

**Lampiran 1 Data Pengujian Kekerasan (Vicker Test)**

Kekerasan dihitung dengan dengan persamaan rumus :

$$VHN = \frac{1,854 P}{L^2}$$

Dengan, VHN = nilai kekerasan Vickers (HV)  
 P = beban yang diberikan (kg) = 1000 kgf  
 L = diameter jejak rata-rata (mm)

Sampel	d1	d2	d rata	HV	HV rata2	HRC
A	0,0615	0,0625	0,062	482,3101	459,0258	46
	0,0645	0,0645	0,0645	445,6463		
	0,066	0,0625	0,06425	449,1211		
B	0,06	0,056	0,058	551,1296	534,6871	51
	0,06	0,061	0,0605	506,5228		
	0,0585	0,058	0,05825	546,409		
C	0,052	0,0535	0,05275	666,2923	672,8684	59
	0,053	0,053	0,053	660,0214		
	0,051	0,0525	0,05175	692,2915		
D	0,069	0,069	0,069	389,414	389,414	40
	0,069	0,069	0,069	389,414		
	0,069	0,069	0,069	389,414		
E	0,073	0,073	0,073	347,9077	351,1514	36
	0,071	0,075	0,073	347,9077		
	0,072	0,072	0,072	357,6389		

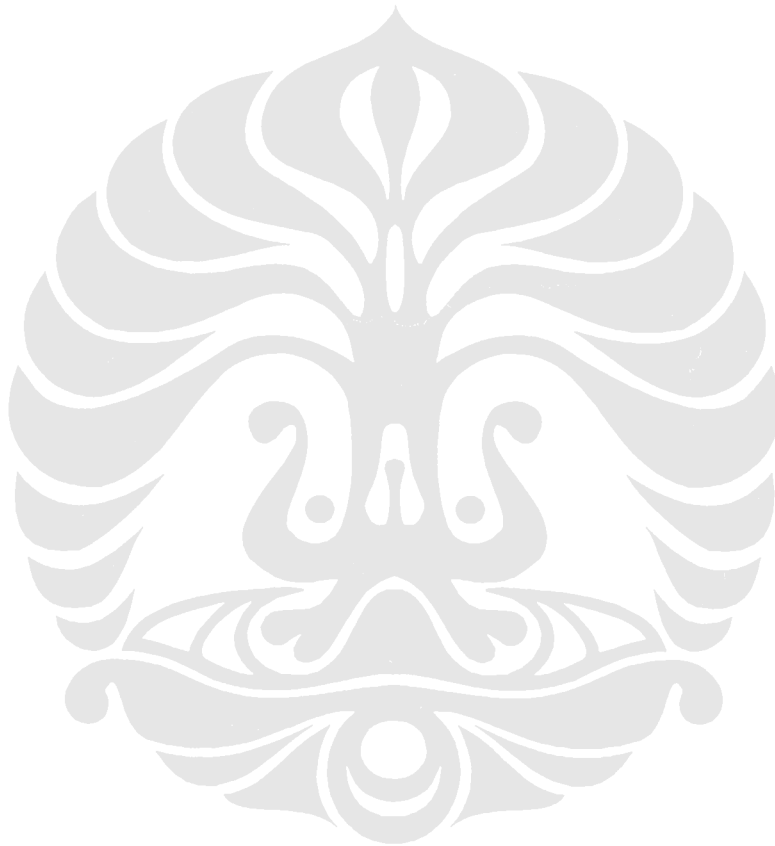
Sampel	d1	d2	d rata	HV	HV rata2	HRC	
600°C	A	0,066	0,066	0,066	425,6198	381,8604	39
		0,0672	0,0695	0,06835	396,8558		
		0,074	0,0775	0,07575	323,1056		
	B	0,0805	0,0835	0,082	275,7287	270,6056	27
		0,0846	0,0845	0,08455	259,3478		
		0,0835	0,0802	0,08185	276,7403		
	C	0,074	0,0765	0,07525	327,4136	317,5261	32
		0,079	0,0778	0,0784	301,6321		
		0,0761	0,0753	0,0757	323,5325		
	D	0,0753	0,0745	0,0749	330,4807	303,2087	30
		0,0818	0,081	0,0814	279,8085		
		0,0775	0,0799	0,0787	299,3369		
	E	0,075	0,0755	0,07525	327,4136	255,5604	23
		0,0871	0,089	0,08805	239,1393		
		0,097	0,0955	0,09625	200,1282		

Sampel	d1	d2	d rata	HV	HV rata2	HRC	
640°C	A	0,0705	0,072	0,07125	365,2078	359,7381	37
		0,0737	0,0719	0,0728	349,8219		
		0,072	0,0707	0,07135	364,1848		
	B	0,093	0,0908	0,0919	219,5223	240,5953	20
		0,0812	0,0832	0,0822	274,3886		
		0,0901	0,0903	0,0902	227,875		
	C	0,0805	0,081	0,08075	284,3313	293,6811	29
		0,078	0,074	0,076	320,9834		
		0,0835	0,0805	0,082	275,7287		
	D	0,0878	0,0907	0,08925	232,7519	225,8676	17
		0,0895	0,0906	0,09005	228,6348		
		0,0912	0,094	0,0926	216,216		
	E	0,0815	0,081	0,08125	280,8426	262,3359	24
		0,0832	0,0865	0,08485	257,5171		
		0,0855	0,0872	0,08635	248,648		

Sampel	d1	d2	d rata	HV	HV rata2	HRC	
690°C	A	0,082	0,0808	0,0814	279,8085	275,6887	26
		0,0807	0,0855	0,0831	268,4774		
		0,0804	0,0827	0,08155	278,7801		
	B	0,094	0,094	0,094	209,8234	219,3588	15
		0,0915	0,0955	0,0935	212,0736		
		0,0887	0,0885	0,0886	236,1795		
	C	0,0802	0,0825	0,08135	280,1526	269,7277	25
		0,083	0,0855	0,08425	261,198		
		0,0832	0,0832	0,0832	267,8324		
	D	0,0865	0,0864	0,08645	248,0731	248,6512	22
		0,0865	0,0865	0,0865	247,7864		
		0,084	0,0882	0,0861	250,0941		
	E	0,0875	0,0905	0,089	234,0614	219,8526	15
		0,0915	0,0855	0,0885	236,7136		
		0,0982	0,1	0,0991	188,7828		

