Hardness Determination in Decarburized Steel

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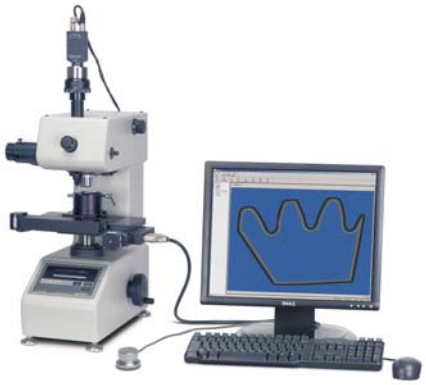


Instrument: AMH43 Vickers Microindentation Package with 50X and 10X Objectives

Decarburization

Decarburization can be defined as the loss of carbon from the surface of iron-based 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-based 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	MSX300R1
Vises	808-957, 809-388
Blade	14" x 0.098", Resin Bonded, Al_2O_3, 809-346
Speed	2410 RPM
Coolant/Rust Inhibitor	812-469

Mounting

Press	PR-32
Media	Bakelite (Red) 811-118
Other Comments	"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)*
3µ Diamond Compound, Ultra Silk, Microid Extender, 810-872, 812-438, 811-003	1:30	Medium	CCW	200
1µ Diamond Compound, Red Felt, Microid Extender, 810-870, 812-225, 811-003	0:30	Light	CCW	200

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 (Min:Sec)	*Head Dir.*	*Head Pressure (lb.)*	*Head Speed (RPM)*	*Wheel Dir.*	*Wheel Speed (FPM)*
Platinum #1 812-337, Water	2:00	CW	35	75	CCW	200

Pre-Polishing - FAS Magnetic System, 10", 812-382

	Time (Min:Sec)	*Head Dir.*	*Head Pressure (lb.)*	*Head Speed (RPM)*	*Wheel Dir.*	*Wheel Speed (FPM)*
Silver Disk, 6µ Cameo Suspension, Microid Extender, 812-340, 812-356, 811-003	2:00	CW	35	75	CCW	200

Polishing

	Time (Min:Sec)	*Head Dir.*	*Head Pressure (lb.)*	*Head Speed (RPM)*	*Wheel Dir.*	*Wheel Speed (FPM)*
3µ Premium Suspension, Ultra Silk, Microid Extender, 810-997-016, 812-438, 811-003	3:00	CW	40	100	CCW	200
1µ 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 Micro-indentation 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

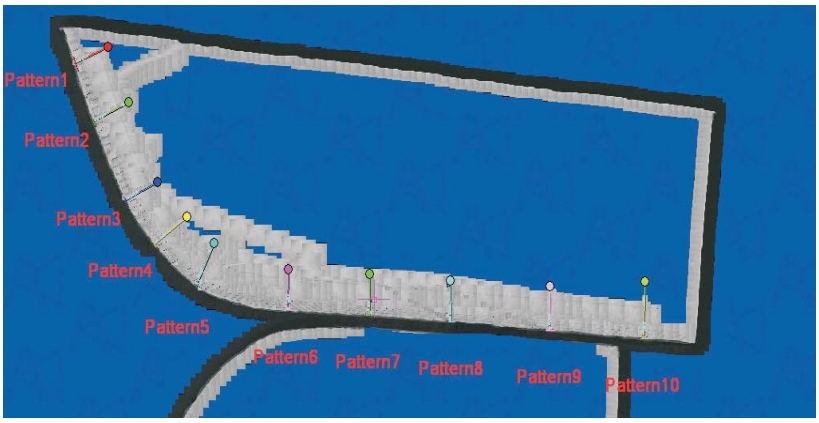
863-586-B/O AMH43 Advanced Analysis Software Module

Metallographic Application Note

Delivering the Right Results

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)

