Wear Protection with
Borocoat-Diffusion Layers

AVION MANUFACTURING

BorTec
THE EXPERTS FOR WEAR PROTECTION

Outline

Brief Introduction to Heat Treatments

Boronizing

- Properties
- Applications
- Boronizing agents

Surface Treatments

- **Thermal**
  - Flame hardening
  - Induction hardening
  - Electron beam hardening
- **Thermo-chemical**
  - Carburizing
  - Nitriding
  - **Boronizing**
- **Gas phase**
  - CVD
  - PACVD
  - PVD
- **Galvanic**
  - Hard Chrome plating
  - Nickel plating
  - Zinc plating

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

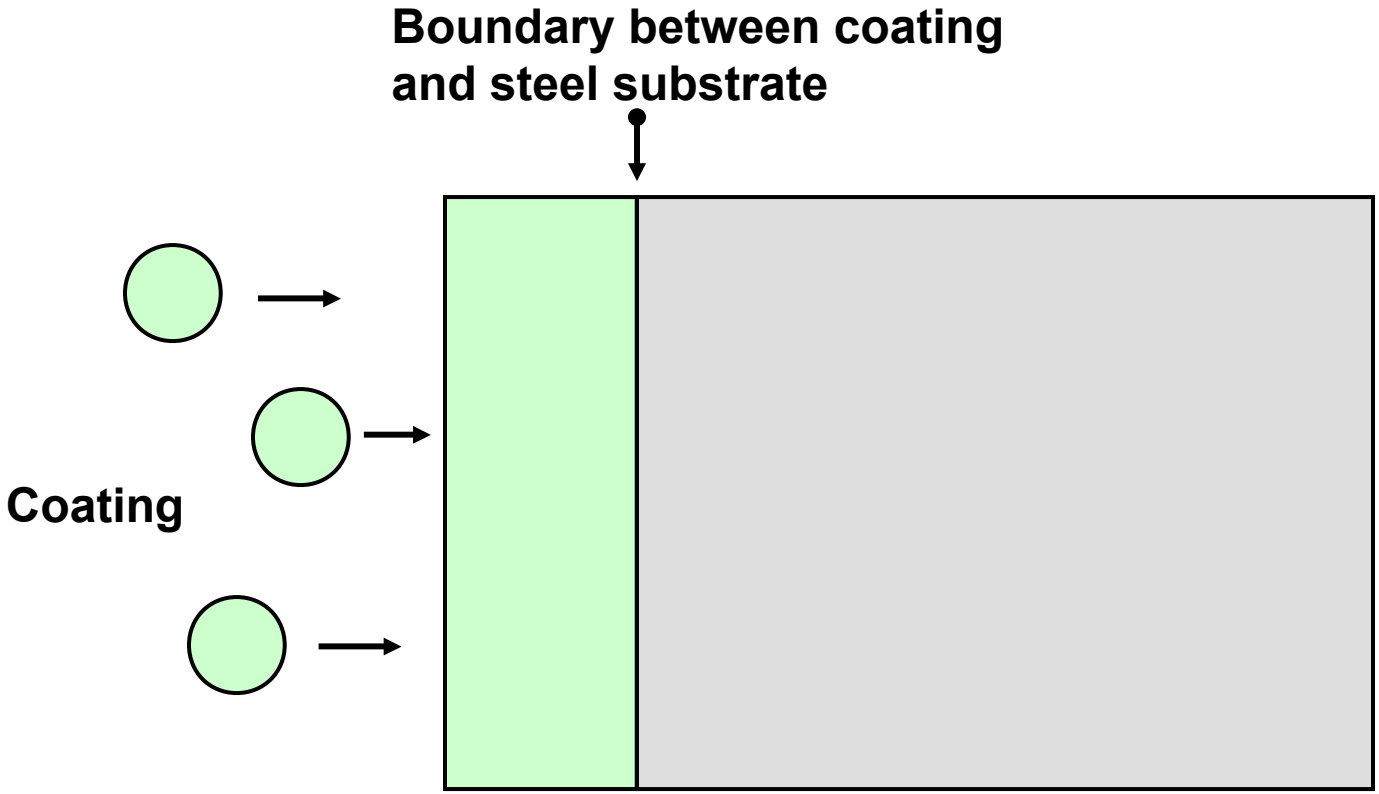
Heat Treatment Overview

- **Annealing**
  - Recrystallization annealing
  - Stress relief annealing
  - Soft annealing
  - Normalizing
  - Diffusion annealing
- **Hardening**
  - Through hardening
  - Surface hardening
- **Tempering**
  - <200°C
  - >500°C
  - Secondary (>480°C)
  - Age hardening
- **Diffusion treatments***
  - Nitriding
  - Carburizing
  - **Boronizing**
  - Oxidizing

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

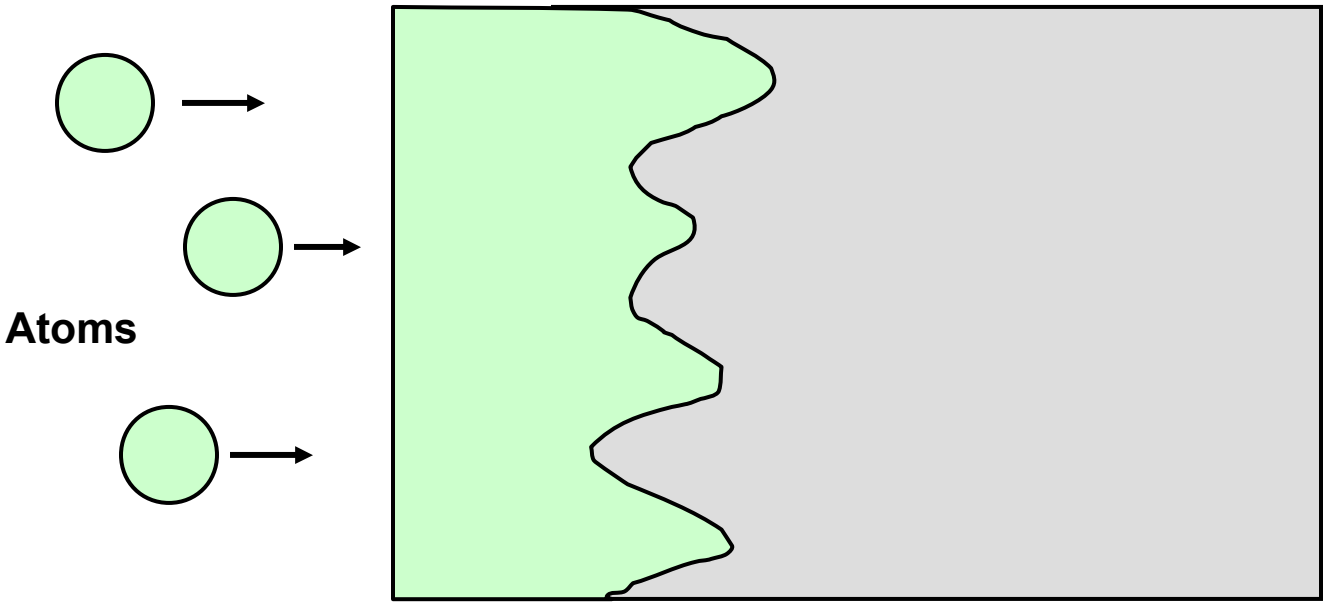
Coatings (CVD, PVD, Thermal spray...)



Functional layer develops on top of the substrate

- Moderate adhesion
- High stresses on interface

Diffusion Processes (e.g. Boronizing)



Functional surface is developed within the material

- **Superior adhesion**
- **Low dimensional changes**

What is Boronizing?

Boronizing is a thermocemical surface treatment in which Boron atoms diffuse into the steel substrate and form a very hard Borocoat-layer.

Boronizing easily tops the performance of commonly used methods such as carburizing or nitriding.

Properties of Borocoat Layers

- High hardness 1400-2600 HV, even on non-alloyed steels
- Diffusion depth 10-250 µm
- High abrasion resistance, resistance against cold welding
- Excellent thermal stability
- Self lubricating effect at high temperatures
- Superior bonding strength, no coating but diffusion layer
- Good resistance against molten metals (Al, Zn)

Material Selection for Boronizing

- Non alloyed and low alloyed steels.
- Stainless steels
- Cast iron, casted steel
- Cold work, hot work and HSS steel
- Powder metallurgical steels
- Cobald based materials
- Cemented carbides
- Nickel-based alloys (Nimonic® , Inconel®, Hastelloy®, Haynes®)

Boronizing is the most effective wear solution for Nickel-based alloys!