Sampel	d1	d2	d rata	HV	HV rata2	HRC	
SA	A	0,0865	0,0867	0,0866	247,2145	249,4257	22
		0,0828	0,0825	0,08265	271,4089		
		0,0885	0,0912	0,08985	229,6538		
	B	0,0876	0,0908	0,0892	233,0129	229,573	18
		0,0868	0,089	0,0879	239,9562		
		0,0939	0,0915	0,0927	215,7497		
	C	0,0845	0,081	0,08275	270,7533	267,9576	25
		0,0818	0,0844	0,0831	268,4774		
		0,084	0,0834	0,0837	264,642		

D	0,0745	0,0761	0,0753	326,9789	272,6725	26
	0,0848	0,0884	0,0866	247,2145		
	0,086	0,0884	0,0872	243,8242		
E	0,078	0,078	0,078	304,7337	213,829	15
	0,101	0,1004	0,1007	182,8314		
	0,1111	0,1084	0,10975	153,922		



**Lampiran 2 Data Pengujia Aus (Metode Ogoshi)**

jarak luncur (x) = 100.000 mm; v = 0,78 m/s; beban (P) = 6,32 Kg.

dengan rumus: 
$$W = \frac{Bb^3}{12r}$$
 dan 
$$V = \frac{W}{x}$$

Dimana,

W = volume sampel yang terabrasi (mm<sup>3</sup>)

B = tebal cincin putar (3,4 mm)

b = lebar celah yang terabrasi (mm)

r = jari-jari cincin putar (15 mm)

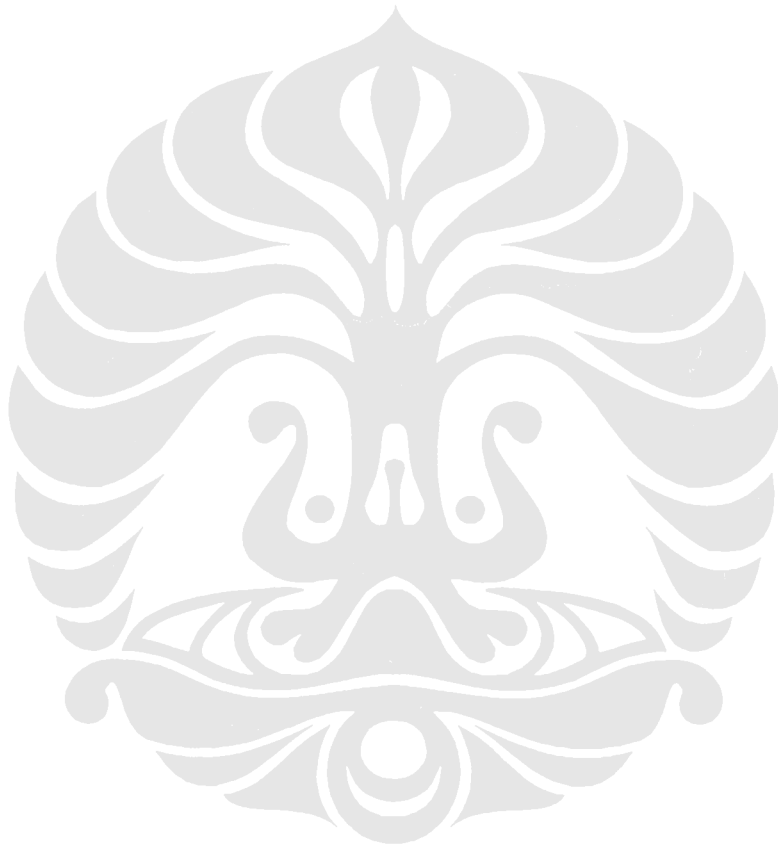
V = laju aus (mm<sup>3</sup>/mm)

x = jarak luncur (100.000 mm)

Sampel	r1	r2	r rata2	R RATA	x	w	LA (10 <sup>-6</sup> mm <sup>3</sup> /mm)	
AS CAST	A	2,145	2,122	2,1335	2,191167	100000	0,1753376	1,753
		2,217	2,236	2,2265				
		2,202	2,225	2,2135				
	B	2,349	2,348	2,3485	2,350333	100000	0,21639	2,164
		2,539	2,502	2,5205				
		2,186	2,178	2,182				
	C	2,515	2,493	2,504	2,512	100000	0,2641847	2,642
		2,431	2,347	2,389				
		2,647	2,639	2,643				
	D	2,199	2,235	2,217	2,156167	100000	0,1670689	1,671
		2,169	2,169	2,169				
		2,083	2,082	2,0825				
	E	1,975	1,983	1,979	2,003333	100000	0,1340011	1,34
		2,107	2,105	2,106				
		1,917	1,933	1,925				
Sampel	r1	r2	r rata2	R RATA	x	w	LA (10 <sup>-6</sup> mm <sup>3</sup> /mm)	
Q/T 600°C	A	2,673	2,67	2,6715	2,6055	100000	0,2947963	2,948
		2,559	2,559	2,559				
		2,578	2,594	2,586				
	B	2,712	2,697	2,7045	2,64625	100000	0,3088456	3,088
		2,675	2,757	2,716				
		2,525	2,549	2,537				
	C	2,615	2,64	2,6275	2,581333	100000	0,2866692	2,867
		2,781	2,798	2,7895				
		2,384	2,367	2,3755				
	D	2,583	2,575	2,579	2,29	100000	0,2001498	2,001
		2,455	2,465	2,46				
		2,169	2,232	2,2005				
	E	2,207	2,212	2,2095	2,697333	100000	0,327079	3,271
		2,807	2,878	2,8425				
		2,706	2,768	2,737				
	2,514	2,511	2,5125					

