

Optics Application Note

Hardness Determination in Decarburized Steel

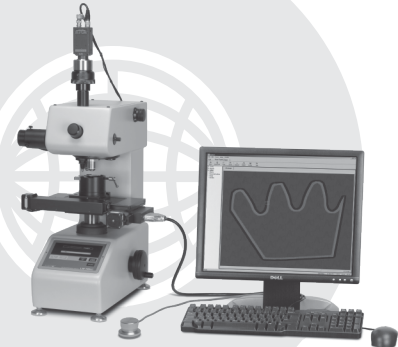
Instrument

AMH43 Vickers Microindentation package with 50X and 10X objectives.

Decarburization

Decarburization can be defined as the loss of carbon from the surface of iron-base alloys as the result of heating in a medium that reacts with the carbon.

While "Case Hardening" refers to a process by which the surface layer of iron-base alloys is substantially harder than the interior, the opposite occurs during decarburization. The surface of decarburized steel is SOFTER than the core. At times it is necessary to quantify the degree of decarburization.



Sampling and Sample Preparation

Sample Identification

Decarburized Steel

Sectioning

Saw	Vises	Blade	Speed	Coolant/Rust Inhibitor
MSX300R1	808-957 809-388	14" x 0.098", Resin Bonded Al ₂ O ₃ , 809-346	2410 RPM	812-469

Mounting

Press	Media	Other Comments
PR-32	Bakelite (Red) 811-118	"Normal Cycle"

Manual Preparation

Grinding

GPX200 10" Wheel	Time (Minutes:Seconds)	Hand Pressure (Manual)	Wheel Direction	Wheel Speed (FPM)
180 grit SiC 812-206-PRM, water	1:00	Medium	CCW	250
320 grit SiC 812-210-PRM, water	1:00	Medium	CCW	250
600 grit SiC 812-214-PRM, water	1:00	Medium	CCW	250

Polishing

	Time (Minutes:Seconds)	Hand Pressure (Manual)	Wheel Direction	Wheel Speed (FPM)
3 μ Diamond Compound, Ultra Silk, Microid Extender, 810-872, 812-438, 811-003	1:30	Medium	CCW	200
1 μ Diamond Compound, Red Felt, Microid Extender, 810-870, 812-225, 811-003	0:30	Light	CCW	200

AMH43

Etching

	Time (Minutes:Seconds)
2% Nital Reagent	00:20 to 00:30

Automatic Prep

Sample Identification

Decarburized Steel

Grinding (Fixed Holder)

GPX200 10" Wheel	Time (Minutes:Seconds)	Head Direction	Head Pressure (lb.)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
Platinum #1 812-337, Water	2:00	CW	35	75	CCW	200

Pre-Polishing

FAS Magnetic System (10") 812-382	Time (Minutes:Seconds)	Head Direction	Head Pressure (lb.)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
Silver Disk, 6 μ Cameo Suspension, Microid Extender, 812-340, 812-356, 811-003	2:00	CW	35	75	CCW	200

Polishing

	Time (Minutes:Seconds)	Head Direction	Head Pressure (lb.)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
3 μ Premium Suspension, Ultra Silk, Microid Extender, 810-997-016, 812-438, 811-003	3:00	CW	40	100	CCW	200
1 μ Premium Suspension, Red Felt, Microid Extender, 810-998-016, 812-225, 811-003	0:30	CW	40	100	CCW	200

Etching

	Time (Minutes:Seconds)
2% Nital Reagent	00:20 to 00:30

Calibration Samples

Calibration is performed using a Certified Microindentation Hardness Standard from LECO, NIST, or other suitable reference material. The Hardness Standard should be certified with the same load and indenter type as the sample analysis, and have a hardness close to the material being analyzed. A multi-point calibration is available if needed. This would allow multiple hardness points to be calibrated within a given load.

Accessories

863-586-B/O AMH43 Advanced Analysis Software Module

Application Parameters—Individual Patterns

Load: 300 g
Indenter Type: Vickers (Diamond Pyramid)
Dwell: 13 seconds
Patterns: 10 evenly-spaced patterns along surface edge (expected Decarb surface)



Pattern Configuration: 5 impressions spaced 100 microns apart; 6th impression @ 1200 microns total depth

Decarb Transition Determination: 88% of Core Average (Core Average = Avg. of 5th & 6th impression);
This formula is input into the Case Depth Hardness area in each pattern, and is automatically calculated per pattern

Application Parameters—Complete Sample Surface

Load: 300 g
Indenter Type: Vickers (Diamond Pyramid)
Dwell: 13 seconds
Patterns: 5 Segment Patterns based off the sample surface profile



Pattern/Segment Configuration: 5 Segment Patterns with 250 micron spacing between impressions; 75 micron spacing between segment lines; 5th segment @ 1200 microns from surface

Decarb Transition Determination: Color Hardness Contour Plot is used to visually display Hardness/Location relationships along the Decarb layer

Analysis Procedure

Follow the macro buttons at the top of the AMH43 Application page from left to right in order to run the analysis.

