MOST COMMON METALLOGRAPHIC APPLICATIONS IN

HEAT TREATMENT

QUARTER CENTURY OF EXPERIENCE

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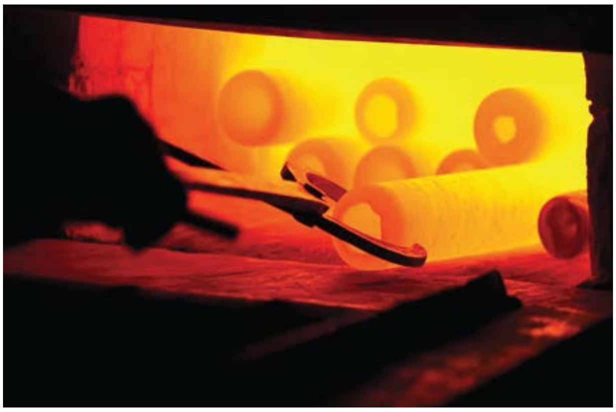
CONTENTS

BASIC INFORMATION ABOUT HEAT TREATMENTS

Heat treatment is a process that uses controlled heating and cooling to modify the crystalline structure of metals and metal alloys. Depending on the material and treatment process, heat treating can provide numerous benefits, including enhanced hardness, increased temperature resistance, greater ductility, and improved material strength. Heat treatments are a critical aspect of metal fabrication processes, as they allow the materials to gain desirable physical and mechanical properties without altering the shape of the product.

Common types of heat treating methods include annealing, hardening, quenching, and stress relieving, each of which has its own unique process to produce different results.

1. ANNELING



Annealing is a heat treatment process used to modify the microstructure of a metal to improve its ductility while reducing internal stress and overall hardness. This allows the material to be more easily shaped without cracking. This process is particularly useful for steels, which can be too hard or brittle for forming processes.

The annealing process involves heating metal to a temperature at which the crystalline structure becomes fluid, but the metal remains in a solid form. The metal is held at this temperature, which allows for any defects in the material to repair themselves. The metal is then allowed to cool back to room temperature at a slow pace to produce a more ductile crystalline structure.

2. HARDENING

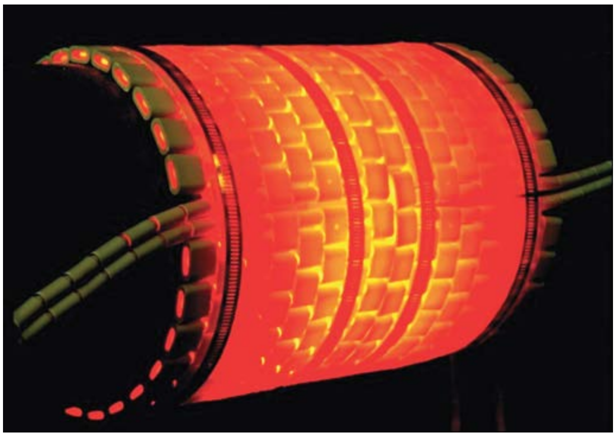
Hardening heat treatments are used to enhance the hardness of the metal's surface through heating and rapid cooling. The material is heated in a hardening furnace to a temperature that transforms its internal structure without melting it. The metal is then held at this temperature for one hour per every inch of thickness, followed by rapid cooling. The quick cooling process establishes a harder, more stable crystalline structure.

3. QUENCHING

Quenching refers specifically to heat treatments that rely on rapid cooling of the metal to achieve the desired physical or mechanical properties. Heated materials are often cooled in oil, but can also be quenched using air, water, and brine, depending on the material and desired qualities.

As with other heat treating processes, the metal is heated to a point below the melting point where the crystalline structure is fluid. It is held for a specific period of time, depending on the desired properties, and then quenched in one of the abovementioned media to reduce the temperature of the material and establish the required internal structure.

4. STRESS RELIEVING



Stress relieving processes involve heating the material above the point where the internal structure transforms and then air cooling it at a particular rate. This process allows the structure to become more stable, reducing internal stress and enhancing the strength and hardness of the metal. It is particularly useful for metals that have been subject to stress-inducing forming processes, such as machining, straightening, and rolling.

FUNDAMENTALS OF METALLOGRAPHIC PREPARATION OF HEAT TREATED SAMPLES

- The main inspection areas are samples' cross section edges especially surface hardened samples.
- Hardness value of samples are higher than routine samples. Hardness testing may be required during the sample preparation.
- High magnification values (500x, 1000x etc.) are necessary for a lot of details especially for fine grains, thin hardness surfaces,nitration,decarburization and carbonization layers, martensite,bainite and pearlite structure.
- As a result; prepared samples have to include good edge sharpness, planarity and parallelism.
- Methods and consumables for all metallographic steps are determine factor for this level.

1. Cutting Operation

- Cutting disc should be suitable for sample hardness and structure.
- Parameters should be optimized for burrless,unburned and planar surface for cutting operation. (avoid to possible hardness decrease.)
- Cooling process should be effective during the operations and cooling parameters shoud be suitable for sample quality.

- Pre-moulding can use for some sensitive sample (nitration,boronizing etc.) about protect surface quality before cutting operation.
- Hard cutting discs for soft materials and soft cutting discs for hard materials should be choose.

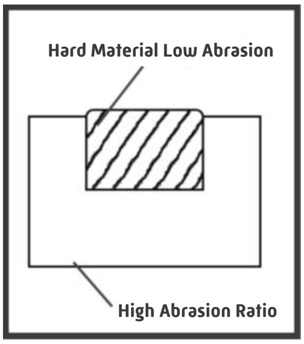
SiC	
NF	Ti
20 – 130 HB	140 – 350 HB

Al_2O_3			
Hard	Medium	Soft	Super Soft
< 23 HRC	>23–35 HRC<	>35–55 HRC<	>55–70 HRC<




2. Mounting Operation

- Mounting powder must be appropriate for sample hardness and structure(epoxy and diallyphalat etc.)
- Sample planarity should be done before mounting operation. There should be no burrs and pollutions.
- Sample should be placed middle point in mould.



3. Grinding Operation

- During the operation; planarity should be more important. If manuel operation is choosed, force should be applied to the middle of the sample.
- Metal-based diamond grinding discs should be preferred instead of SiC grinding papers.
- If automatic grinding/polishing machine is choosed; sample holder shoud be positioned to edge of the grinding disc. Double surface and half moon effect can be eliminated with this method.

4. Polishing Operation

- Wowen polishing cloths should be preffered for maximum flatness and edge sharpness especially for coarse and intermediate polishing. (METAPO Series)
- Flocked polishing cloths should be preffered only for final polishing with low force and operation time. Flocked cloths are not good for fine edge quality.
- Polycristalline diamond suspensions improve surface quality and operation time for high hardness sample.

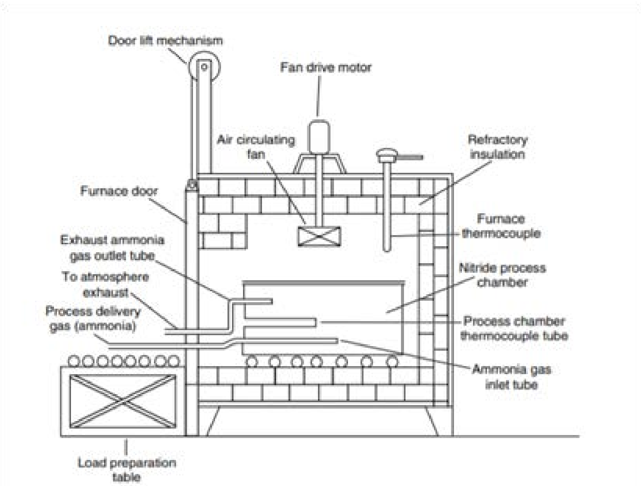
1. METALLOGRAPHIC PREPARATION OF NITRIDED PISTOL BARREL

INTRODUCTION

The nitriding process, first developed in the early 1900s, continues to play an important role in many industrial applications. The process was discovered around the same time in the U.S.A and Germany but wasn't used much until after WW 2. Along with the derivative nitrocarburizing process, nitriding often is used in the manufacture of aircraft, bearings, automotive components, textile machinery, and turbine generation systems. The secret of the nitriding process is that it does not require a phase change from ferrite to austenite, nor does it require a further change from austenite to martensite. In other words, the steel remains in the ferrite phase (or cementite, depending on alloy composition) during the complete procedure. Heat treated material we can use for many different kind of working area Automotive, aerospace, minig, defense, oil&gas, electronics, medical health etc.

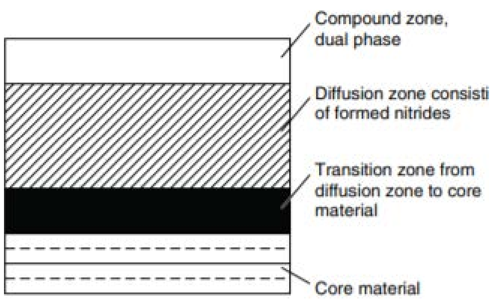
The purpose of nitriding is to increase the surface hardness of the steel and improve its wearing properties. This treatment takes place in a medium (gas or salt) which gives off nitrogen. In nitriding, nitrogen diffuses into the steel and forms hard, wearresistant nitrides. This results in an intermetallic surface layer with good wearing and frictional properties.

Nitriding is done in gas at about 510oC (950oF). The process therefore requires steels that are resistant to tempering in order that the core strength is not reduced.



