Böhler WELDING

METAL POWDER AND CASTING RODS

Top blade, welded with BÖHLER metal powder Super DUR WC-P
with the plasma transferred arc welding process.
(RWE Rheinbraun AG)

Content

Everything under control: The know-how of metallurgy, production technology and welding technology

For more than 75 years the BÖHLER THYSSEN SCHWEISSTECHNIK Deutschland GmbH has dealt with the development and production of welding materials.

An important application area of welding engineering is overlay welding, e.g. to give a work piece surface a special wear and/or corrosion resistance.

BÖHLER offers a wide range of gas atomized metal powders and casting rods on Co, Ni and Fe basis, which are suitable for hardfacing and thermal spraying. These products are manufactured to the highest standards.

The starting point is the production of alloyed ingots manufactured in our steel foundry. This enables us to use our considerable experience gained over many years at an early stage of production.

Filling the liquid metal into the atomizing funnel.

Temperature measurement during continuous casting.

Wind screening for the powder grain size.

For the powder production the ingots are liquefied in an induction furnace and brought to the gas atomization plant. The atomizing process is carried out in a closed container where a stream of molten metal is atomized under high pressure with the aid of an inert gas, usually nitrogen. With this so-called gas atomization the speed of solidification is so slow that, during the time of the fall in the container, the drops formed during atomization are transformed into balls.

The globular form of the grains guarantees excellent flow behavior and thus, good controllability of the powder supply.

Continuous casting of the hardfacing rods.

The powder is also precipitated under inert gas. This guarantees that the powder cools down without harmful surface oxidation. Low oxygen contents of the metal powders are the result. It is necessary to screen the powder to the required grain size before using the powder for spraying, plasma transferred arc welding or sintering. This is done in modern screening units or air separators.

BÖHLER has a modern five-strand, horizontal continuous casting machine for the production of hardfacing rods. For this production, the ingots have to be liquefied in an induction furnace the molten metal is then decanted into a "Tundish". To reach the optimal weld ability of the qualities, the melt is washed during the process with shielding gas. The rods are straightened and then separated to the length requested by the customer. On request the surface of the rod can be ground.

The metal powders and casting rods are subjected to extensive quality controls. For determination of the chemical composition a laboratory with modern analytical equipment is used. Equipment for carrying out screen analyses as well as measurements of the flow rate, bulk density, hardness and mechanical technological properties is part of the standard equipment of the laboratory.

Straightening the casting rods.

Screen analyses instrument to determine the powder grain size.

Optical emission spectrometer (OES) for the determination of the chemical analysis.

View through a scanning electron microscope of gas atomized spherical metal powder grains.

Hardfacing and thermal spraying

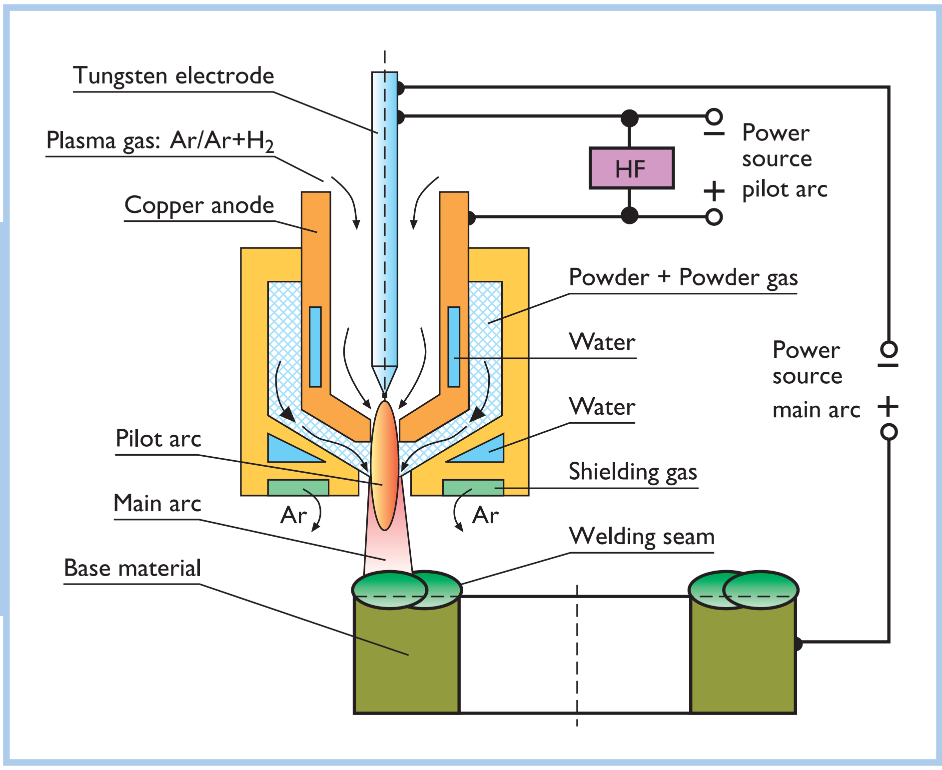
Metal powder hardfacing process

Plasma transferred arc welding (PTA)

This method is a plasma welding process with a continuous powder feeding. The powder feeding may be added separately as well as directly via the torch.

The arc is initiated between the tungsten electrode and the workpiece. It is ignited and stabilized simultaneously with the aid of a pilot arc between the tungsten electrode and the copper nozzle (anode). Main arc and pilot arc are supplied independently from their own power source. The tungsten electrode is enveloped in argon as a centre gas. Within the arc, the argon is ionized forms a plasma with high beam energy. Argon shielding gas is supplied via the outer nozzle. This shielding gas protects the molten pool against the ingress of oxygen. The powder supply to the arc is carried out via a mechanical metering device. Argon is used as a carrier gas for the powder. The powder grains can pass into the molten pool either in solid or molten form. This depends upon the size, the shape and the quantity of the grains, the thermo-physical properties of the powder and the plasma, as well as upon the transfer time of the powder grains in the plasma.

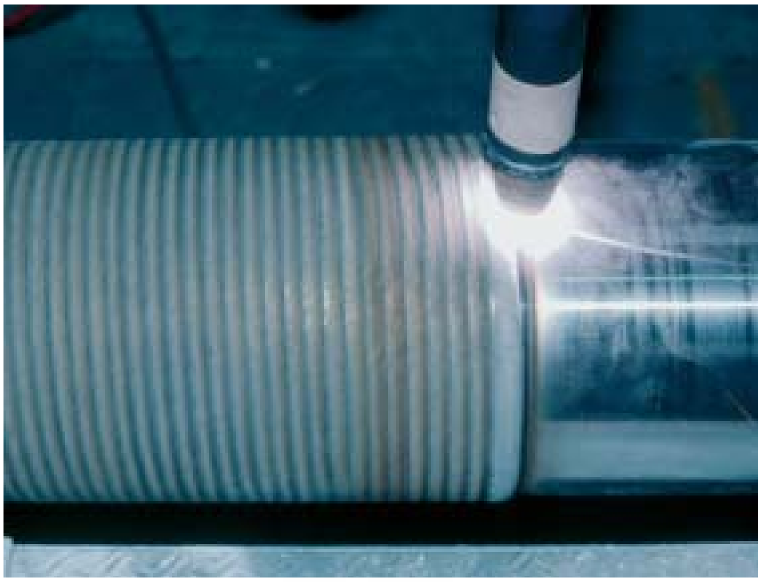
Plasma transferred arc welding has gained increasing significance in recent years. This process facilitates a build-up of powder alloys, which in the form of rods or wire, are difficult to produce or often cannot be produced. The advantages of plasma powder transferred arc welding is the precise adjustment of the penetration depth and the build-up thickness (dilution) as well as the high energy density of the plasma arc. Because of the continuous addition of powder, build-up welds of uniformity and low porosity are produced so that, in respect of mass production, a high degree of automation is possible.