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Applications

- Automotive components (turbo charger engineering)
- Oil and gas industry (valves and accessories)
- Power plant engineering
- Toolmaking and metal forming technology
- Plastics processing
- Glass production
- Gear manufacturing
- Components for textile machinery
- Aluminum processing
- Mechanical engineering

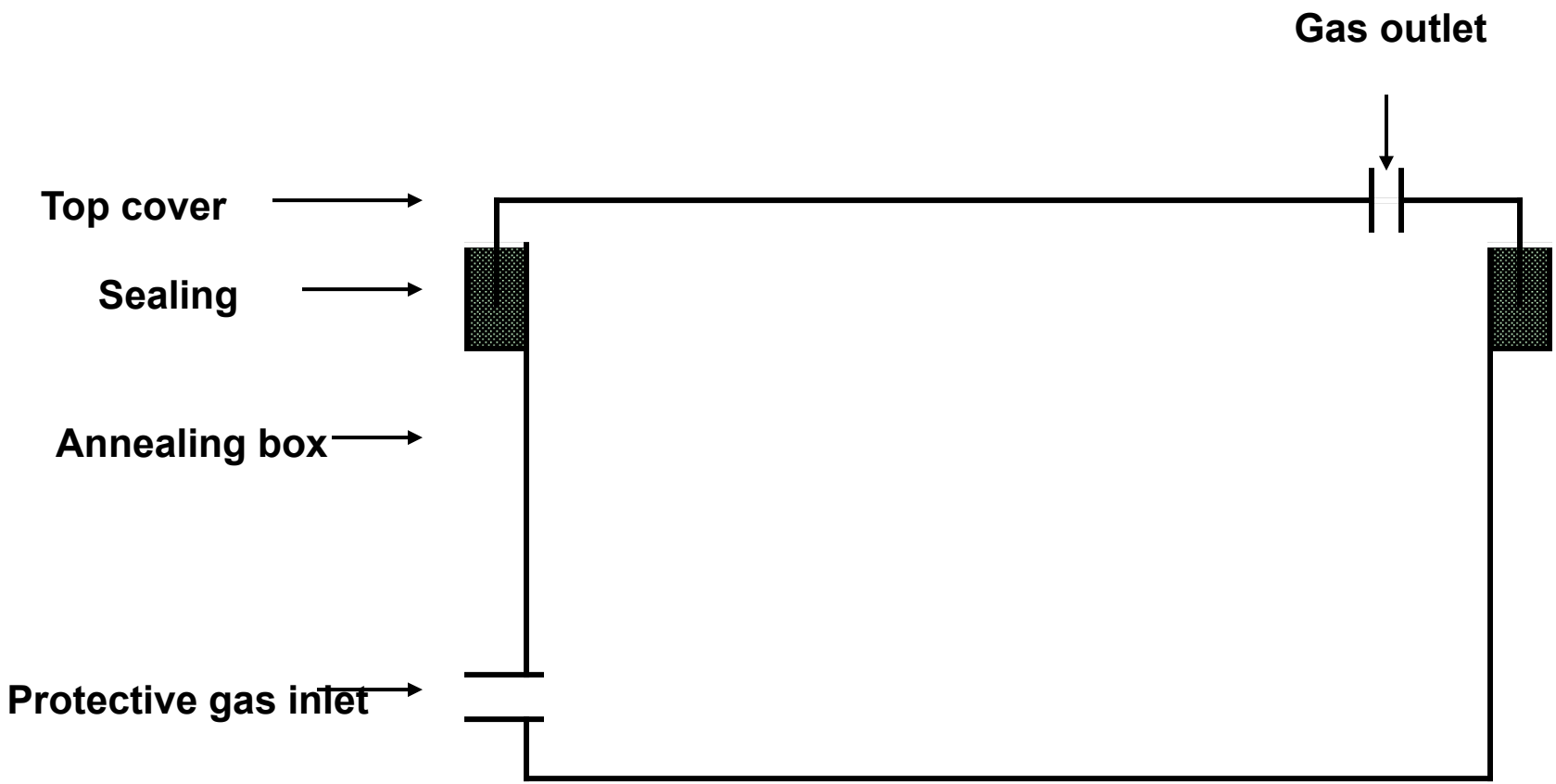
Boronizing - Setup-

Metal Box

Ekabor® Boronizing powder

Furnace

Box for Boronizing



Material AISI 314 (1.4841)

