

LAMPIRAN A
CONTOH PERHITUNGAN

Lampiran A. Contoh Perhitungan

A.1 Perhitungan Koefisien Difusi

Koefisien difusi adalah ukuran yang menggambarkan kemampuan suatu zat untuk berdifusi atau menyebar dalam medium lainnya. Dalam konteks ilmiah dan teknis, koefisien difusi mengacu pada laju perpindahan zat dari daerah konsentrasi tinggi ke daerah konsentrasi rendah melalui difusi. Dalam perhitungan ini didapatkan mengenai nilai koefisien difusi *carbon* pada baja yang dipengaruhi oleh jumlah dan komposisi dari *carburizer* dan *energizer*

Digunakan Hukum 2 Fick;s sebagaimana persamaan di bawah ini:

$$\frac{Cx - Co}{Cs - Co} = 1 - \operatorname{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

Didapatkan hasil dari perhitungan koefisien difusi berdasarkan kalkulasi menggunakan Hk. II Fick's sebagaimana persamaan di atas dengan nilai

$$Q = 148 \text{ kJ/mol}$$

$$T = 1223 \text{ K (950 } ^\circ\text{C)}$$

$$C_o = 0,261\%$$

Dikarenakan persamaan dengan variabel yang ditanyakan sudah diketahui, maka dilakukan invers perhitungan dengan mencari nilai D sehingga diperoleh persamaan sebagaimana di bawah ini:

$$D = \frac{\left(\frac{x}{2 * \sqrt{t}}\right)^2}{-2 \log\left(\frac{Cx - Co}{Cs - Co}\right) - 1}$$

Diperoleh variabel sebagai berikut :

Tabel 4. 4 Hasil Kalkulasi Koefisien Difusi

Komposisi	t (jam)	X (cm)	Cs (%)	C _x (%)	D (x 10 ⁻¹⁰ cm ² /s)
60-40	1	0,0119	10%	5,38%	0,057
	2	0,0091	7,80%	6,23%	0,040
	3	0,0092	14,94%	8,84%	0,027
70-30	1	0,0081	25,10%	7,67%	0,163
	2	0,0137	9,34%	8,28%	0,066
	3	0,0058	48,70%	28,04%	0,061
80-20	1	0,0083	7,88%	2,85%	1,573
	2	0,0060	35,92%	9,45%	0,411
	3	0,0057	13,83%	6,23%	0,367

Contoh perhitungan laju difusi pada sampel 1 Jam 60-40

Diketahui : Q = 148 kJ/mol (Callister, 2007)
t = 3600; 7200; dan 10800 s
C₀ = 0,261%

Sehingga untuk 1-60A40E sebagai berikut :

$$D = \frac{\left(\frac{x}{2 * \sqrt{t}}\right)^2}{-2 \log\left(\frac{C_x - C_0}{C_s - C_0}\right) - 1}$$

$$D = \frac{\left(\frac{0,0119}{2 * \sqrt{3600}}\right)^2}{-2 \log\left(\frac{5,38\% - 0,261\%}{10\% - 0,261\%}\right) - 1}$$

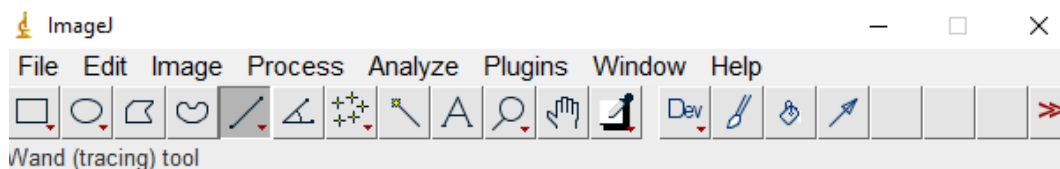
$$D = 0,057 \times 10^{-10} \frac{cm^2}{s}$$

A.2 Perhitungan *Case Depth*

Case depth, juga dikenal sebagai *depth of hardening*, merujuk pada ketebalan lapisan permukaan yang mengalami proses pengerasan pada logam. Proses pengerasan permukaan seperti pengerasan pada permukaan baja dilakukan untuk meningkatkan kekerasan, ketahanan aus, dan ketahanan terhadap keausan. Cara menghitung *case depth* melibatkan software ImageJ dan gambar *cross section* hasil OEM.