Q/T 640°C	A	2,679	2,678	2,6785	2,604333	100000	0,2944004	2,944
		2,654	2,639	2,6465				
		2,471	2,505	2,488				
	B	2,817	2,81	2,8135	2,901667	100000	0,4071846	4,072
		2,984	3,031	3,0075				
		2,86	2,908	2,884				
	C	2,976	3,011	2,9935	2,946833	100000	0,4264965	4,265
		2,979	3,006	2,9925				
		2,865	2,844	2,8545				
	D	2,848	2,825	2,8365	2,892167	100000	0,4031983	4,032
		2,906	2,911	2,9085				
		2,921	2,942	2,9315				
E	2,543	2,544	2,5435	2,651	100000	0,3105117	3,105	
	2,803	2,889	2,846					
	2,574	2,553	2,5635					
Q/T 690°C	A	2,507	2,581	2,544	2,55925	100000	0,2793746	2,794
		2,655	2,637	2,646				
		2,602	2,621	2,6115				
		2,44	2,431	2,4355				
	B	2,935	2,964	2,9495	2,939333	100000	0,4232483	4,232
		2,975	3,022	2,9985				
		2,85	2,89	2,87				
	C	2,785	2,747	2,766	2,899333	100000	0,4062031	4,062
		2,961	2,942	2,9515				
		2,93	3,031	2,9805				
	D	2,346	2,338	2,342	2,416	100000	0,2350388	2,35
		2,406	2,353	2,3795				
2,529		2,524	2,5265					
E	2,705	2,688	2,6965	2,5945	100000	0,2910783	2,911	
	2,639	2,658	2,6485					
	2,387	2,49	2,4385					
SA	A	2,059	2,132	2,0955	2,130667	100000	0,1612112	1,612
		2,014	2,009	2,0115				
		2,255	2,315	2,285				
	B	2,502	2,376	2,439	2,661833	100000	0,314334	3,143
		2,84	2,857	2,8485				
		2,699	2,697	2,698				
	C	2,68	2,572	2,626	2,806375	100000	0,3683714	3,684
		2,681	2,699	2,69				
		2,734	2,746	2,74				
	D	3,187	3,152	3,1695	1,955167	100000	0,1245662	1,246
		2,199	2,188	2,1935				
		1,906	1,864	1,885				

	1,772	1,802	1,787				
E	2,097	2,07	2,0835	2,070833	100000	0,1480077	1,48
	2,023	2,056	2,0395				
	2,102	2,077	2,0895				



### Lampiran 3 Data Uji Tarik

Kekuatan tarik maksimum didapat melalui rumus :

$$\sigma_u = \frac{P_{max}}{A_o}$$

Dengan,  $\sigma_u$  = kuat tarik maksimum (Kg/mm<sup>2</sup>)  
 P max = beban maksimum (1000 kg)  
 A<sub>o</sub> = luas awal

#### As Cast

Sampel	D(mm)	A (mm <sup>2</sup> )	y1	UTS (kg/ mm <sup>2</sup> )	UTS rata2
A	12,7	126,6127	6750	53,31221	44,20725
	12,85	129,6212	4550	35,10229	
B	13	132,665	7700	58,04093	64,16703
	12,7	126,6127	8900	70,29313	
C	12,6	124,6266	10200	81,84449	64,59295
	12,6	124,6266	5900	47,34142	
D	12,7	126,6127	9850	77,79633	80,7509
	12,85	129,6212	10850	83,70547	
E	12,7	126,6127	11450	90,4333	87,74369
	12,6	124,6266	10600	85,05407	

#### Q/T 600<sup>o</sup>C

Sampel	d(mm)	A(mm <sup>2</sup> )	y1	UTS (kg/ mm <sup>2</sup> )	UTS rata2
A	12,8	128,6144	3700	28,76816	33,90459
	12,9	130,6319	5100	39,04101	
B	13,3	138,8587	8900	64,09395	64,09395
C	12,65	125,6177	10550	83,985	83,985
D	12,95	131,6465	9950	75,58122	75,58122
E	12,8	128,6144	9100	70,75413	70,75413

#### Q/T 640<sup>o</sup>C

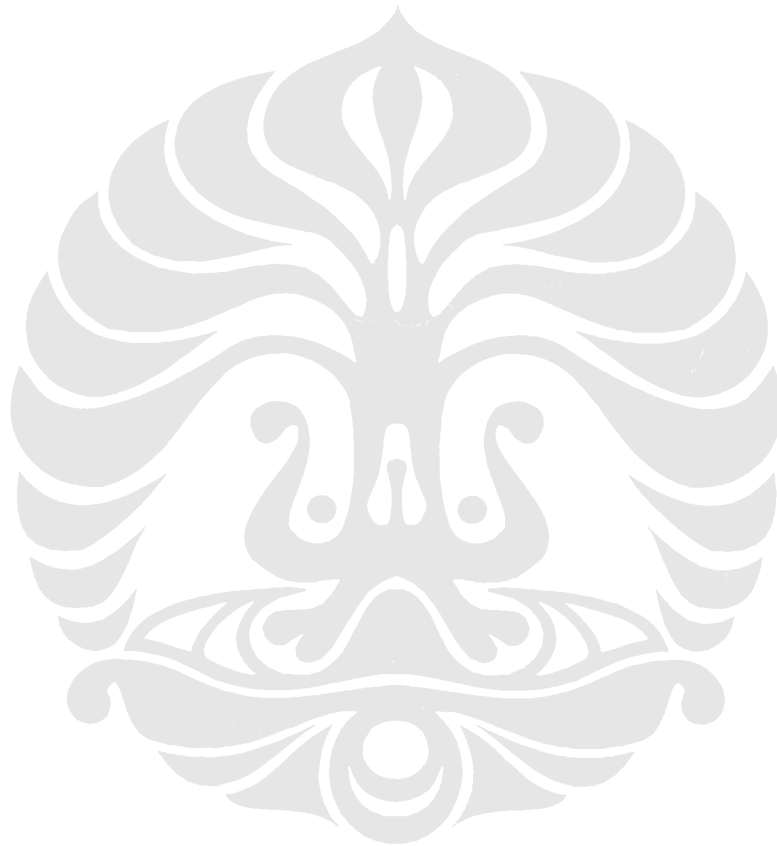
Sampel	d(mm)	A(mm <sup>2</sup> )	y1	UTS (kg/ mm <sup>2</sup> )
A	12,15	115,8837	12250	105,7095
B	13	132,665	14150	106,6596
D	12,6	124,6266	15850	127,1799
C	12,7	126,6127	12750	100,7008
E	12,8	128,6144	11300	87,85952