AVION MANUFACTURING

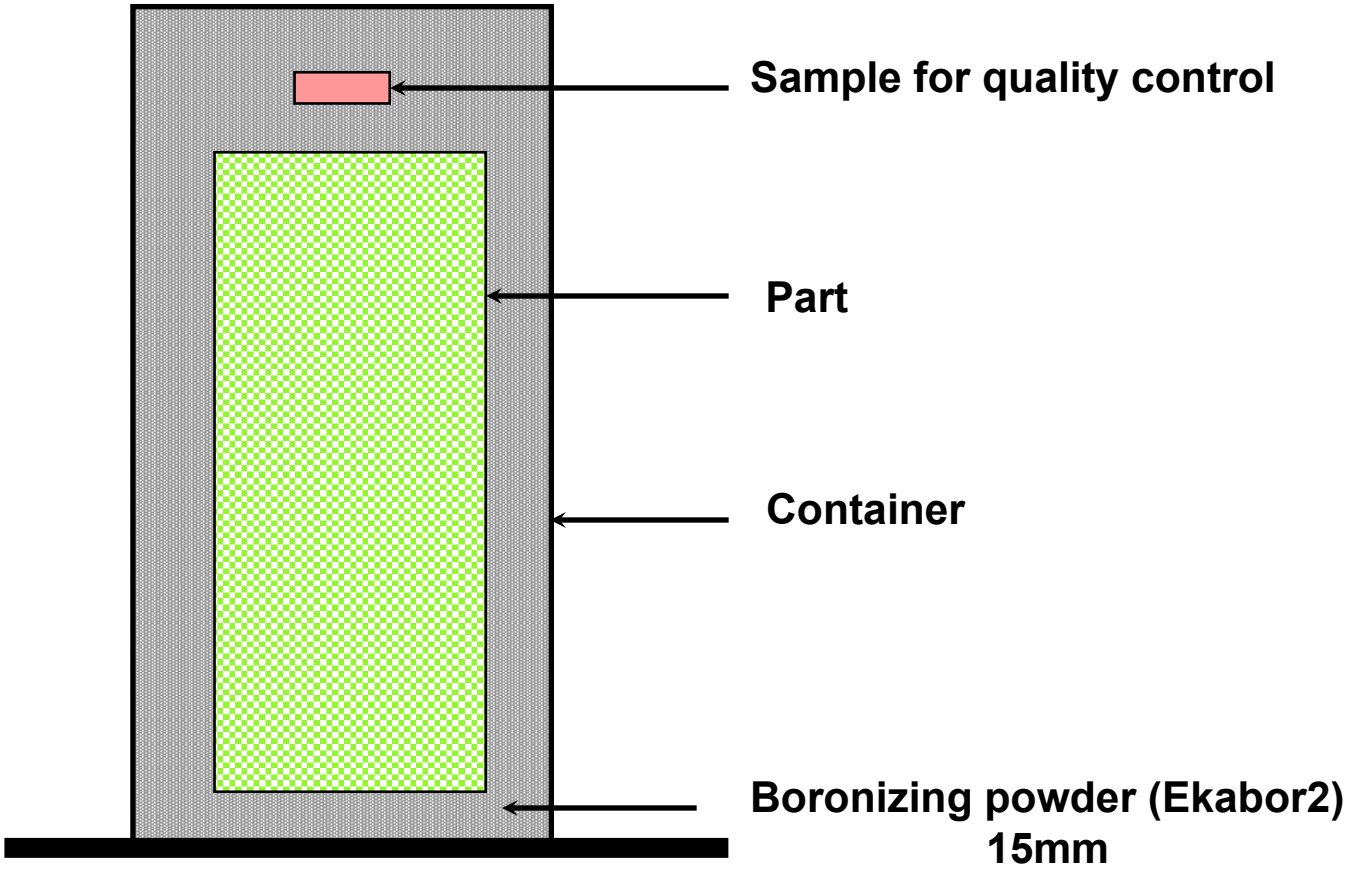
BorTec THE EXPERTS FOR WEAR PROTECTION

Box for Boronizing

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Parts Preparation

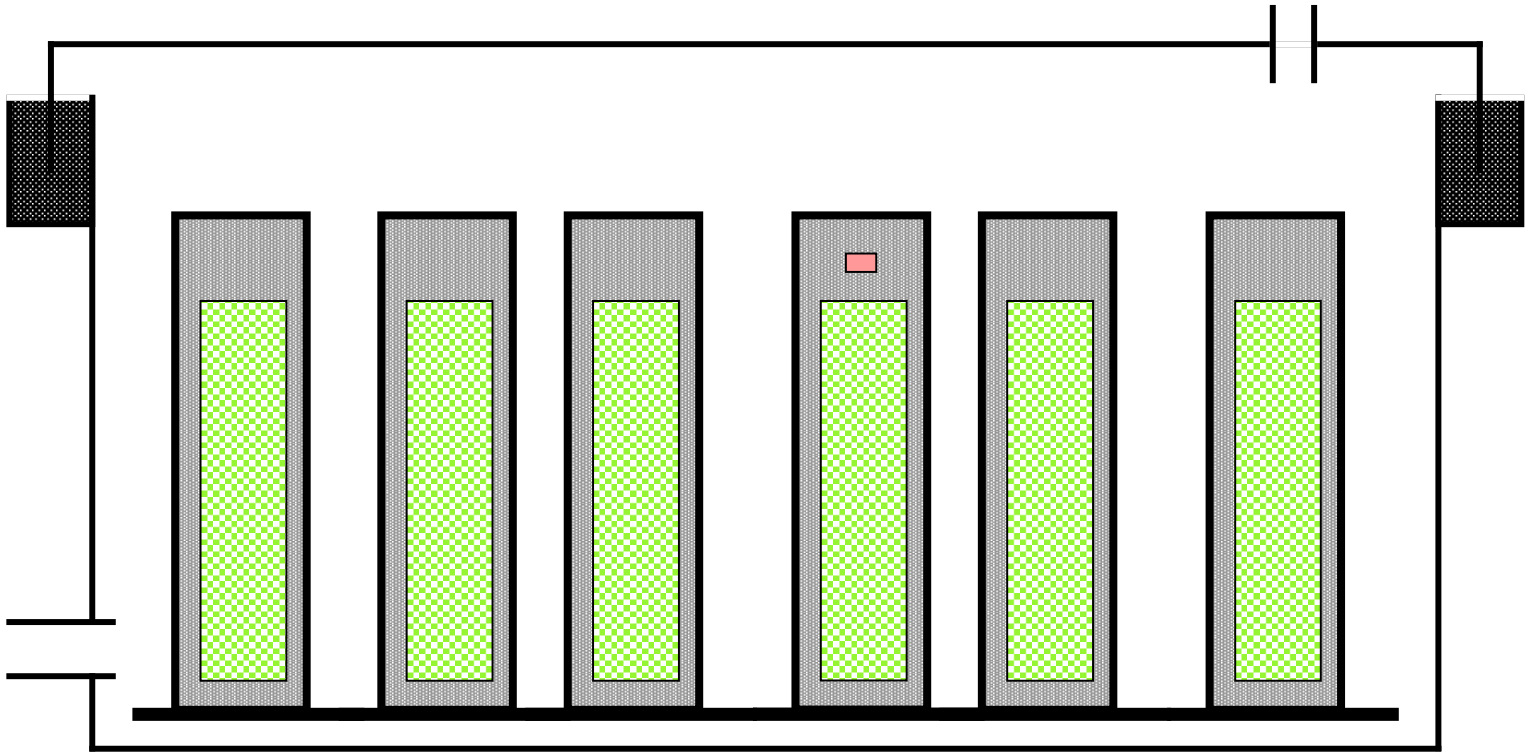


Parts Preparation

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Batch for Boronizing packed in a Box



Batch for Boronizing packed in a Box

AVION MANUFACTURING

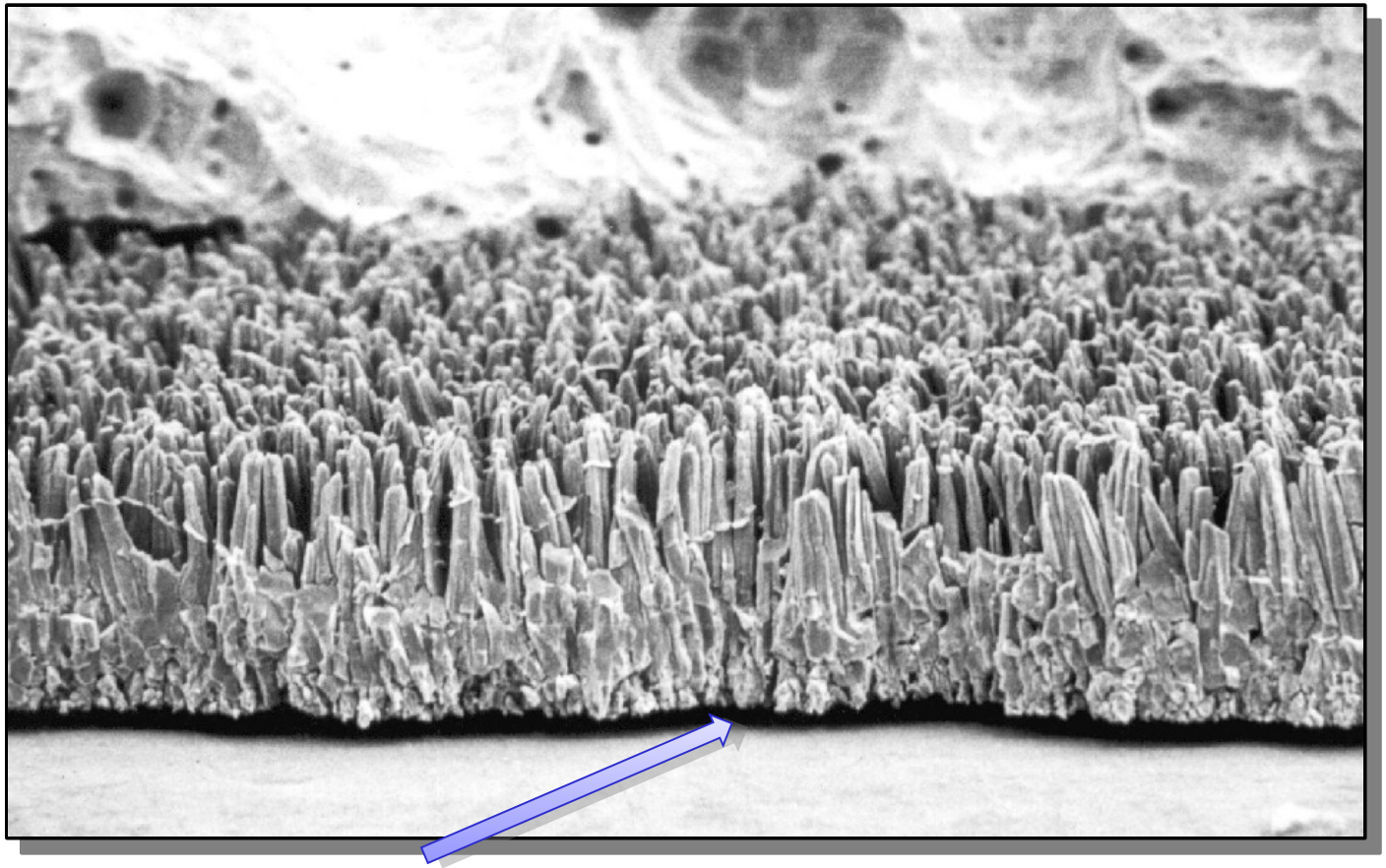
BorTec THE EXPERTS FOR WEAR PROTECTION

Properties of Borides

	FeB	**Fe2B**
% Bor	16,23	8,83
Lattice Structure	rhombic	tetragonal
Stress after cooling down	Tension	Compressive
Coefficient of Linear Expansion10^{-6}/K	23	7,9-9,2
Hardness [HV0.1]	1900-2100	1650-2000
Density [g/cm^3]	6,75	7,43
Modulus of Elasticity [GPa]	343	284
Thermal Conductivity [W/mK]	12	30

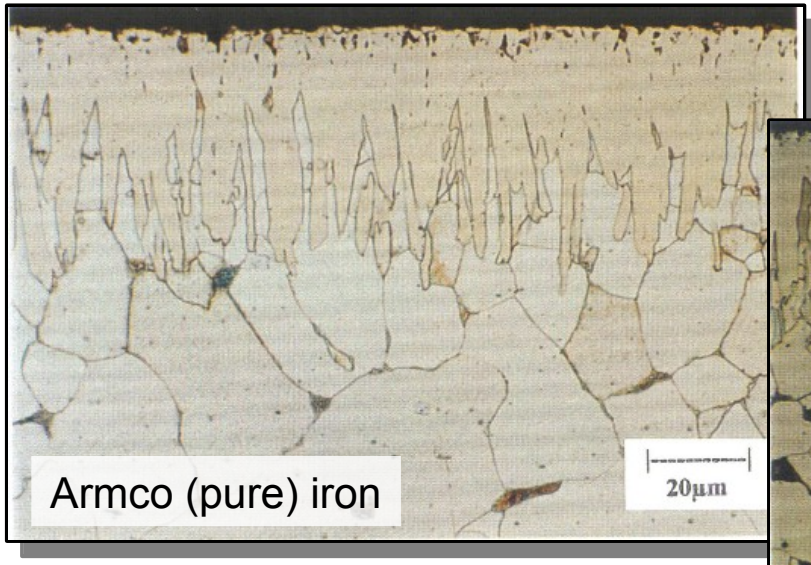
Boronizing Layer

(Iron matrix has been etched off, only boronized layer structure is visible)