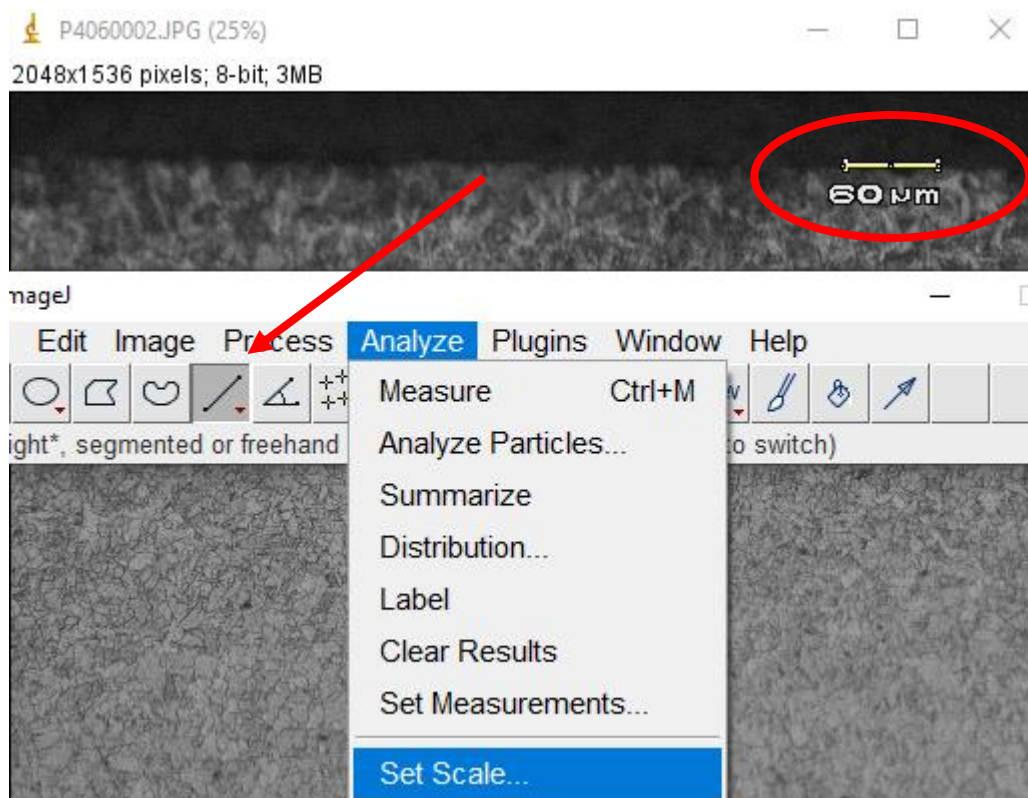
Langkah-langkah perhitungan

1. Buka aplikasi ImageJ, dan *drag* gambar OM yang ingin diuji perihal *case depth*

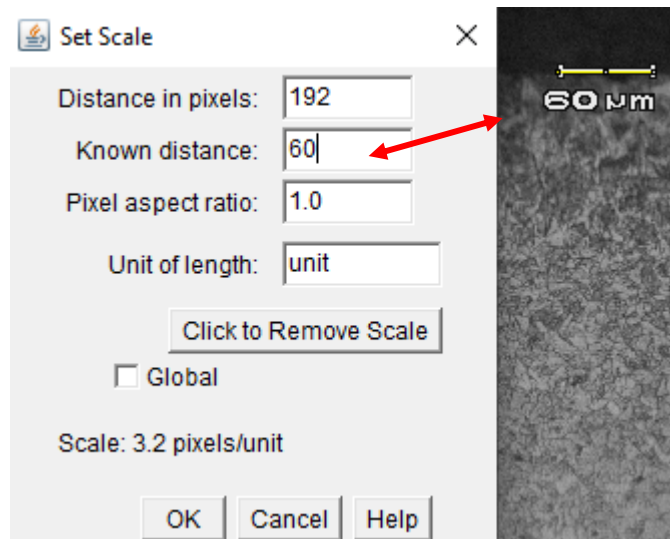


2. Klik *line tool* dan buat garis pada skala yang terdapat pada gambar.

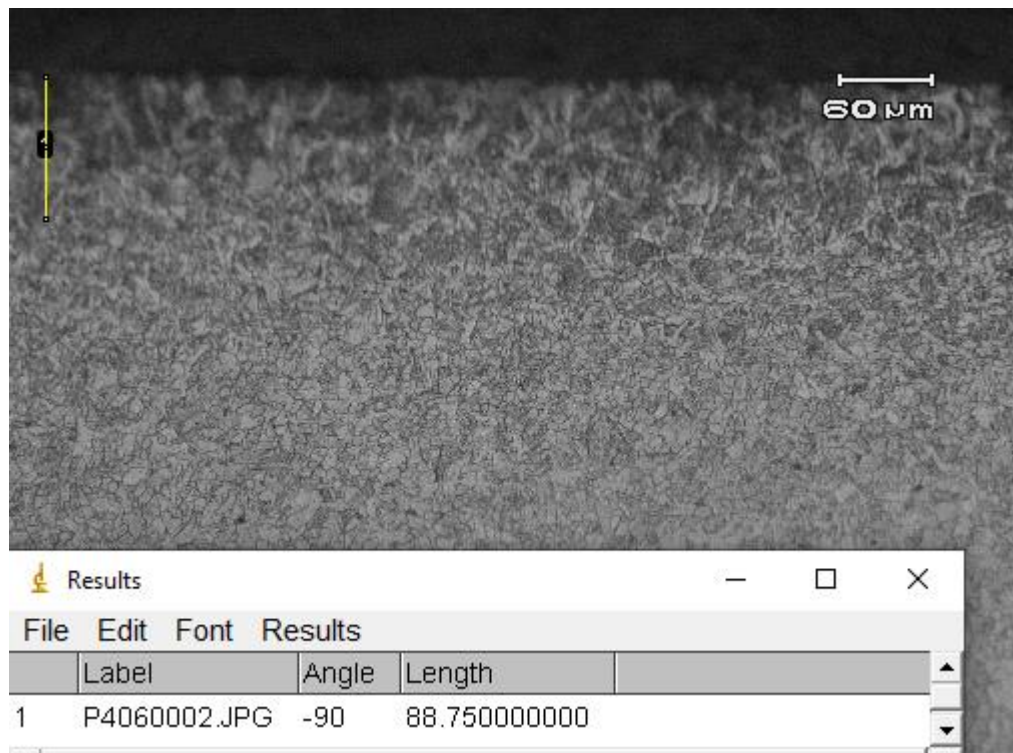
Selanjutnya *Analyze > Set Scale*



3. Selanjutnya isi nilai *Known Distance* sesuai dengan skala, dan klik Ok



4. Buat Garis dan klik “m” untuk mengukur jarak, lakukan ini hingga beberapa garis dan didapat nilai *length* yang dapat dirata-ratakan.



A.3 Perhitungan Nilai Kekerasan

$$\text{Kekerasan (HV)} = \frac{\text{Indentasi 1} + \text{Indentasi 2} + \text{Indentasi 3}}{\text{Total Indentasi}}$$

a. 1 Jam Waktu Tahan

- 60A40E

$$\text{Kekerasan (HV)} = \frac{213,8 + 267,1 + 241,9}{3} = 240,93 \text{ HV}$$

- 70A30E

$$\text{Kekerasan (HV)} = \frac{268,1 + 260,6 + 202,5}{3} = 243,73 \text{ HV}$$

- 80A20E

$$\text{Kekerasan (HV)} = \frac{401,8 + 197,5 + 204,4}{3} = 267,9 \text{ HV}$$

b. 2 Jam Waktu Tahan

- 60A40E

$$\text{Kekerasan (HV)} = \frac{450,5 + 395 + 293}{3} = 379,5 \text{ HV}$$

- 70A30E

$$\text{Kekerasan (HV)} = \frac{412,9 + 354,9 + 437,6}{3} = 401,8 \text{ HV}$$

- 80A20E

$$\text{Kekerasan (HV)} = \frac{412,9 + 354,9 + 438,9}{3} = 406,3 \text{ HV}$$

c. 3 Jam Waktu Tahan

- 60A40E

$$\text{Kekerasan (HV)} = \frac{646,3 + 539,4 + 672}{3} = 619,23 \text{ HV}$$

- 70A30E

$$\text{Kekerasan (HV)} = \frac{674,7 + 642,8 + 671,5}{3} = 663 \text{ HV}$$

- 80A20E

$$\text{Kekerasan (HV)} = \frac{742,6 + 712,2 + 880,3}{3} = 778,36 \text{ HV}$$

A.4 Perhitungan Volume

Diketahui :

$$P \times L \times T : 14 \times 14 \times 5 = 980 \text{ cm}^3$$

$$\text{Densitas Arang} = 0,716 \text{ g/cm}^3$$

$$\text{Densitas BaCO}_3 = 4,29 \text{ g/cm}^3$$

a. Arang : BaCO₃ = 60% : 40%

$$\text{Arang} = 60\% \times 980 \times 0,716 = 432,008 \text{ g}$$

$$\text{BaCO}_3 = 40\% \times 980 \times 4,29 = 1681,68 \text{ g}$$

$$\text{Total} = 2113,68 \text{ g atau } 2,1 \text{ Kg}$$

b. Arang : BaCO₃ = 70% : 30%

$$\text{Arang} = 70\% \times 980 \times 0,716 = 491,178 \text{ g}$$

$$\text{BaCO}_3 = 30\% \times 980 \times 4,29 = 1261,26 \text{ g}$$

$$\text{Total} = 1752,43 \text{ g atau } 1,8 \text{ Kg}$$

c. Arang : BaCO₃ = 80% : 20%

$$\text{Arang} = 80\% \times 980 \times 0,716 = 561,348 \text{ g}$$

$$\text{BaCO}_3 = 20\% \times 980 \times 4,29 = 840,84 \text{ g}$$

$$\text{Total} = 1402 \text{ g atau } 1,4 \text{ Kg}$$

LAMPIRAN B
DATA PENELITIAN

Hasil Pengujian Uji Keras

Micro/Vickers Hardness (HV) Test Results

Submitter				Date Submitted									
Part Name		1		Part #		1							
# of Samples				Sample Descri.									
Qual. UL		650.0		Qual. LL		450.0							
Sample Cyl./Sph. Diam (mm)		0.0		Test Load		1kg							
Test Results													
#	Depth	Y	D1	D2	Hard.	Conver.	#	Depth	Y	D1	D2	Hard.	Conver.
	mm	mm	µm	µm	HV	HRB;HRC ;HBS;HR A		mm	mm	µm	µm	HV	HRB;HRC ;HBS;HR A
1			93.4	92.8	231.8	96.5; ;208.8 ;	6			73.2	75.0	202.5	;35. 8;329.6 ;68.3
2			83.5	83.2	267.1	;27. 2;264.1 ;63.9	7			74.4	79.6	401.8	;33. 0;305.9 ;66.9
3			85.0	90.1	241.9	;23. 2;240.6 ;61.8	8			84.7	82.0	197.5	;27. 2;264.1 ;63.9
4			78.0	75.9	268.1	;33. 0;305.9 ;66.9	9			72.0	75.9	204.4	;35. 9;330.9 ;68.4
5			85.6	85.0	260.6	;25. 3;252.9 ;62.9							
Case Hardness (HV)								Case Depth (mm)					