#### Q/T 690<sup>o</sup>C

Sampel	d(mm)	A(mm <sup>2</sup> )	y1	UTS (kg/ mm <sup>2</sup> )
A	13	132,665	12400	93,46851
B	12,8	128,6144	12800	99,52229
C	12,7	126,6127	13200	104,255
D	12,8	128,6144	11900	92,52463
E	12,85	129,6212	11000	84,86269

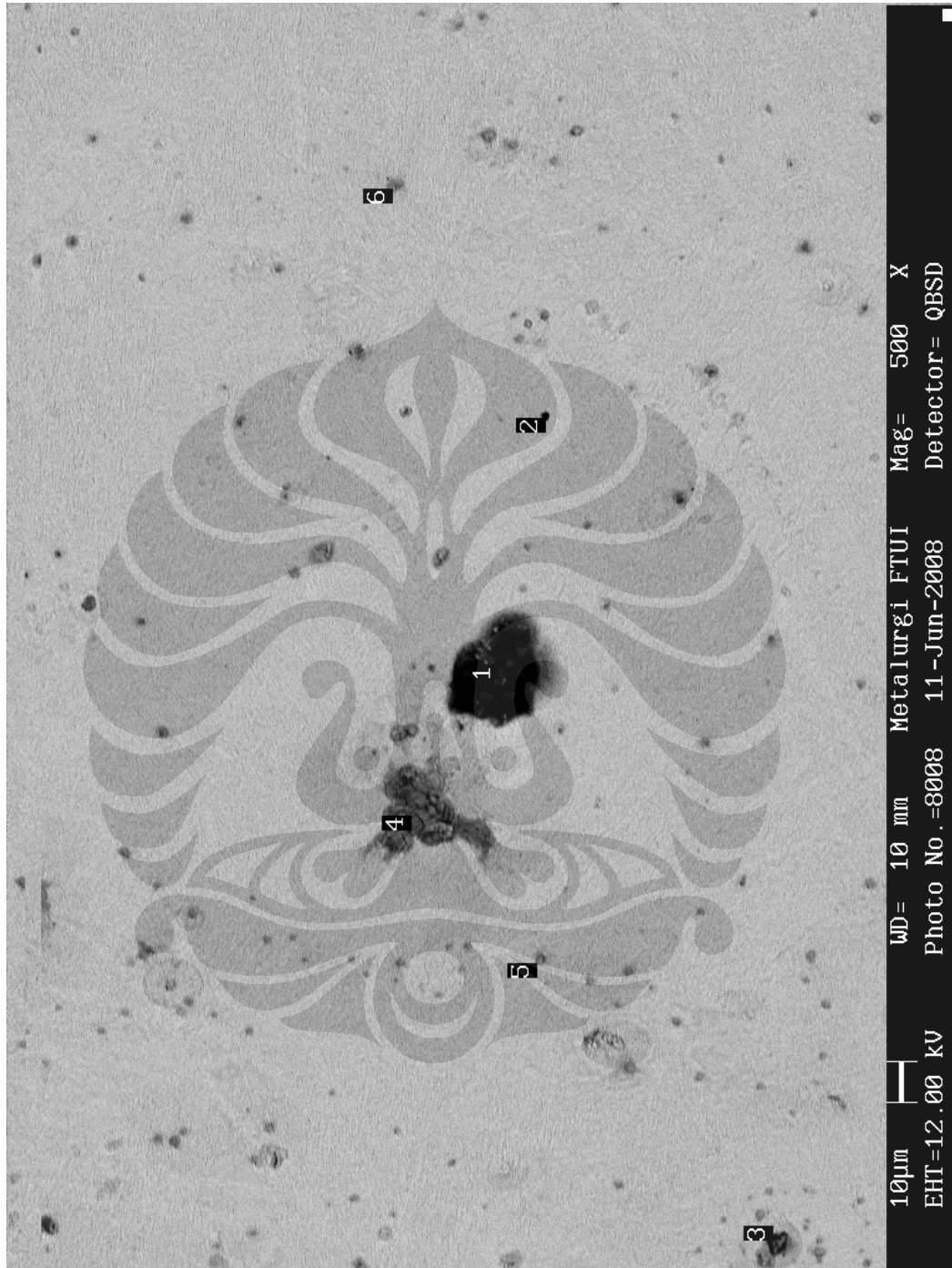
### Spheroidized Anneal

Sampel	d(mm)	A(mm <sup>2</sup> )	y1	UTS (kg/ mm <sup>2</sup> )
A	12,7	126,6127	12430	98,17344
B	12,7	126,6127	10870	85,8524
C	12,9	130,6319	12500	95,68876
D	12,8	128,6144	13350	103,7986
E	12,95	131,6465	13200	100,2686