Schematic diagram of a torch for plasma transferred arc welding.

BÖHLER metal powders are used for hardfacing of bearing and sealing surfaces of gas, water, steam and acid fittings, also valve production for vehicle and shipping engines as well as for highly stressed and wear resistant hardfacing on hotwork, crushing, stirring, extracting and drilling tools.

The preheat and intermediate layer temperatures during the plasma transferred arc welding are dependant on the base material, the size of the workpiece and the number of layers.



Plasma transferred arc welding of a continuous casting roll for steel production.

Plasma transferred arc welding (hardfacing of a sealing surface).

Flame spray welding

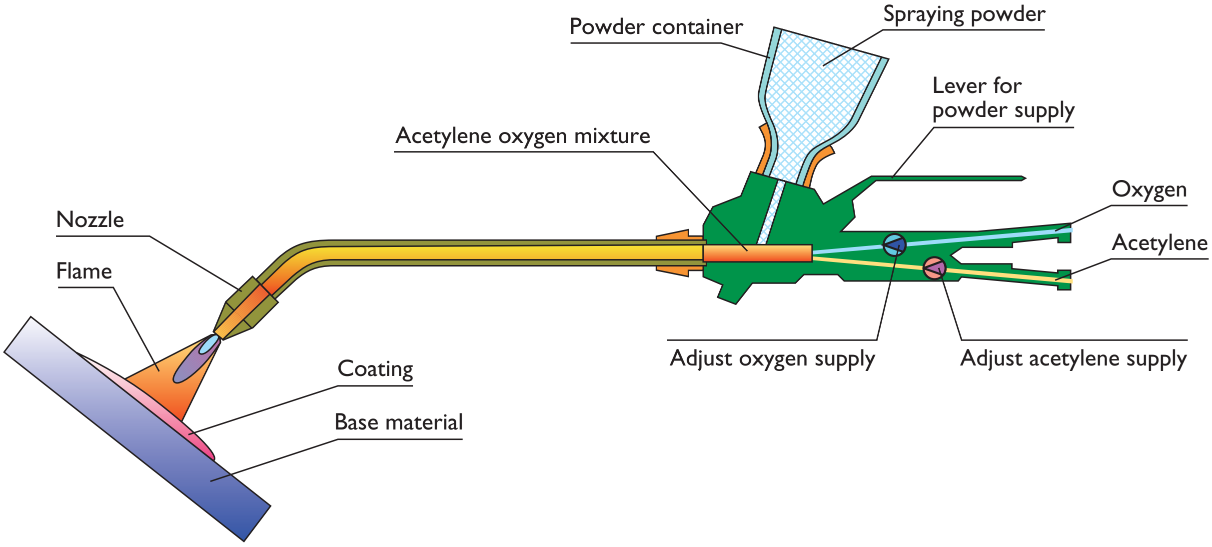
Flame spray welding is a surface coating process. From a short distance, via a torch the metal powder is sprayed onto the base material and simultaneously fused. This produces fusion between the sprayed layer and the base material comparable to welding.

With flame spray welding, the surface of the workpiece has to be cleaned thoroughly of rust, grease and oil. The roughening of the metallically clean surface should be effected by blasting or rough grinding in order to facilitate a good bond of the sprayed layer. Spraying should immediately be carried out after surface preparation.

This method is suitable for applying thin layers to small areas, edges and repair work. Low and high alloy steels, stainless steels, cast steels, malleable cast iron, flake and spheroidal graphite cast iron can be sprayed. Powder based on with additions of Cr-Si-B and powder-mix qualities are available.

Flame spray welding with BÖHLER metal powder Niborit 4-P.

Schematic representation of the flame spray welding.



Flame spray welding with BÖHLER Niborit 5-P.

Flame spraying

Powder flame spraying is a coating process, during which the spraying powder is melted by means of an oxy-fuel gas flame and sprayed onto the surface of the workpiece. This process is based upon a flame temperature of about 3,100 °C. The powder particles reach a speed up to 250 m/s, depending on particle size, spraying distance and operational data of the spray gun. Whilst passing through the flame, the powder particles should be in a melted and/or plastic condition.

Powder flame spraying can be divided into two processes:

- Powder flame spraying without secondary thermal treatment (cold spraying process)
- Powder flame spraying with subsequent fusing-in (melt fusion)

With flame spraying the surface of the workpiece has to be cleaned thoroughly of rust, grease and oil before the real base preparation. The roughening of the metallically clean

Flame spraying with the
BÖHLER metal powder Niborit 6-P.

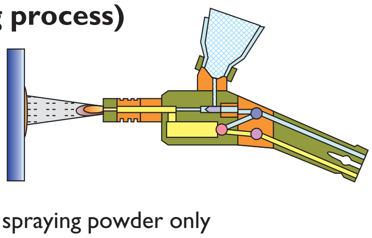
Flame spraying with BÖHLER metal powder Niborit 6-P.

surface should be made by blasting or rough grinding to facilitate a good bond with the sprayed layer. Spraying should immediately be carried out after the surface preparation.

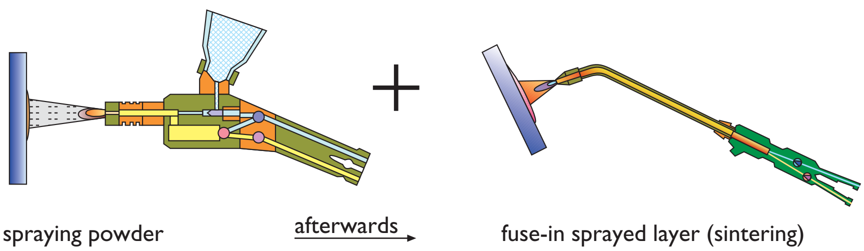
With powder flame spraying without secondary thermal treatment (called cold spraying process) a workpiece temperature of up to 300 °C is not exceeded, so that no changes in the structure of the component occur. With cold spraying process, the problem of distortion is eliminated all conventional powder alloys used in industry can be sprayed.

With the powder flame spraying process with subsequent fusing-in (called melt fusion), the applied metallic spraying layers are subsequently sintered at temperatures of 1,000 to 1,200 °C. The subsequent treatment can either be carried out with the aid of torches, with furnaces or by induction. For these process variations only the so-called self-flowing alloys with a nickel base and cobalt base are used. Their portions of boron and silicon aid the fusing process. Through this fusing process dense sprayed layers are produced and have considerably improved properties in respect of homogeneity, adhesion and surface roughness. Fields of application for these powder flame spraying processes are to be found, in the chemical, glass, plastic and electrical industry as well as in machine, pump and compressor constructions.