In nitriding, this can be accomplished by increasing the processing temperature and ammonia flowrate. However, in nitriding, higher processing temperatures and higher ammonia flowrates lead to an increase in the growth rate of the white layer. In some cases, it can be acceptable to have white layer on a resulting part. Since the white layer can be very hard and brittle, it may be desirable to minimize or completely eliminate it. This can be accomplished by controlling the nitriding potential during the nitriding process.

The carburizing gas, the nitriding atmosphere is not in equilibrium since the ammonia flow rate is too high to allow it to fully dissociate to nitrogen and hydrogen during the process. For this reason, the furnaces exhaust gas consists of ammonia, nitrogen, and hydrogen. It is customary to use a burette to determine the percentage of ammonia dissociation. Ammonia is the only constituent that is soluble in water. Agraduated burette filled with water can be used to measure the ammonia dissociation rate of the furnace exhaust gas. Since this method is not continuous and is manual, it introduces operator induced variability, which makes it difficult to repeat the process. For this reason, work began on a new control parameter, nitriding potential as a means to reduce the white layer thickness or eliminate the white layer altogether. Nitriding potential, Kn, is based upon the partial pressure of the ammonia still present in a furnace (the amount of ammonia that has not yet dissociated) and the partial pressure of hydrogen (H2) that has already dissociated from ammonia.

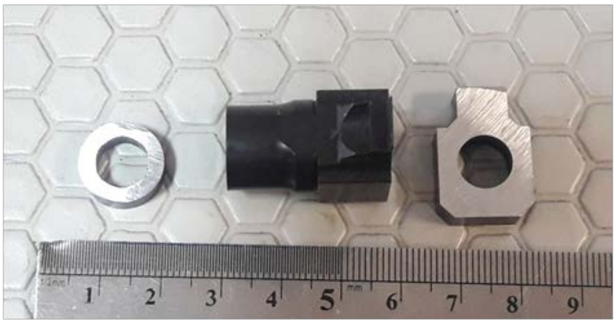


In this application Nitrided Pistol Barrel samples, which we are using in defense industry will be prepared as Metallographic purpose and hardness determination.

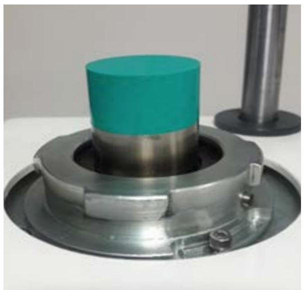
SAMPLE PREPARATION PROCESES

With the help of GR 0548 Quick Acting Clamping Vise Nitrided Barrel sample fixed to MICRACUT 202 Automatic High Speed Precision Cutter table.

Cutting Parameters	
Feed rate	150 µ/sec.
RPM	2850 r/min.
Travel	35 mm.
Force	5.0 A.



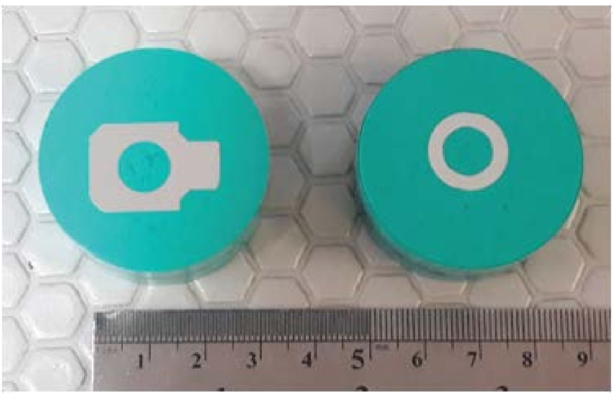
After cutting operation, samples mounted with Diallyptalat powder in ECOPRESS 102 Programmable Automatic Hot Mounting Press.



Mounting Parameters	
Heating Temperature	180°C
Pressure	260 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35°C

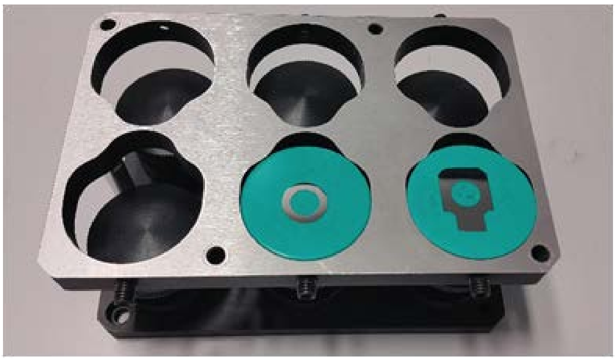
Nitrided Barrel mounted samples have been grinded&polished with the parametres below;

	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grinding Step 1	MAGNETO 38-040-054	Diamond 54 µ	Water	25 N	1 min.	300 CCW	100 CCW
Final Grinding	MAGNETO 38-040-018	Diamond 18 µ	Water	30 N	2 min.	300 CCW	100 CCW
Polishing Step 1	MAGNETO-P 38-013-250	DIAPAT-P 6µ 39-430-P	DIAPAT [39-502]	25 N	2 min.	250 CW	100 CCW
Polishing Step 2	MAGNETO-B 38-033-250	DIAPAT-P 3µ 39-420-P	DIAPAT [39-502]	20 N	2 min.	250 CW	75 CCW
Final Polishing	FEDO-1M 39-067-250	DIAPAT-P 1µ 39-410-M	DIAPAT [39-502]	15 N	2 min.	200 CW	50 CCW

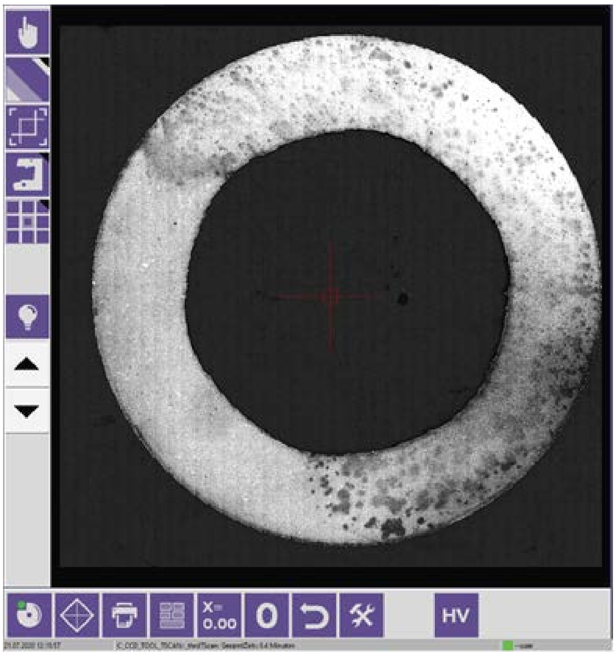


HARDNESS TESTING

We fixed the samples on GR 2037 Multiple Specimen holder to ensure the surface is perfectly perpendicular to indenter.

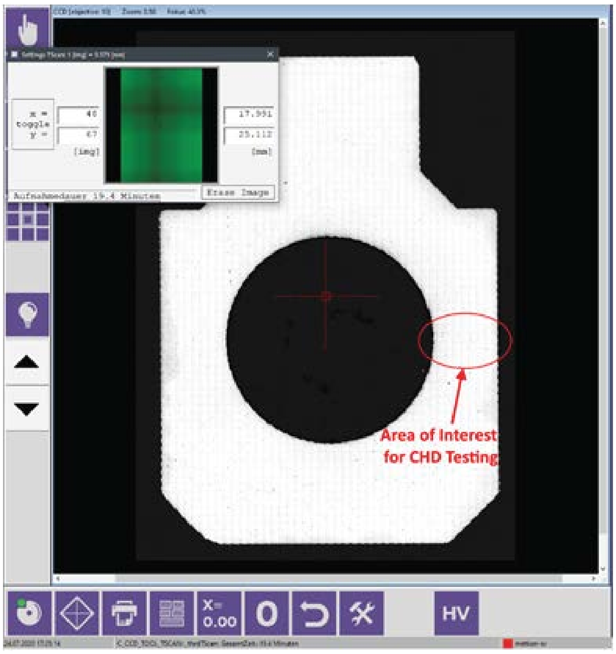


We used the Scan Overview funtion to see general image of both samples and determine measurement points. Sample on the left is normally etched. Sample on the right is slightly etched. For this sample, slightly etching is better for accurate hardness testing.



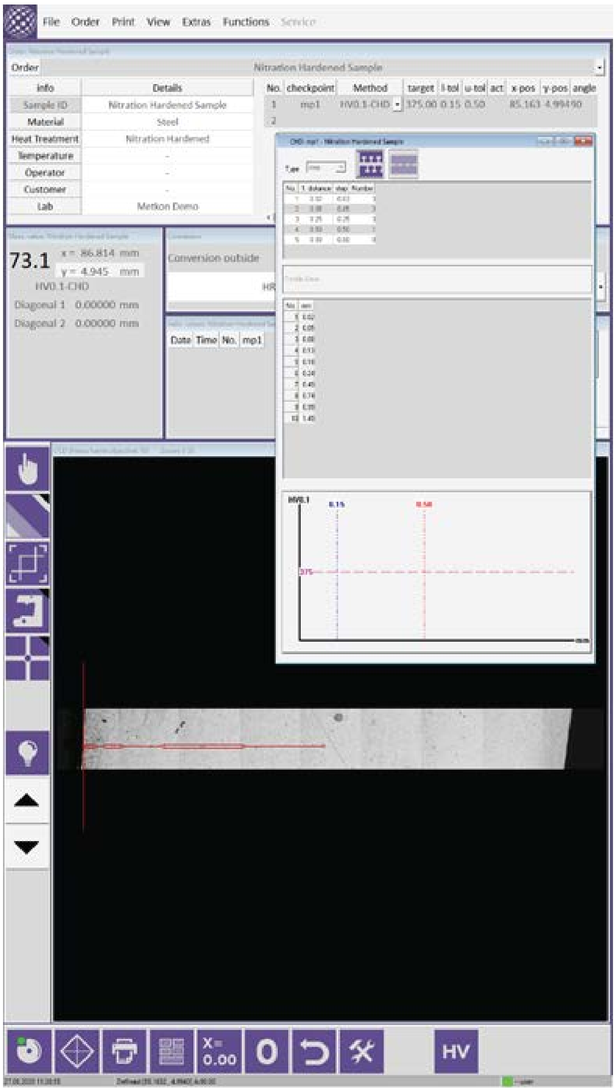
Scanning function 15x15 mm
(Normally Etched Sample)

Etching is required for discriminate hardened zone on the edges. According to hardened zone, we will determine measurement distances for Case Hardening Depth testing. If we make normally or heavy etch, in this case it is difficult to measure indent diagonals for hardness evaluation. For this reason, light etching is required.