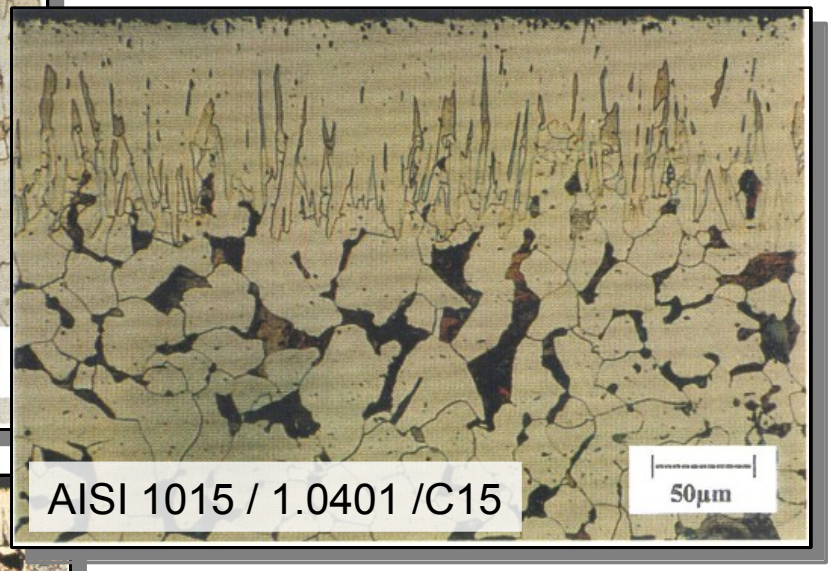


Former surface

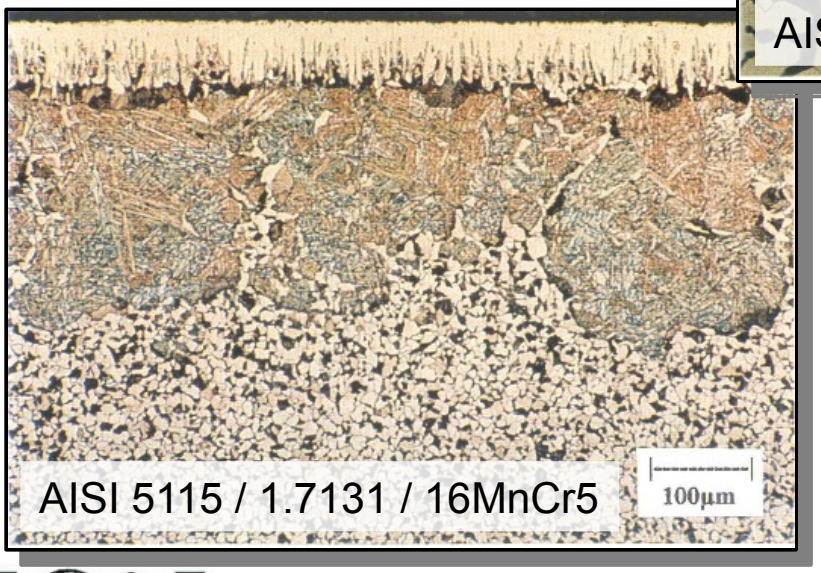
Microsections of Boronized Steels



Armco (pure) iron



AISI 1015 / 1.0401 /C15

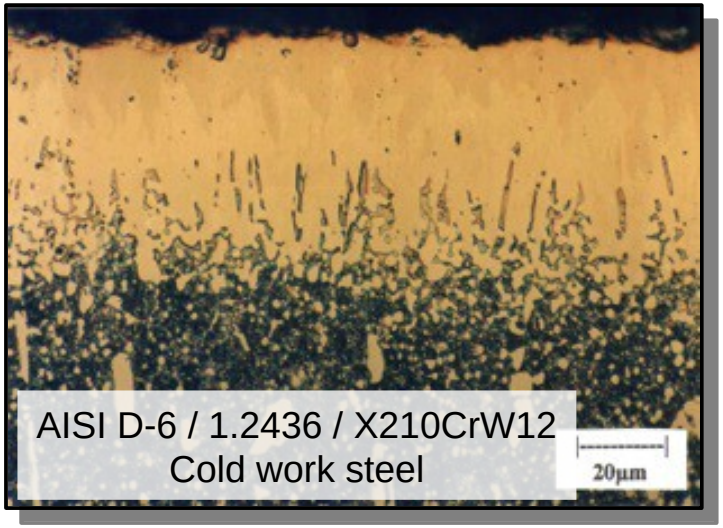


AISI 5115 / 1.7131 / 16MnCr5

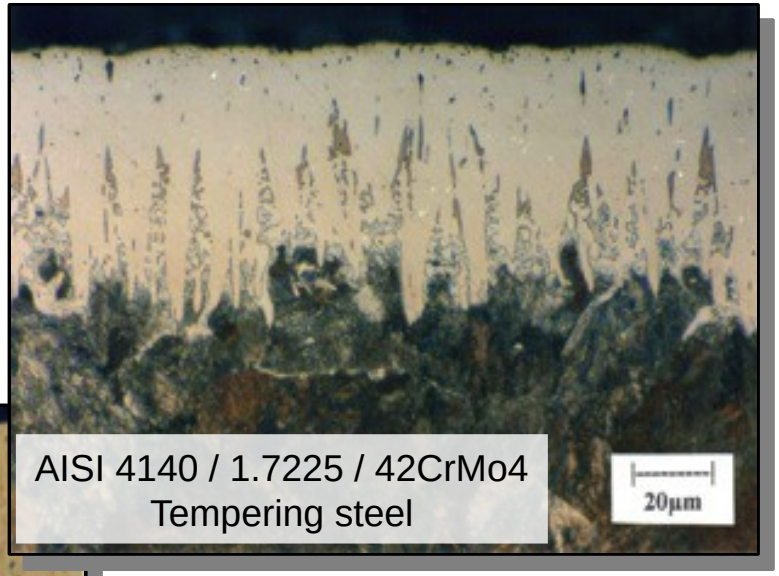
AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

