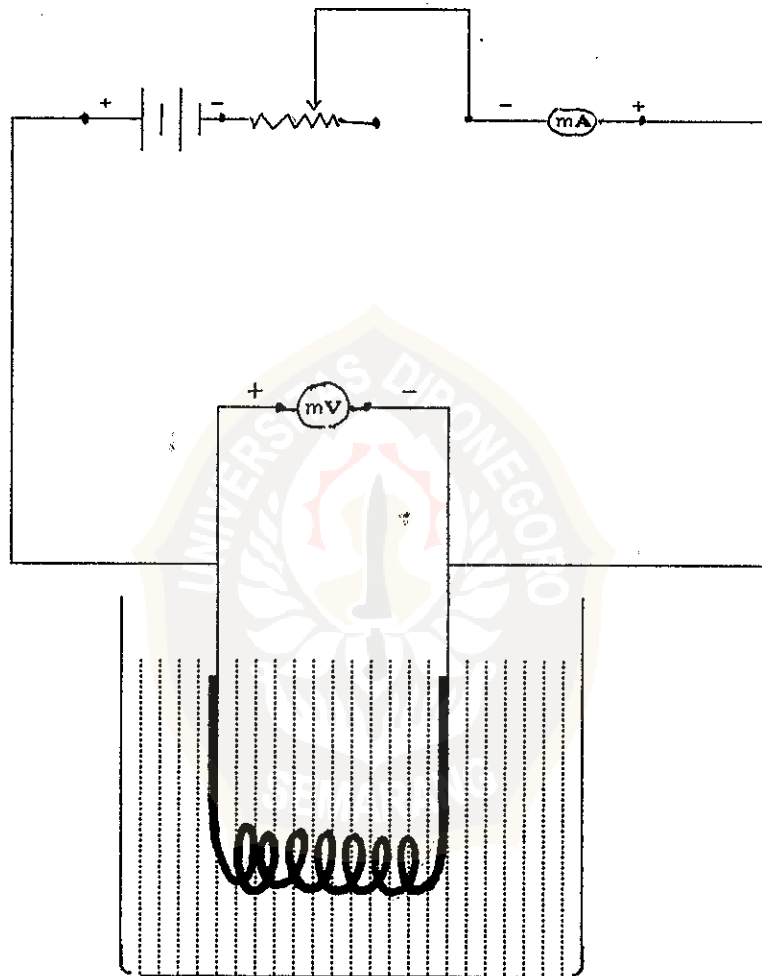
$$\rho_d = 4,7710 \text{ gr/cm}^3, I = 150 \text{ mA}$$

Tabel 4.8. Pengukuran resistansi kawat tembaga dengan perbandingan volume  $\text{HCl}:\text{HNO}_3:\text{H}_2\text{O} = 3:3:8$ .

Waktu rendam t (menit)	Voltase (mV)	Resistansi, R ( $\Omega$ ) $10^1$	$(1/R)^{1/2}$ ( ) $^{1/2}$
0	44,3	2,953	1,8401
15	45,8	3,053	1,8097
30	47,7	3,180	1,7733
45	53,5	3,567	1,6744
60	48,9	3,260	1,7514
75	54,7	3,647	1,6560
90	56,0	3,733	1,6366
105	60,4	4,027	1,5759
120	64,1	4,273	1,5297
135	72,2	4,813	1,4414
150	84,4	5,627	1,3332
165	110,7	7,380	1,1640
180	122,6	8,173	1,1061
195	148,5	9,900	1,0050

$$\rho_d = 4,7378 \text{ gr/cm}^3, I = 150 \text{ mA}$$

LAMPIRAN III  
SISTEM PENGUKURAN RESISTANSI



LAMPIRAN IV  
CONTOH PERHITUNGAN

IV.1 Penentuan berat jenis ( $\rho_d$ ) dan berat yang hilang ( $\Delta m$ ).