Scanning Function 25x18 mm
(Slightly Etched Sample)

We determined the measurement pattern for Case Hardnening Depth testing on slightly etched sample. Interested test area is partly scanned again to discriminate hardened zone.



Target value is 375HV between 0.15 and 0.50 mm from the edge. So we entered these parameters to show on the graphic automatically.

No.	checkpoint	Method	target	l-tol	u-tol	act	x-pos	y-pos	angle
1	mp1	HV0.1-CHD	375.00	0.15	0.50		85.163	4.99490	

We determined the test force as 100 gf. Because, the depth of hardened zone under nitration layer is very low. Therefore, we selected low force for a small indent. 10, 25 or 50 gf is also possible for this sample but, as the sample is etched, measurement of smaller indent maybe little difficult.

We determined 10 measurement points as a line with total length of 1.49 mm. The line is consist of four different sections.

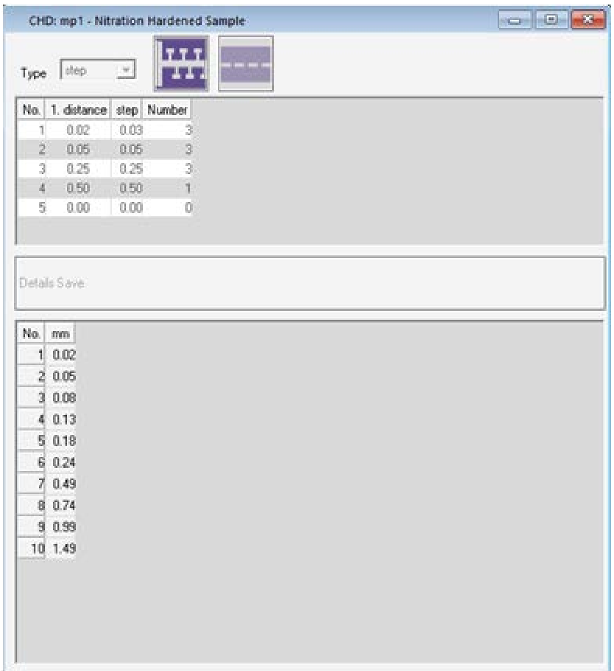
First section: We set three measurement point for the first section. Distance between the first three measurements will be 0.03. The first measurement will start from 0.02 mm depth of nitration layer. Thus, total 0.08 mm depth will be measured, which is the aproximate distance of hardened zone.

Second section: Second section is start 0.05 mm away from the last measurement of first section. We set again three measurement point but, this time the distance between measurements will be 0.05 mm. We intended to measure the area between hardened zone and core. Measurements will start from 0.13 mm and ends 0.24 mm from the nitration layer.

Third section: Third section is not heat effected zone. This section will start 0.25 mm away from the second section. There will be three measurements in this section and distance between the measurements will be 0.25 mm. Measurements will start from 0.49 mm and ends 0.99 mm from the nitration layer.

Fourth section: We intended to measure the middle of test area. This section consist of only one measurement. Distance from third section is 0.99 mm. Distance from the nitration layer is 1.49 mm.

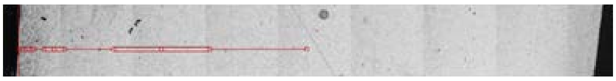
You can see distance settings below for all sections:



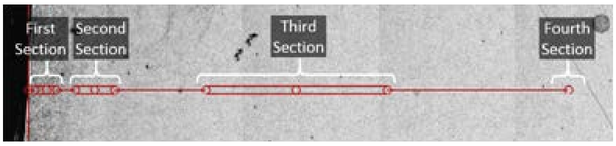
No.	1. distance	step	Number
1	0.02	0.03	3
2	0.05	0.05	3
3	0.25	0.25	3
4	0.50	0.50	1
5	0.00	0.00	0

No.	mm
1	0.02
2	0.05
3	0.08
4	0.13
5	0.18
6	0.24
7	0.49
8	0.74
9	0.99
10	1.49

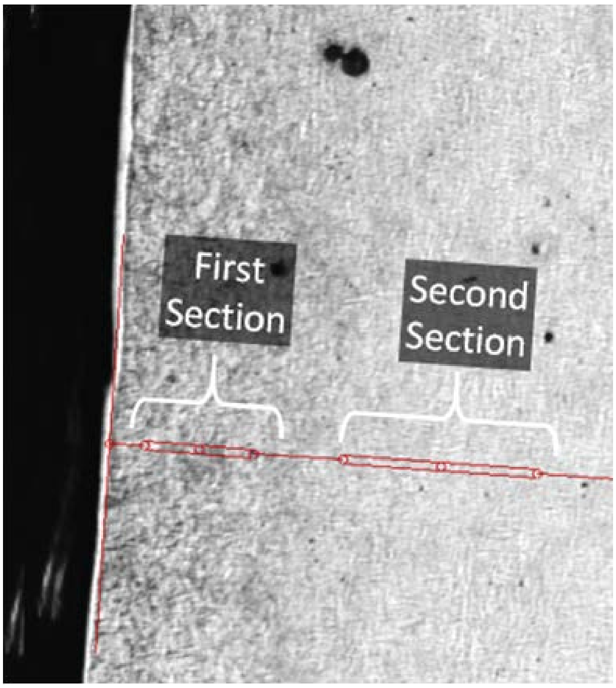
See below photo for measurement line:



Sections:

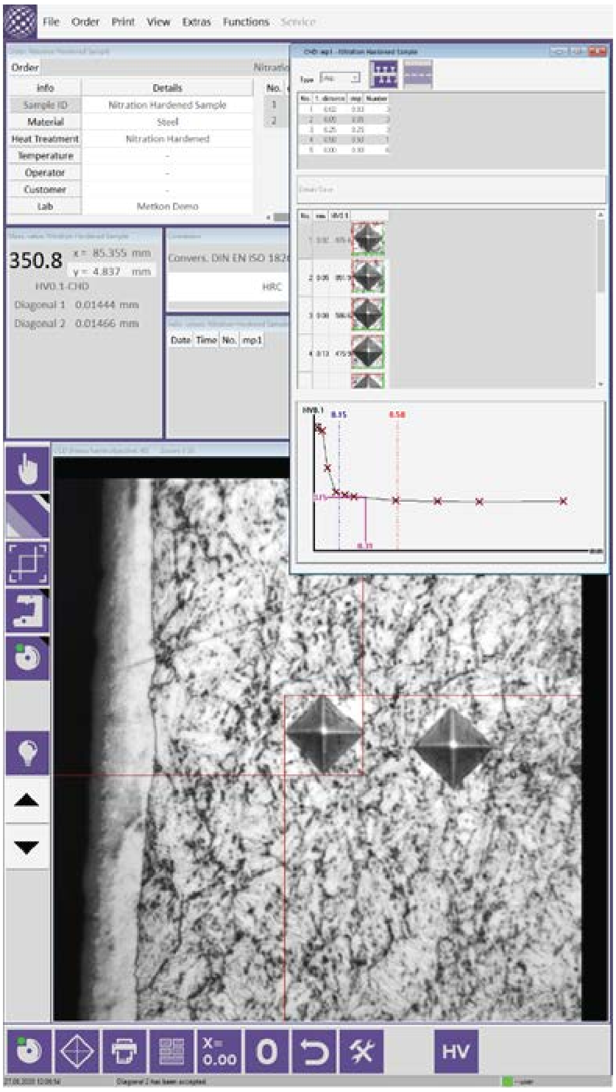


Close up view for first and second sections:
(Hardened zone under nitration layer can be seen)

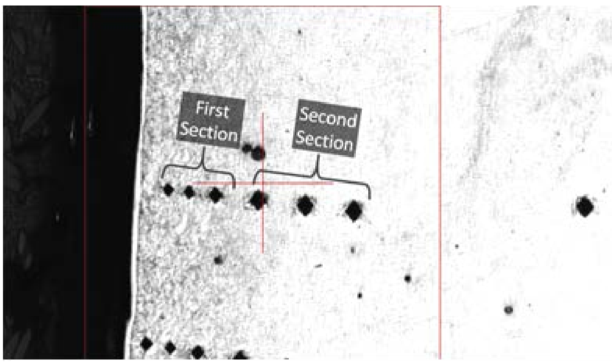


RESULT

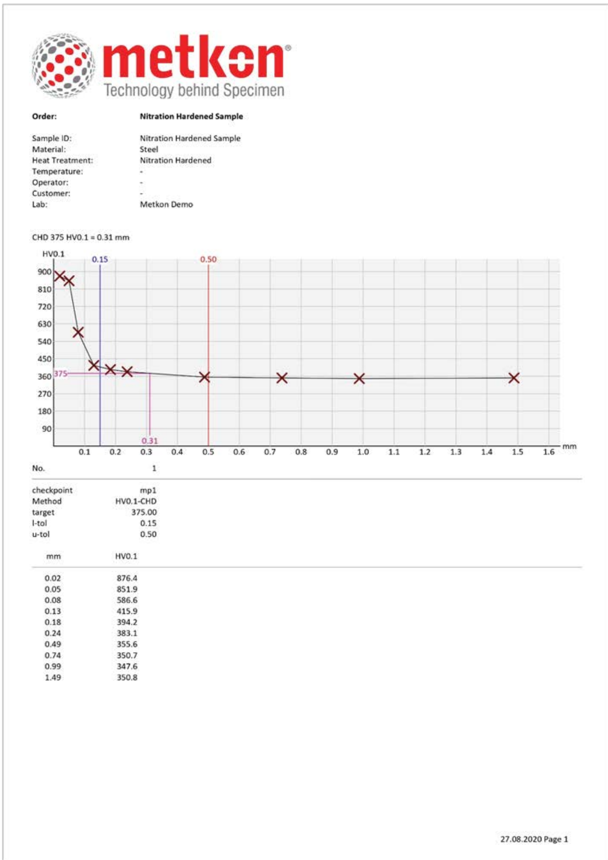
After we set all necessary parameters, we pressed start button for testing. DUROLINE M4 made indent on all 10 measurement points automatically. After that, it measured all indents automatically and generated a CHD graphic.