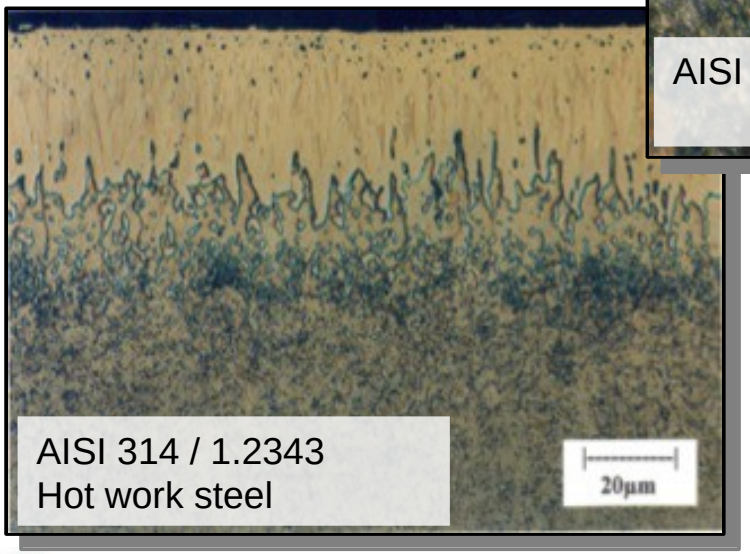
Microsections of Boronized Steels



AISI D-6 / 1.2436 / X210CrW12
Cold work steel



AISI 4140 / 1.7225 / 42CrMo4
Tempering steel

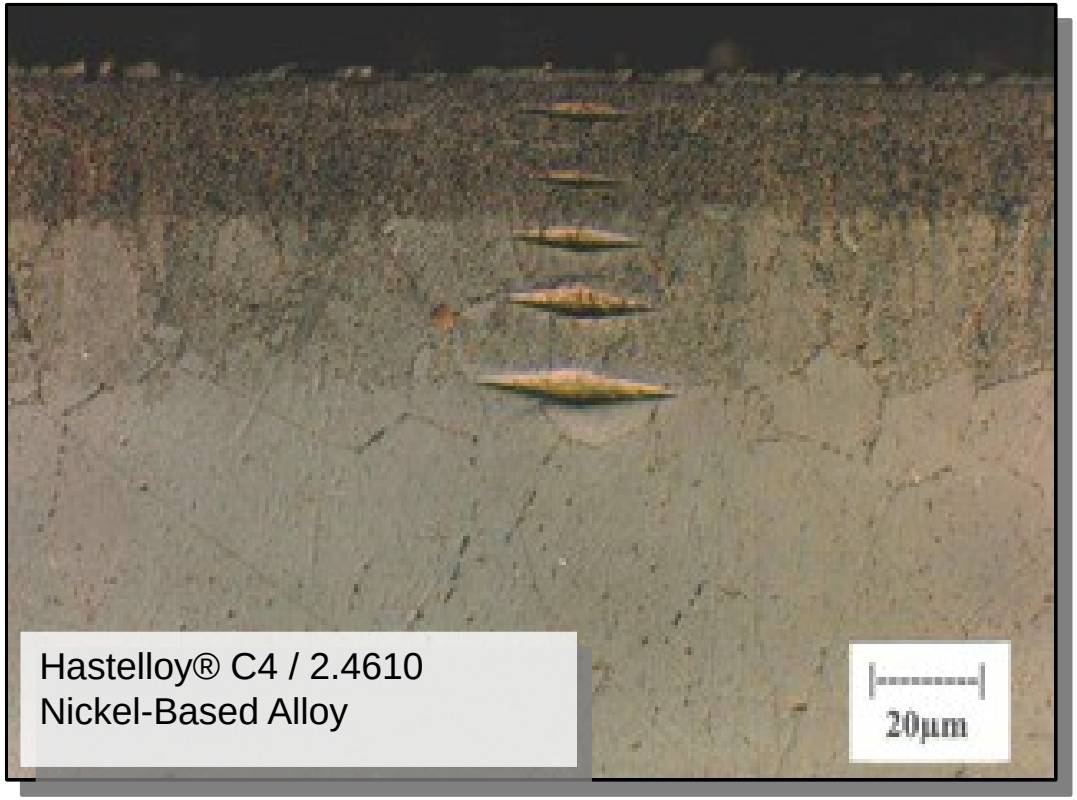


AISI 314 / 1.2343
Hot work steel

AVION MANUFACTURING

BorTec
THE EXPERTS FOR WEAR PROTECTION

Microsections of Boronized Nickel-Based Alloy