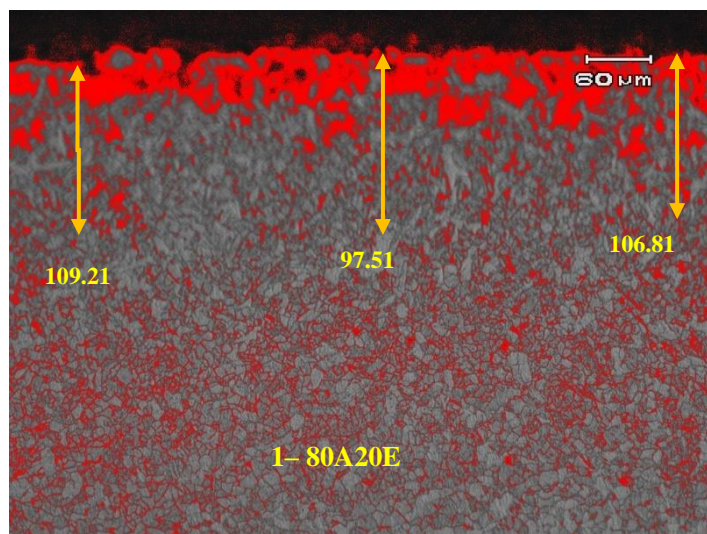
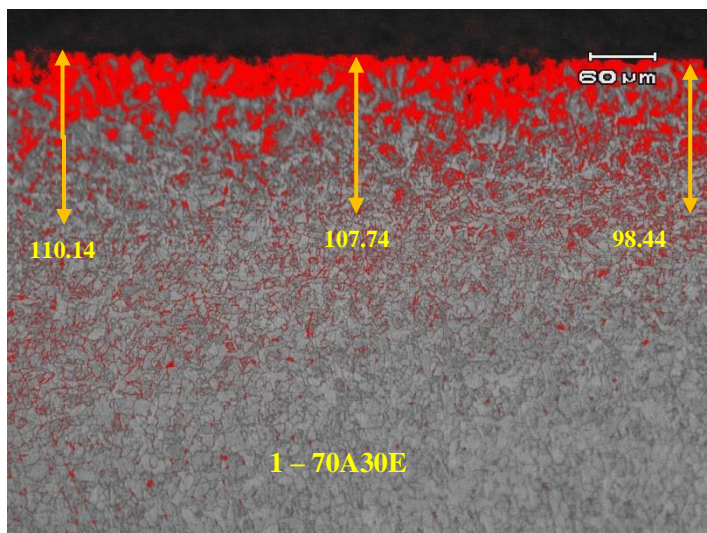
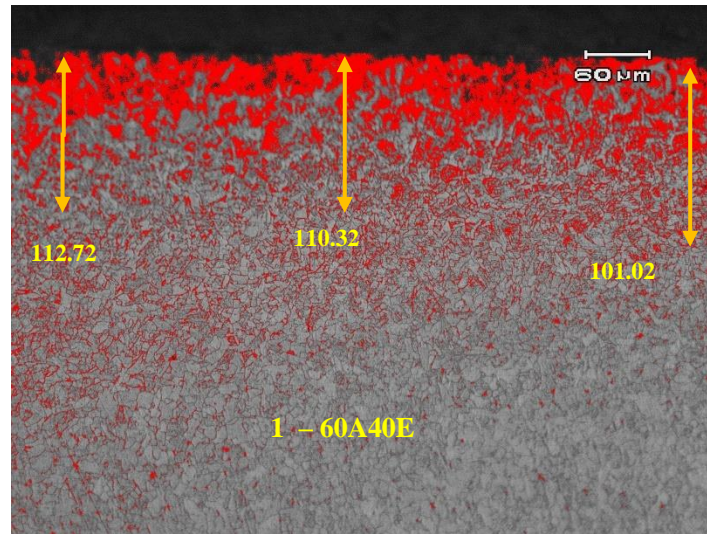
Micro/Vickers Hardness (HV) Test Results

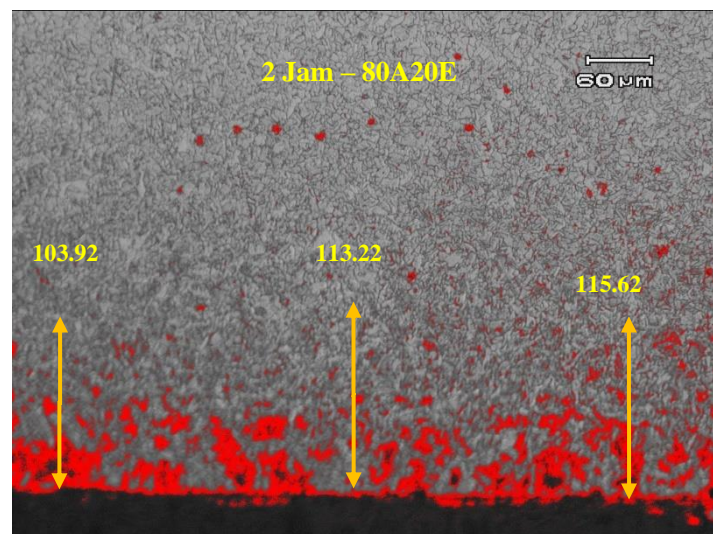
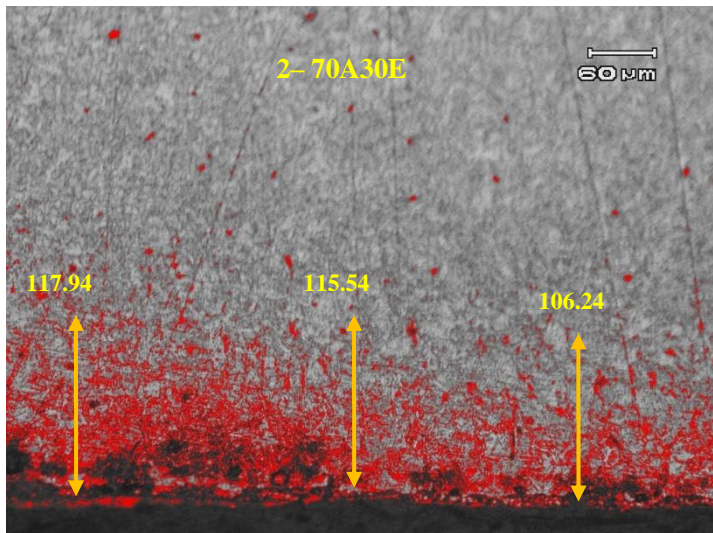
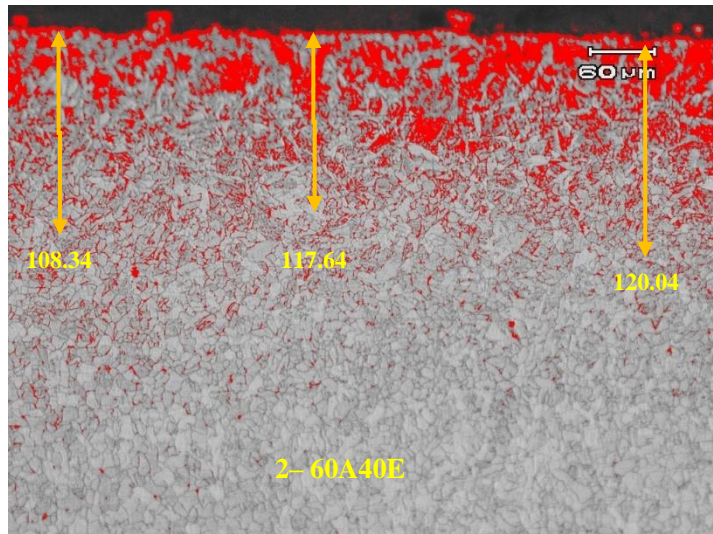
Submitter								Date Submitted							
Part Name				1				Part #				1			
# of Samples								Sample Descri.							
Qual. UL				650.0				Qual. LL				450.0			
Sample Cyl./Sph. Diam (mm)				0.0				Test Load				1kg			
Test Results															
#	Depth	Y	D1	D2	Hard.	Conver.	#	Depth	Y	D1	D2	Hard.	Conver.		
	mm	mm	μm	μm	HV	HRB;HRC ;HBS;HR A		mm	mm	μm	μm	HV	HRB;HRC ;HBS;HR A		
1			86.5	85.6	450.5	:24. 6;248.5 ;62.5	6			92.2	99.2	497.6	94.4; ;196.5 ;		
2			100.4	94.6	395	92.8; ;188.0 ;	7			65.1	70.8	412.9	;41. 8;388.8 ;71.5		
3			79.3	79.9	293.0	:30. 6;288.0 ;65.6	8			97.7	96.2	367	93.3; ;190.5 ;		
4			83.2	83.2	412.9	:27. 4;265.1 ;63.9	9			94.6	95.9	438.9	94.7; ;198.4 ;		
5			97.4	107.0	354.9	88.9; ;171.6 ;									
Case Hardness (HV)								Case Depth (mm)							