Indents for first and second sections:



After that we export all test result as a pdf report:
(Possible to make customization on logo, font type, font size and information related to sample)



metkon
Technology behind Specimen

Order: **Nitration Hardened Sample**

Sample ID:	Nitration Hardened Sample
Material:	Steel
Heat Treatment:	Nitration Hardened
Temperature:	-
Operator:	-
Customer:	-
Lab:	Metkon Demo

CHD 375 HV0.1 = 0.31 mm

No.	1
checkpoint	mp1
Method	HV0.1-CHD
target	375.00
l-tol	0.15
u-tol	0.50

mm	HV0.1
0.02	876.4
0.05	851.9
0.08	586.6
0.13	415.9
0.18	394.2
0.24	383.1
0.49	355.6
0.74	350.7
0.99	347.6
1.49	350.8

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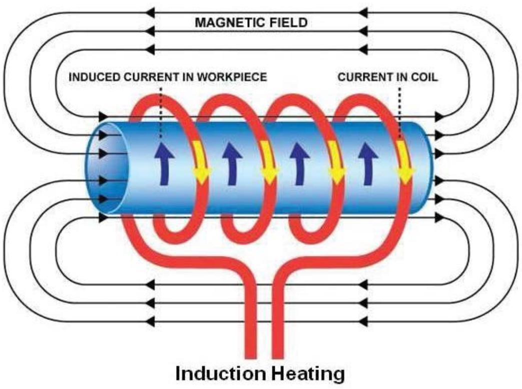
2. PREPARATION OF INDUCTION-HARDENED STEEL PART

INTRODUCTION

Induction hardening is a form of heat treatment in which a metal part is heated by induction heating and then quenched. The quenched metal undergoes amartensitic transformation, increasing the hardness and brittleness of the part. Induction hardening is used to selectively harden areas of a part or assembly without affecting the properties of the part as a whole.

Induction heating is a non contact heating process which utilises the principle of electromagnetic induction to produce heat inside the surface layer of a work-piece. By placing a conductive material into a strong alternating magnetic field, electrical current can be made to flow in the material thereby creating heat due to the I2R losses in the material. In magnetic materials, further heat is generated below the curie point due to hysteresis losses. The current generated flows predominantly in the surface layer, the depth of this layer being dictated by the frequency of the alternating field, the surface power density, the permeability of the material, the heat time and the diameter of the bar or material thickness. By quenching this heated layer in water, oil, or a polymer based quench, the surface layer is altered to form amartensitic structure which is harder than the base metal.



Investigated samples with requested cutting lines.

SAMPLE PREPARATION PROCESES

As samples in different size, we have used 2 different clamping way and both of them was success. In the first clamping, we have only used GR 0030 quick acting clamping vise assembly. You can see detailed explanations
below.

In these cutting operations, we have cut 2 side of sample in order to acquire parallel surfaces to take very parallel slice from sample. After that, we took the slice middle of the sample.

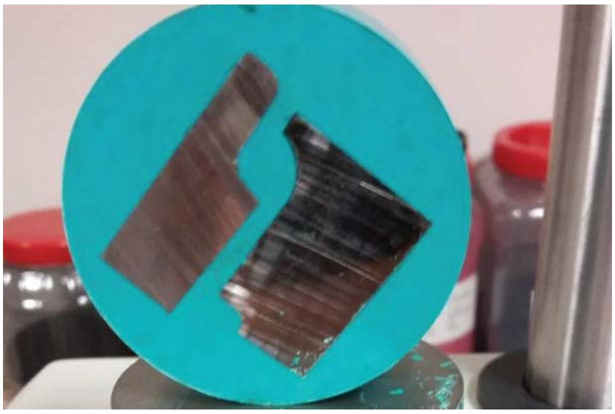
As can be seen, clamped sample cut with very good parallelism with X-axis. We hadn't needed to re-clamp the sample(it can cause to lose parallelism). Operation completed with only automatic X-axis movement.

In the second clamping way, we have used 2 x 15 02 vertical clamping device with clamping shoe. You can see detailed explanations below.

Also with the help of laser unit we can see the exact cutting point on our sample as in above photos.

We clamped 2 side of sample(front and back side) and made the first cut. After that, again without any movement, we just re-located the sample with automatic X-axis. In that way sample did not moved at all.

The cutting parameters are below;
The Table feedrate is adjusted to; 100-300 µ / sec
The Rpm is adjusted to; 2200
The Force is adjusted to; 8A



Mounting Parameters	
Heating Temperature	180˚C
Pressure	240 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35˚C

The polishing operation have been made with DIGIPREP 251 machine by using following parameters;

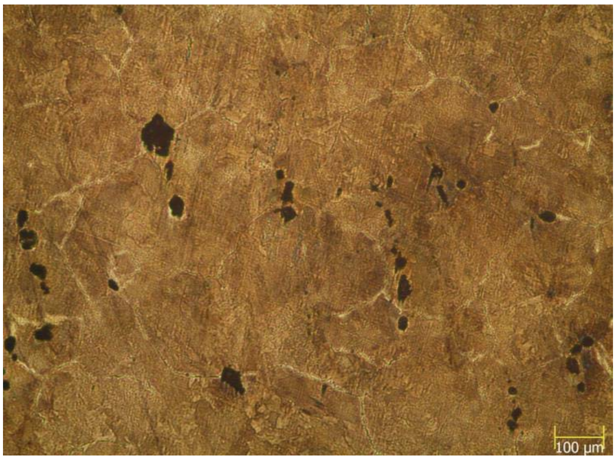
	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grind. Step 1	MAGNETO I 38-040-54	Diamond 54 µ	Water	20 N	1 min.	250 CW	100 CW
Grind. Step 2	MAGNETO II 38-040-018	Diamond 18 µ	Water	25 N	2 min.	250 CW	100 CW
Final Grinding	MAGNETO III 38-040-006	Diamond 6 µ	Water	25 N	2 min.	250 CW	100 CW
Polishing Step 1	FEDO-3 39-025-250	DIAPAT-M 3µ 39-420-M	DIAPAT [39-502]	25 N	3 min.	150 CW	75 CCW
Final Polishing	FEDO-1 39-065-250	DIAPAT-M 1µ 39-410-M	DIAPAT [39-502]	20 N	2 min.	150 CW	50 CCW

Etching: Nital %3

RESULT

You can see the both slices which have been cut with 2 different way.

After the preparation; sample observed in the metallographic microscope. Microstructure of sample can be seen below.



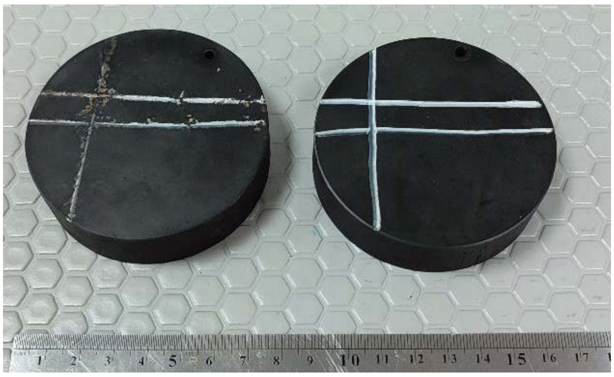
For big piece on bakalite (100x)

Panoramic

3. VICKERS HARDNESS DETERMINATION OF NITRATED VALVE COMPONENTS

INTRODUCTION

In this application, valve components samples prepared with Metallographic method and measuring Vickers hardness value.

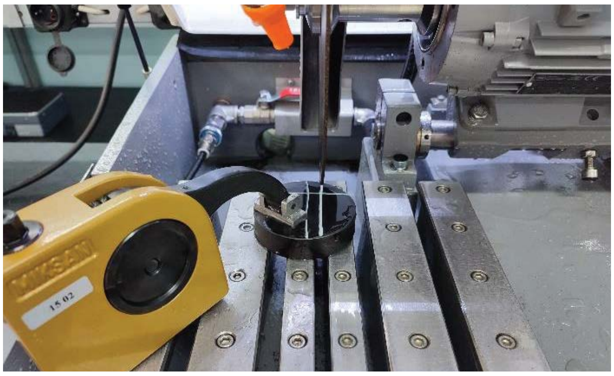


Mounting Parameters	
Heating Temperature	180°C
Pressure	240 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35°C

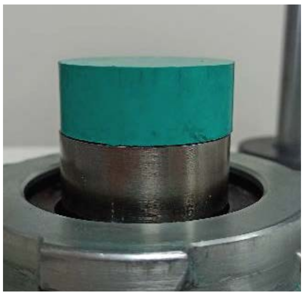
Mounted valve component samples were prepared with Forcipol 102 + Focimat 52.