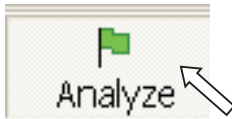


New—Input sample data

Trace Part—Shows sample outline

Load—Select pre-defined pattern

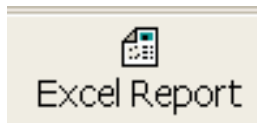
Verify—Position each pattern



Push the "Analyze" button and the hardness impressions will be made and measured as instructed by the pattern's detail.

Vector	Indents	Units								
Indent	Distance	Spacing	Offset	Load	Est. Length	Est. Hardness	Circle Radius	Dwell	Objective	
1	100.00		0.00	300	43.06	300.00	0.00	13	50x	
2	200.00	100.00	0.00	300	43.06	300.00	0.00	13	50x	
3	300.00	100.00	0.00	300	43.06	300.00	0.00	13	50x	
4	400.00	100.00	0.00	300	43.06	300.00	0.00	13	50x	
5	500.00	100.00	0.00	300	43.06	300.00	0.00	13	50x	
6	1200.00	700.00	0.00	300	43.06	300.00	0.00	13	50x	
*										

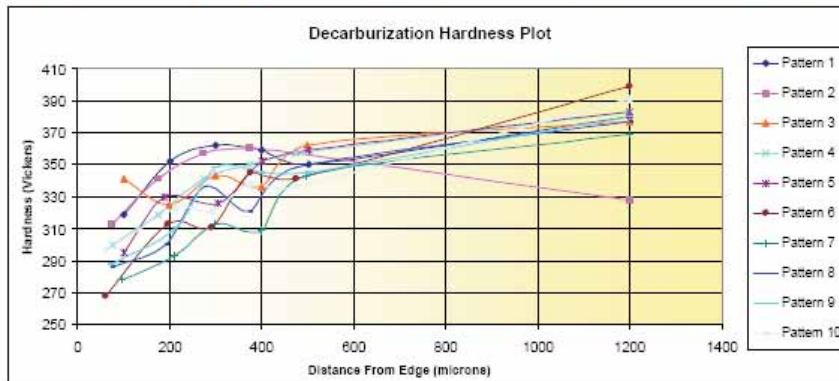
Typical Results—Individual Patterns



Push the "Excel Report" macro button and the test data will automatically be inputted into an Excel template.

Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5										
Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC
319	100	32.1	313	74.6	31.4	341	99.8	34.5	300	76	29.8	305	101	29.1
352	200	35.8	341	174	34.5	325	199	32.8	319	175	32.2	330	189	33.3
352	300	36.9	357	274	36.3	343	299	34.8	341	274	34.5	326	305	32.8
359	400	36.8	380	373	36.5	336	369	34	350	374	35.5	352	401	35.8
350	501	35.5	357	474	36.5	350	499	36.9	357	475	36.3	339	501	36.6
380	1200	38.8	328	1200	35.1	377	1200	36.5	383	1200	36.1	388	1200	39.1
321	108		391	0		325	0		325	203		327	161	

Pattern 6	Pattern 7	Pattern 8	Pattern 9	Pattern 10										
Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC	Hardness	Distance	HRC
298	59.9	25.4	278	66.7	26.8	286	74.2	28	288	74	28.2	297	81.6	29.3
313	165	31.4	293	219	28.9	300	189	29.8	311	214	31.2	323	212	32.6
311	261	31.2	313	299	31.4	336	275	34	348	300	35.3	321	260	32.4
345	375	35	309	400	30.9	321	374	32.4	345	400	36	338	375	34.3
341	475	34.5	343	498	34.8	348	474	35.3	345	500	36	336	474	34
399	1200	40.1	359	1200	37.7	377	1200	38.5	380	1200	38.8	391	1200	39.9
328	327		313	411		319	334		319	332		328	183	



Typical Results— More Complicated Patterns

Individual hardness data from complicated patterns (involving hundreds of impressions) does not lend itself to easy viewing and interpretation (see example at right).