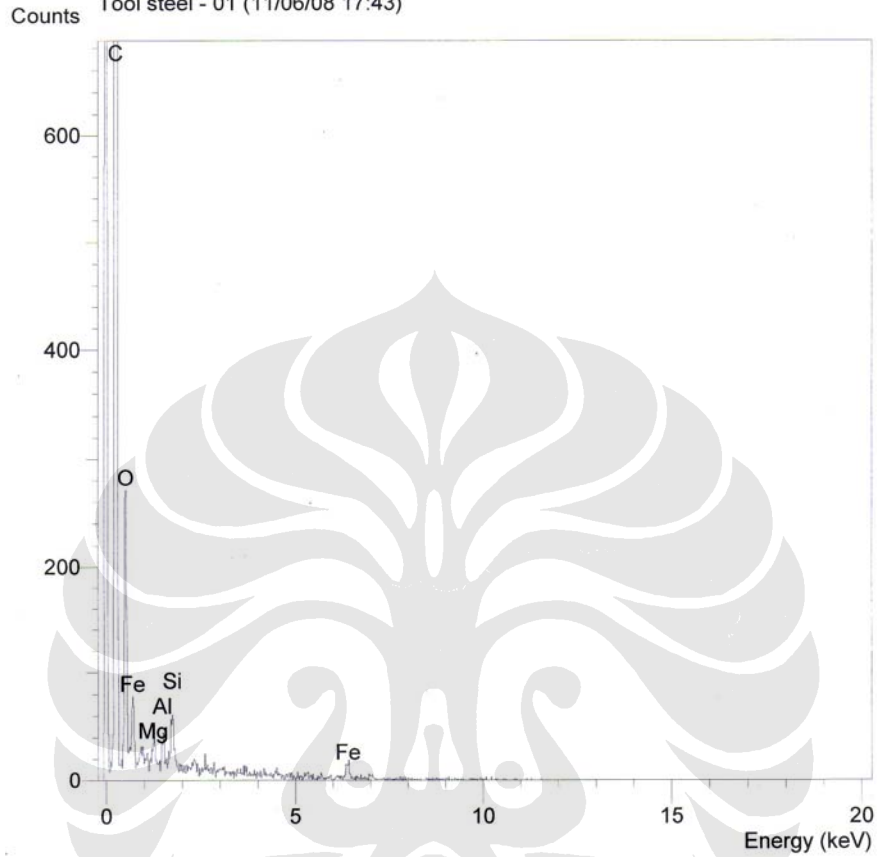


Lampiran 4 Data Pengujian SEM dan EDS



# Titik 1

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 01 (11/06/08 17:43)



SEMQuant results. Listed at 17:48:20 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 01

System resolution = 60 eV

Quantitative method: ZAF ( 3 iterations).  
Analysed all elements and normalised results.

Standards :

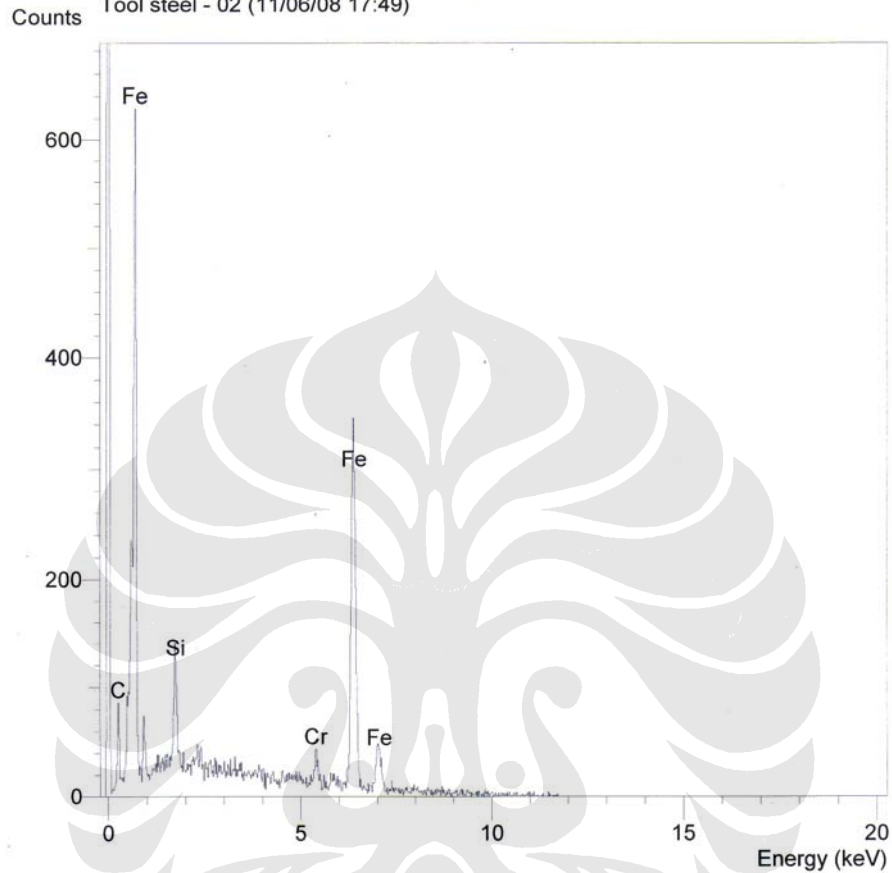
C K	Carbon Low 13/09/06
Mg K	MagOxide 22/03/06
Al K	CeAl2 03/03/07
Si K	Low Carbon Steel 13/09/06
Fe K	FeS2 22/03/06

Elmt	Spect.	Element	Atomic
	Type	%	%
C K	ED	64.89	86.99
Mg K	ED	2.95	1.95
Al K	ED	2.72	1.62
Si K	ED	3.32	1.90
Fe K	ED	26.12	7.53
Total		100.00	100.00

\* = <2 Sigma

## Titik 2

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 02 (11/06/08 17:49)



SEMQuant results. Listed at 17:55:20 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 02

System resolution = 60 eV

Quantitative method: ZAF ( 2 iterations).  
Analysed all elements and normalised results.

Standards :

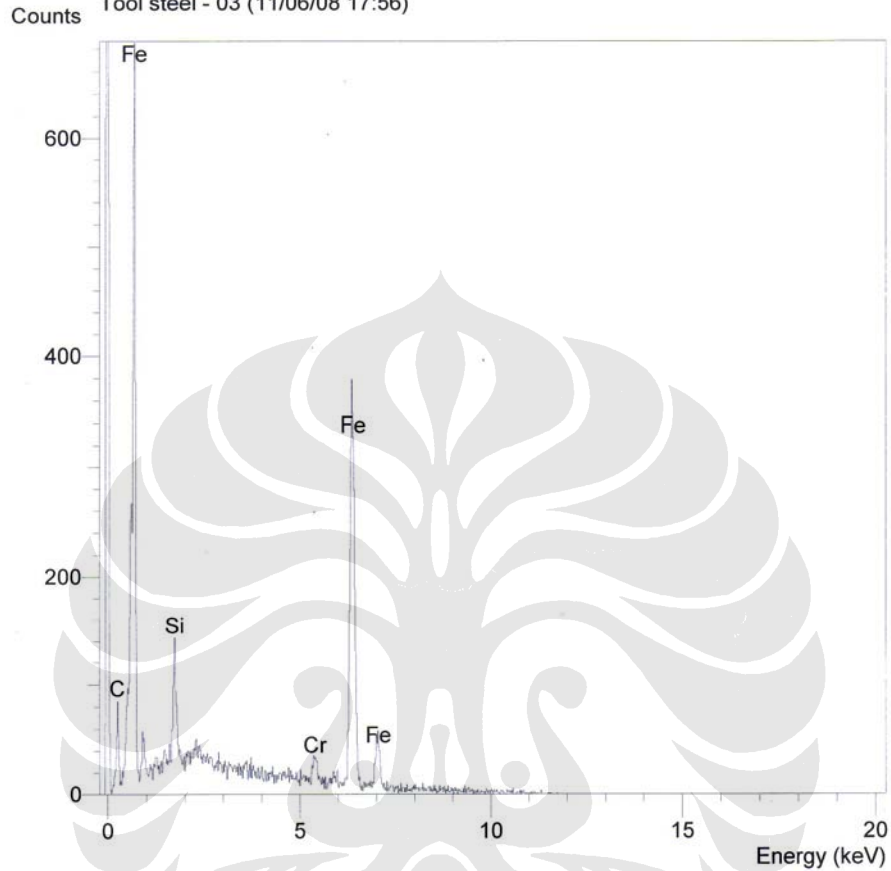
C K	Carbon Low 13/09/06
Si K	Low Carbon Steel 13/09/06
Cr K	Chromium 22/03/06
Fe K	FeS2 22/03/06