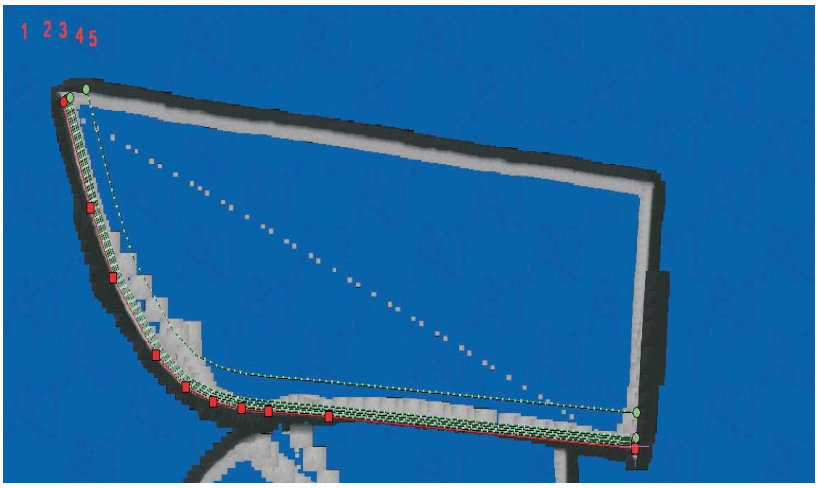


Pattern Configuration
5 impressions spaced 100 microns apart; 6th impression @ 1200 microns total depth

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



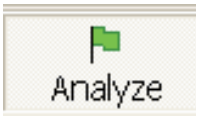
Pattern/Segment Configuration
5 Segment Patterns with 250 micron spacing between impressions; 75 micron spacing between segment lines; 5th segment @ 1200 microns from surface

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

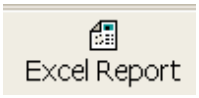


Push the "Analyze" button and the hardness impressions will be made and measured as instructed by the pattern's detail.

Vector | Indents | Units

Indent	Distance	Spacing	Offset	Load	Est. Length	Est. Hardness	Circle Radius	Dwell	Objective
1	100.00	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

Hardness	Distance	HRC
319	100	32.1
352	200	35.8
362	300	36.9
359	400	36.6
350	501	35.5
380	1200	38.8
321	105	

Pattern 2

Hardness	Distance	HRC
313	74.6	31.4
341	174	34.5
357	274	36.3
360	373	36.6
357	474	36.3
328	1200	33.1
301	0	

Pattern 3

Hardness	Distance	HRC
341	99.8	34.5
325	199	32.8
343	299	34.8
336	399	34
362	499	36.9
377	1200	38.5
325	0	

Pattern 4

Hardness	Distance	HRC
300	76	29.8
319	175	32.2
341	274	34.5
350	374	35.5
357	475	36.3
383	1200	39.1
325	203	

Pattern 5

Hardness	Distance	HRC
295	101	29.1
330	189	33.3
328	305	32.8
352	401	35.8
359	501	36.6
383	1200	39.1
327	181	

Pattern 6

Hardness	Distance	HRC
288	99.9	25.4
313	195	31.4
311	291	31.2
345	375	35
341	475	34.5
399	1200	40.7
326	327	

Pattern 7

Hardness	Distance	HRC
278	98.7	28.8
293	210	28.9
313	299	31.4
309	400	30.9
343	498	34.8
369	1200	37.7
313	411	

Pattern 8

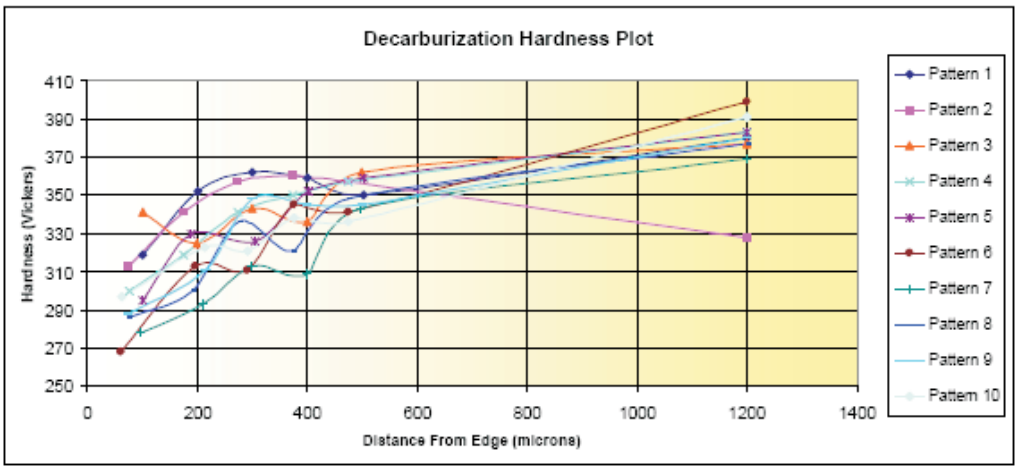
Hardness	Distance	HRC
286	74.2	28
300	190	29.8
336	275	34
321	374	32.4
348	474	35.3
377	1200	38.5
319	234	