Line Number 1

Hardness	Distance	HRC
852	753	35.8
848	704	35.3
848	753	35.3
880	1000	38.8
841	1250	34.5
823	1500	32.6
852	1750	35.8
828	2000	33.1
864	2250	37.2
834	2500	33.8
836	2750	34.0
836	3000	34.0
848	3250	35.3
845	3500	35.0
848	3750	35.3
852	4000	35.8
832	4260	33.6
830	4500	33.3
836	4750	34.0
832	5010	33.6
826	5250	32.8
838	5500	34.3
828	5760	33.1
841	6000	34.5
841	6250	34.5
834	6500	33.8
830	6750	33.3
832	7000	33.5
841	7250	34.5
819	7500	32.1
828	7750	34.3
830	8000	33.3
817	8250	31.9
817	8500	31.9
821	8750	32.4

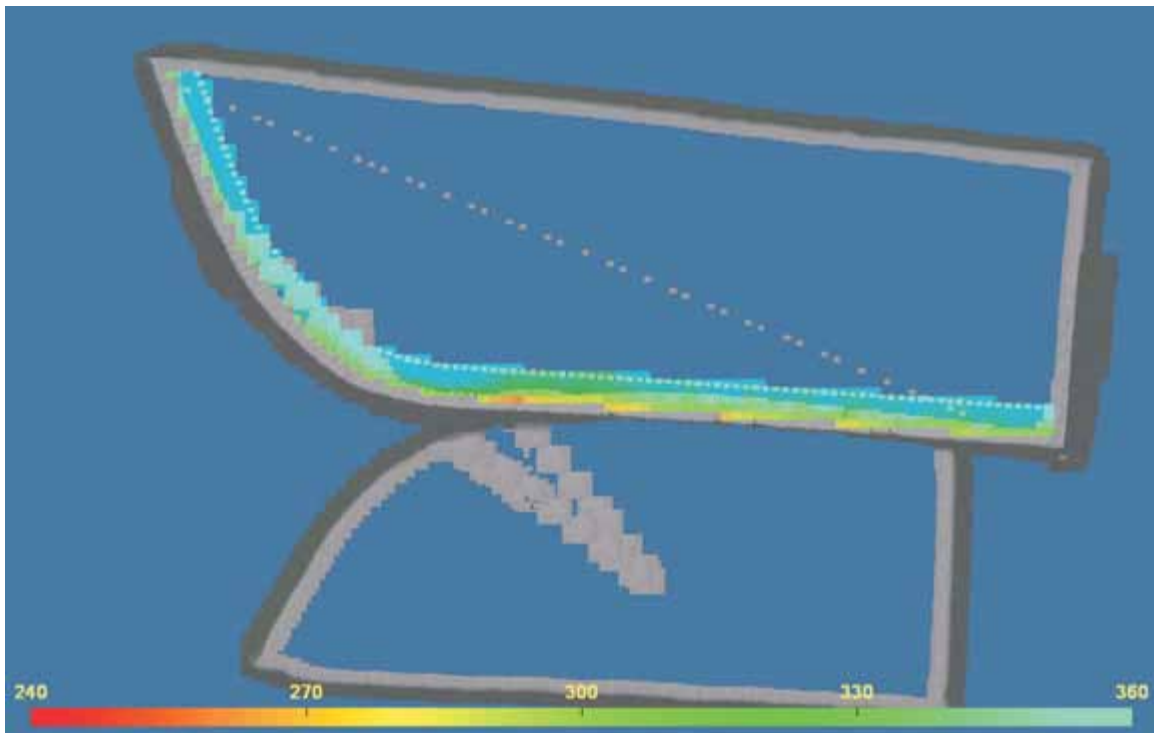
Line Number 2

Hardness	Distance	HRC
852	753	35.8
848	704	35.3
848	753	35.3
880	1000	38.8
841	1250	34.5
823	1500	32.6
852	1750	35.8
828	2000	33.1
864	2250	37.2
834	2500	33.8
836	2750	34.0
836	3000	34.0
848	3250	35.3
845	3500	35.0
848	3750	35.3
852	4000	35.8
832	4260	33.6
830	4500	33.3
836	4750	34.0
832	5010	33.6
826	5250	32.8
838	5500	34.3
828	5760	33.1
841	6000	34.5
841	6250	34.5
834	6500	33.8
830	6750	33.3
832	7000	33.5
841	7250	34.5
819	7500	32.1
828	7750	34.3
830	8000	33.3
817	8250	31.9
817	8500	31.9
821	8750	32.4

Line Number 3

Hardness	Distance	HRC
830	751	33.3
848	701	35.3
841	752	34.5
855	1000	36.1
845	1250	35.0
845	1500	35.0
841	1750	34.5
857	2000	36.3
843	2250	34.8
832	2500	33.5
843	2750	34.8
848	3000	35.3
869	3250	37.7
836	3500	34.0
834	3750	33.8
852	4000	36.2
841	4250	34.5
843	4500	34.8
843	4750	34.8
845	5000	35.0
847	5250	35.3
847	5500	35.3
848	5750	35.3
864	6000	37.1
845	6250	35.0
850	6500	35.5
845	6750	35.0
843	7000	34.8
845	7250	35.0
836	7500	34.0
843	7750	34.8
836	8000	34.0
828	8250	33.1
832	8500	33.4
830	8750	33.3

When this is the case, it is useful to utilize the Color Hardness Contour mapping feature of the AMH system (see image below).



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