SAMPLE PREPARATION PROCESES

By the help of vertical clamping shoe (15-02) samples fixed Metacut 302 abrasive cutting machine table. According to request line we completed cutting operation and obtain to samples for mounting process.

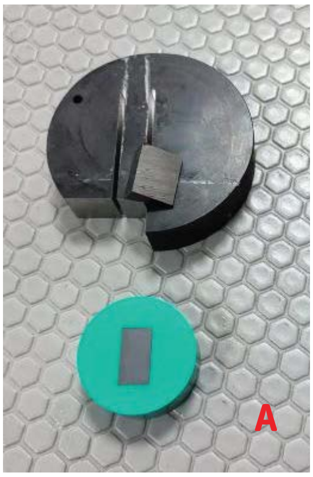


After cutting operation, samples mounted with Diallyphtalat (DAP) polymeric powder in ECOPRESS 102 press.

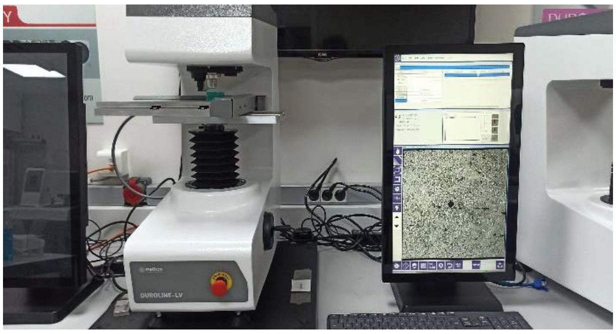


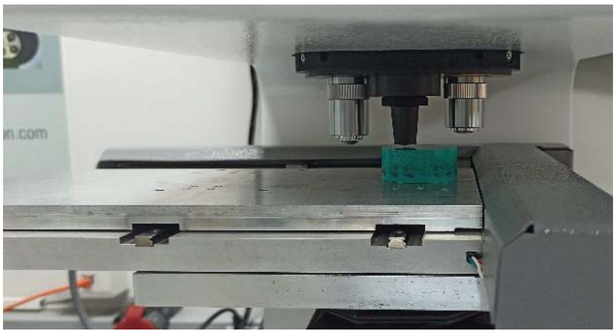
	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grinding Step 1	DEMPAX-F 38-040-240F	240 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Grinding Step 1	DEMPAX-F 38-040-600F	600 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Final Grinding	DEMPAX-F 38-040-1200F	1200 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Polishing Step 1	METAPO-B 39-033-250	DIAPAT-M 3µ 39-420-M	DIAPAT 39-502	20 N	4 min.	150 CCW	75 CW
Final Polishing	FEDO-1M 39-065-250	DIAPAT-M 1µ 39-410-M	DIAPAT 39-502	15 N	2 min.	150 CCW	75 CW

Etching: Nital %3



Nitrated specimens after polished they were light etched and hardness values determinated under HV 0.1 (0.1 kg) load with CHD method start from nitrated layer to core.

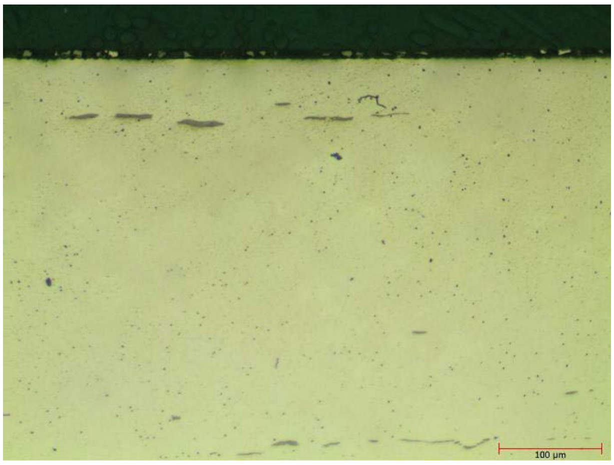




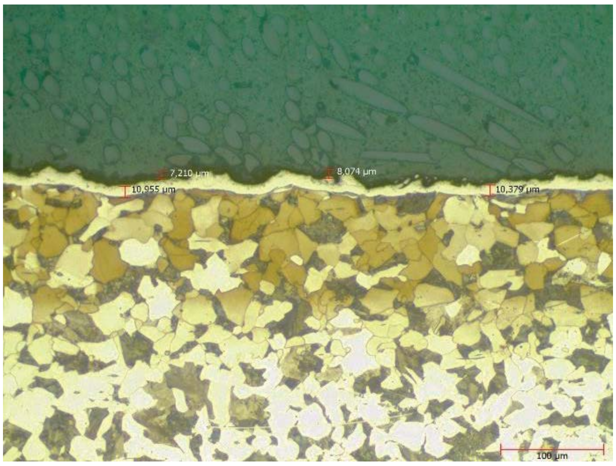
RESULT

Samples hardness determination values and microstructure observation in the below:

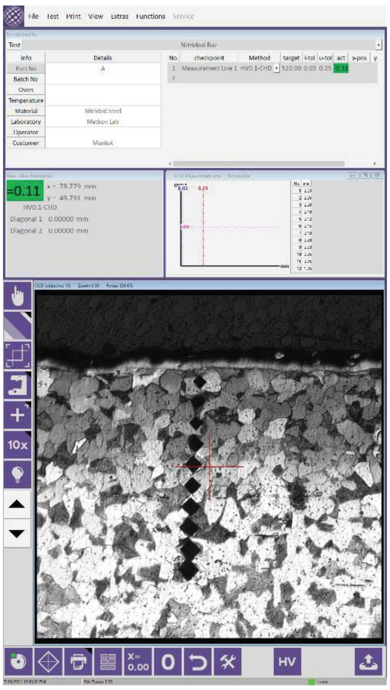
Sample A

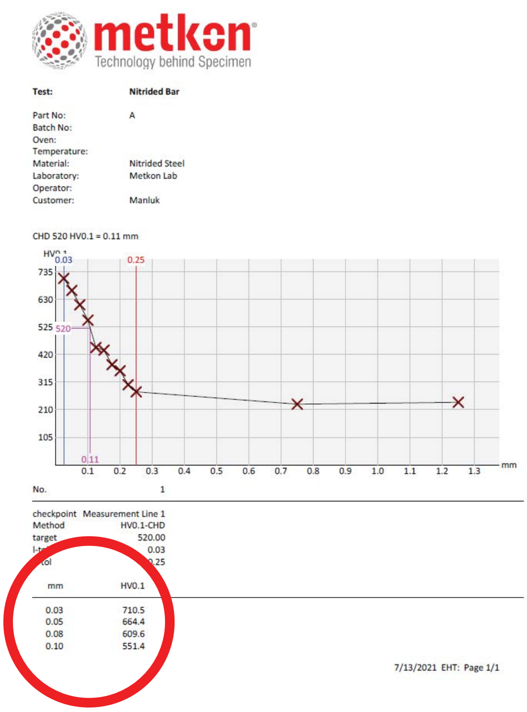


200x Polished



200x Etched





metkon Technology behind Specimen

Test: **Nitrided Bar**

Part No: A
Batch No:
Oven:
Temperature:
Material: Nitrided Steel
Laboratory: Metkon Lab
Operator:
Customer: Manluk

CHD 520 HV0.1 = 0.11 mm

No. 1

checkpoint Measurement Line 1
Method HV0.1-CHD
target 520.00
l-tol 0.03
u-tol 0.25

mm	HV0.1
0.03	710.5
0.05	664.4
0.08	609.6
0.10	551.4

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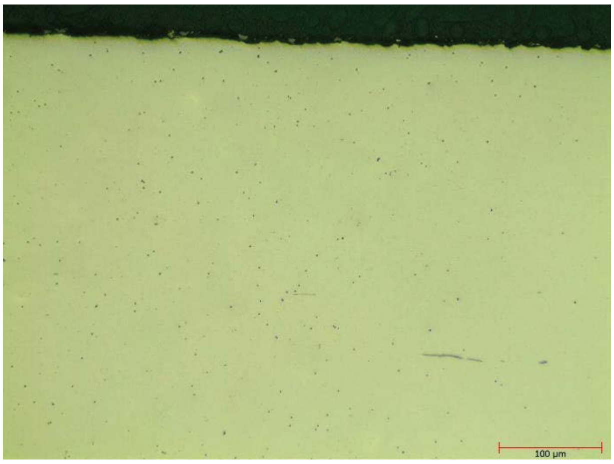
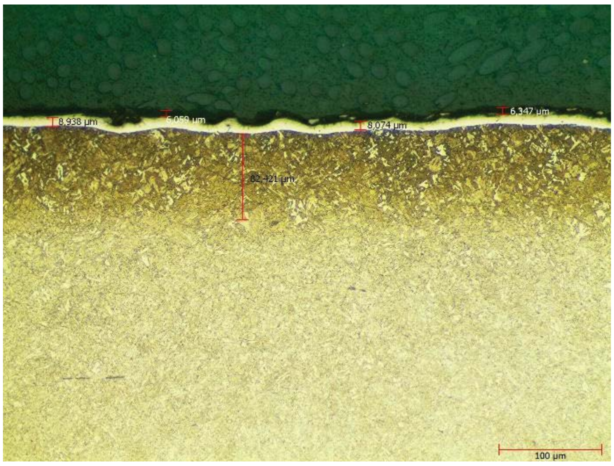
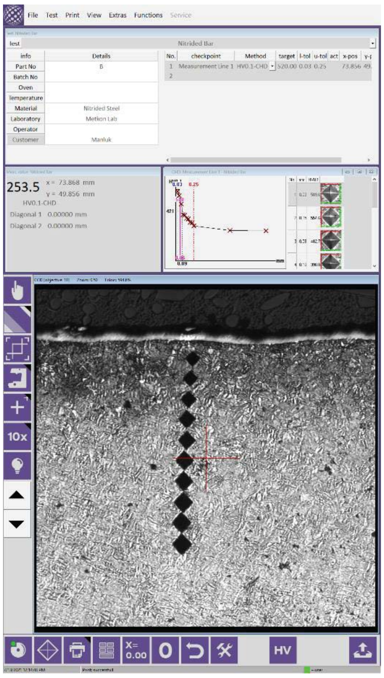
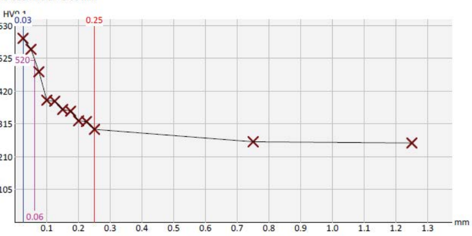
mm	HV0.1
0.13	447.1
0.15	436.9
0.18	381.6
0.20	358.3
0.23	305.2
0.25	278.4
0.75	231.1
1.25	238.3