Elmt	Spect. Type	Element %	Atomic %
C K	ED	2.93	12.13
Si K	ED	1.54	2.72
Cr K	ED	3.16	3.02
Fe K	ED	92.37	82.14
Total		100.00	100.00

\* = <2 Sigma

### Titik 3

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 03 (11/06/08 17:56)



SEMQuant results. Listed at 17:56:47 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 03

System resolution = 60 eV

Quantitative method: ZAF ( 2 iterations).  
Analysed all elements and normalised results.

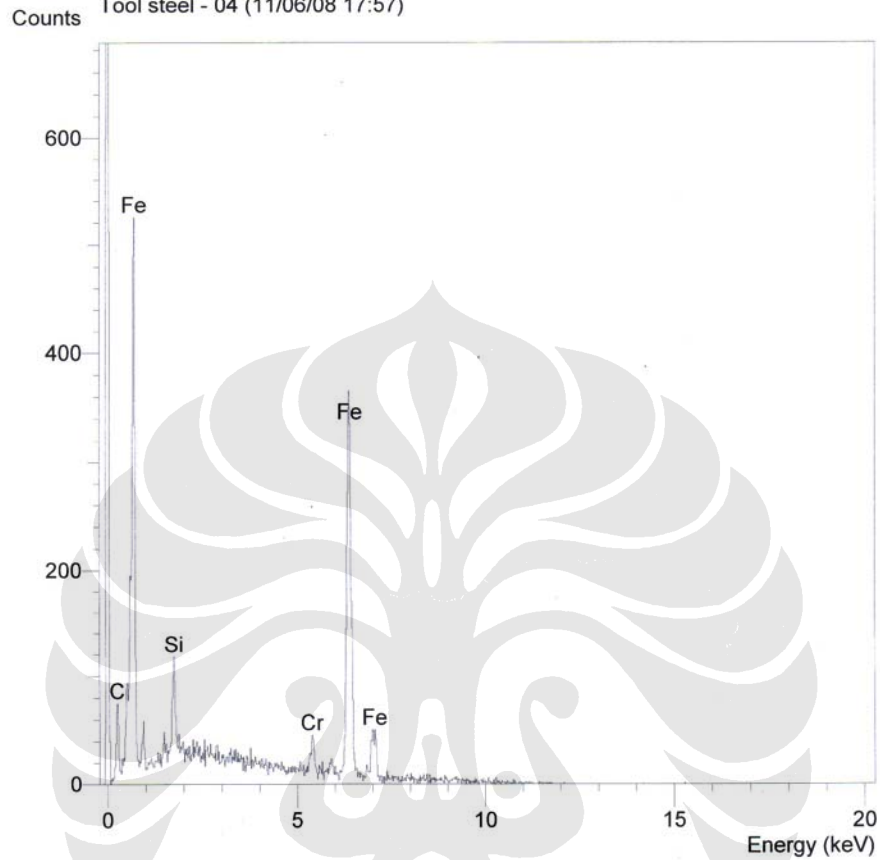
Standards :  
C K Carbon Low 13/09/06  
Si K Low Carbon Steel 13/09/06  
Cr K Chromium 22/03/06  
Fe K FeS2 22/03/06

Elmt	Spect. Type	Element %	Atomic %
C K	ED	2.72	11.33
Si K	ED	1.36	2.43
Cr K	ED	2.72	2.63
Fe K	ED	93.20	83.61
Total		100.00	100.00

\* = <2 Sigma

#### Titik 4

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 04 (11/06/08 17:57)



SEMQuant results. Listed at 17:58:13 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 04

System resolution = 60 eV

Quantitative method: ZAF ( 2 iterations).  
Analysed all elements and normalised results.

Standards :

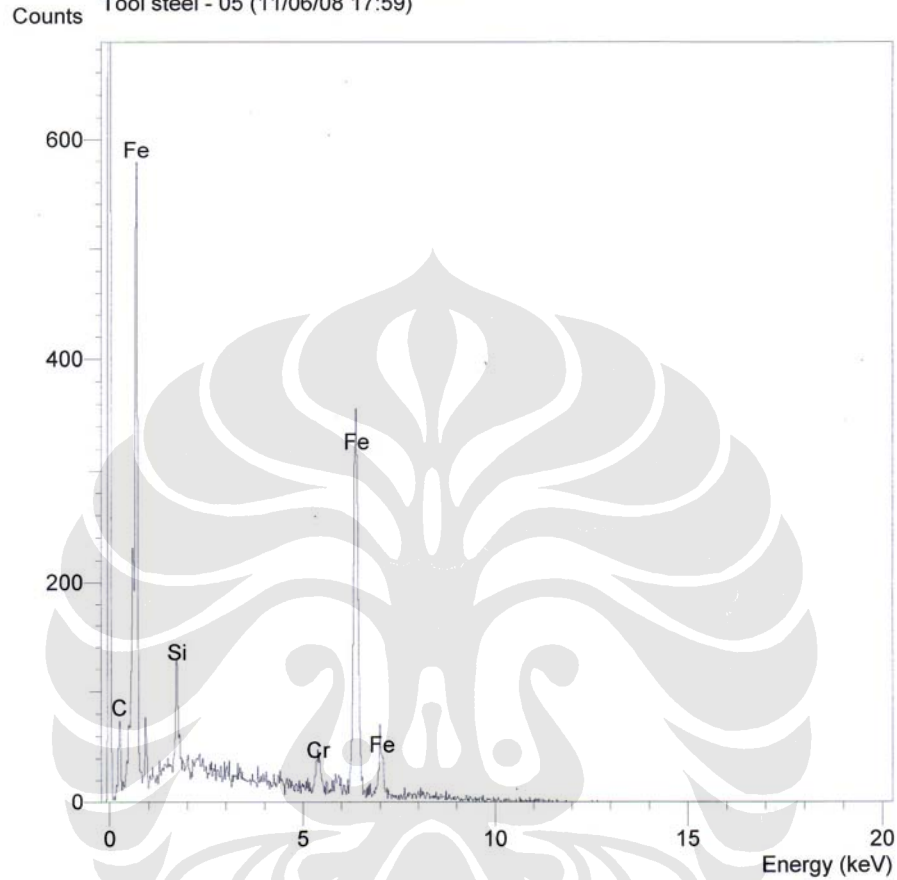
C K Carbon Low 13/09/06  
Si K Low Carbon Steel 13/09/06  
Cr K Chromium 22/03/06  
Fe K FeS2 22/03/06