Hardness before boronizing: 425 HK0.1

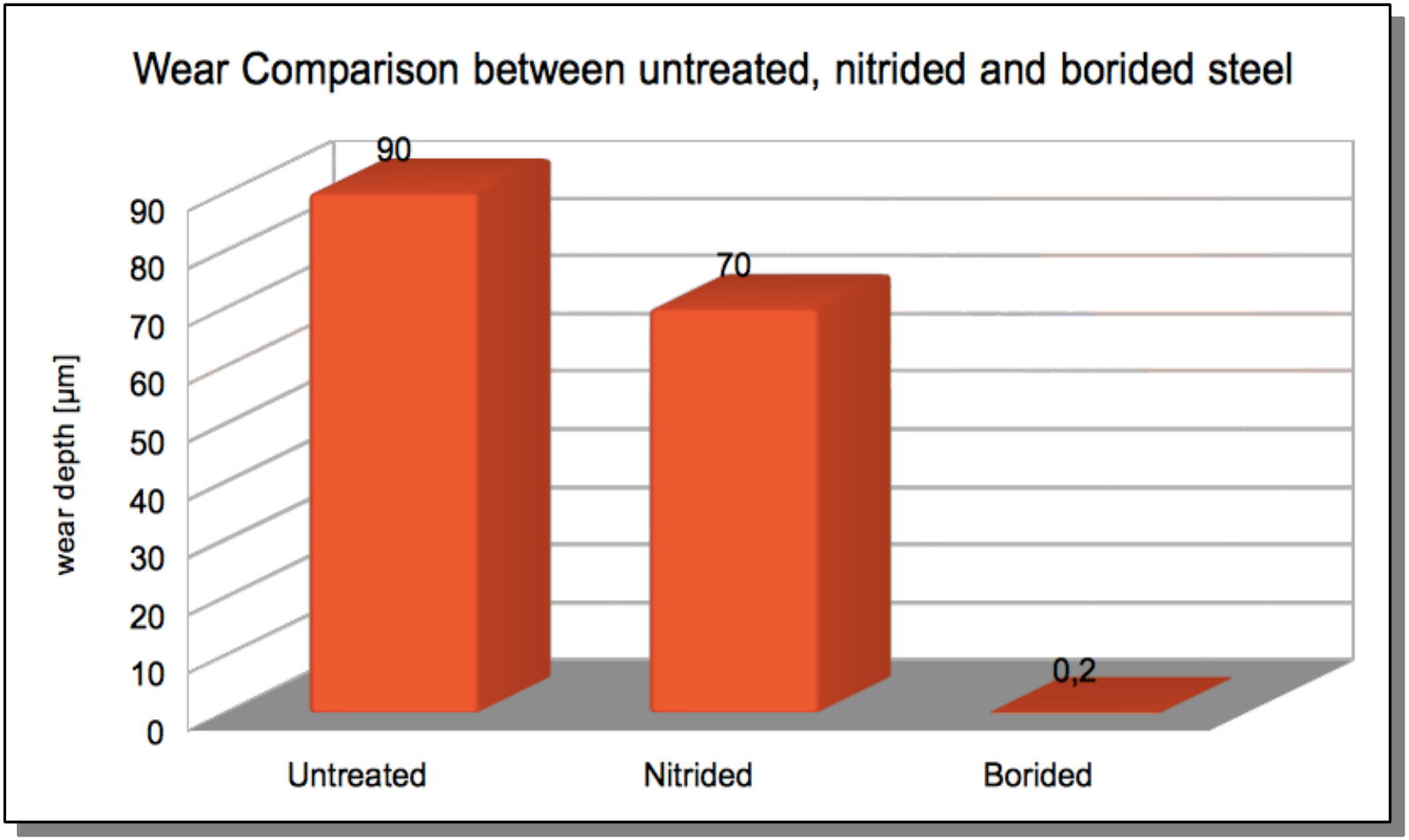
Hardness boronized: 1715 HK0.1

AVION MANUFACTURING

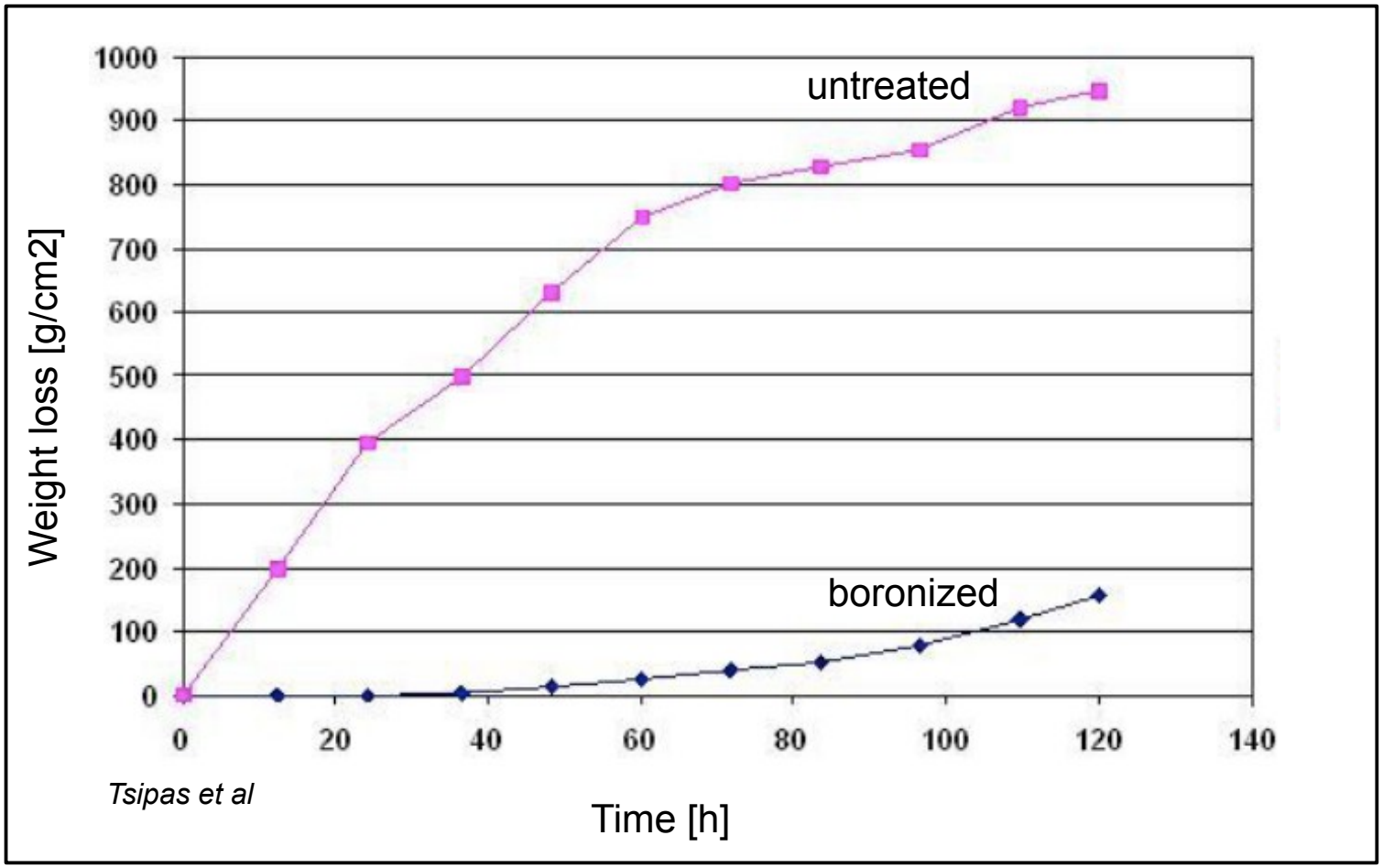
BorTec THE EXPERTS FOR WEAR PROTECTION

Wear Comparison of AISI 4131

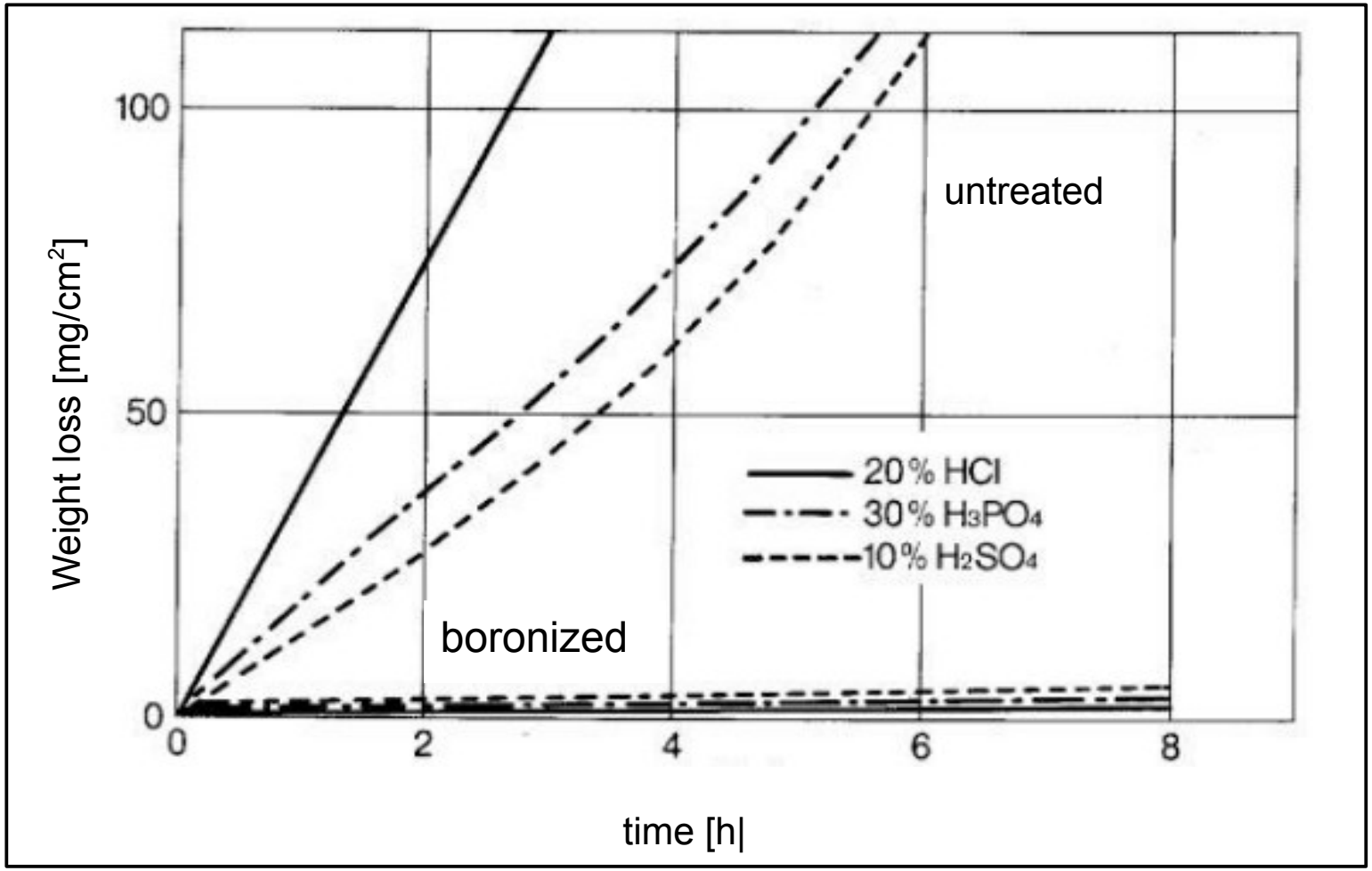
Ball-disc test (F_N=17N, 500m)