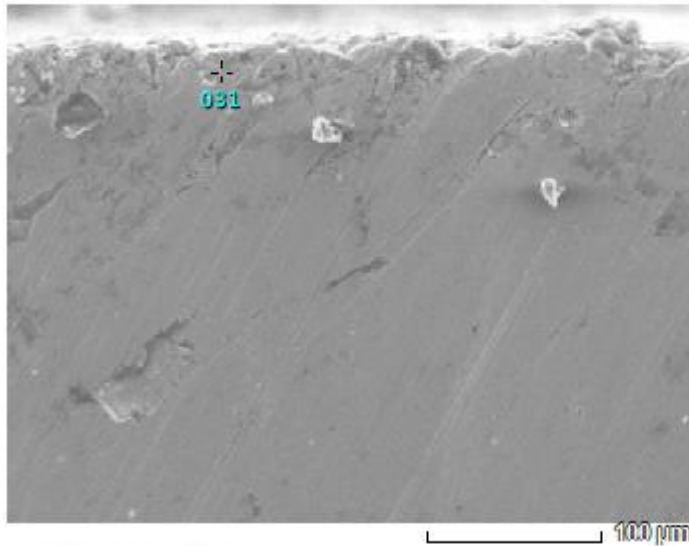
Micro/Vickers Hardness (HV) Test Results

Submitter				Date Submitted									
Part Name		1		Part #		1							
# of Samples				Sample Descri.									
Qual. UL		650.0		Qual. LL		450.0							
Sample Cyl./Sph. Diam (mm)		0.0		Test Load		1kg							
Test Results													
#	Depth	Y	D1	D2	Hard.	Conver.	#	Depth	Y	D1	D2	Hard.	Conver.
	mm	mm	µm	µm	HV	HRB:HRC ;HBS;HR A		mm	mm	µm	µm	HV	HRB:HRC ;HBS;HR A
1			60.8	68.1	646.3	:45. 4;428.5 ;73.4	6			69.3	72.0	671.5	:39. 0;360.5 ;70.0
2			87.1	88.9	539.4	:22. 7;238.4 ;61.6	7			49.1	50.9	742.6	:61. 9; ;8 2.2
3			82.9	82.3	672	:27. 9;268.3 ;64.2	8			49.1	53.0	712.2	:60. 6; ;8 1.5
4			71.7	69.0	674.7	:39. 4;363.7 ;70.2	9			44.5	47.3	880.3	:67. 0; ;8 5.0
5			85.3	89.5	642.8	:23. 3;241.2 ;61.9							
Case Hardness (HV)						Case Depth (mm)							

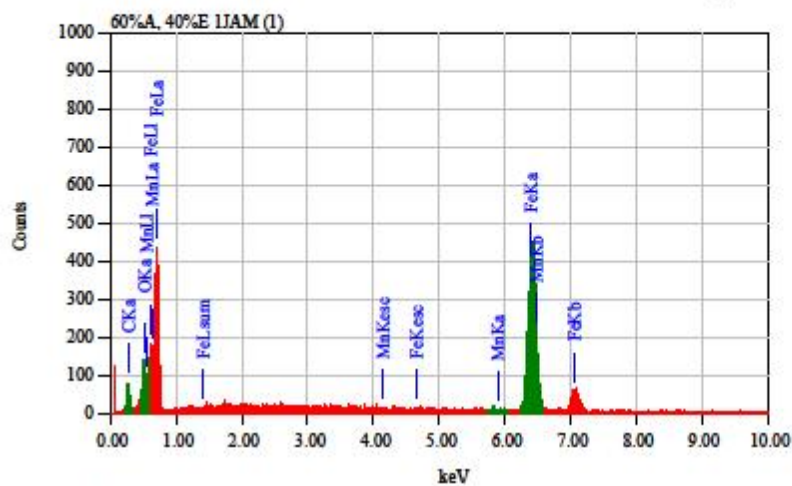
A. Hasil Analisa Case Depth







Title	: IMG1
Instrument	: JCM-6000PLUS
Volt	: 15.00 kV
Mag.	: x 300
Date	: 2023/03/24
Pixel	: 512 x 384

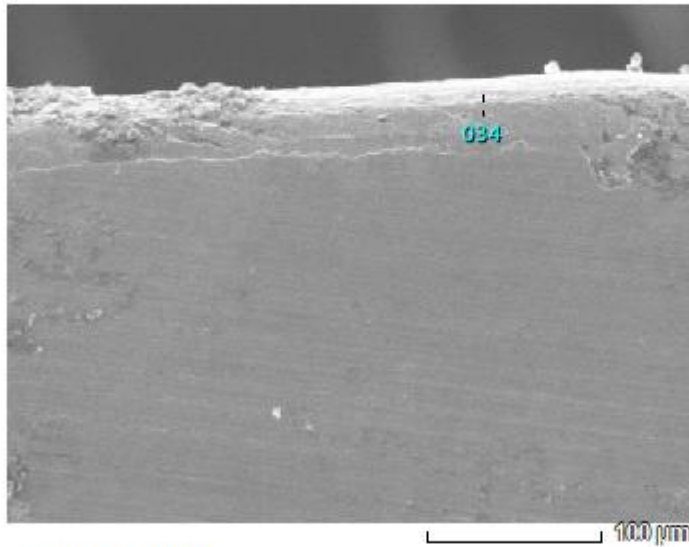


Acquisition Parameter	
Instrument	: JCM-6000PLUS
Acc. Voltage	: 15.0 kV
Probe Current	: 1.00000 nA
PHA mode	: T3
Real Time	: 30.43 sec
Live Time	: 30.00 sec
Dead Time	: 1 %
Counting Rate	: 1084 cps
Energy Range	: 0 - 20 keV

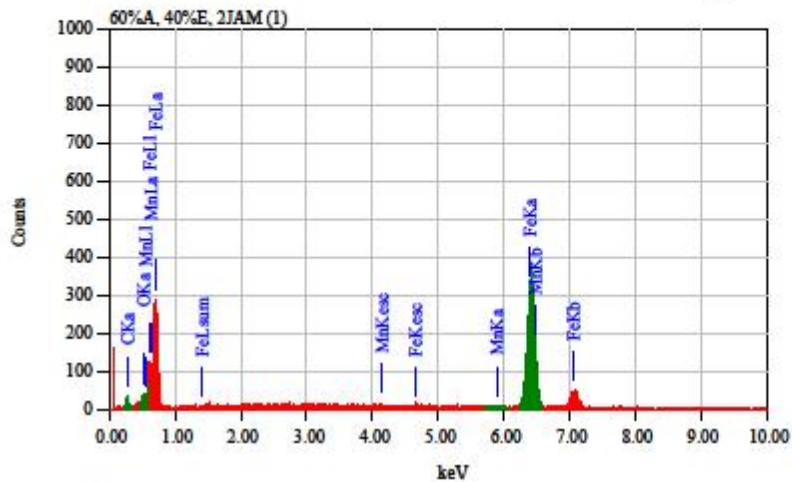
EAF Method Standardless Quantitative Analysis

Fitting Coefficient : 0.2190

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K	0.277	10.06	0.29	30.62				3.5662
O K	0.525	6.43	0.28	14.69				8.8503
Mn Kα	5.894	0.23	0.15	0.15				0.2351
Fe K	6.398	83.29	1.48	54.54				87.3484
Total		100.00		100.00				



Title : IMG1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 300
 Date : 2023/03/24
 Pixel : 512 x 384