Powder flame spraying without secondary thermal treatment (cold spraying process)



Powder flame spraying process with subsequent fusing-in (melt fusion)

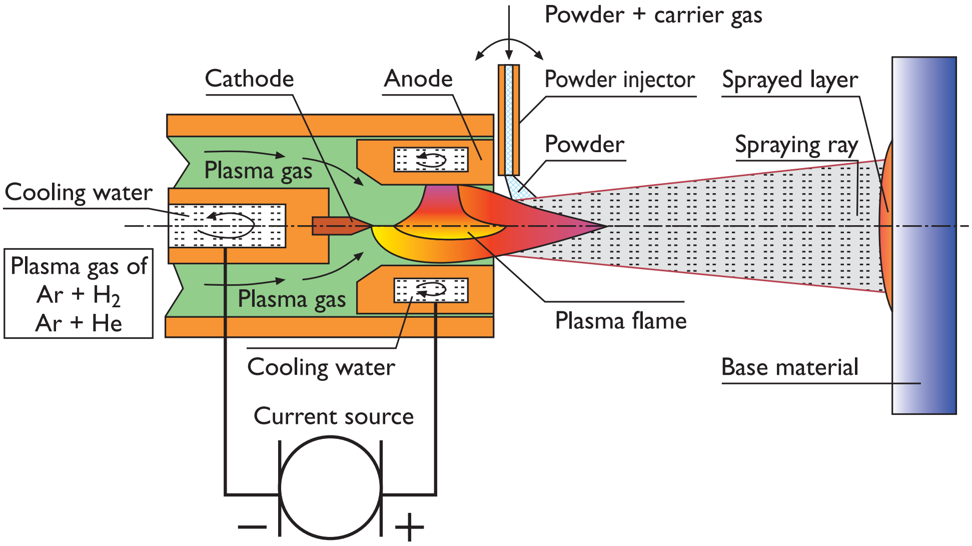


Schematic representation of flame spraying

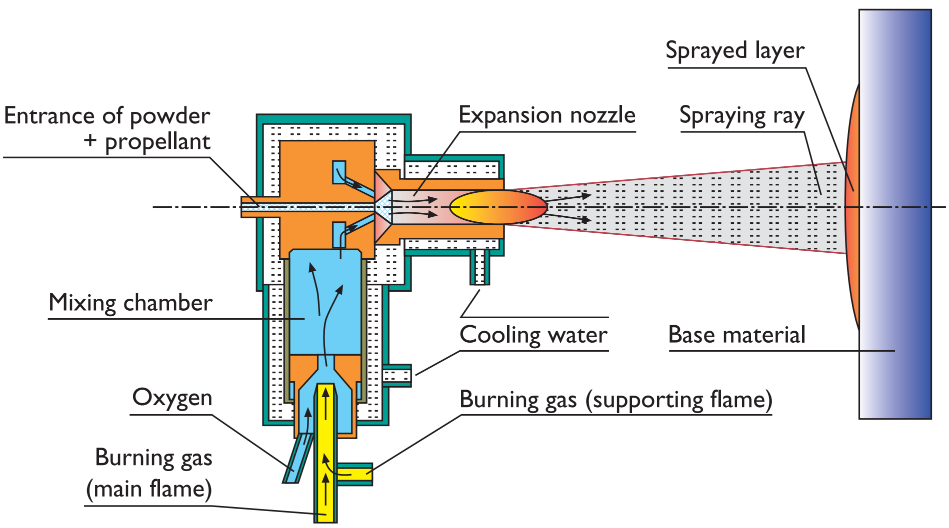
Plasma and high-velocity flame spraying (HVOF)

Plasma spraying belongs to the so-called arc spraying processes. In a plasma torch, an electrical arc is ignited by high frequency between a water-cooled tungsten cathode located centrically and a water-cooled jet shaped copper anode. Gasses such as argon, helium, nitrogen or hydrogen or mixtures thereof are forced under high pressure into the arc. The supplied gasses are ionized in the arc to plasma and reach temperatures up to 30,000 °C.

This hot plasma flow leaves the torch nozzle with high speed (approx. 1,000 m/s) as a brightly glowing plasma beam.



Schematic representation of the plasma spraying.



Schematic representation of high-velocity flame spraying (HVOF).

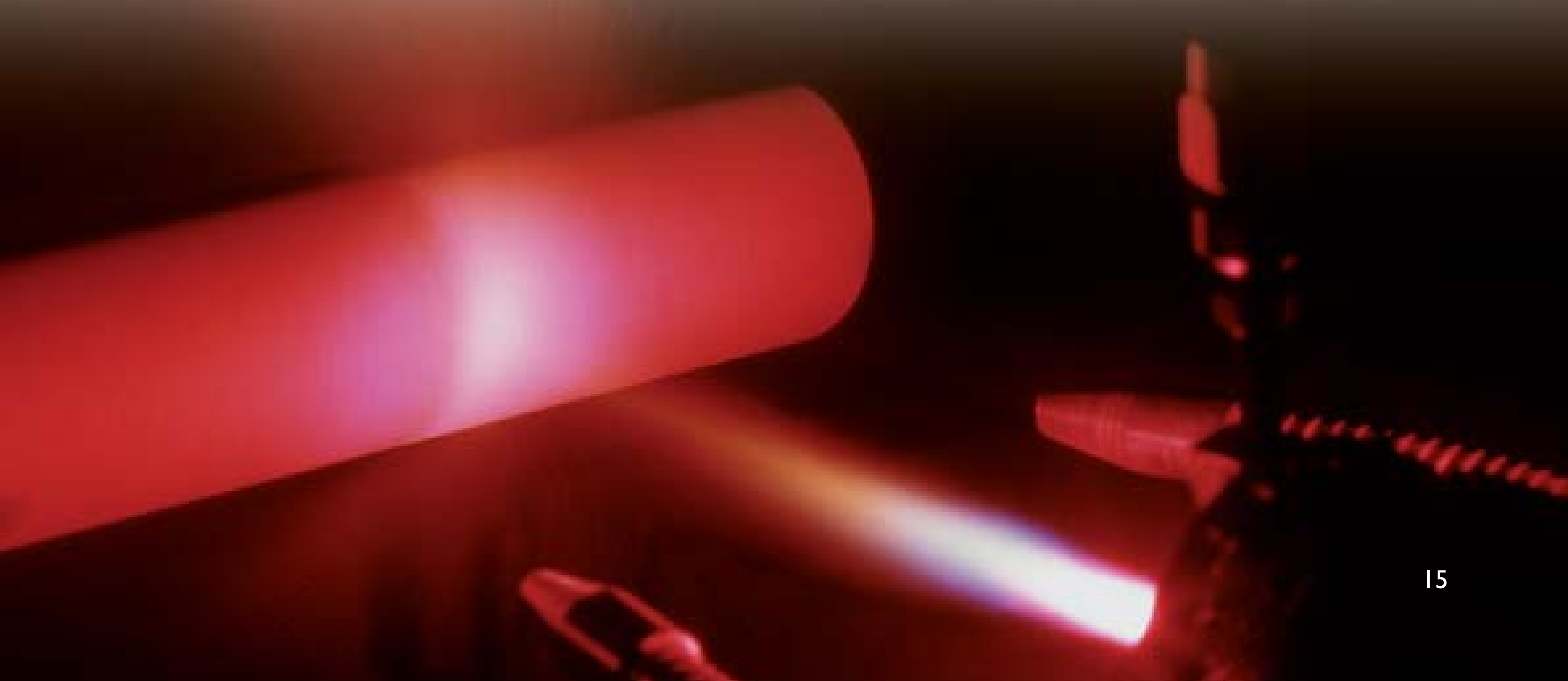
The spraying powder is added, by means of a conveying gas, in controlled doses to the plasma gas stream inside or outside the torch. In the plasma beam the spraying powder is accelerated to very high speed (approximately 400 m/s), melted and shot onto the surface of the workpiece. Upon striking the pretreated surface, the powder particles, which have become liquefied or plastic, form flat lamellas and solidify at once. The plasma stream, rich in energy, and the high impact speed of the powder particles upon the surface of the workpiece, result in a dense, firmly adhesive spraying layers of high quality which has a lamellar structure.

