Low Pressure Carburizing and Corresponding Furnace Solutions

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Industrial Load with 900 Nozzles
Industrial load with 10200 “Nozzle bodies”

Detail view

Total view

Hardness Profiles of three nozzle bodies from layer 1, 6 and 12

Distance from surface in mm

Hardness in HV1

- \( T = 930 \, ^\circ \text{C} \)
- \( t = 70 \, \text{min} \)
- 20 bar \( N_2 \)
**AvaC® Process Procedure**

- **Temperature T**: 850 - 1100 °C
- **Pressure p**: -10 - 1000 Pa

**Carbon Profile Development**

- **CD<sub>1</sub>**
- **CD<sub>2</sub>**
- **CD<sub>3</sub>**
- **CD<sub>4</sub>**

**Cycle with pulsed pressure**

- **Carburize 1**
- **Diffuse 1**
- **Carburize 2**
- **Diffuse 2**
Case depths with constant and pulsed pressure

- **C₂H₂**
- **t = 86 min**
- **T = 900 °C**
- **16MnCr5**
- **p = const.**
- **p = pulsed**

Carbon Transfer with Acetylene

- Monolayer Carbon

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Sensors

Standard Sensors/Controlled Process Parameters:
• Furnace Temperature
• Furnace Pressure
• C₂H₂-Flow
• Boost-/Diffusion Times

Additional Monitoring Sensors:
• H₂-Sensor
• O₂-Sensor

Controlling Sensors (research projects, not in use)
• C₂H₂-flow, boost duration (under development)
• Carbon Transfer (available since years, not reliable)

Carburizing in Hydrocarbons

Advantages
- No internal oxidation
- Complex geometries
- Higher carbon transfer
- Faster carburizing
- Shorter cycle duration
- Large CHD
- Higher temperatures
- Very small CHD
- Lower gas consumption
- Lower consumption expenses
- No thermal radiation, no flames
- Environmental friendly
- No conditioning of the furnace

Disadvantages
- Formation of soot and tar
- Too high carbon content in edges and tips
- Effusion of Mn, Cr, Si
High Temperature Carburizing

Material: 14NiCrMo13-4
CHD = 2.0 – 2.3 mm
Carburizing Temp.: 1050 °C
Cycle Time: 10.5 h

Example: Mining Shafts

Specification:
Material: ~25NiCrMo12-5
Surface hardness: > 60 HRC
CHD 600: 0.9 - 1.2 mm external > 0.30 mm internal
Core hardness: 400-500 HV30

Results:
Surface hardness: 62-64 HRC
CHD 600: 0.90-0.94 mm external 0.77 mm internal
Core hardness: 460 HV30

T= 950 °C
l= 185 min
p= 1.5 bar N₂
Example: AvaC of aerospace bearings

REQUIREMENTS:
Hardness under the surface: >697 HV1 (60HRC) at 0.3 mm depth
Core hardness: 402-471 HV30 (41-47 HRC)
CHD 650HV1: 0.8-1.2 mm

SAMPLE PARTS SPECIFICATION
Name: Bearing, outer ring
Material: M50NIL
Dimension: Øo = 66.5 mm
Øi = 46.7 mm
l = 66.5 mm
Weight of part: 0.95 kg

HEAT TREATMENT
LPC (AvaC) temperature: 910 °C
LPC time: 20 h
Annealing: 580 °C, 2 h
Hardening temperature: 1080 °C
Sub-zero treatment: < -150 °C, 1 h
Tempering: 545 °C, 2 h

AvaC Results
Surface Hardness: 61.2; 60.9; 60.7 HRC
Core Hardness: 423, 426, 433 HV10
CHD(650HV): 1.10 – 1.12 mm
Wind Power

Material: 18CrNiMo7-6
Weight: 128 kg

Material: 18CrNiMo7-6
Weight: 60 kg

Hardness Profile after Case Hardening

Distance from surface in mm
Hardness in HV1

Furnace: T²T (AvaC), 12bar, N₂
Furnaces for Low Pressure Carburizing

- Single Chamber
- Two Chamber Chamber (Oil or Gas)
- Multi Chamber Furnaces, and
- Automatic Furnaces Lines

Turbo²Treater, etc.

RVHT-QGP 20 bar, etc
Ipsen Turbo²Treater®

Size M Installation at Customer

Ipsen Turbo²Treater®

Graphite Heating Chamber

- Graphite insulation
- Graphite load hearth
- Graphite heating elements

- Heating Power:
  - “S-size”: 75 kW/84 kVA
  - “M-size”: 150 kW/166 kVA
  - “XL-size”: 270 kW/297 kVA

- Special gas distribution system
- Heating chamber door closing system (3 closing positions with 1 turn)
- Load thermocouple feed through connections
Single chamber vacuum furnace line

Fully automatic vacuum furnace line
Loader 1.500 kg, rotating to both sides

Atlas Copco; Sweden
Oil quench vacuum hardening furnace

**RVFOQ-524**
Furnace back side with heating chamber

- Vacuum tight inner door
- Maintenance door for easy and safe access
- Vacuum pump system

Available standard sizes: S, M, XL
Single and two chamber vacuum furnace line

ARGOS Multi Chamber System
### Example: Automotive shaft

<table>
<thead>
<tr>
<th>Part</th>
<th>Shafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>20MnCr5</td>
</tr>
<tr>
<td>Dimensions</td>
<td>( l = 250 \text{ mm} ) ( \varnothing = 30 - 70 \text{ mm} )</td>
</tr>
<tr>
<td>SH</td>
<td>58-62 HRC</td>
</tr>
<tr>
<td>CH</td>
<td>&gt; 340 HV</td>
</tr>
<tr>
<td>CHD</td>
<td>0.5 + 0.4 mm</td>
</tr>
<tr>
<td>Carb.-temp.</td>
<td>950 °C</td>
</tr>
<tr>
<td>Quenching</td>
<td>20 bar, ( \text{N}_2 )</td>
</tr>
</tbody>
</table>

### Charge (similar dimensions)

![Charge Image]
Automotive Results

Surface hardness: 61-62
CHD: 0.58 – 0.83 mm
Core hardness: 345-380 HV10

Quenching: 20 bar, N₂

Low Pressure Carbonitriding Cycle AvaC®-N
Summary

- **AvaC®(-N) Process Description**
  - Boost / Diffuse process
  - Pulsed Pressure Process
  - Acetylene pressure < 10 mbar (Ammonia pressure < 40 mbar)

- **Process Advantages**
  - High carbon transfer rate
  - Optimum case uniformity
  - Part-to-part, load-to-load repeatability
  - Absence of internal oxidation and accurate case uniformity lead to enhanced component quality
  - High furnace availability/reliability due to minimization of soot or tar formation
  - No post cleaning process (with high pressure gas quenching)

- **Furnaces for AvaC**
  - Depending on part size and throughput, Ipsen can provide the right furnace solution for low pressure carburizing

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