Sample B









metkon Technology behind Specimen

Test:	**Nitrided Bar**
Part No:	B
Batch No:	
Oven:	
Temperature:	
Material:	Nitrided Steel
Laboratory:	Metkon Lab
Operator:	
Customer:	Manluk

CHD 520 HV0.1 = 0.06 mm

No. 1

checkpoint Measurement Line 1
Method HV0.1-CHD
target 520.00
l-tol 0.03

mm	HV0.1
0.03	589.6
0.05	554.6
0.08	482.7
0.10	390.8

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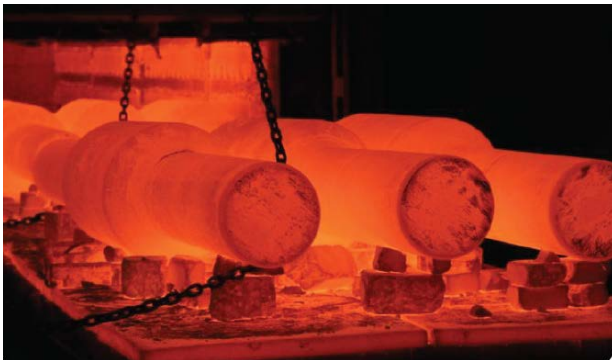
mm	HV0.1
0.13	387.9
0.15	361.3
0.18	356.2
0.20	324.8
0.23	322.8
0.25	297.4
0.75	257.5
1.25	253.5

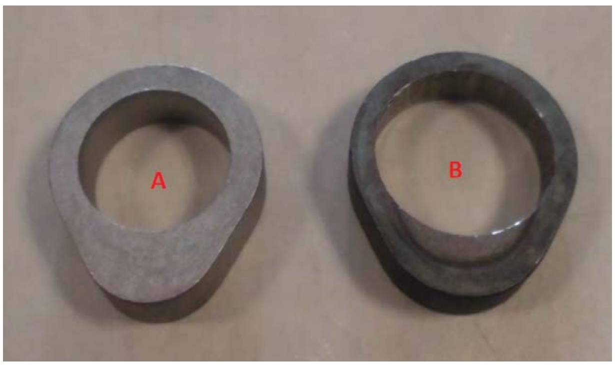
4. METALLOGRAPHIC PREPARATION OF BLANK & HEAT TREATED SAMPLES

INTRODUCTION

Heat treating is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering and quenching. It is noteworthy that while the term heat treatment applies only to processes where the heating and cooling are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

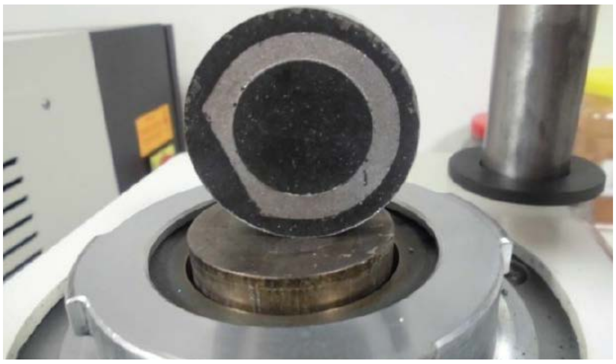


In this application we have prepared 2 sample as A and B.



SAMPLE PREPARATION PROCESES

Samples are attached as they shown in the above photos with GR 0548 and specimen holder(GR 0400).



Mounting Parameters	
Heating Temperature	190˚C
Pressure	260 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35˚C

The polishing operation have been made with FORCIPOL 2V & FORCIMAT machine by using following parameters;

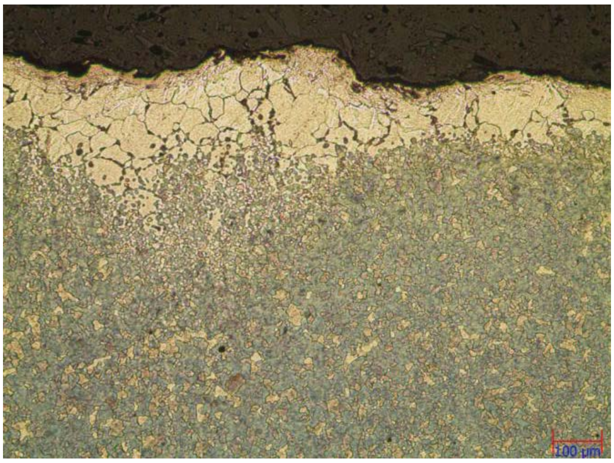
	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grinding Step 1	MAGNETO I 38-040-054	Diamond 54 µ	Water	20 N	Until Plane	200	100
Grinding Step 1	MAGNETO II 38-040-018	Diamond 18 µ	Water	25 N	2 min.	200	100
Final Grinding	MANETO III 38-040-006	Diamond 6 µ	Water	25 N	2 min.	200	100
Polishing Step 1	METAPO-B 39-033-250	DIAPAT-M 3µ 39-420-M	DIAPAT 39-502	20 N	3 min.	150	75
Final Polishing	FEDO-1M 39-065-250	DIAPAT-M 1µ 39-410-M	DIAPAT 39-502	15 N	2 min.	150	50

Etching: Nital %3

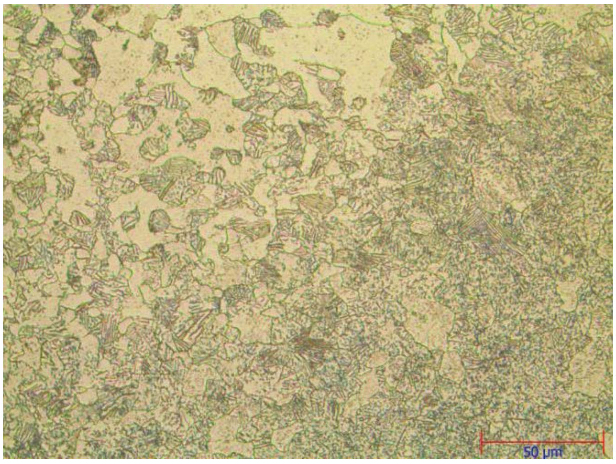
RESULT

After the preparation; samples observed in the metallographic microscope. Microstructure of samples can be seen below.

Sample A



100x outer surface



500x outer surface

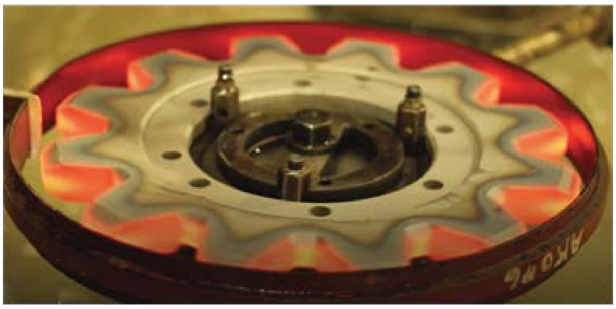
Sample B

200x outer surface

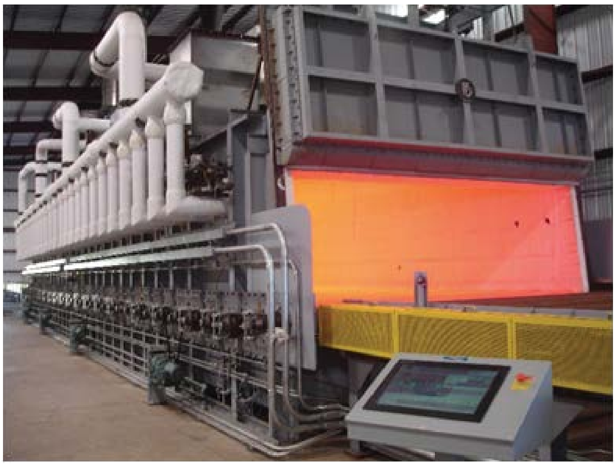
5. METALLOGRAPHIC PREPARATION OF HEAT TREATED GEAR PART

INTRODUCTION

In the present sense of the term, the 'steel industry' began around the 1870s. Of metallurgical science there was likewise essentially none previous to that day. None was possible until the modern science of chemistry came into existence in the early decades of the 19th century. Quickly thereafter, chemical analysis became an important laboratory activity, and, by 1870, the major chemical components of cast iron and steel were generally recognized. It was realized that carbon was the somewhat inconsistent heroine of the play, phosphorus and sulfur the villains, silicon and manganese controlled the action, and oxygen furnished the suspense – all these working in complicated unison to develop the character of the iron.