The outstanding difference between the conventional flame spraying and the high-velocity flame spraying (HVOF) is the high flow speed of the flame, which is above the speed of sound. A HVOF system consists of a spray gun, control unit, gas supply and a powder supply. The spray gun is the main part of the system. It consists of a gas mixing chamber, combustion chamber and an expansion nozzle. The spraying powder is supplied by the feeding system and is transported centrically by the conveying gas through the combustion chamber to the HVOF flame. The flame is formed using a combustible gas and oxygen mixture in a water-cooled pistol. Inside the expansion nozzle the powder particles are heated up and the powder particles are accelerated to very high speeds. As in the case of plasma spraying, high-quality sprayed layers are achieved, due to the high impact speed of the powder particles and the high-energy flame.

When plasma and HVOF spraying, the surface of the workpiece has to be cleaned carefully of rust, grease and oil, before the base preparation. The roughening of the metallically clean surface should be effected by blasting in order to facilitate a good bonding of the sprayed layer. The spraying process should immediately be carried out after the surface preparation.

The main areas of application of the plasma and HVOF spraying are protective layers against wear, corrosion, erosion, heat and abrasion and heat insulation, in the chemical industry, textile, paper and automobile industry, as well as in the construction of gas turbines, aircraft engines, ovens, pumps and reactors.

Plasma spraying.



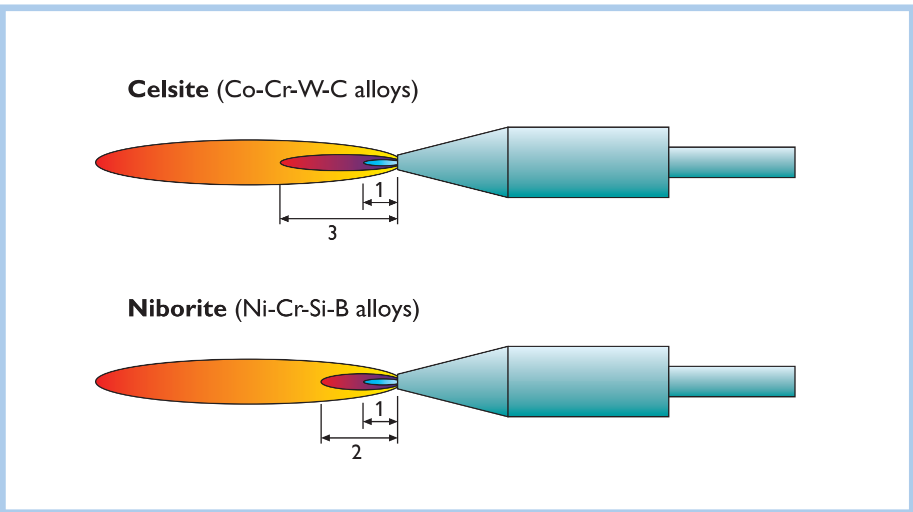
Hardfacing process with casting rods

Gas welding (Oxy-acethylene method)

The gas welding process is carried out with the acetylene oxygen flame. The chemical composition of the weld metal and the properties of the deposit are dependant on the composition of the welding rod and the dilution with the base material.

When gas welding, the base material is not melted but heated up to surface-fuse due to the low melting point of the hard alloys. Therefore the dilution with the base material is negligibly small. It is usual to weld hard alloys with a reducing flame, which means with acetylene gas surplus, with a neutral flame, a thick oxide film would build up making welding difficult. A reducing flame adjustment, the flame consists of three zones, the flame core, flame feather and the outer sheath of the flame. With an increasing acetylene gas surplus carbon is induced into the liquid weld pool. This carbon can lead to strong carburizing and pore formation in the weld metal. The carburizing of the weld metal also can increase hardness of the overlay. To reduce or to avoid carburizing and pore formation the hard alloys are welded with the following flame adjustment: hard alloys on Co base proportionally 3/1 (flame feather to flame core) and hard alloys on Ni base (Ni-Cr Si-B alloys) proportionally 2/1.

Gas welding with the casting rod BÖHLER Celsit V.



Gas welding flame adjustment.

TIG welding

In the TIG welding process, a burnout of carbon or other alloying elements doesn't occur because of the argon shielding gas. The weld metal composition depends on the composition of the alloy used and the dilution with the base material. To keep the dilution with the base material as low as possible it is recommended, to sharpen the tip of the tungsten electrode frustum shaped and not pointed as usual. This procedure avoids a strongly concentrated arc, which would cause much more melting of the base material and lead to a higher dilution with the welding material. During the overlay process the arc has to be turned towards the liquid weld pool and not to the base material so that a lower dilution can be achieved.

The investigations on the mechanism of pore formation showed, that during TIG welding the main cause lies in the oxygen content. The shielding gas (argon) prevents oxygen reaching the weld pool during welding. If pore formation takes place, so this must be seen in connection with an oxide film (scale) of the base material and/or with an oxidation of the welding rod. Therefore it is important the base material is cleaned sufficiently and the welding rod does not leave the shielding gas too early.

If necessary, the base material can get buffer layer before hardfacing.

TIG welding with the casting rod
BÖHLER Celsit SN.

Typical properties of metal powder coatings and overlay welding

Coating and overlay welding process	Layer Thickness of coating (mm)	Dilution (%)	Workpiece	
			Warming up during coating	Distortion after coating
Plasma-transferred-arc welding (PTA)	2.0 - 6.0 per layer	5 - 20	high but locally	high
Flame spray welding	up to 2.0	< 5	medium	medium
Flame spraying (melt fusion)	0.5 - 2.0	0	high	low
Flame spraying (cold spraying)	0.5 - 2.0	0	very low	no distortion
Plasma and HVOF-spraying	up to 0.8	0	very low	no distortion
Gas welding	1.5 - 5.0 per layer	< 5	very high	high
TIG welding	1.5 - 5.0 per layer	10 - 30	high but locally	high