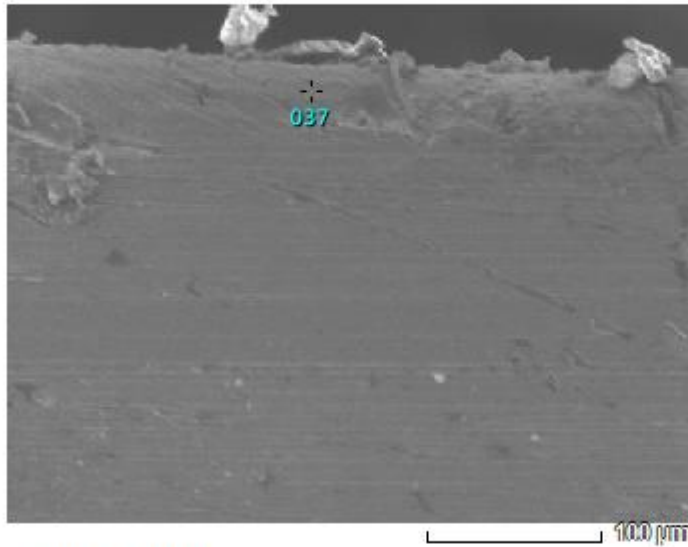


Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.43 sec
 Live Time : 30.00 sec
 Dead Time : 1 %
 Counting Rate : 900 cps
 Energy Range : 0 - 20 keV

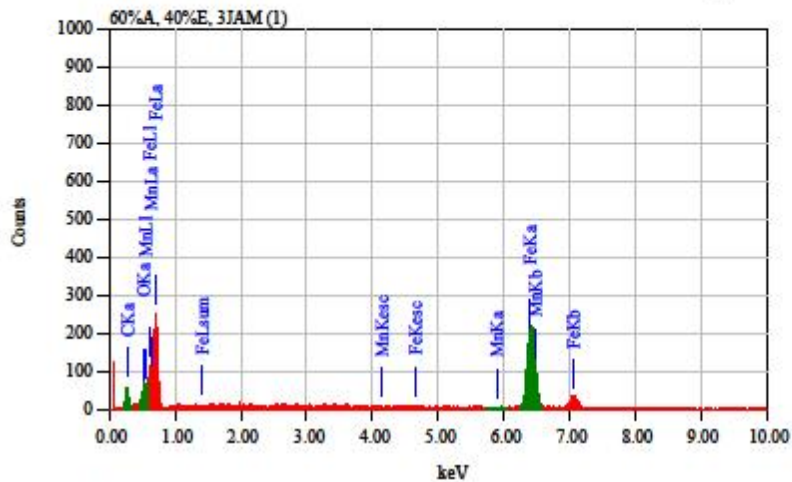
ZAF Method Standardless Quantitative Analysis

Fitting Coefficient : 0.2428

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K*	0.277	6.15	0.28	22.83				2.1148
O K*	0.525	1.14	0.16	3.18				1.6606
Mn K*	5.894	0.32	0.20	0.26				0.3298
Fe K	6.398	92.38	1.86	73.73				95.8948
Total		100.00		100.00				



Title : IMG1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 300
 Date : 2023/03/24
 Pixel : 512 x 384

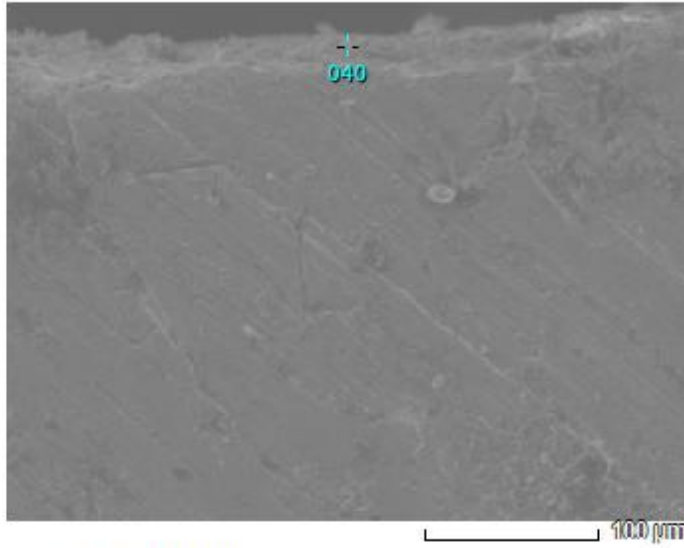


Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.36 sec
 Live Time : 30.00 sec
 Dead Time : 1 %
 Counting Rate : 776 cps
 Energy Range : 0 - 20 keV

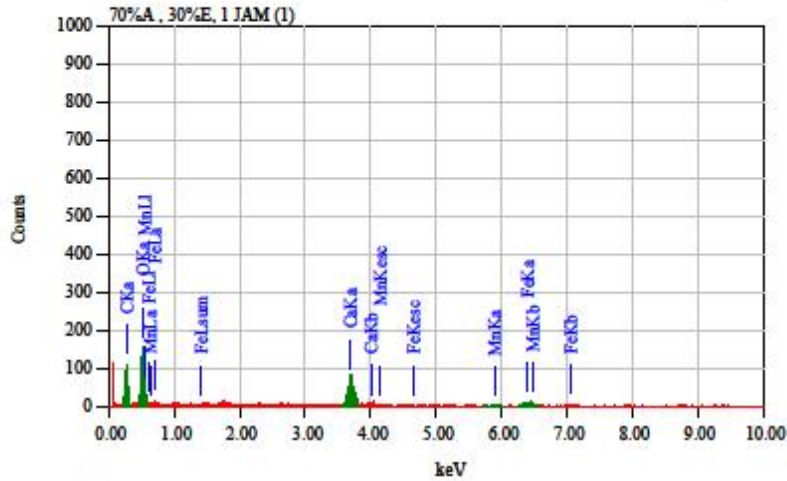
ZAF Method Standardless Quantitative Analysis

Fitting Coefficient : 0.2925

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C	0.277	14.94	0.50	41.58				5.6364
O	0.525	5.04	0.38	10.53				6.5773
Mn	5.894	0.08	0.19	0.05				0.0860
Fe	6.398	79.94	2.05	47.85				87.7003
Total		100.00		100.00				



Title : IMC1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 300
 Date : 2023/03/24
 Pixel : 512 x 384

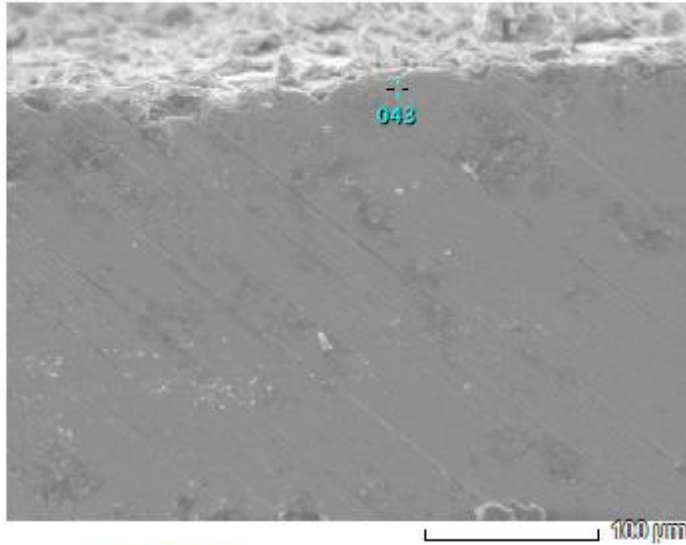


Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.26 sec
 Live Time : 30.00 sec
 Dead Time : 0 %
 Counting Rate : 526 cps
 Energy Range : 0 - 20 keV

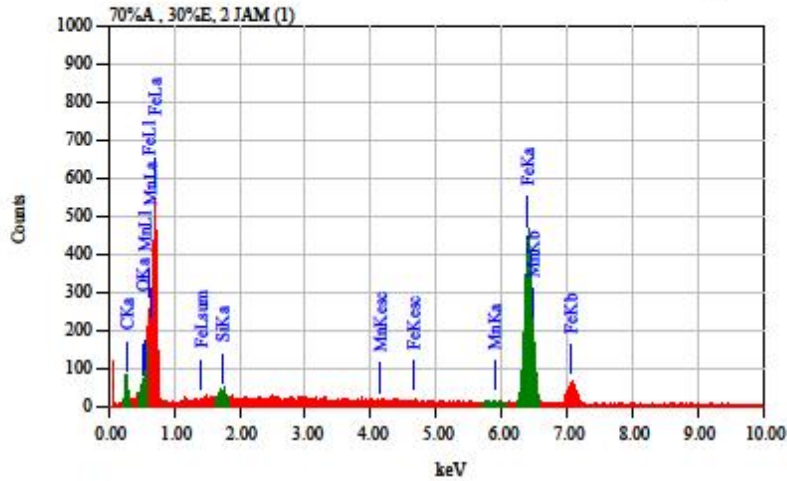
ZAF Method Standardless Quantitative Analysis