Pattern 9

Hardness	Distance	HRC
288	74	28.2
311	214	31.2
348	300	35.3
345	400	35
345	500	35
380	1200	38.8
319	232	

Pattern 10

Hardness	Distance	HRC
297	61.6	29.3
323	212	32.8
321	290	32.4
338	375	34.3
336	474	34
391	1200	39.9
320	193	



Metallographic Application Note

Delivering the Right Results

Typical Results—More Complicated Patterns

Line Number 1

Hardness	Distance	HRC
352	253	35.8
348	504	35.3
348	753	35.3
380	1000	38.8
341	1250	34.5
323	1500	32.6
352	1750	35.8
328	2000	33.1
364	2250	37.2
334	2500	33.8
336	2750	34.0
336	3000	34.0
348	3250	35.3
345	3500	35.0
348	3750	35.3
352	4000	35.8
332	4260	33.6
330	4500	33.3
336	4750	34.0
332	5010	33.6
326	5250	32.8
338	5500	34.3
328	5760	33.1
341	6000	34.5
341	6250	34.5
334	6500	33.8
330	6750	33.3
332	7000	33.5
341	7250	34.5
319	7500	32.1
338	7750	34.3
330	8000	33.3
317	8250	31.9
317	8500	31.9
321	8750	32.4

Line Number 2

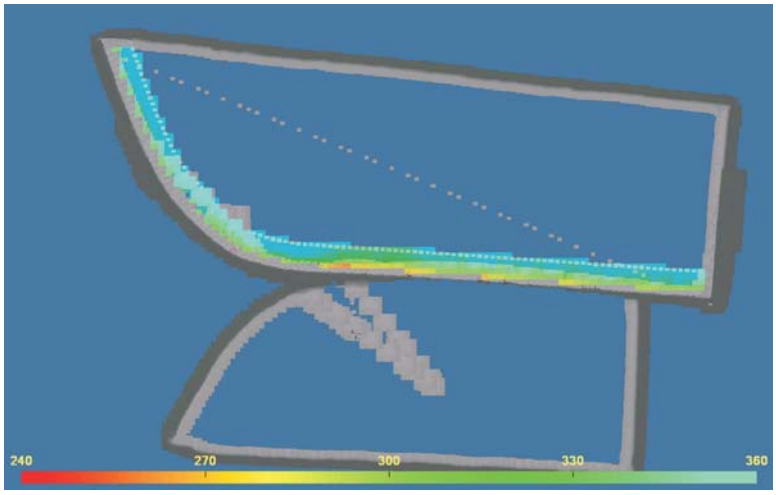
Hardness	Distance	HRC
352	253	35.8
348	504	35.3
348	753	35.3
380	1000	38.8
341	1250	34.5
323	1500	32.6
352	1750	35.8
328	2000	33.1
364	2250	37.2
334	2500	33.8
336	2750	34.0
336	3000	34.0
348	3250	35.3
345	3500	35.0
348	3750	35.3
352	4000	35.8
332	4260	33.6
330	4500	33.3
336	4750	34.0
332	5010	33.6
326	5250	32.8
338	5500	34.3
328	5760	33.1
341	6000	34.5
341	6250	34.5
334	6500	33.8
330	6750	33.3
332	7000	33.5
341	7250	34.5
319	7500	32.1
338	7750	34.3
330	8000	33.3
317	8250	31.9
317	8500	31.9
321	8750	32.4

Line Number 3

Hardness	Distance	HRC
330	251	33.3
348	501	35.3
341	752	34.5
355	1000	36.1
345	1250	35.0
345	1500	35.0
341	1750	34.5
357	2000	36.3
343	2250	34.8
332	2500	33.5
343	2750	34.8
348	3000	35.3
369	3250	37.7
336	3500	34.0
334	3750	33.8
362	4000	36.9
341	4250	34.5
343	4500	34.8
343	4750	34.8
345	5000	35.0
347	5250	35.3
347	5500	35.3
348	5750	35.3
364	6000	37.2
345	6250	35.0
350	6500	35.5
345	6750	35.0
343	7000	34.8
345	7250	35.0
336	7500	34.0
343	7750	34.8
336	8000	34.0
328	8250	33.1
332	8500	33.6
330	8750	33.3

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

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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