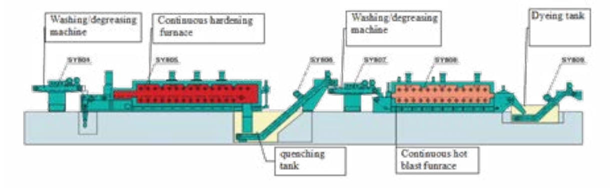


Heat treatment is an endeavor to obtain the maximum efficiency of the material under the demanding conditions of service. Steel is an outstanding versatile engineering material, with which the reader will also agree because it is used in the widest variety of products. Much of the versatility of steel arises due to the fact that the properties of the steel can be controlled and changed at will (though within reasonable good limits) by heat treatment. For example, if the steel is to be deformed into intricate shape, then, it can be made very soft and ductile by one heat treatment cycle; if on the other hand, it is supposed to resist wear, it can be heat treated to a very hard and wear resistant state by another cycle.



A process of metal heat treatment. Reheat the quenched workpiece to a proper temperature lower than the lower critical temperature, and heat treat the metal cooled in air, water, oil and other media after holding for a period of time.

Heat the quenched alloy workpiece to a proper temperature, keep it warm for some time, and then cool it slowly or rapidly. Generally used to reduce or eliminate the internal stress in the quenched steel, or reduce its hardness and strength to improve its ductility or toughness. According to different requirements, low temperature tempering, medium temperature tempering or high temperature tempering can be used. Generally, with the increase of tempering temperature, hardness and strength decrease, ductility or toughness gradually increase.



After quenching, the workpiece has the following characteristics: The unbalanced (i.e. unstable) structures such as martensite, bainite and retained austenite are obtained. There is a large internal stress. The mechanical properties can not meet the requirements. As a result, steel parts are usually tempered after quenching.

It is required that workpieces with different applications shall be tempered at different temperatures to meet the requirements in use. Tools, bearings, carburized and quenched parts and surface quenched parts are usually tempered at low temperature below 250 ˚C. After low temperature tempering, hardness changes little, internal stress decreases and toughness slightly increases. The spring can obtain high elasticity and necessary toughness by tempering at 350 ~ 500 ˚C. The parts made of medium carbon structural steel are usually tempered at 500-600 ˚C to obtain a good fit of strength and toughness. The heat treatment process of quenching and high temperature tempering is generally called tempering.

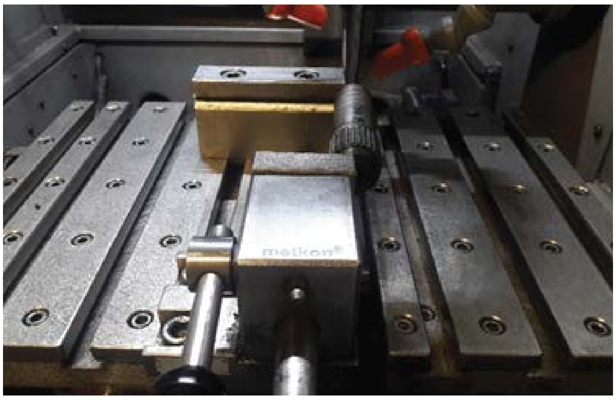
The first kind of temper brittleness is also called irreversible temper brittleness. Low temperature temper brittleness mainly occurs when the temper temperature is 250-400 ˚C, characterized.

In this application, Heat-treated gear samples, which we are using in automotive industry, will be prepared for Vickers hardness testing purpose.

A parallel, reflective and clean sample surface is needed for Vickers hardness testing. There should be no structure deformation due to heat generation and mechanical deformation during sample preparation process. To obtain required surface quality and to avoid deformations, suitable equipment and correct parameters should be used.

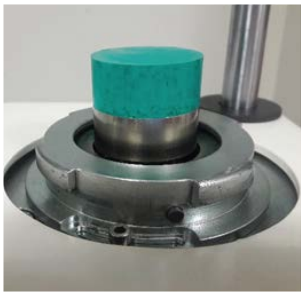
SAMPLE PREPARATION PROCESES

With the help of GR 0172 Quick Acting Clamping Vise Gear sample fixed to SERVOCUT 302 Automatic Abrasive Cutting Machine table.



Cutting Parameters	
Feed rate	250 µ/sec.
RPM	2200 r/min.
Travel	35- 115 mm.
Force	6.5 A

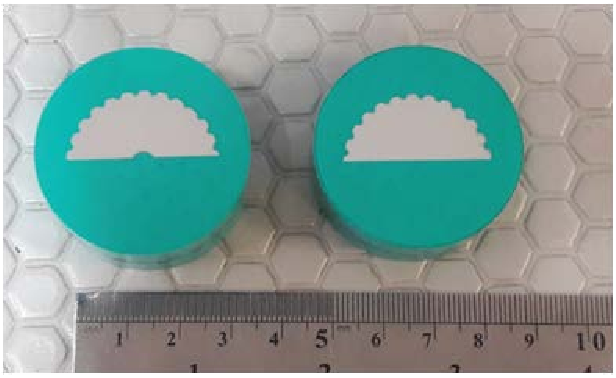
After cutting operation, samples mounted with Diallyptalat powder in ECOPRESS 102 Programmable Automatic Hot Mounting Press.



Mounting Parameters	
Heating Temperature	180°C
Pressure	260 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35°C

We applied grinding&polishing recipe to welded steel specimens with the parameters below;

	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grind. Step 1	DEMPAX-F 38-040-320F	320 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Grind. Step 2	DEMPAX-F 38-040-600F	600 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Final Grinding	DEMPAX-F 38-040-1200F	1200 Grit SiC	Water	25 N	3 min.	250 CW	100 CW
Polishing Step 1	FEDO-3 39-025-250	DIAPAT-M 3µ 39-420-M	DIAPAT [39-502]	20 N	3 min.	150 CCW	75 CW
Final Polishing	FEDO-1M 39-065-250	DIAPAT-M 1µ 39-410-M	DIAPAT [39-502]	15 N	2 min.	150 CCW	50 CW



6. MICROSTRUCTURAL AND HARDNESS EXAMINATION OF 21NiCrMo2 GEAR PIECE

INTRODUCTION

Gear is machine component consisting of a toothed wheel attached to a rotating shaft. Gears operate in pairs to transmit and modify rotary motion and torque (turning force) without slip, the teeth of one gear engaging the teeth on a mating gear. If the teeth on a pair of mating gears are arranged on circles, i.e., if the gears are toothed wheels, the ratios of the rotary speeds and torques of the shafts are constant. If the teeth are arranged on noncircular bodies the speed and torque ratios vary.

Most gears are circular. To transmit motion smoothly and with a nonvarying speed ratio at every instant, the contacting surfaces of gear teeth must be carefully shaped to a specific profile. If the smaller of a gear pair (the pinion) is on the driving shaft, the pair acts to reduce speed and to amplify torque; if the pinion is on the driven shaft the pair acts as a speed increaser and a torque reducer. If the driven gear has twice as many teeth as the pinion, for example, the torque of the driven gear is twice the pinion torque, whereas the pinion speed is twice the speed of the driven gear.

In this application, 21NiCrMo2 transmission gear sample will be prepared metallographically and an examination will be made by applying hardness scanning with HV1 load from the requested regions.

SAMPLE PREPARATION PROCESES

First, a piece was taken from 21NiCrMo2 gear sample, suitable for SERVOCUT 302 device, and this piece was fixed to the table of Servocut-302 device with the help of GR-0170 cam mechanism left group vise and cutting operations were completed.

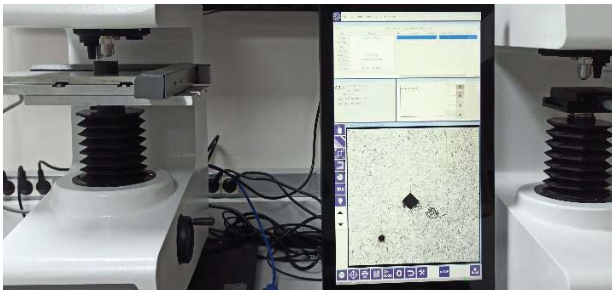
Cutting Parameters	
Feed rate	200 µ/sec.
RPM	2500 r/min.
Travel	40- 60 mm.
Force	8.0 A.

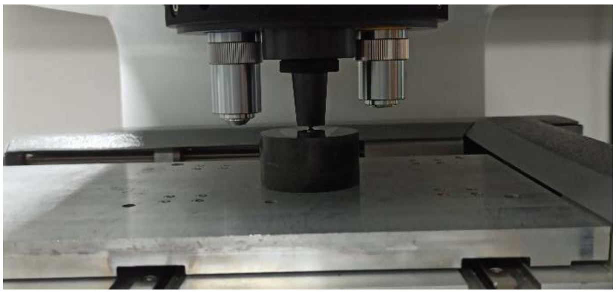
Samples have been molded with the Ecopress 102 Programmable Automatic Sample Molding Press using Epoxy hot bakelite powder.

Mounting Parameters	
Heating Temperature	180˚C
Pressure	260 bar
Heating Time	3 mins.
Cooling Type	Standart Cooling
Cooling Temperature	35˚C

Cut samples have been polished in FORCIPOL 202 & FORCIMAT 52 with the following parameters after the molding process.