Fitting Coefficient : 0.3653

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K	0.277	25.10	0.63	34.90				19.4207
O K	0.525	55.41	1.86	57.85				51.9751
Ca K*	3.690	11.96	0.61	4.99				19.1385
Mn K*	5.894	0.46	0.24	0.14				0.5750
Fe K	6.398	7.07	0.81	2.11				8.8907
Total		100.00		100.00				



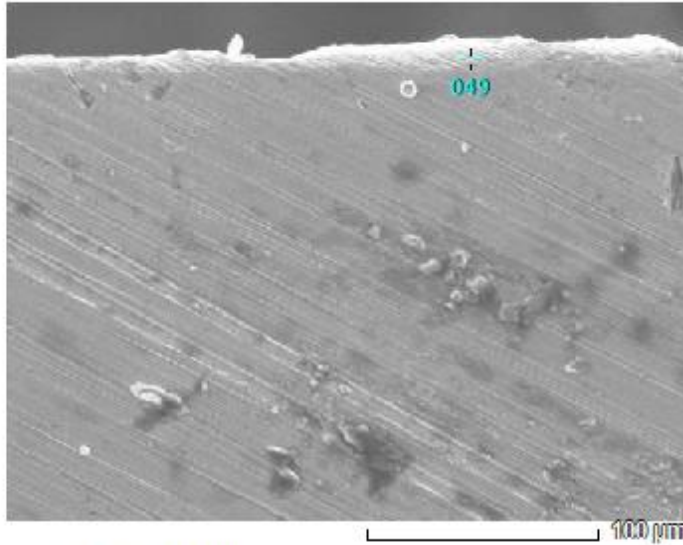
Title : IMC1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 300
 Date : 2023/03/24
 Pixel : 512 x 384



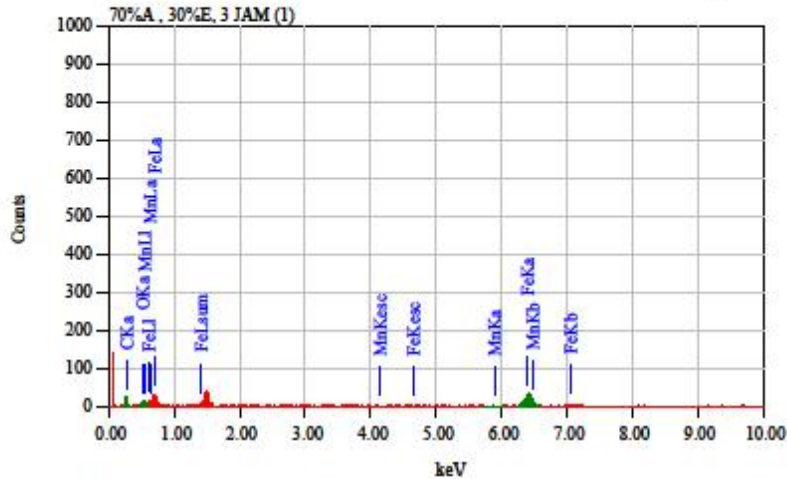
Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.43 sec
 Live Time : 30.00 sec
 Dead Time : 1 %
 Counting Rate : 1166 cps
 Energy Range : 0 - 20 keV

ZAF Method Standardless Quantitative Analysis
 Fitting Coefficient : 0.2154

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K	0.277	9.34	0.30	31.73				3.2584
O K*	0.525	0.83	0.15	2.11				1.1531
Si K	1.739	0.77	0.11	1.12				0.5568
Mn K*	5.894	0.30	0.17	0.22				0.3160
Fe K	6.398	88.76	1.57	64.82				94.7157
Total		100.00		100.00				



Title : IMC1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 400
 Date : 2023/03/24
 Pixel : 512 x 384



Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.24 sec
 Live Time : 30.00 sec
 Dead Time : 0 %
 Counting Rate : 453 cps
 Energy Range : 0 - 20 keV

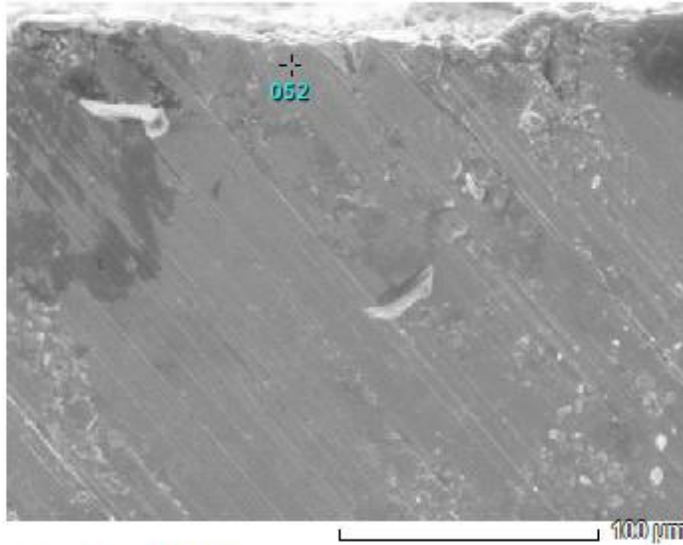
ZAF Method Standardless Quantitative Analysis

Fitting Coefficient : 0.6625

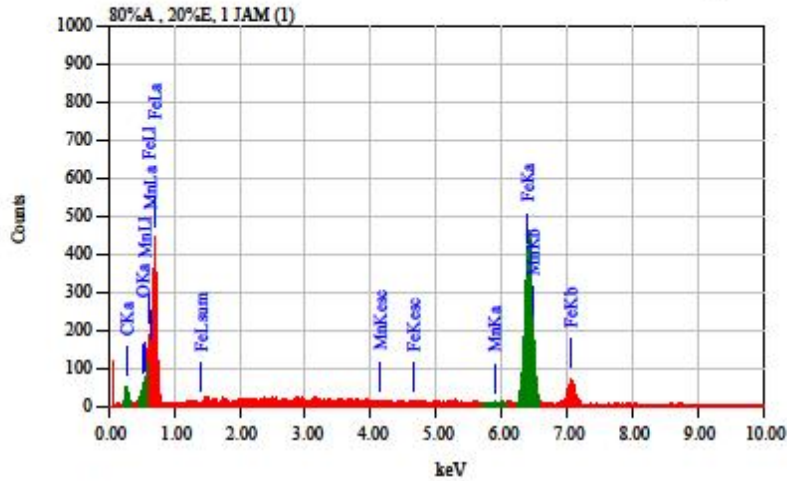
Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K*	0.277	28.04	1.55	58.63				12.9718
O K*	0.525	8.02	1.23	12.59				9.1566
Mn K*	5.894	1.25	0.68	0.57				1.4938
Fe K	6.398	62.70	4.35	28.20				76.3778
Total		100.00		100.00				

View024

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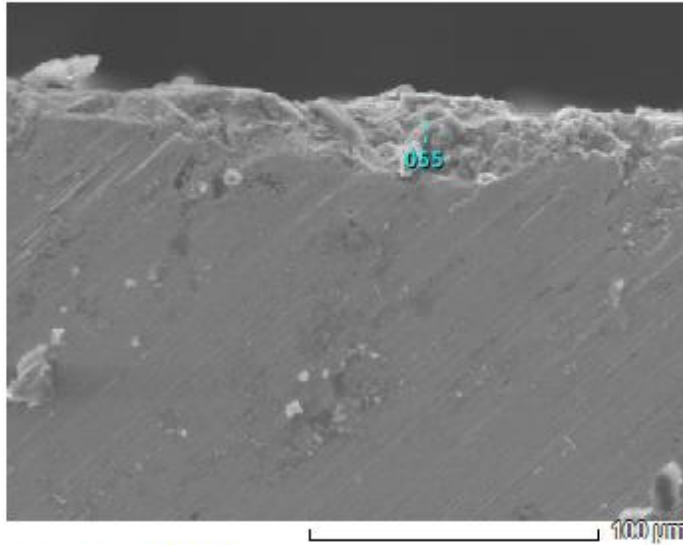
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 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 450
 Date : 2023/03/24
 Pixel : 512 x 384



