Hightech by Gerster:

Heat treatment solutions. Boronising.
Boronising is a thermochemical diffusion process. At treatment temperatures in the range of approx. 800 to 1000 °C the surface of a workpiece is enriched with boron; closed boride coatings are formed. The high degree of hardness and also the particular structure of the coating result in an extraordinarily good resistance to wear.

The production process
Boronising leads to a growth in volume which corresponds to approx. 25 to 30% of the coating thickness. Therefore a corresponding undersize must be provided for finished parts if necessary. The resulting rugosity amounts to approx. 4 µm. Following boronising, honing or grinding with CBN or diamond is possible. In order to avoid breakouts, edges and corners must have a radius which is at least the same size as the coating thickness. In order to reduce the change in size and warpage behaviour to a minimum we recommend carrying out stress free annealing for demanding components before the final processing. Due to the high thermal durability of the boride coating the components can still be hardened or tempered following boronising whereby a good load capacity at high surface loads is attained on the one hand and good strength of the components on the other. Case hardened steels can be carburised, boronised and subsequently hardened for a better supporting effect of the boride coating. Along with the resultant high stability of the coating the tough properties of the core are maintained.

The properties of boride coatings
- Very high degree of hardness:
  - iron based alloys 1600 to 2100 HV
  - nickel based alloys up to 2800 HV
  - titanium up to 4000 HV
- Optimum adhesive strength
- Little tendency to cold welding
- Expansion coefficient comparable with iron materials
- Good temperature resistance
- High heat hardness

The coating thickness can be controlled via the treatment time. It varies from 5 to 10 µm for components for which the tendency to cold welding is to be reduced up to values of 300 µm for components for which a pure abrasion strain is resent. The choice of material is matched to this. The higher the alloy content the lower the attainable coating thickness usually is.
Small parts made of case hardened steel, quenched and tempered steel and hot work tool steel, boronised in bulk blasting process, subsequently hardened or quenched and tempered.
The so-called powder pack method in which the components are exposed to boron containing granules is technically well-engineered and economically successful. Single parts and mass-produced parts thus allow themselves to be treated in a safe process in an organised position or as bulk material. Partial boronising is also possible. Gerster also provides this process in combination with classical hardening processes such as vacuum hardening, hardening under inert gas conditions, case hardening, tempering, partial hardening and surface hardening. Mass produced parts which are exposed to high stresses in a metallic joint are protected against wear by the boronising. The correspondent part is hardened in the normal way. The joint is lubricated where possible. Due to the good sliding properties the partner is protected against excess wear and there are good fail-safe properties in the event of unintended cracking of the lubrication film. Such applications are typical for conveying and transport equipment.

The so-called powder pack method in which the components are exposed to boron containing granules is technically well-engineered and economically successful. Single parts and mass-produced parts thus allow themselves to be treated in a safe process in an organised position or as bulk material. Partial boronising is also possible. Gerster also provides this process in combination with classical hardening processes such as vacuum hardening, hardening under inert gas conditions, case hardening, tempering, partial hardening and surface hardening. Mass produced parts which are exposed to high stresses in a metallic joint are protected against wear by the boronising. The correspondent part is hardened in the normal way. The joint is lubricated where possible. Due to the good sliding properties the partner is protected against excess wear and there are good fail-safe properties in the event of unintended cracking of the lubrication film. Such applications are typical for conveying and transport equipment.

The boride coating maintains the high level of hardness without noticeable drop for short term loads up to temperatures above 1000 °C. For this reason boronised tools are used for the hot forming of metals or glass. Boronising is often used in construction of textile machines for thread guides. Due to the very high speeds a high abrasion load occurs on the contact surfaces of the yarn with the metallic parts. Often these problems cannot be solved with either classical hardening processes or with known coating processes although these protective coatings have an even greater hardness than boride coatings. Boronising also has widespread applications in the area of extrusion technology and injection moulding technology, in instrument manufacture and in general mechanical engineering and manufacture of apparatus. The food and automotive industries also benefit with special uses of the durable boronised components.

Wear Properties
Comparative wear tests were carried out by means of grinding disc processes. In this a boronised sample of 42CrMo4 was compared with a nitrided sample made of the same material. In this the linear wear erosion of the boronised sample was around 1000 times smaller than that for the nitrided sample.

Protection against corrosion
Corrosion resistance for iron based materials in acidic environments is improved. Alkaline stresses do however result in a reduction of corrosion resistance.

Material:

- 42CrMo4
- Boronised: 30 to 40 µm
- Tempered: 1000 to 1150 N/mm²

With highly stressed gears the lifetime is increased considerably with the boronisation of the gearing.
Textile machine construction:
Rotor cup for making threads. Quenched and tempered steel, partially boronised, quenched, tempered and coated.

Comparison of coating thickness/hardness

<table>
<thead>
<tr>
<th>Coating thickness [mm]</th>
<th>Case hardening</th>
<th>Nitriding</th>
<th>Boronising Iron based alloys</th>
<th>Boronising Nickel based alloys</th>
<th>Boronising Hard metals</th>
<th>Boronising Ti-alloys</th>
<th>Thin layer technology (PVD/CVD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0,0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0,001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0,010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0,100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Boronising complements other heat treatment processes with regard to hardness and normal coating sizes. The possible combination with case hardening, through hardening and surface hardening leads to good load capacity.
Almost all iron materials from machine, vehicle and apparatus construction are suitable for boronising. High alloy tool steels, hot working steels and corrosion resistant steels, sinter metals, grey iron and spheroidal iron can be boronised successfully as well. Alloys with a high proportion of aluminium or silicon should however be avoided if tempering is necessary following boronising. They give a soft intermediate coating directly below the boride coating.

Nickel based materials such as e.g. inconel, hastelloy or nimonic have excellent corrosion resistance properties and are often used at higher temperatures. Wear protection measures such as nitriding or case hardening can however not be carried out with these materials. For precipitation hardenable alloys only hardness values below 550 HV are attained. Boronised surfaces have a much better wear resistance up to high operating temperatures with a reduced adhesion resistance at the same time. For the aviation and chemical industries pure titanium or $\alpha/\beta$-alloys (e.g.TiAl6V4) are boronised. The coating thickness is 10 to 20 $\mu$m.
The hardness curves show the typical differences between the four heat treatment processes: boronising, nitriding, case hardening and hardening. Boronising is used when the other processes are not adequate from a wear perspective.
Surface hardening
- Induction hardening
- Dual frequency hardening
- Impulse hardening
- Flame hardening
- Non-destructive determination of hardening depth

Laser technology
- Laser hardening

Through hardening/annealing
- Hardening under inert gas conditions
- Vacuum hardening with pressurised gas quenching
- Tempering
- Annealing under inert gas conditions
- Stress relief treatments
- Cryogenic treatments down to –180 °C
- Precipitation hardening of aluminium alloys

Brazing
- Under vacuum conditions
- Under inert gas conditions
- Inductive
- With flame

Thermochemical diffusion methods
- Carburising
- Carbonitriding
- Case hardening
- Gas nitriding
- Oxinitriding
- Gas nitrocarburisation
- Pronox
- Plasma nitriding
- Plasox
- Boronising
- Performance enhancing treatments for stainless steels SolNit-A®, SolNit-M®, HARD-INOX®

Consulting and additional services