

Application Note

Carbon Determination for the Control of Carburization in Heat Treatment Processes

G4 ICARUS HF

I. Introduction

A tough core and hard casing are the target properties of components made of case-hardened steel. The combination of wear resistance and fatigue strength in the surface and impact strength in the core is achieved by carburizing the surface layer of the component.

In the carburization process for surface hardening of low-carbon steels the material is treated in a carbon-rich atmosphere. The atmosphere is produced with a gas generator from methane, ethane or propane and consists primarily of CO, H₂ and N₂ at temperatures of about 850°C to 980°C in a special tempering kiln where carbon atoms can diffuse into the surface layer of the work piece. The carburization depth depends on the temperature, gas composition and treatment time. Quenching and tempering following the carburization process produces a high-carbon martensitic structure near the surface with superior hardness and wear resistance, while the core retains its original strength and toughness properties.

The case hardening depth of carburized steel is a function of carburizing time and the available carbon potential at the surface. The precise control of the 'carbon-bearing' atmosphere is mandatory during the entire carburization process, which can take several hours or even up to days to complete. The most important control parameter in the process is the 'carbon potential' which depends on temperature and gas composition.

Direct furnace atmosphere analysis is used to determine the carbon potential and is made by the 'shim stock' method, which utilizes heat treatment test foils that are placed inside the furnace. The test foils are exposed to the carburization atmosphere for a sufficient dwell time that allows saturation of carbon in austenite for the temperature selected.

Such test foils are made of 0.1 - 0.4 mm thick low-carbon annealed steel sheets or gauze that are free of oil, grease, or dirt and have an initial carbon concentration of approximately 0.1% C. The measurement of the carbon content in the exposed test samples, which corresponds to the carbon potential in the furnace, can be performed most precisely and rapid by the combustion method.

Measuring Principle

Using the combustion method with a high frequency induction furnace and infrared detection the **G4 ICARUS HF** proves highly effective for rapid and precise carbon and sulfur measurements, especially with metallic-based materials.

The solid sample, placed in a ceramic crucible together with accelerator material, is combusted in the high-frequency furnace in an oxygen-rich environment. The carbon and sulfur components in the sample are oxidized to release CO_2 and SO_2 , respectively. These measuring components are swept by the carrier gas (O_2) to the solid-state non-dispersive infrared (NDIR) detector system of maximum selectivity and stability.



The analyzer features as standard two measuring ranges for both CO_2 and SO_2 with automatic baseline compensation and automatic optimum range selection. The calibration of the analyzer is made by means of a certified reference material (CRM).

Note: For heat treatment applications (i.e., carburization foils) a special version of the G4 ICARUS HF is available that features a very precise single NDIR detector for CO_2 . The measuring range of this analyzer is optimized for the carbon concentration range of the base foils (i.e., approximately 0.1% C) and the charged material after the carburization process (i.e., up to approximately 1.5% C).

The analyzer is characterized by an intuitive software interface on an external PC. During analysis detector signals are displayed in real-time on the screen and upon completion the final results and parametric data are displayed and archived for future reference.

The innovative design of the combustion area (**patent pending**) with the gas outlet positioned directly above the ceramic crucible efficiently removes most of the formed metal oxide particles leading to drastically reduced contamination of the quartz combustion tube by dust and slag. The integrated pressure and flow regulation enable a fully automatic leak test which can be invoked via the software.

III. Sample Preparation



Example of a test steel gauze

No special sample preparation is required for this application. The test foils must be free of grease, oil and dirt. Carburized test foils are wrapped, wound, or folded such that they fit into the ceramic crucible. The typical sample weight is approximately 0.5 to 1 g.



Test foil in crucible

IV. Consumables

Ceramic crucible JW-N009250423
 Magnesium perchlorate JW-L031V05873
 Sodium hydroxide on carrier JW-L031U01564

V. Accelerator Material

Tungsten granules JW-L030000217, or
 Copper granules JW-L014000366

VI. Analysis Procedure

The copper accelerator (e.g., approximately 1.3 g) is added to an annealed combustion crucible. Then the wrapped or folded test foil is weighed and placed into the crucible. After electronically transferring the sample weight from the balance, entering the sample code and comment (if applicable), and placing the crucible on the crucible carrier, the analysis is started.