No.	D/2 perc.	berat (gr)		Resistansi	
		awal	akhir	awal	akhir
1	0,1889	15,9460	15,7739	3,3936	3,3636
2	0,1893	16,0549	15,0568	3,4965	3,3411
3	0,1891	16,0220	8,9522	3,3667	2,2422
4	0,1891	16,3833	16,0848	3,4247	3,3704
5	0,1893	16,0966	15,6396	3,3704	3,3036
6	0,1893	16,1321	11,1337	3,2971	2,5465
7	0,1889	16,1178	1,9188	3,3864	1,0101

1. Penentuan berat jenis ( $\rho_d$ )

Volume dirumuskan sebagai  $V = \pi (D/2)^2 L$

Sedangkan berat jenis dirumuskan  $\rho_d = \text{berat/volume (gr/cm}^3\text{)}$

$$\begin{aligned} \text{Perc.1. } V &= 3,14 (0,1889)^2 \cdot 30 & \rho_d &= \frac{15,9460}{3,3605} \\ &= 3,3605 & &= 4,741517 \end{aligned}$$

$$\begin{aligned} \text{Perc.2 } V &= 3,14 (0,1893)^2 \cdot 30 & \rho_d &= \frac{16,0549}{3,3738} \\ &= 3,3738 & &= 4,75866 \end{aligned}$$

$$\begin{aligned} \text{Perc.3 } V &= 3,14 (0,1891)^2 \cdot 30 & \rho_d &= \frac{16,0220}{3,36837} \\ &= 3,36937 & &= 4,75519 \end{aligned}$$

Perc.4	$V = 3,14 (0,1891)^2 \cdot 30$	$\rho_d = \frac{16,3822}{3,3694}$
	$= 3,3694$	$= 4,8621$
Perc.5	$V = 3,14 (0,18925)^2 \cdot 30$	$\rho_d = \frac{16,0966}{3,3738}$
	$= 3,3738$	$= 4,7710$
Perc.6	$V = 3,14 (0,18925)^2 \cdot 30$	$\rho_d = \frac{16,1321}{3,3738}$
	$= 3,3738$	$= 4,7710$
Perc.7	$V = 3,14 (0,18888)^2 \cdot 30$	$\rho_d = \frac{16,1178}{3,3605}$
	$= 3,3605$	$= 4,7378$

## 2. Berat yang hilang ( $\Delta m$ )

$$\Delta m = L^2 \rho_r \rho_d (1/R_i - 1/R_f)$$

Dan berat yang hilang dihitung dengan penimbangan adalah

$$\Delta m = m_{\text{awal}} - m_{\text{akhir}}$$

Perc.1.  $\Delta m = 900 \times 1,43 \cdot 10^{-3} \times 4,74152 (3,3936 - 3,3636)$   
 $= 0,1831 \text{ gr}$

dengan penimbangan,

$$\Delta m = 15,4460 - 15,7739 = 0,1721 \text{ gr}$$

Perc 2.  $\Delta m = 900 \times 1,43 \cdot 10^{-3} \times 4,75866 (3,4965 - 3,3411)$   
 $= 0,9517 \text{ gr}$

dengan penimbangan

$$\Delta m = 10,0549 - 15,0568 = 0,9981 \text{ gr}$$

Perc 3.  $\Delta m = 900 \times 1,43 \cdot 10^{-3} \times 4,75519 \cdot (3,3557 - 2,2422)$   
 $= 6,8146 \text{ gr}$

dengan penimbangan

$$\Delta m = 16,022 - 8,9522 = 7,0698 \text{ gr}$$

$$\begin{aligned} \text{Perc 4. } \Delta m &= 900 \times 1,4310^{-3} \times 4,8621 \times (3,4247 - 3,3704) \\ &= 0,3396 \text{ gr} \end{aligned}$$

dengan penimbangan

$$\begin{aligned} \Delta m &= 16,3833 - 16,0848 \\ &= 0,2985 \text{ gr} \end{aligned}$$

$$\begin{aligned} \text{Perc 5. } \Delta m &= 900 \times 1,43 \times 10^{-3} \times 4,7710 \times (3,3704 - 3,3036) \\ &= 0,4102 \text{ gr} \end{aligned}$$

$$\begin{aligned} \Delta m &= 16,0966 - 15,6396 \\ &= 0,457 \text{ gr} \end{aligned}$$

$$\begin{aligned} \text{Perc 6. } \Delta m &= 900 \times 1,43 \times 10^{-3} \times 4,7710 \times (3,2971 - 7,5465) \\ \Delta m &= 4,6089 \text{ gr} \end{aligned}$$