Elmt	Spect. Type	Element %	Atomic %
C K	ED	2.74	11.43
Si K	ED	1.18	2.10
Cr K	ED	3.65	3.52
Fe K	ED	92.43	82.95
Total		100.00	100.00

\* = <2 Sigma

## Titik 5

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 05 (11/06/08 17:59)



SEMQuant results. Listed at 18:00:35 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 05

System resolution = 60 eV

Quantitative method: ZAF ( 2 iterations).  
Analysed all elements and normalised results.

Standards :

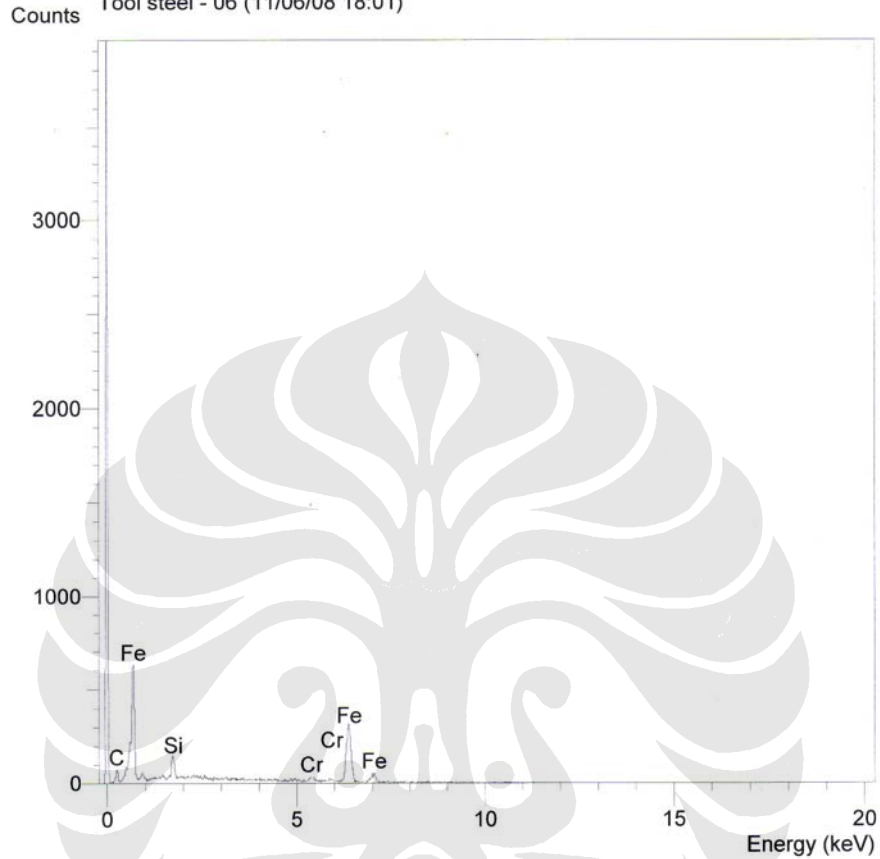
C K Carbon Low 13/09/06  
Si K Low Carbon Steel 13/09/06  
Cr K Chromium 22/03/06  
Fe K FeS2 22/03/06

Elmt	Spect. Type	Element %	Atomic %
C K	ED	2.81	11.70
Si K	ED	1.28	2.27
Cr K	ED	4.00	3.84
Fe K	ED	91.92	82.20
Total		100.00	100.00

\* = <2 Sigma

## Titik 6

Operator : jaya  
Client : Dept. Metalurgi dan Material Universitas Indonesia  
Job : Energy Dispersive X-Ray Analysis  
Tool steel - 06 (11/06/08 18:01)



SEMQuant results. Listed at 18:02:56 on 11/06/08  
Operator: jaya  
Client: Dept. Metalurgi dan Material Universitas Indonesia  
Job: Energy Dispersive X-Ray Analysis  
Spectrum label: Tool steel - 06

System resolution = 60 eV

Quantitative method: ZAF ( 2 iterations).  
Analysed all elements and normalised results.