Composition of BÖHLER metal powders

Grade	Alloy type	Typical analysis of the powder % by weight								
Cobalt based		C	Si	Cr	Mo	Ni	W	Fe	B	Others
Celsit V-P	Alloy 6	1.1		28.0			4.5			
Celsit SN-P	Alloy 12	1.4		30.0			8.5			
Celsit N-P	Alloy 1	2.4		31.0			13.0			
Celsit 21-P	Alloy 21	0.25		28.0	5.0	2.8				
Celsit FN-P	Alloy F-mod.	1.6	1.0	28.0		22.0	13.0	1.0		
Celsit F-P	Alloy F	1.8		26.0		23.0	12.5	1.0		
CN 20 Co 50-P	Alloy 25	< 0.1		20.0		10.0	15.0			
Coborit 45-P	Alloy SF 6	0.8	2.3	19.0		13.0	8.0	3.0	1.7	Cu 0.6
Coborit 50-P		0.2	3.5	18.0	6.0	27.0			3.0	
Coborit 60-P	Alloy SF 1	1.3	2.8	19.0		13.0	15.0		3.0	
Nickel based		C	Si	Cr	Mo	Co	W	Fe	B	Others
Niborit 20-P		0.05	3.0					2.5	2.0	
Niborit 4-P	Alloy 40	0.3	3.5	8.0				3.0	1.6	
Niborit 45-P	Alloy 45	0.4	3.5	9.0				3.0	2.0	
Niborit 5-P	Alloy 50	0.6	3.8	11.0				4.0	2.5	
SZW 5029	Alloy 56	0.6	4.0	12.5				4.0	2.8	
Niborit 6-P	Alloy 60	0.8	4.3	16.0				4.5	3.5	
Niborit 7-P	Alloy M 16C	0.50	3.7	17.0	4.5			2.0	3.75	Cu 2
Nibasit Al 5-P	NiAl 955	<0.03								Al 5
Nibasit Cr 20-P	NiCr 8020	0.1	0.6	20.0						
NiCr70Nb-P	Nicro 82	<0.03	0.3	20.0				< 1.5		Mn 3; Nb 2.5
Nibasit P 60-P	Alloy Ni 60	0.55	3.2	17.5				17.0		Ni 61
Iron based		C	Si	Cr	Mo	Ni	W	Co	B	Others
KW 10-P	1.4009	0.08	0.9	14.0		0.4				Mn 0.6; Cu 0.2
KW 40-P		0.4	0.4	13.0						
KWA-P	1.4015	0.04	0.7	17.0						Mn 0.5
SKWAM-P	1.4115	0.2	0.6	17.0	1.1					Mn 0.5
AS 4-P	Alloy 316	0.1	0.8	17.0	2.2	13.0				
AS 4-P/LC	Alloy 316 L	0.02	0.8	17.0	2.2	13.0				
A7CN-P	1.4370	0.08	0.7	19.0		9.0				Mn 7.0
Antinit DUR 300-P		0.12	5.0	21.0		8.0		<0.07		Mn 6.5
Ledurit 40-P		2.0	0.6	31.0						
Celsit SEO-P		3.9	0.5	31.0						
SZW 5033	Alloy E 6	2.0	1.25	29.0	5.5	12.0				
Mixed powders		C	Si	Cr	Mo	Ni	W	Fe	B	Others
Super DUR WC-P	WSC-Ni/60-40	2.3	1.2			37.0	Balance		1.2	
Super DUR W 6 Ni-P	WSC-Ni/40-60	2.5	2.6	9.6		Balance	38.0	2.7	2.1	

Further powder qualities are available upon request.

Use of BÖHLER metal powders

Grade	Alloy type	Coating process				
Cobalt based		PTA	FSS	FSW	FSK	PS/HVOF
Celsit V-P	Alloy 6	●				●
Celsit SN-P	Alloy 12	●				●
Celsit N-P	Alloy 1	●				●
Celsit 21-P	Alloy 21	●				●
Celsit FN-P	Alloy F-mod.	●				●
Celsit F-P	Alloy F	●				●
CN 20 Co 50-P	Alloy 25	●				●
Coborit 45-P	Alloy SF 6	●		●		●
Coborit 50-P		●		●		●
Coborit 60-P	Alloy SF 1	●		●		●
Nickel based		PTA	FSS	FSW	FSK	PS/HVOF
Niborit 20-P		●	●	●		●
Niborit 4-P	Alloy 40	●	●	●		●
Niborit 45-P	Alloy 45	●	●	●		●
Niborit 5-P	Alloy 50	●	●	●		●
SZW 5029	Alloy 56	●	●	●		●
Niborit 6-P	Alloy 60	●	●	●		●
Niborit 7-P	Alloy M 16C	●	●	●		●
Nibasit Al 5-P	NiAl 955					●
Nibasit Cr 20-P	NiCr 8020					●
NiCr70Nb-P	Nicro 82	●				●
Nibasit P 60-P	Alloy Ni 60	●				
Iron based		PTA	FSS	FSW	FSK	PS/HVOF
KW 10-P	1.4009	●			●	●
KW 40-P		●			●	●
KWA-P	1.4015	●			●	●
SKWAM-P	1.4115	●			●	●
AS 4-P	Alloy 316	●				●
AS 4-P/LC	Alloy 316 L	●				●
A7CN-P	1.4370	●				●
Antinit DUR 300-P		●				
Ledurit 40-P		●				●
Celsit SEO-P		●				●
SZW 5033	Alloy E 6	●				
Mixed powders		PTA	FSS	FSW	FSK	PS/HVOF
Super DUR WC-P	WSC-Ni/60-40	●				
Super DUR W 6 Ni-P	WSC-Ni/40-60		●	●		

Coating process

PTA: Plasma transferred arc welding
FSS: Flame spray welding
FSW: Flame spraying (melt fusion)
FSK: Flame spraying (cold spraying)
PS/HVOF: Plasma spraying / High-velocity flame spraying

Deliverable grain sizes of BÖHLER metal powders

Powder grain sizes from … up to (µm)	Coating processes				
	PTA	FSS	FSW	FSK	PS/HVOF
20 – 45					●
20 – 106		●	●	●	
32 – 106		●	●	●	
45 – 90					●
45 – 125	●	●	●	●	
50 – 150	●				
50 – 160	●				
50 – 180	●				
63 – 150	●				
63 – 160	●				
63 – 180	●				
63 – 200	●				

Other grain sizes are available upon request. Packing is in plastic bottles in units of 5 or 9 kg or in tin buckets in units of 25 kg.

Coating process

PTA: Plasma transferred arc welding
FSS: Flame spray welding
FSW: Flame spraying (melt fusion)
FSK: Flame spraying (cold spraying)
PS/HVOF: Plasma spraying / High-velocity flame spraying