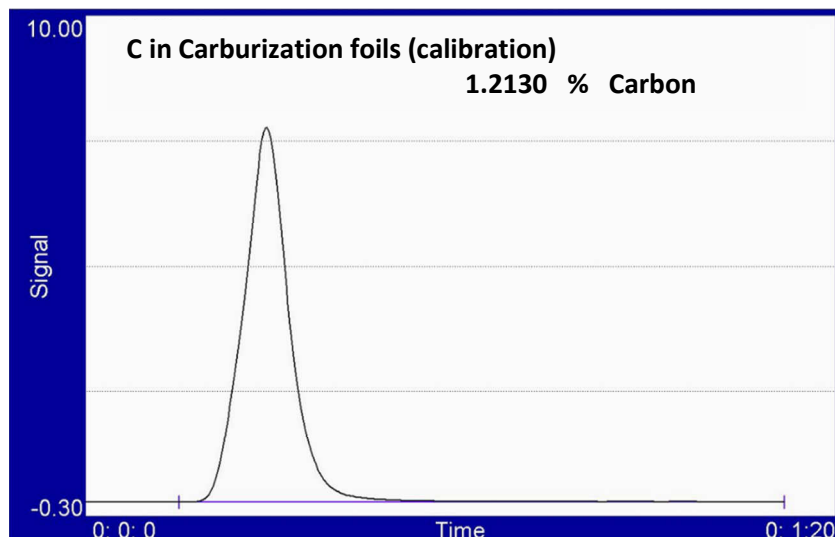


VII. Analysis Parameters

Configuration			
Configuration name:	C in Carburization Test Foils		
Comment:	G4 ICARUS HF		
Analysis:			
	Time [s]		Power level
Purge:	10 [s]		
Startdelay:	5	5-30	
Baseline check (before analysis):	5	5-30	
Analysis time 1:	50	15-600	4 0-4
Analysis time 2:	10	1-600	0 0 or unchanged
Baseline check (after analysis):	5	5-30	
Detectors:			
Carbon:	<input type="checkbox"/> Carbon (low)	<input checked="" type="checkbox"/> Carbon (high)	
Sulfur:	<input type="checkbox"/> Sulfur (low)	<input type="checkbox"/> Sulfur (high)	
Gas:	<input checked="" type="checkbox"/> Gas flow [l/min]	<input checked="" type="checkbox"/> Furnace pressure [bar]	
Show results in:	<input type="radio"/> ppm	<input checked="" type="radio"/> %	

VIII. Calibration

The calibration of the analyzer is made by means of a certified reference material (CRM) using the single point calibration.



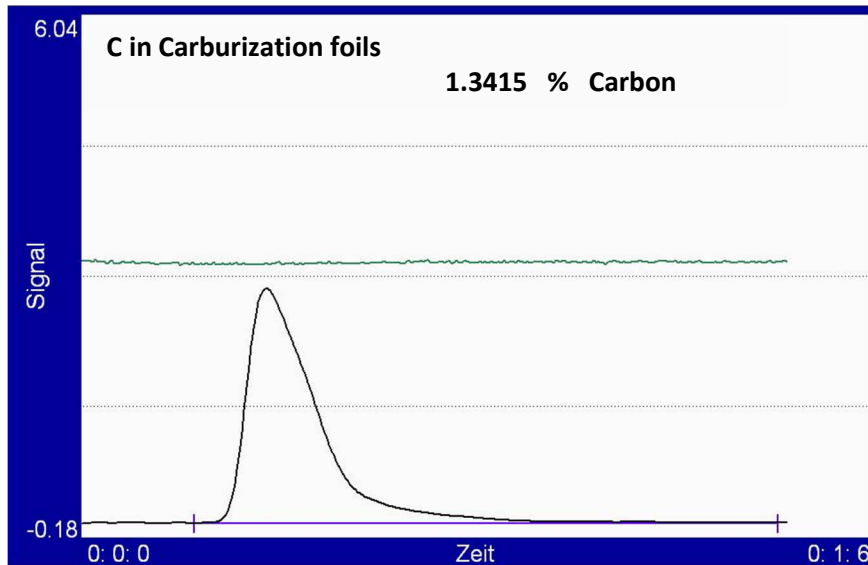
Typical calibration signal

CRM:
 Euronorm-ZRM 283-1
 High-speed steel

$C = 1.219 \pm 0.009 \%$

IX. Analysis Results

Typical Analysis Signal



Carburization Foil

Dwell time in furnace:
15 – 30 min

Sample weight:
0.5002 g

Analysis time: 60 s

Typical Analysis Results

a) Carburization at 930°C, target C level approximately 1.3 - 1.4%

Lot	Time	Sample weight	Sample Code	Comment	Carbon (%)
1	20:20	0,5002 g	Foil 930°C	1x Cu	1,3415
1	22:35	0,4891 g	Foil 930°C	1x Cu	1,4055

2	04:55	0,5016 g	Foil 930°C	1x Cu	1,2556
2	07:06	0,5071 g	Foil 930°C	1x Cu	1,3705

b) Carburization at 820°C, target C level approximately 0.6 – 0.7%

Lot	Time	Sample weight	Sample Code	Comment	Carbon (%)
3	07:00	0,5406 g	Foil 820°C	1x Cu	0,6209
3	08:15	0,4936 g	Foil 820°C	1x Cu	0,6350

4	13:00	0,4876 g	Foil 820°C	1x Cu	0,6287
4	18:08	0,4818 g	Foil 820°C	1x Cu	0,6282

Our service to you:

We would be pleased to examine your samples in our applications laboratory. We invite you to convince yourself of the high performance of our advanced technology analyzers.

All configuration and specifications are subject to change without notice.
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