Dengan penimbangan

$$\begin{aligned} \Delta m &= 16,1321 - 11,1337 \\ &= 4,7378 \text{ gr} \end{aligned}$$

$$\begin{aligned} \text{Perc 7. } \Delta m &= 900 \times 1,43 \times 10^{-3} \times 4,7378 \times (3,3864 - 1,0101) \\ &= 14,4896 \text{ gr} \end{aligned}$$

Dengan penimbangan

$$\begin{aligned} \Delta m &= 16,1178 - 1,9188 \\ &= 14,199 \text{ gr} \end{aligned}$$

#### IV.2 Penentuan laju korosi

Laju korosi dapat ditentukan dengan dua cara, yaitu penentuan laju secara teoritik dengan menggunakan persamaan (30) dan penentuan laju korosi dari grafik 2.

1. Perhitungan menurut grafik.

Penjabaran persamaan (30) menghasilkan

$$R^{-1/2} = R_{aw}^{-1/2} - \frac{\frac{\Delta m}{A t}}{\rho_d (\rho_r L/\pi)^{1/2}} t$$

Plot  $R^{-1/2}$  versus  $t$  menghasilkan slope sebesar

$$\text{Slope} = - \frac{\frac{\Delta m}{A t}}{\rho_d (\rho_r L/\pi)^{1/2}}$$

sehingga laju korosi  $(\Delta m/at) = - \text{slope} \times \rho_d (\rho_r L/\pi)^{1/2}$

Dengan rumus regresi linier,

$$b = \frac{n \sum x_i y_i - (\sum x_i) (\sum y_i)}{n \sum x_i^2 - (\sum x_i)^2}$$

didapat slope dan laju korosi masing-masing percobaan seperti pada tabel 4.3.

Perc. 1. Slope =  $-3,3692 \times 10^{-5}$

Laju korosi =  $1,8673 \times 10^{-5}$

Perc. 2. slope =  $-1,6784 \times 10^{-4}$

Laju korosi =  $9,3361 \times 10^{-5} \text{ gr/cm}^2 \text{ min}$

Perc. 3. Slope =  $-1,3201 \times 10^{-3}$

Laju korosi =  $7,338 \times 10^{-3}$

Perc. 4. Slope =  $-6,9232 \times 10^{-5}$

Laju korosi =  $3,9346 \times 10^{-5}$

Perc. 5. Slope =  $-7,5016 \times 10^{-5}$

$$\text{Laju korosi} = 4,1835 \times 10^{-5}$$

$$\text{Perc. 6. Slope} = -9,7803 \times 10^{-4}$$

$$\text{Laju korosi} = 5,4664 \times 10^{-4}$$

$$\text{Perc.7. Slope} = 4,1696 \times 10^{-3}$$

$$\text{Laju korosi} = 2,3091 \times 10^{-3}$$

2. Perhitungan teoritik dengan menggunakan rumus

$$\frac{\Delta m}{A t} = \left[ \frac{\rho_d}{t} \right] \left[ \frac{\rho_{rL}}{\pi} \right]^{1/2} \left[ \left( \frac{1}{R_i} \right)^{1/2} - \left( \frac{1}{R_f} \right)^{1/2} \right]$$

Dari tabel 4.2 dan lampiran 2.1 didapat harga  $\rho_d$ ,  $(1/R_{aw})^{-1/2}$ ,  $(1/R_{ak})^{-1/2}$  untuk masing-masing percobaan sebagai berikut :

$$\begin{aligned} \text{Perc. 1. } \rho_d &= 4,741517 \\ (1/R_{aw})^{-1/2} &= 1,8421 \\ (1/R_{ak})^{-1/2} &= 1,8339 \end{aligned}$$

Maka laju korosi adalah

$$\begin{aligned} \frac{\Delta m}{A t} &= \left[ \frac{4,741517}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8421 - 1,8339) \\ &= 0,01976 \times 0,11689 \times 7,6 \times 10^{-3} \\ &= 1,894 \times 10^{-5} \text{ gr cm}^{-2} \text{ min}^{-1} \end{aligned}$$