Composition of BÖHLER casting rods

Grade	Alloy type	Typical analysis of the rod % by weight								
Cobalt based		C	Si	Cr	Mo	Ni	W	Fe	B	Others
Celsit V	Alloy 6	1.1	1.3	27.0		1.0	4.5	1.0		
Celsit SN	Alloy 12	1.8	1.3	29.0		1.0	8.5	1.0		
Celsit N	Alloy 1	2.4	1.1	32.0		1.0	13.0	1.0		
Celsit 20	Alloy 20	2.2		32.0		1.0	16.5	1.0		
Celsit 21	Alloy 21	0.25	0.5	28.0	5.0	2.8		1.0		
Celsit F	Alloy F	1.6	1.2	26.5		23.0	12.5	1.0		
CN 20 Co 50	Alloy 25	0.04	0.7	20.0		10.5	15.0	1.5		Mn 1.0
SZW 6002	Alloy 4H	1.7	0.8	32.0		0.5	11.0	1.0		
SZW 6014	Alloy 12 AWS	1.45	1.2	29.0		0.5	8.5	1.0		
SZW 6043	Alloy T-400	0.08	2.4	8.5	27.5	1.5		1.5		
Nickel based		C	Si	Cr	Mo	Co	W	Fe	B	Others
Celsit T-7	Alloy T-700	0.04	2.9	15.0	32.0	0.5		0.5		
SZW 36	Ni 60	0.8	3.6	16.0				17.0		Ni 61.0
SZW 6026	Alloy 60-Soft	0.7	2.0	14.5				4.5	3.2	
SZW 6024	Alloy 60-Hard	0.75	2.0	14.5				4.0	3.8	
SZW 6037	Alloy 50	0.6	3.5	11.5				3.7	1.9	
Iron based		C	Si	Cr	Mo	Ni	W	Co	B	Others
Antinit DUR 300		0.08	5.5	21.5		7.8		<0.05		Mn 6.2
Celsit SEO		3.9	0.6	31.0						
SZW 6046	Alloy E-6	2.0	1.2	29.0	5.5	13.0				
Special alloys / dental alloys in Co and Ni base		C	Si	Cr	Mo	Ni	Co	Fe	B	Others
SZW 6048	Spring-hard	0.38	0.6	27.0	5.5	<0.1	Balance	<0.5		
SZW 6049	Hard	0.45	0.6	30.0	5.5	<0.1	Balance	<0.5		
SZW 6050	Ceramic alloy	<0.05	1.5	26.0	11.0	Balance				
SZW 6051	Ceramic alloy	0.15	0.4	30.0	5.5	<0.1	Balance	0.5		Nb 1.0
SZW 6052	Ceramic alloy	<0.03	1.6	26.5	5.0	Balance		<0.3	0.25	
SZW 6058	Hard	0.5	0.6	29.0	5.0	<0.1	Balance	<0.3		

Other casting rod qualities are available upon request.

Use of BÖHLER casting rods

Grade	Alloy type	Hardfacing		Other application	
		Gas	TIG	Core wires	Dental
Cobalt based					
Celsit V	Alloy 6	●	●	●	
Celsit SN	Alloy 12	●	●	●	
Celsit N	Alloy 1	●	●	●	
Celsit 20	Alloy 20	●	●	●	
Celsit 21	Alloy 21		●	●	
Celsit F	Alloy F	●	●		
CN 20 Co 50	Alloy 25	●	●	●	
SZW 6002	Alloy 4H	●	●		
SZW 6014	Alloy 12 AWS	●	●	●	
SZW 6043	Alloy T-400		●		
Nickel based		Gas	TIG	Core wires	Dental
Celsit T-7	Alloy T-700		●		
SZW 36	Ni 60		●		
SZW 6026	Alloy 60-Soft	●	●		
SZW 6024	Alloy 60-Hard	●	●		
SZW 6037	Alloy 50	●	●		
Iron based		Gas	TIG	Core wires	Dental
Antinit DUR 300			●		
Celsit SEO			●	●	
SZW 6046	Alloy E-6		●		
Special alloys / dental alloys in Co and Ni base		Gas	TIG	Core wires	Dental
SZW 6048	Spring-hard				●
SZW 6049	Hard				●
SZW 6050	Ceramic alloy				●
SZW 6051	Ceramic alloy				●
SZW 6052	Ceramic alloy				●
SZW 6058	Hard				●

Remark

Hardfacing:
Gas: Gas welding (oxyacetylene welding) / O
TIG: Tungsten inert gas welding / W

Core wires:
Used with coated electrodes

Dental:
Dental alloys for the production of dental casting

Deliverable dimensions of BÖHLER casting rods

Grade	**rod diameter in mm**				
Cobalt based	3.0 / 3.2	4.0	5.0	6.0 / 6.4	8.0
Celsit V	●	●	●	●	●
Celsit SN	●	●	●	●	●
Celsit N	●	●	●	●	●
Celsit 20		●	●	●	●
Celsit 21	●	●	●	●	●
Celsit F	●	●	●	●	●
CN 20 Co 50	●	●	●	●	
SZW 6002		●	●		
SZW 6014	●	●	●	●	●
SZW 6043			●		
Nickel based	3.0 / 3.2	4.0	5.0	6.0 / 6.4	8.0
Celsit T-7			●		
SZW 36			●		
SZW 6026		●	●	●	
SZW 6024		●	●	●	
SZW 6037		●	●	●	
Iron based	3.0 / 3.2	4.0	5.0	6.0 / 6.4	8.0
Antinit DUR 300		●	●	●	
Celsit SEO		●	●	●	●
SZW 6046		●	●	●	
Special alloys / dental alloys in Co and Ni base	3.0 / 3.2	4.0	5.0	6.0 / 6.4	8.0
SZW 6048					●
SZW 6049					●
SZW 6050					●
SZW 6051					●
SZW 6052					●
SZW 6058					●

Rod lengths

- Rods in standard manufacture are straightened and available in length of 300, 350, 400, 450, 500, 1,000 and 2,000 mm.
- Dental alloys are available in length up to 2,000 mm.
- Further lengths are available upon request.

Rod surface

- Rods in standard manufacture have a cast finish.
- Ground rods are available upon request.

Reference values for weld metal hardness at room temperature and for elevated temperature hardness of the pure weld metal

Grade	HRC at RT	elevated temperature hardness in HV 10 at …									
		20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	800 °C	900 °C
Celsit V, ...V-P	41	410	394	344	330	322	311	272	197	180	152
Celsit SN, ... SN-P	48	485	447	412	401	388	368	357	333	285	230
Celsit N, ... N-P	53	626	605	571	523	487	451	445	386	304	263
Celsit 20	56										
Celsit 21, ... 21-P	32	325	291	271	254	239	222	201	186	166	150
Celsit FN-P	43										
Celsit F, ... F-P	45	446	442	400	355	333	315	304	295	271	228
CN 20 Co 50, ... -P	230 HB										
Coborit 45-P	45	447	447	428	409	390	361	295	238	271	
Coborit 50-P	50										
Coborit 60-P	60	760	740	700	650	580	500	420	225		
SZW 6002	53										
SZW 6014	46										
SZW 6043	54										
Celsit T-7	47										
Niborit 20-P	42										
Niborit 4-P	40	400	388	377	366	344	285	222	120		
Niborit 45-P	45										
Niborit 5-P	50	540	515	471	447	420	380	280	138		
SZW 5029	55										
Niborit 6-P	60	740	674	657	626	580	502	368	170		
Niborit 7-P	62										
Nibasit Al 5-P	Bond layer										
Nibasit Cr 20-P	170 HB										
NiCr70Nb-P	170 HB										
Nibasit P 60-P	240 HV										
SZW 36	250 HV										
SZW 6026	54										
SZW 6024	58										
SZW 6037	50										
KW 40-P	44-55										
KWA-P	20-40										
SKWAM-P	30-55										
AS 4-P	170 HB										
AS 4-P/LC	170 HB										
A7CN-P	170 HB										
Antinit DUR 300, ...-P	30	420	381	351	326	278					
Ledurit 40-P	43										
Celsit SEO, ... -P	57	650	650	650	526	428	435	335	238	222	141
Super DUR WC-P	> 60										
DUR W 6 Ni-P	> 60										

Remark

The hardness values given are valid for the alloy type independently of the product form or the coating processes.