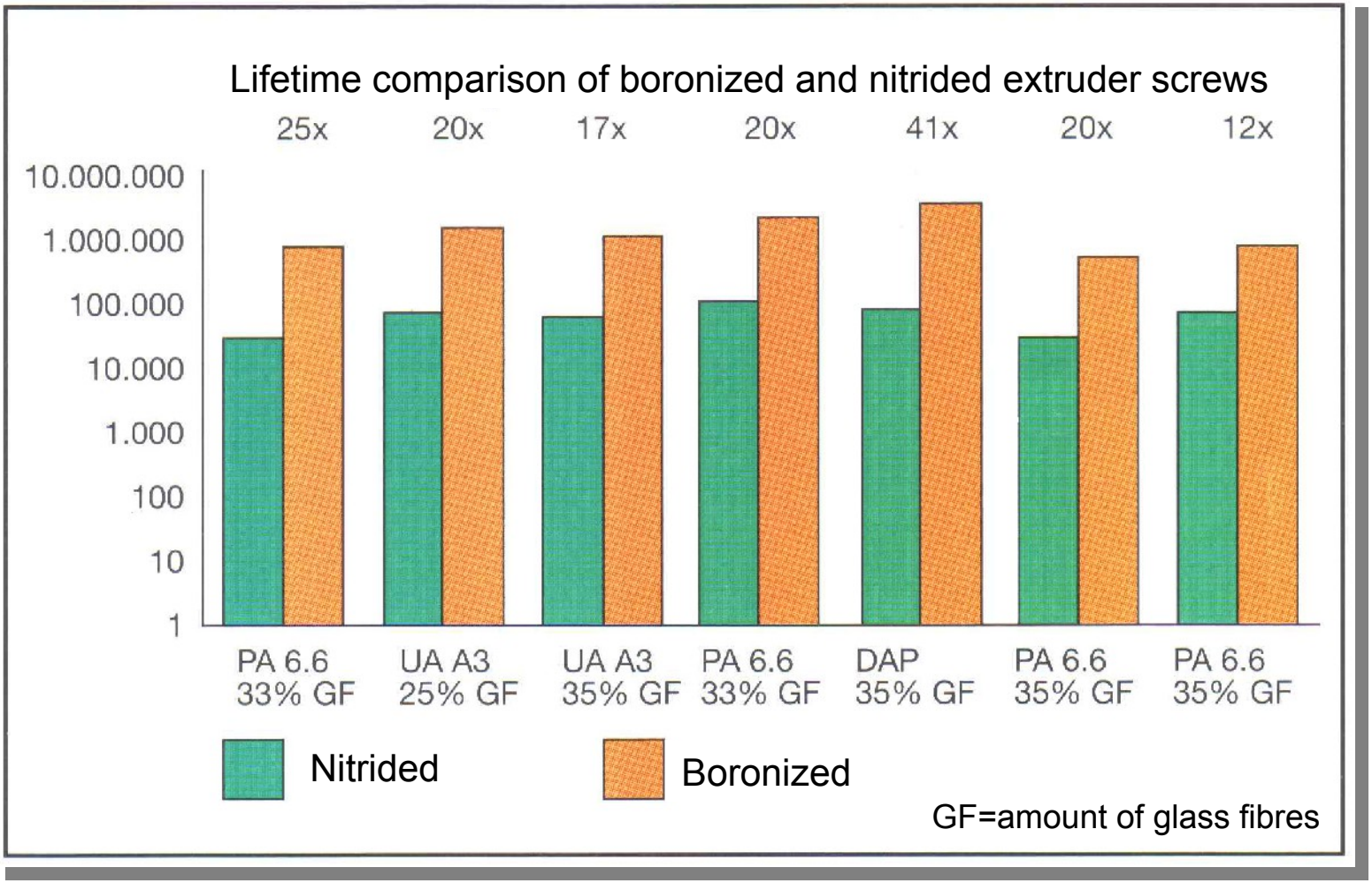


Corrosion of high alloyed Steel in molten Zink



Corrosion Resistance of Boronized vs Untreated Steel AISI 1045 (Ck45) at 56°C





AVION MANUFACTURING

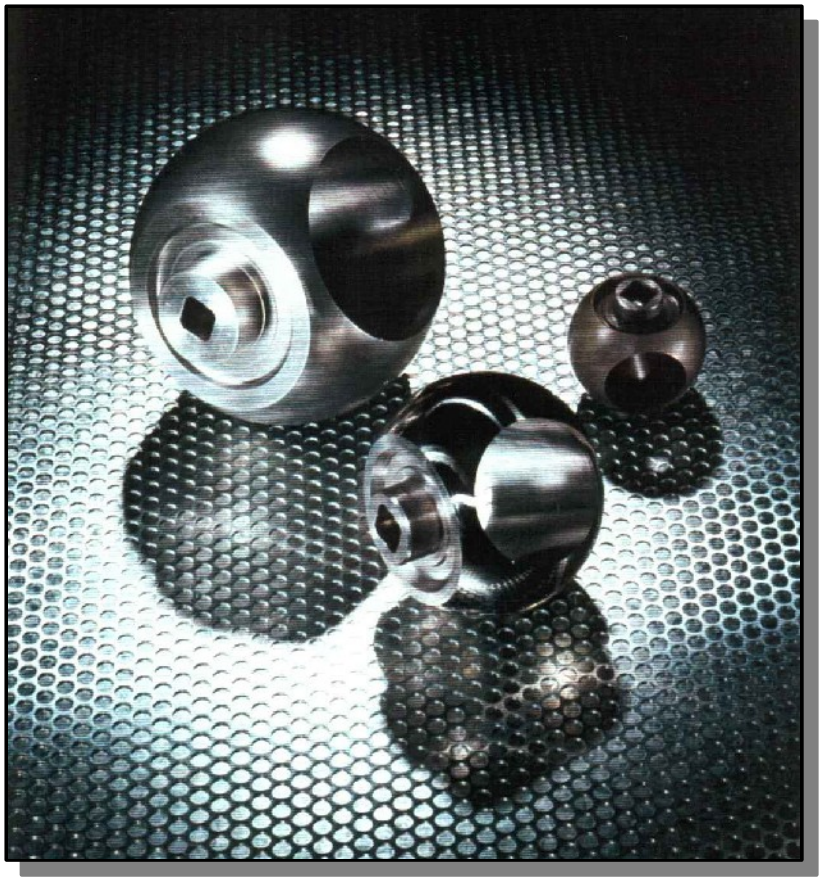
BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Extrusion Screws

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Ball Valves (Stainless Steel)