Penyimpangan jika dibandingkan dengan laju dair grafik

$$|s| = \frac{(\text{hasil pengamatan} - \text{hasil teoritik})}{\text{hasil pengamatan}} \times 100\%$$

$$\begin{aligned} |s| &= \frac{(1,8673 \cdot 10^{-5} - 1,894 \cdot 10^{-5})}{1,8673 \cdot 10^{-5}} \times 100\% \\ &= 1,43 \% \end{aligned}$$

$$\begin{aligned} \text{Perc. 2. } \rho_d &= 4,75866 \\ (1/R_{aw})^{-1/2} &= 1,8699 \end{aligned}$$



$$(1/R_{ak})^{-1/2} = 1,8278$$

$$\frac{\Delta m}{A t} = \left[ \frac{4,75866}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8699 - 1,8278)$$

$$|s| = \frac{(9,3361 \cdot 10^{-5} - 9,7585 \cdot 10^{-5})}{9,3361 \cdot 10^{-5}} \times 100\% \\ = 4,52 \%$$

Perc. 3.  $\rho_d = 4,75519$   
 $(1/R_{aw})^{-1/2} = 1,8319$   
 $(1/R_{ak})^{-1/2} = 1,4974$

Maka laju korosi adalah

$$\frac{\Delta m}{A t} = \left[ \frac{4,75519}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8319 - 1,4974)$$

$$= 7,7469 \cdot 10^{-4} \text{ gr cm}^{-2} \text{ min}^{-1}$$

$$|s| = \frac{(7,338 \cdot 10^{-5} - 7,7469 \cdot 10^{-5})}{7,338 \cdot 10^{-5}} \times 100\% \\ = 5,572 \%$$

Perc. 4.  $\rho_d = 4,8621$   
 $(1/R_{aw})^{-1/2} = 1,8506$   
 $(1/R_{ak})^{-1/2} = 1,8360$

$$\frac{\Delta m}{A t} = \left[ \frac{4,8621}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8506 - 1,8360)$$

$$= 3,4573 \times 10^{-5} \text{ gr cm}^{-2} \text{ min}^{-1}$$

$$|s| = \frac{(3,9346 \cdot 10^{-5} - 3,4573 \cdot 10^{-5})}{3,9346 \cdot 10^{-5}} \times 100\% \\ = 12,1 \%$$

Perc. 5.  $\rho_d = 4,7710$   
 $(1/R_{aw})^{-1/2} = 1,8360$   
 $(1/R_{ak})^{-1/2} = 1,8177$

Maka laju korosi adalah

$$\begin{aligned} \frac{\Delta m}{A t} &= \left[ \frac{4,7710}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8360-1,8177) \\ &= 4,2523 \times 10^{-5} \\ |s| &= \frac{(4,1835 \cdot 10^{-5} - 4,2523 \cdot 10^{-5})}{4,1835 \cdot 10^{-5}} \times 100\% \\ &= 1,645 \% \end{aligned}$$

Perc. 6.  $\rho_d = 4,771$   
 $(1/R_{aw})^{-1/2} = 1,8157$   
 $(1/R_{ak})^{-1/2} = 1,5958$

$$\begin{aligned} \frac{\Delta m}{A t} &= \left[ \frac{4,7710}{240} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8157-1,5958) \\ &= 5,1098 \times 10^{-4} \text{ gr cm}^{-2} \text{ min}^{-1} \\ |s| &= \frac{(5,4664 \cdot 10^{-4} - 5,1098 \cdot 10^{-4})}{5,4664 \cdot 10^{-4}} \times 100\% \\ &= 6,52 \% \end{aligned}$$

Perc. 7.  $\rho_d = 4,7378$   
 $(1/R_{aw})^{-1/2} = 1,8401$   
 $(1/R_{ak})^{-1/2} = 1,005$

Maka laju korosi adalah

$$\begin{aligned} \frac{\Delta m}{A t} &= \left[ \frac{4,7378}{195} \right] \left[ \frac{1,43 \cdot 10^{-3} \cdot 30}{3,14} \right]^{1/2} (1,8401-1,005) \\ &= 2,3717 \times 10^{-3} \text{ gr cm}^{-2} \text{ min}^{-1} \\ |s| &= \frac{(2,3091 \cdot 10^{-3} - 2,3717 \cdot 10^{-3})}{2,3091 \cdot 10^{-3}} \times 100\% \\ &= 2,639 \% \end{aligned}$$