Physical properties

Thermal expansion

Grade	Thermal expansion in 10^{-6} m/m °C at temperatures (°C)								
	20-100	20-200	20-300	20-400	20-500	20-600	20-700	20-800	20-900
Celsit V, ... V-P	11.9	13.5	14.0	14.4	14.7	15.3	15.8	16.0	16.1
Celsit SN, ... SN-P	11.3	12.5	12.9	13.3	13.7	14.2	15.0	15.1	15.3
Celsit N, ... N-P	11.1	11.6	12.3	12.8	13.0	13.3	14.0	14.4	14.6
Celsit 21, ... 21-P	11.3	12.3	13.0	13.6	14.0	14.3	14.9	15.2	15.5
Celsit F, ... F-P	11.5	12.6	13.0	13.2	13.5	13.9	14.5	14.9	15.4
Coborit 45-P	9.7	10.8	11.9	12.3	12.8	13.4	13.8	14.1	
Coborit 60-P	11.5	13.6	14.2	14.9	15.2	15.5	15.9	16.7	
Niborit 4-P	11.4	12.7	12.9	13.3	13.5	13.9	14.5	14.9	15.4
Niborit 5-P	11.4	12.1	12.2	12.5	12.7	12.9	13.4	13.8	14.2
Niborit 6-P	11.0	11.6	12.0	12.3	12.5	12.8	13.1	13.5	14.0
KW 40-P	10.5	11.0	11.0	11.5	12.0				
KWA-P	10.0	10.0	10.5	10.5	11.0				
SKWAM-P	10.5	11.0	11.0		12.0				
AS 4-P	16.5	17.5	17.5	18.5	18.5				
A7CN-P					18.0				
Antinit DUR 300, ...-P						15.7			
Celsit SEO, ... -P	11.3	12.5	13.1	13.3	13.5	13.6	14.4	14.5	14.5

Specific gravity, melting range and heat conductivity

Grade	Specific gravity	Melting range		Heat conductivity
	g/cm³	°C	°F	W/mK
Celsit V, ... V-P	8.30	1240 - 1340	2264 - 2444	15.0
Celsit SN, ... SN-P	8.40	1220 - 1310	2228 - 2390	15.0
Celsit N, ... N-P	8.70	1230 - 1290	2246 - 2354	15.0
Celsit 21, ... 21-P	8.35	1360 - 1405	2480 - 2561	
Celsit F, ... F-P	8.40	1230 - 1290	2246 - 2354	
CN 20 Co 50, ... -P	9.15	1345 - 1395	2453 - 2543	10.5
Coborit 45-P	8.30	1080 - 1150	1976 - 2102	
Coborit 50-P	8.30	1040 - 1120	1904 - 2048	
Coborit 60-P	8.40	1005 - 1210	1841 - 2210	
Niborit 4-P	8.20	1000 - 1150	1832 - 2102	
Niborit 45-P	8.20	990 - 1130	1814 - 2065	
Niborit 5-P	8.10	980 - 1070	1796 - 1958	
Niborit 6-P	7.90	960 - 1030	1760 - 1886	
KW 40-P	7.70			30.0
KWA-P	7.70	1476 - 1501	2689 - 2734	25.0
SKWAM-P	7.70	1435 - 1470	2615 - 2678	25.0
AS 4-P	7.80	1412 - 1441	2574 - 2626	15.0
A7CN-P	7.90			15.0
Antinit DUR 300, ...-P	7.80	1360 - 1390	2480 - 2534	
Celsit SEO, ... -P	7.50	1230 - 1325	2246 - 2417	

Properties of hardfacing and coatings with BÖHLER metal powders and casting rods

Grade	Adhesive wear	Abrasive wear	Impact stress	Corrosion*	Inter-crystalline corrosion	Heat-resistant	High temperature resistant	Resistance to thermal shocks	Magnetic
Celsit V, ... V-P	●		●	●	●	●	●	●	
Celsit SN, ... SN-P	●	●	●	●		●	●		
Celsit N, ... N-P		●		●		●	●		
Celsit 20		●		●		●	●		
Celsit 21, ... 21-P	●		●	●	●	●	●	●	
Celsit FN-P	●		●	●		●	●	●	
Celsit F, ... F-P	●		●	●		●	●	●	
CN 20 Co 50, ... -P	●		●	●	●	●	●	●	
Coborit 45-P	●		●	●			●		
Coborit 50-P	●	●		●			●		
Coborit 60-P	●	●		●			●		
SZW 6002	●	●	●	●		●	●		
SZW 6014	●	●	●	●		●	●		
SZW 6043	●	●	●	●	●	●	●	●	
Niborit 20-P	●		●	●			●	●	
Niborit 4-P	●		●	●			●	●	
Niborit 45-P	●		●	●			●		
Niborit 5-P	●	●	●	●			●		
SZW 5029	●	●		●			●		
Niborit 6-P	●	●		●			●		
Niborit 7-P	●	●		●					
Nibasit Al 5-P				●				●	
Nibasit Cr 20-P				●	●			●	
NiCr70Nb-P	●			●	●	●	●	●	
Nibasit P 60-P	●			●		●	●	●	
Celsit T-7	●	●	●	●	●	●	●	●	
SZW 36	●			●		●	●	●	
SZW 6026	●	●		●			●		
SZW 6024	●	●		●			●		
SZW 6037	●	●	●	●			●		
KW 40-P	●		●	●		●			●
KWA-P	●		●	●	●	●			●
SKWAM-P	●		●	●		●			●
AS 4-P				●				●	
AS 4-P/LC				●	●			●	
A7CN-P			●	●	●				
Antinit DUR 300, ...-P	●			●	●	●	●	●	●
Ledurit 40-P	●	●	●	●		●	●		●
Celsit SEO, ... -P	●	●	●			●			
SZW 5033	●		●	●		●	●	●	
SZW 6046	●		●	●		●	●	●	
Super DUR WC-P		●	●						
Super DUR W 6 Ni-P		●	●						

● = stable / yes

* The corrosion resistance depends essentially on medium and temperature (see table on the next page).