Material AISI 316

Hadness base material: 315 HV

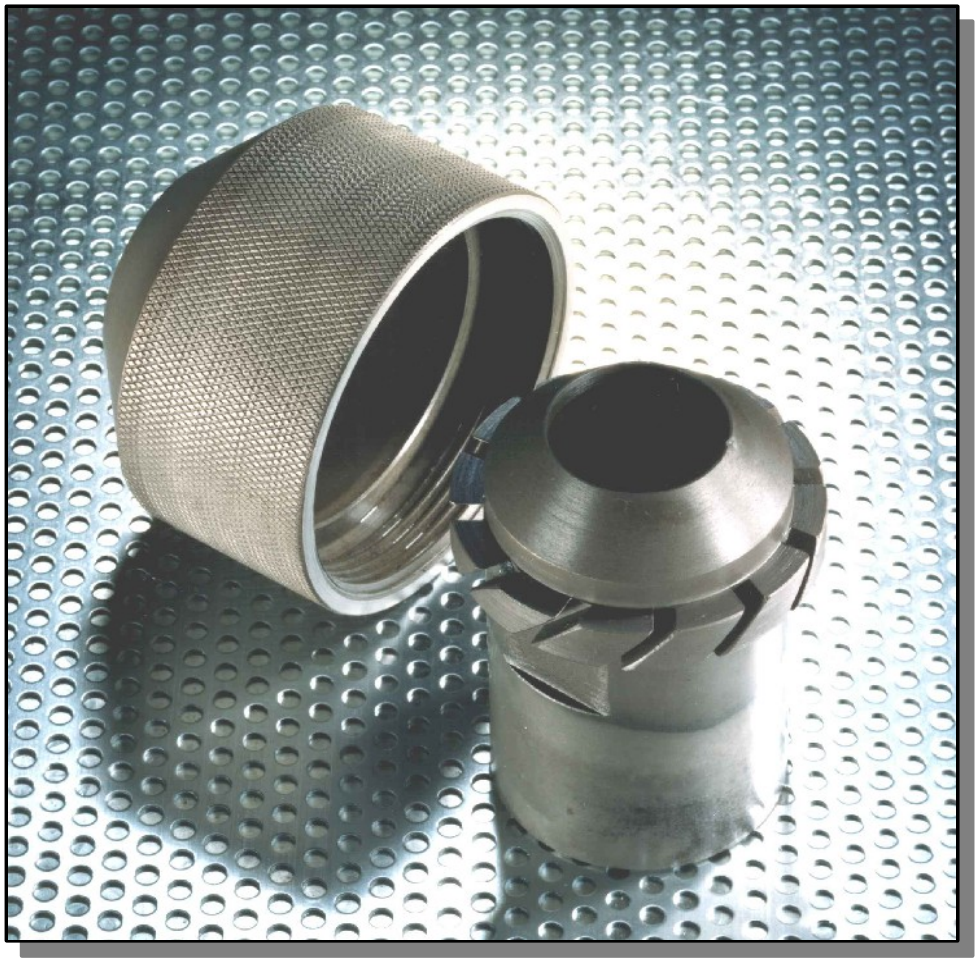
Hardness boronized 1950 HV

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Ball Valves

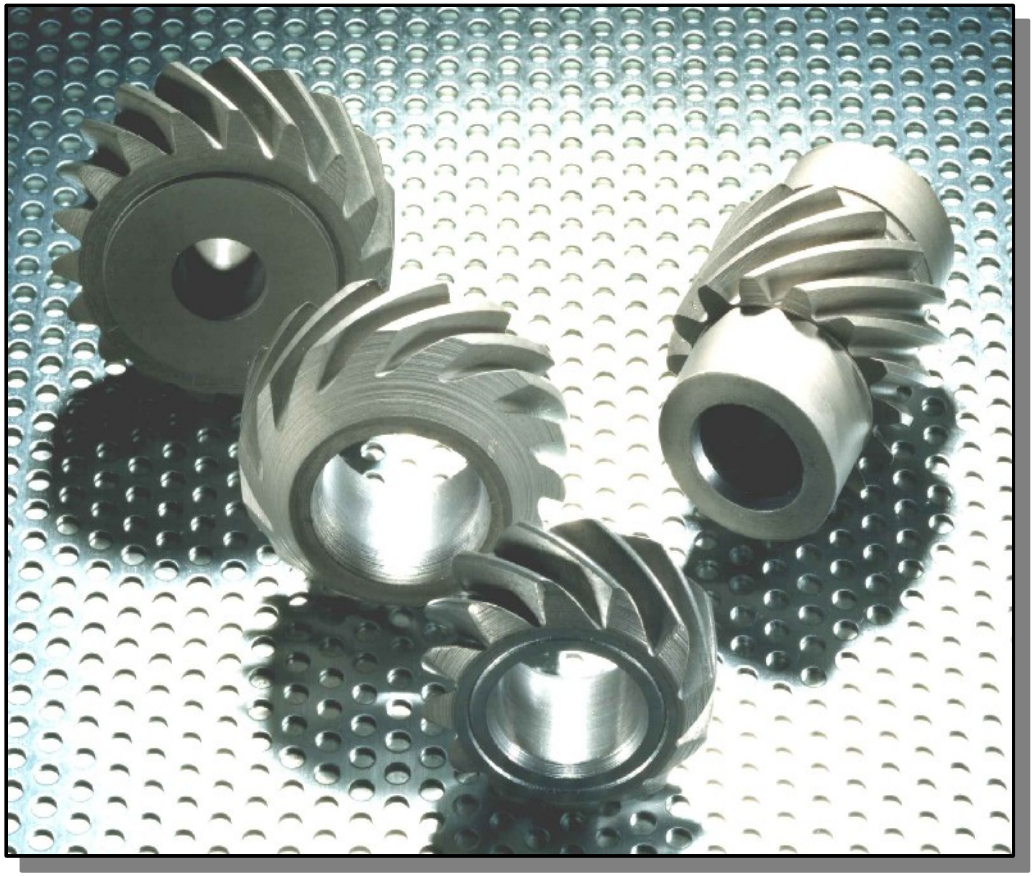
Boronized Burner Nozzle



AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Automotive Parts



Oil pump gears

Only teeth boronized

Hardness 1700 HV

Depth 40µm

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

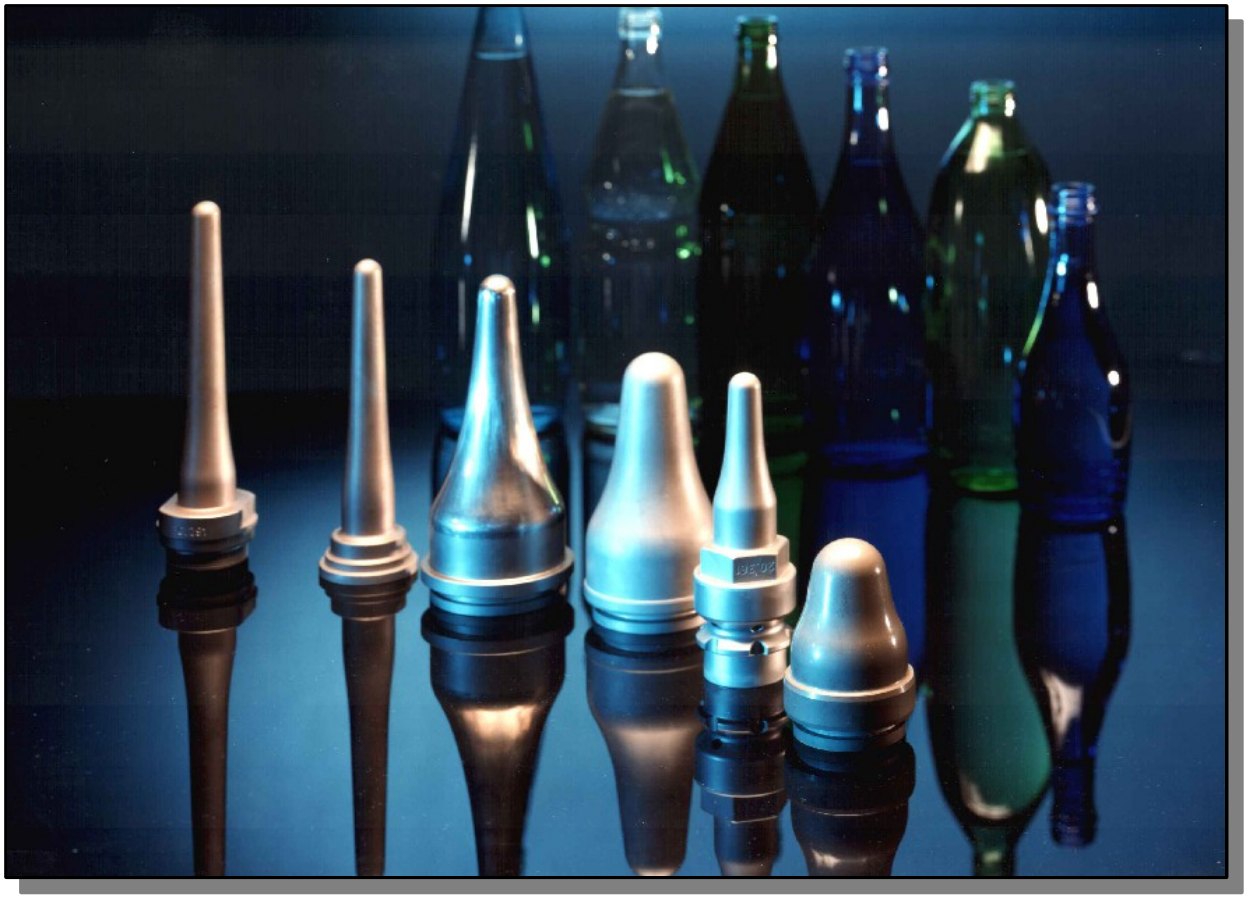
Boronized Parts for Glass Bottle Production

Prevention of sticking (glass-metal)

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

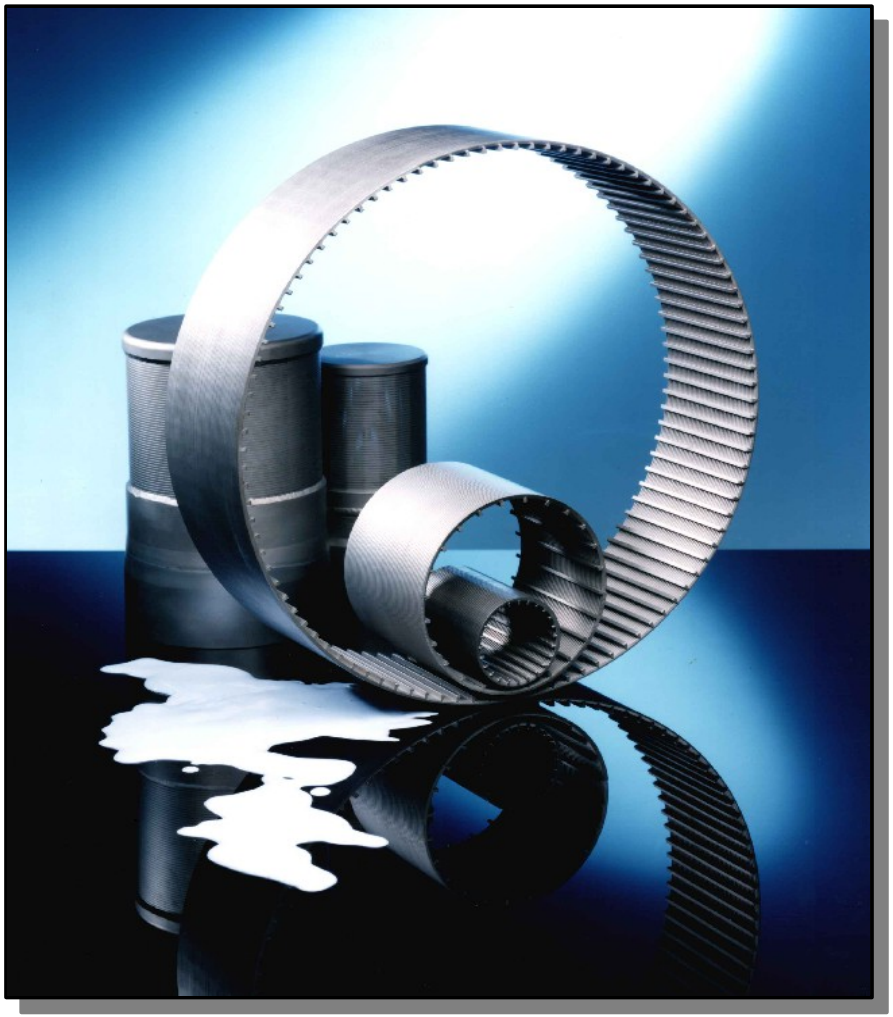
Boronized Parts for Glass Bottle Production



AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Filters



Stainless Steel

Hardness before: 285HV

Boronized: 1800HV

Prevention of Abrasion

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Pump Part

Inconel®

Hardness before: 425 HK

Boronized 2880 HK

Depth 50µm

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Boronized Compressor Wheel

Inconel® 625

Hardness before: 396 HV

Boronized: 2715 HK

Depth: 60µm

AVION MANUFACTURING

BorTec THE EXPERTS FOR WEAR PROTECTION

Ekabor® Boronizing Agents	
Ekabor® 1	High quality boronizing agent for non- and low-alloyed steel
Ekabor® 2	Standard boronizing agent for all kind of steels
Ekabor® 3	Quality as Ekabor®2. Easy unpacking (no baking) after boronizing
Ekabor® Ni	For boronizing of Ni-based alloys
Ekabor® Paste	Paste for special requirements such as partial boronizing.