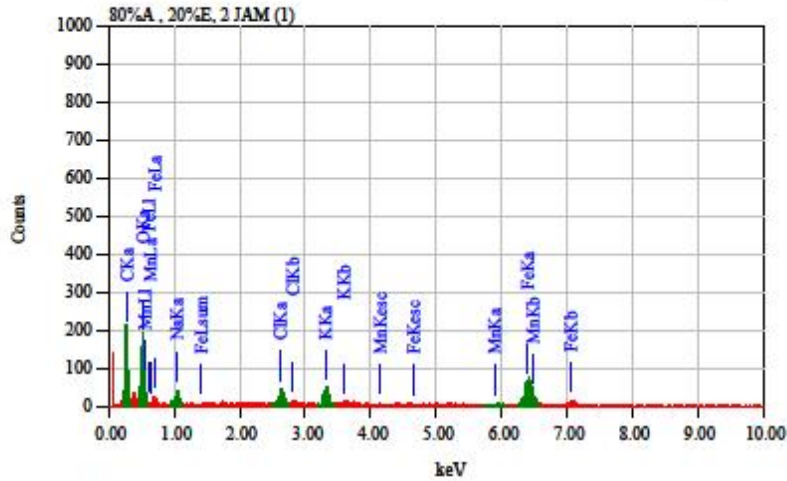
Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.46 sec
 Live Time : 30.00 sec
 Dead Time : 1 %
 Counting Rate : 1098 cps
 Energy Range : 0 - 20 keV

ZAF Method Standardless Quantitative Analysis
 Fitting Coefficient : 0.2135

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K	0.277	7.88	0.27	27.60				2.7507
O K	0.525	1.61	0.16	4.24				2.2908
Mn K*	5.894	0.20	0.16	0.15				0.2048
Fe K	6.398	90.31	1.60	68.01				94.7537
Total		100.00		100.00				



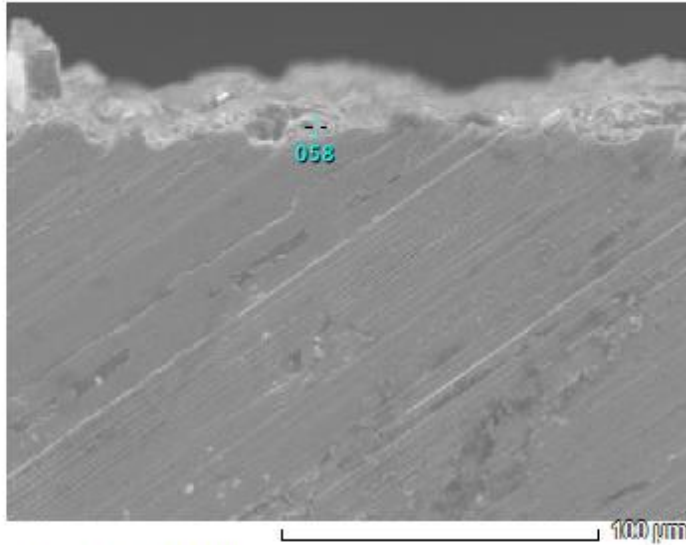
Title : IMC1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 500
 Date : 2023/03/24
 Pixel : 512 x 384



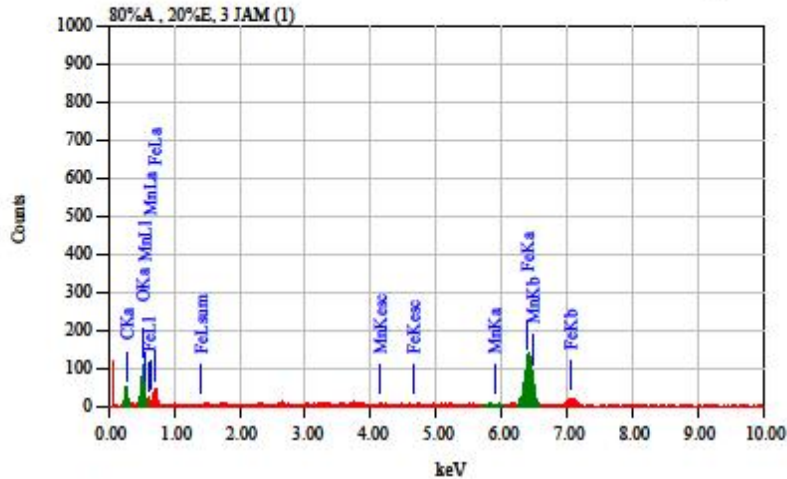
Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.26 sec
 Live Time : 30.00 sec
 Dead Time : 0 %
 Counting Rate : 656 cps
 Energy Range : 0 - 20 keV

ZAF Method Standardless Quantitative Analysis
 Fitting Coefficient : 0.3086

Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K	0.277	35.92	0.62	51.80				22.3509
O K	0.525	34.00	1.02	36.81				35.8844
Na K*	1.041	2.80	0.25	2.11				2.2988
Cl K	2.621	2.06	0.15	1.00				3.3879
K K*	3.312	3.40	0.23	1.51				5.6076
Mn K*		ND		ND				
Fe K	6.398	21.82	0.98	6.77				30.4705
Total		100.00		100.00				



Title : IMC1
 Instrument : JCM-6000PLUS
 Volt : 15.00 kV
 Mag. : x 550
 Date : 2023/03/24
 Pixel : 512 x 384