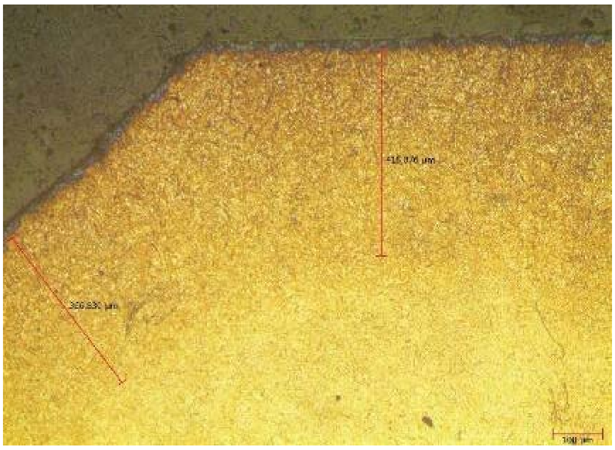
	Surface	Abrasive	Lubricant	Force Per Sample (N)	Time Min.	Disc Speed Rpm.	Head Speed Rpm.
Grind. Step 1	DEMPAX-F 38-040-240F	320 Grit SiC	Water	25 N	Until Plane	250 CW	100 CW
Grind. Step 2	DEMPAX-F 38-040-600F	600 Grit SiC	Water	25 N	2 min.	250 CW	100 CW
Final Grinding	DEMPAX-F 38-040-1200F	1200 Grit SiC	Water	220 N	3 min.	250 CW	100 CW
Polishing Step 1	METAPO-B 39-033-250	DIAPAT-M 3µ 39-420-M	DIAPAT [39-502]	20 N	3 min.	150 CCW	75 CW
Final Polishing	FEDO-1M 39-065-250	DIAPAT-M 1µ 39-410-M	DIAPAT [39-502]	15 N	2 min.	150 CCW	75 CW



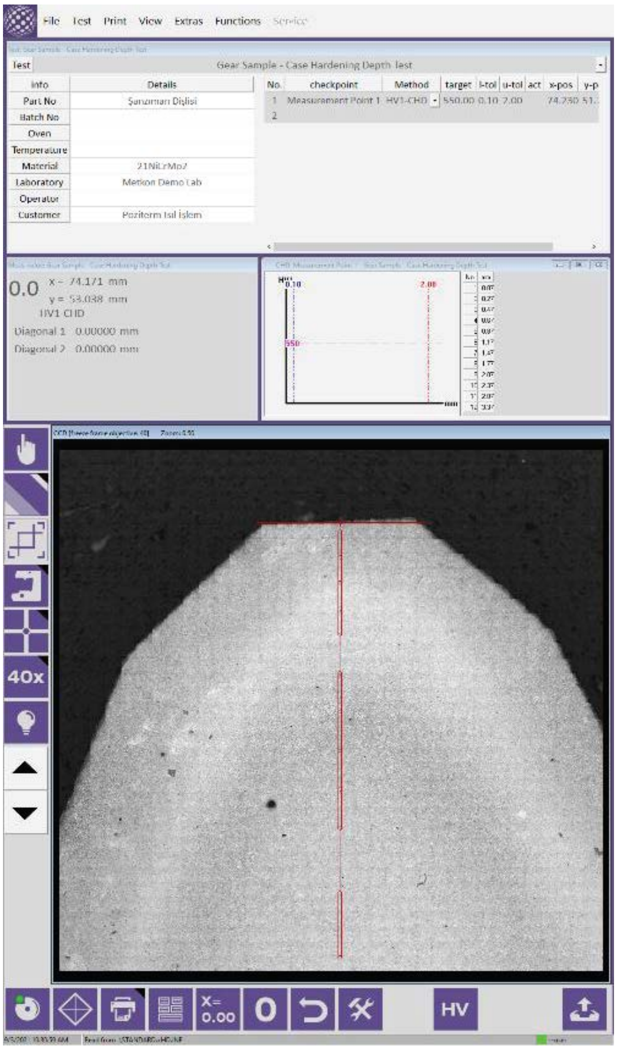


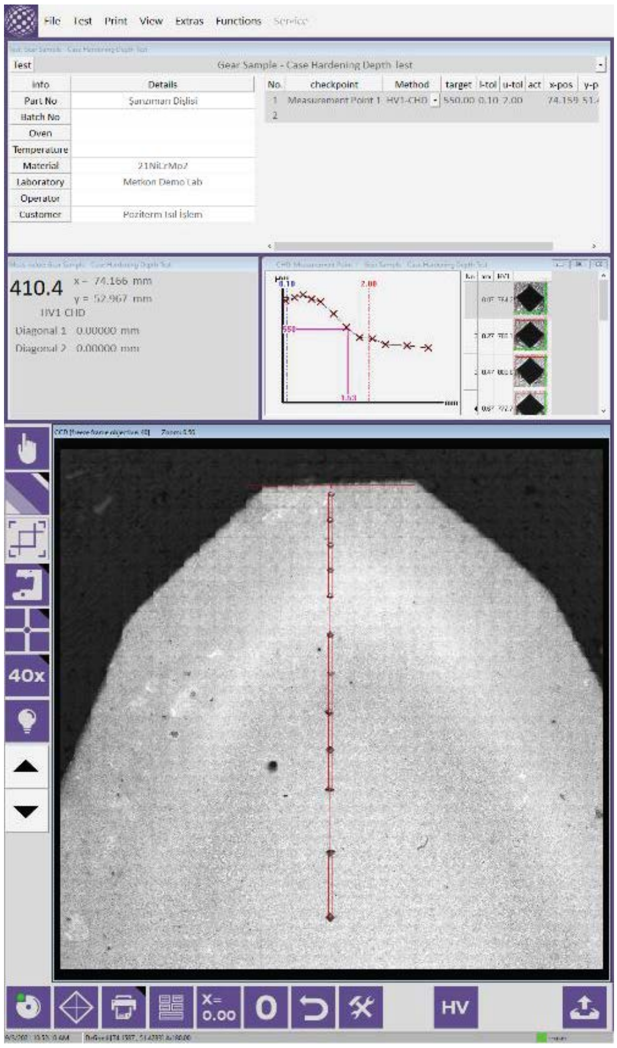
RESULT

Samples microstructure image and hardness measurement points are as follows.



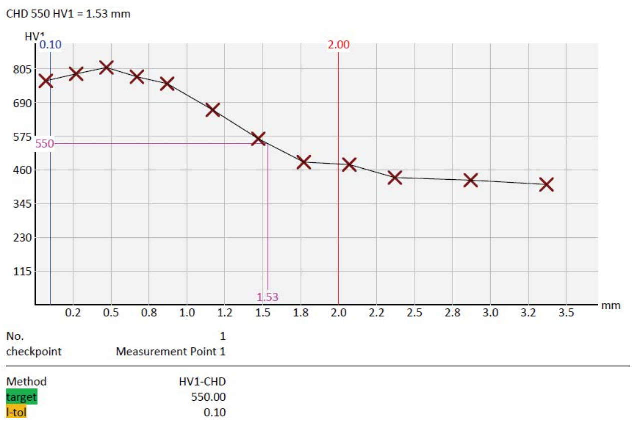
Hardness scanning has been performed under HV1 (1 kg) load in order to determine the cemented area of samples that had heat treatment applied to cement. By the help of the scanning function, 4x4 mm area from the toothed part of the sample has been scanned.

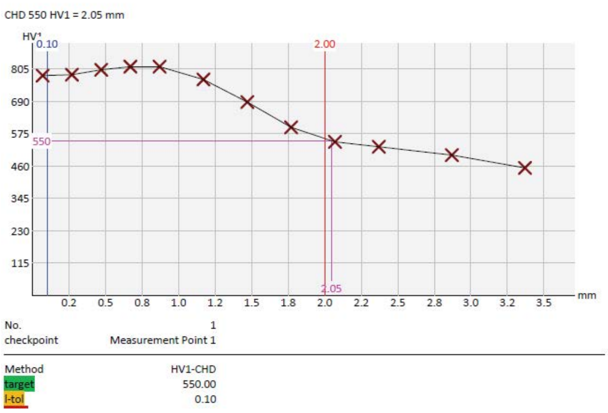




Starting from the 0.07 mm end of the gear, 5 measurements of 0.2 mm, 5 measurements of 0.3 mm and 2 units of 0.5 mm were taken.

As a result of the scanning, it was observed that the target hardness value of 550 HV was reached at 1.53 mm in the 1st gear and at 2.05 mm in the 2nd gear.





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full range of equipment to deliver repeatable and reproducible quality of test results.

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HOT MOUNTING


ECOPRESS 52


ECOPRESS 102


ECOPRESS 202

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FORCIPLAN 102

MODULAR GRINDING & POLISHING


FORCIPOL 102


FORCIPOL 202


FORCIPOL CONTROL UNIT


FORCIMAT 52


FORCIMAT 102

ADVANCED GRINDIG & POLISHING


ACCURA 102

ELECTROLYTIC PREPARATION


ELOPREP 102

PORTABLE METALLOGRAPHY


MOBIPREP


MOBISCOPE

MICROSCOPY

UPRIGHT

UPM 902

INVERT

IMM 901

IMM 902

POLARIZE

IPP 902

STEREO

PST 901

PST 902

HARDNESS TESTING

VICKERS HARDNESS TESTING

10 gf - 1 kgf

DUROLINE M1/M2/M4

100 gf - 10 kgf

DUROLINE LV1/LV2/LV4

300 gf - 30 kgf

DUROLINE V1

ROCKWELL HARDNESS TESTING

3 kgf - 250 kgf

DUROLINE R1

metkon
Technology behind Specimen

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