Standards :

C K Carbon Low 13/09/06  
Si K Low Carbon Steel 13/09/06  
Cr K Chromium 22/03/06  
Fe K FeS2 22/03/06

Elmt	Spect.	Element	Atomic
	Type	%	%
C K	ED	3.13	12.79
Si K	ED	2.03	3.55
Cr K	ED	3.26	3.08
Fe K	ED	91.58	80.57
Total		100.00	100.00

\* = <2 Sigma





Foto Mikro Struktur Paduan A Q/T 690<sup>o</sup> C Perbesaran 100X etsa nital 4%

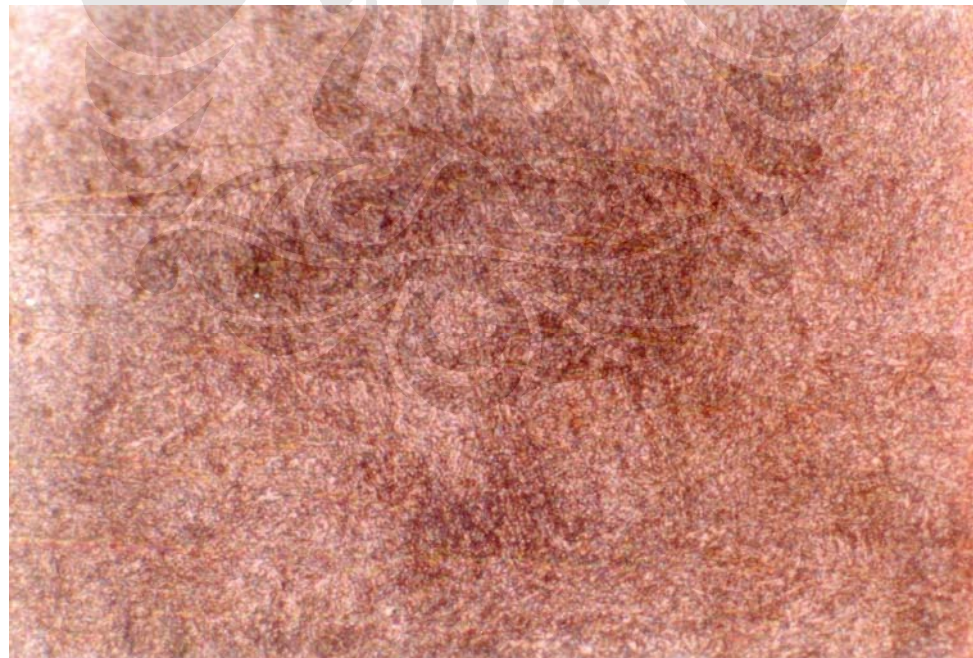


Foto Mikro Struktur Paduan A Q/T 690<sup>o</sup> C Perbesaran 500X etsa nital 4%



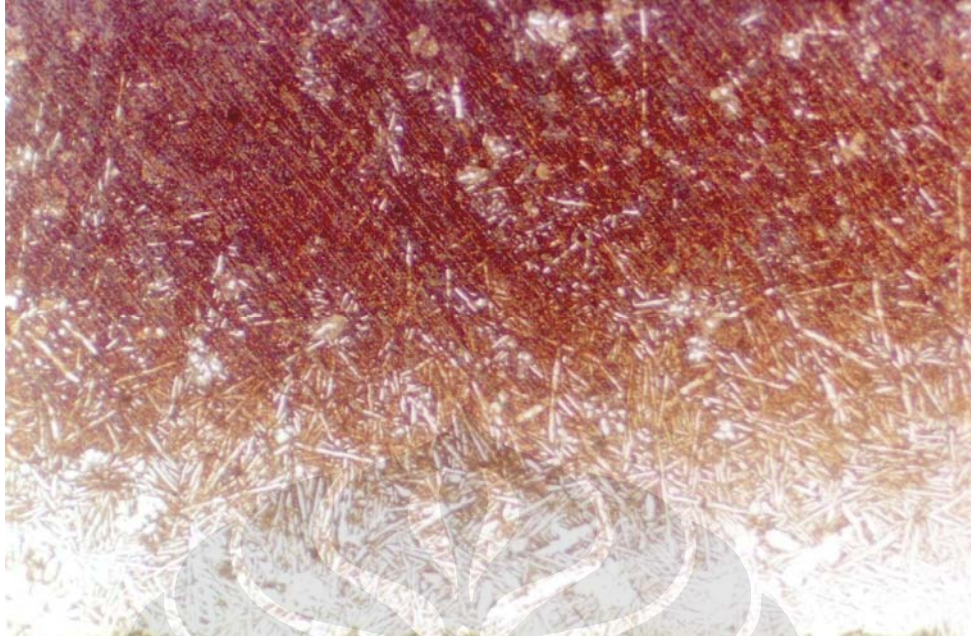


Foto Mikro Struktur Paduan C Q/T 600° C Perbesaran 100X etsa nital 4%

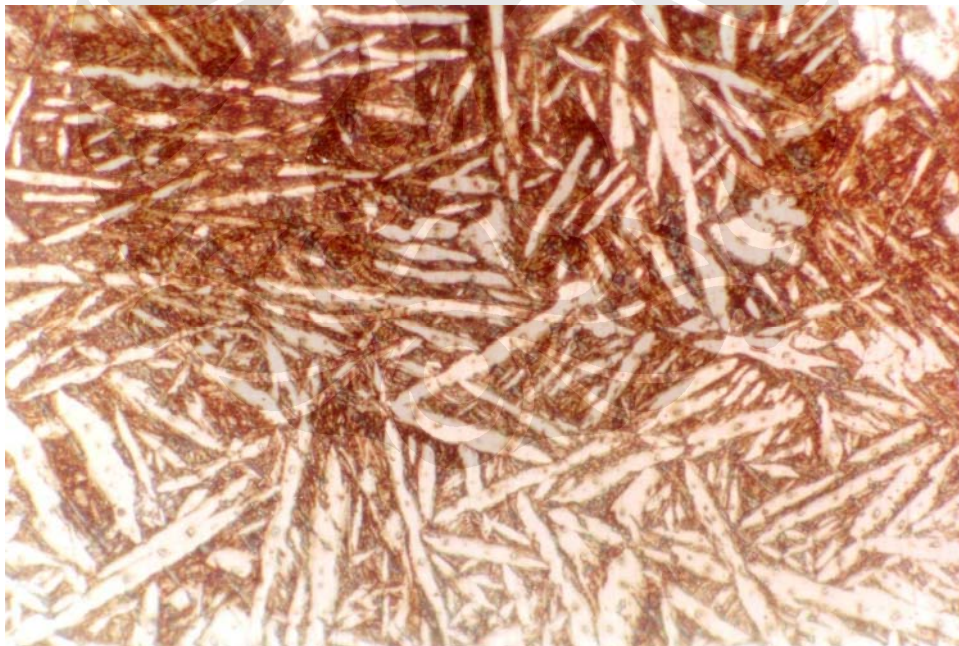


Foto Mikro Struktur Paduan C Q/T 600° C Perbesaran 500X etsa nital 4%