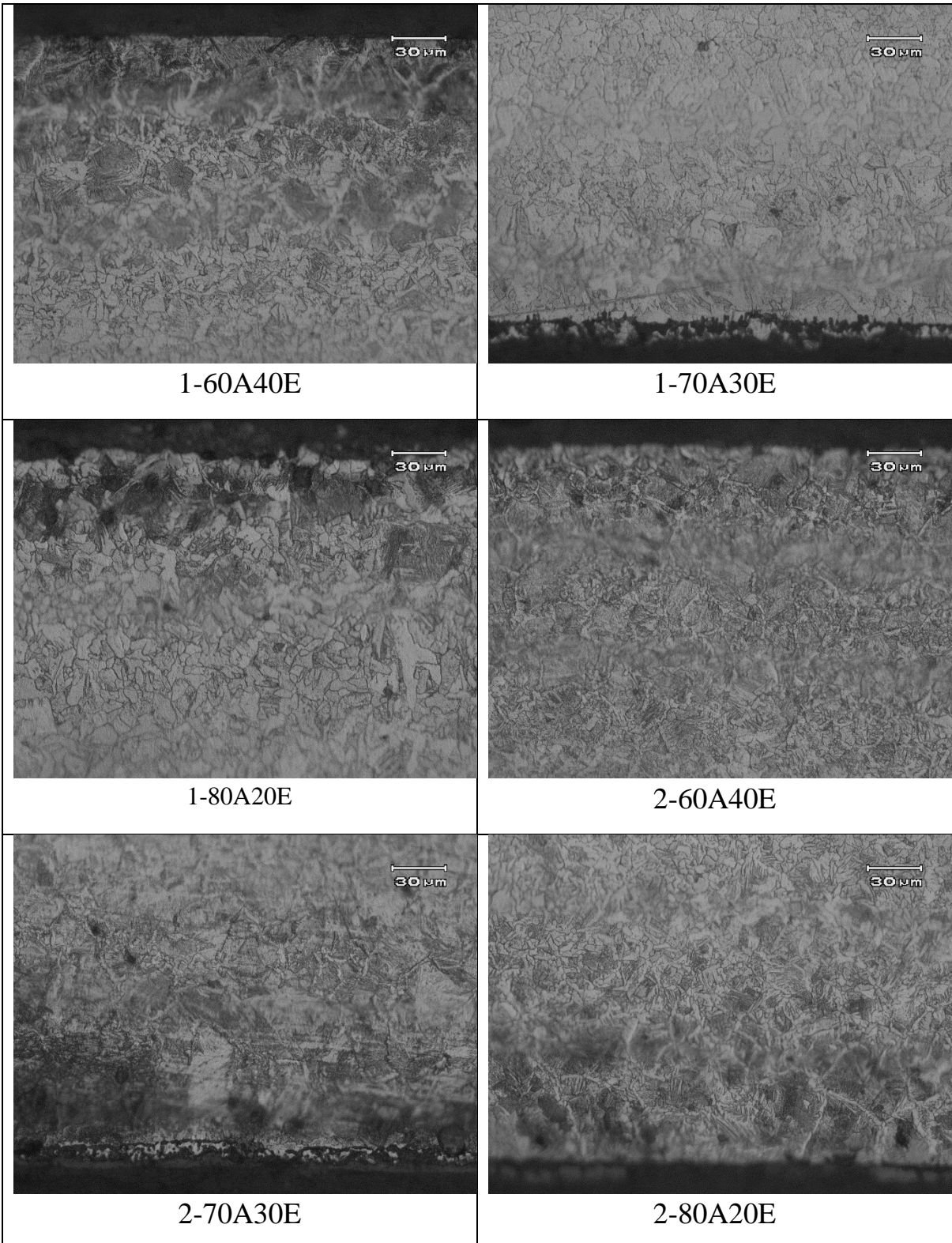


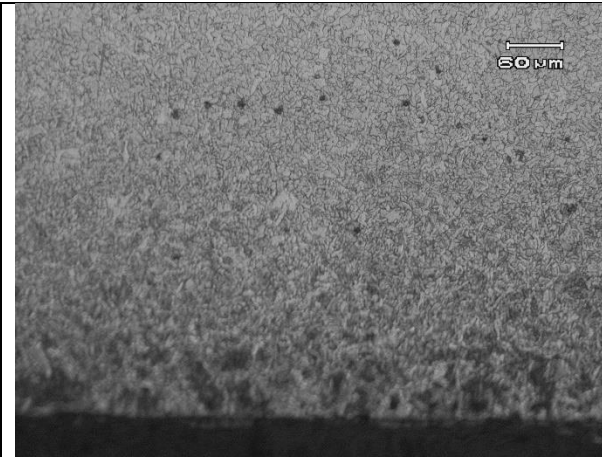
Acquisition Parameter
 Instrument : JCM-6000PLUS
 Acc. Voltage : 15.0 kV
 Probe Current : 1.00000 nA
 PHA mode : T3
 Real Time : 30.26 sec
 Live Time : 30.00 sec
 Dead Time : 0 %
 Counting Rate : 580 cps
 Energy Range : 0 - 20 keV

ZAF Method Standardless Quantitative Analysis
 Fitting Coefficient : 0.3513

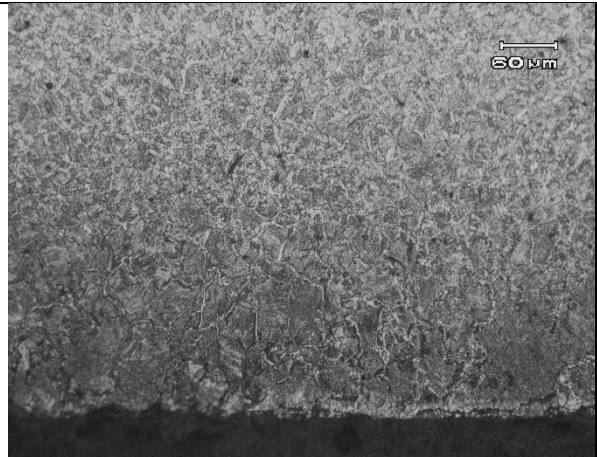
Element	(keV)	Mass%	Sigma	Atom%	Compound	Mass%	Cation	K
C K*	0.277	13.83	0.54	33.27				5.1919
O K	0.525	17.16	0.71	31.00				22.5698
Mn K*	5.894	1.68	0.37	0.88				1.7266
Fe K	6.398	67.34	2.16	34.85				70.5117
Total		100.00		100.00				

Struktur Mikro

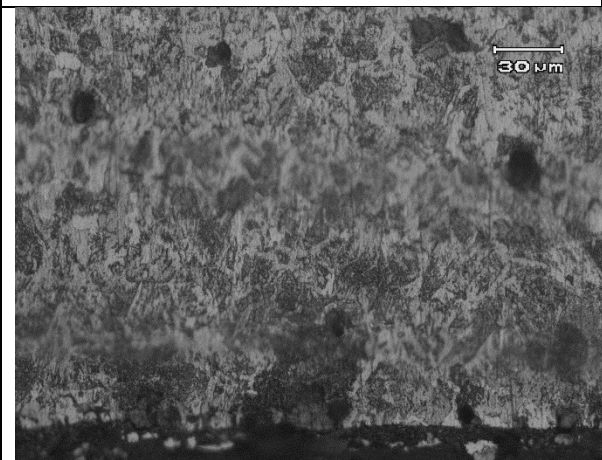




3-60A40E



3-70A30E



3-80A20E

Hasil Uji OES

	Fe %	C %	Si %	Mn %	P %	S %	Cr %	Mo %
Min					0.0000	0.0000		
Max					0.0500	0.0500		
1	96.5	0.528	0.388	1.74	0.0247	0.0087	0.0297	0.0212
2	97.5	0.0838	0.418	1.77	0.0102	< 0.0010	0.0278	< 0.0010
3	97.3	0.174	0.403	1.80	0.0165	< 0.0010	0.0247	< 0.0010
Ave	97.1	0.262	0.403	1.77	0.0172	0.0029	0.0274	0.0070

	Ni %	Al %	Co %	Cu %	Nb %	Ti %	V %	W %
Min								
Max								
1	0.0269	0.108	0.0047	0.0213	0.0600	0.0547	0.0128	0.272
2	0.0096	0.0529	0.0033	0.0113	0.0333	0.0287	0.0026	< 0.0100
3	0.0075	0.0610	0.0031	0.0135	0.0469	0.0378	0.0025	0.0214
Ave	0.0147	0.0738	0.0037	0.0153	0.0467	0.0404	0.0060	0.101

	Pb %	Sn %	B %	Ca %	Zr %	Zn %	Bi %	As %
Min								
Max								
1	0.0842	0.0093	0.0047	> 0.0080	0.0033	0.0061	< 0.0010	0.0146
2	0.0086	0.0024	0.0007	< 0.0001	0.0007	0.0025	< 0.0010	0.0079
3	0.0174	0.0059	0.0016	0.0011	0.0067	0.0034	< 0.0010	0.0126
Ave	0.0367	0.0059	0.0023	> 0.0080	0.0035	0.0040	< 0.0010	0.0117

	Se %	Sb %
Min		
Max		
1	0.0026	0.0044
2	0.0031	< 0.0030
3	0.0047	< 0.0030
Ave	0.0035	< 0.0030

LAMPIRAN C
GAMBAR ALAT DAN BAHAN



Gambar C. 1 Ampelas.



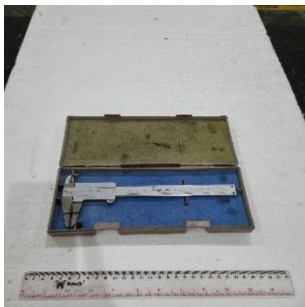
Gambar C. 2 Apron.



Gambar C. 3 Hairdryer.



Gambar C. 4 Helm.



Gambar C. 5 Jangka Sorong.



Gambar C. 6 Mesin Polishing.



Gambar C. 7 Mesin Potong.



Gambar C. 8 Mikrometer Skrup.



Gambar C. 9 Mikroskop Optik.



Gambar C. 10 *Muffle Furnace*.



Gambar C. 11 Penjepit.



Gambar C. 12 Wadah Sampel.



Gambar C. 13 Polish wol



Gambar C. 14 Sarung Tangan.



Gambar C. 15 Wadah Media Pendingin.



Gambar C. 16 Mesin *Mounting*