Corrosion behaviour of BÖHLER metal powders and casting rods

Corrosion medium	Concentration % by weight	Temperature °C	Celsit 21	Celsit V	Celsit SN	Celsit N	Niborit 4	Niborit 6
Phosphoric acid	10	RT		1		1		2
H_3PO_4	85	RT		1		1		2
	10	65		1		1		4
Nitric acid	10	RT		1	1	1	4	4
HNO_3	70	RT		1	1	1	4	4
	10	65	1	2	1	1	4	4
Sulphuric acid	10	RT	1	1	1	1	3	2
H_2SO_4	90	RT	1	2	1	1	4	4
	10	65	1	4	4	1	4	4
Hydrochloric acid	5	RT	1	3	3	1		2
HCL	37	RT	2	4	4	3-4		
	10	ST		4	4	4		
Acetic acid	20	RT	1	1	1			
CH_3COOH	90	RT	1	1	1			
	30	ST	1	1	1	1	4	4
Hydrofluoric acid	6	RT		4	4	2		
HF	40	ST				4		
Chromic acid	10	RT		1		1		1
	10	ST		4		4		4
Caustic soda lye	10	RT		1	1	1		
NaOH	40	RT		1				1
	5	ST				1		1
Copper chloride	2	RT		1		1		
$CuCl_2$	10	RT		1		1		
Ferric chloride $FeCl_3$	2	RT		1	1	1		
Ammonium nitrate NH_4NO_3	10		1		1			
Strauss test			1	1	3	1		2

Remark

RT: Room temperature
ST: Boiling point

Erosion rates

1 = < 1 g/m² Day
2 = 1-10 g/m² Day
3 = 11-25 g/m² Day
4 = > 25 g/m² Day

Application of BÖHLER metal powders and casting rods

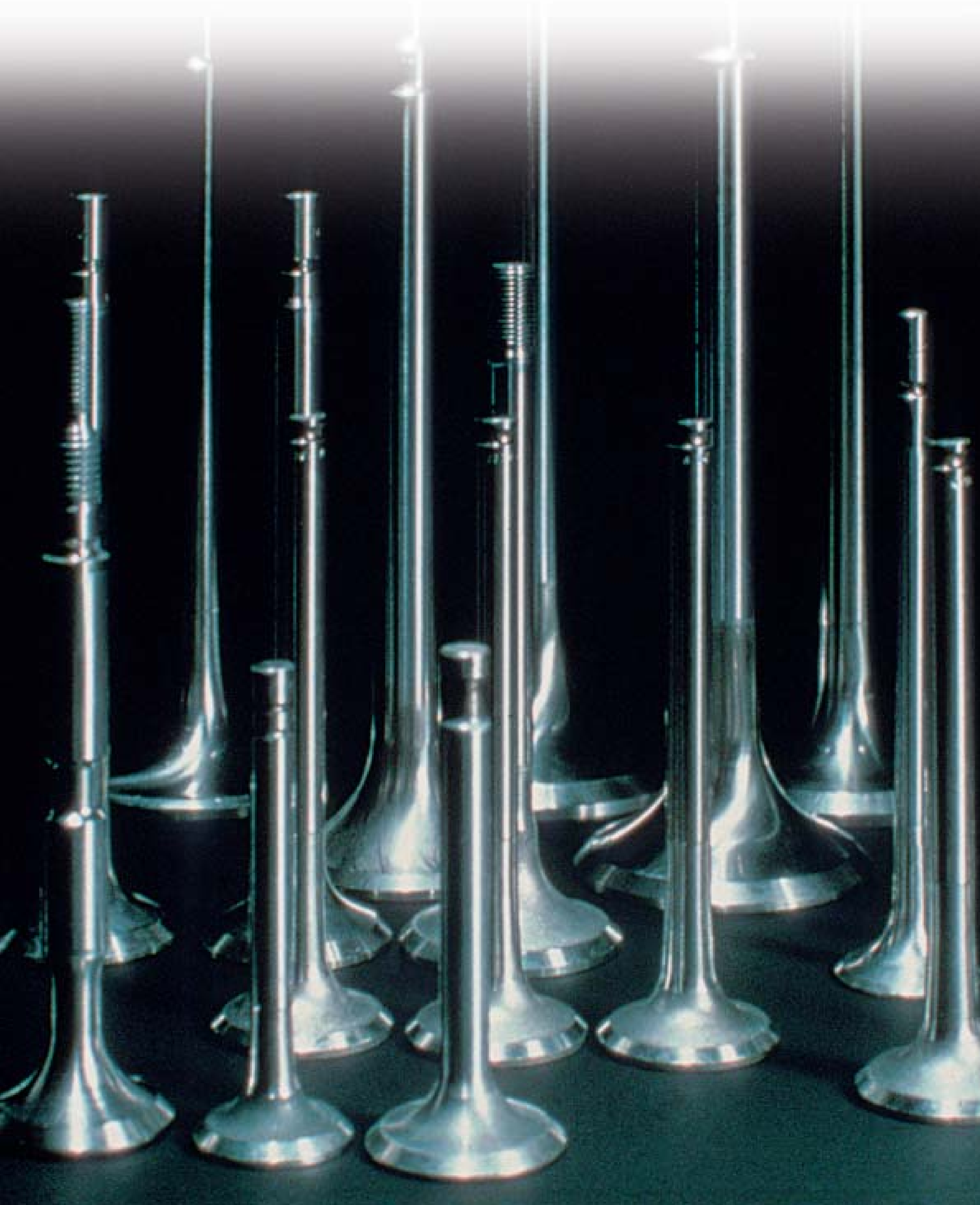
Industry	Parts for hardfacing or coating	Metal powder or casting rods
Automotive/Vehicle engineering	Engine valves, seats	Celsit FN-P, Celsit F-P, Celsit V-P, Celsit SN-P, SZW 5033, Celsit F
Shipbuilding	Engine valves, seats	Celsit V-P, Celsit SN-P, Nibasit P 60-P, Celsit V, Celsit SN, Celsit T-7, SZW 36, SZW 6002, SZW 6024, SZW 6026, SZW 6043
Glass industry	Press-press/blow-press dies, die plates, press moulds	Niborit 4-P, Niborit 20-P, Niborit 45-P
Power plants	Valves, spindles, bushes, cones, other wear parts	Celsit V-P, Celsit SN-P, Celsit 21-P, Celsit V, Celsit SN, Celsit 21, Antinit DUR 300-P, KWA-P, SKWAM-P
Plastic industry	Barrel extruders, bushes	Celsit V-P, Celsit SN-P, Celsit N-P, Niborit 5-P, Celsit V, Celsit SN, Celsit N
Pumps/Fitting engineering	Seat and guiding surfaces, cones, spindles, other wear parts	Celsit V-P, Celsit SN-P, Celsit 21-P, KWA-P, SKWAM-P, Celsit V, Celsit SN, Celsit 21
Wood/Paper industry	Motor saw rails, cutting rails and strips, cutting knifes, agitator blades	Celsit V-P, Celsit SN-P, Celsit N-P, Niborit 5-P, Niborit 6-P, Celsit V, Celsit SN, Celsit N
Steel/Metal processing	Transport rollers, guide rollers, hot shears, grates, rolling mill rolls	Celsit V-P, Celsit SN-P, Celsit N-P, Celsit 21-P, Celsit SEO-P, Niborit 6-P, Coborit 60-P, Celsit V, Celsit SN, Celsit N, Celsit 21, Celsit SEO
Agricultural	Plough blades, knifing discs, disc harrows	Celsit SEO, Niborit 5-P, Niborit 6-P, Super DUR W-6 Ni-P, Super DUR WC-P, Celsit SEO, SZW 6024
Cement/Mining/ Quarrying	High-pressure dies, worm conveyors, dredger teeth, single-blade cutters, crusher jaws, grinding bodies, wear plates	Niborit 6-P, Celsit SEO-P, Super DUR WC-P, Super DUR 6 Ni-P, Celsit SEO, SZW 6024
Chemistry	Bushes, seat surfaces, rotor shafts, bearing and sealing surfaces	AS4-P, Celsit 21-P, Celsit V-P, Celsit 21, Celsit V
Buffer material	When hardfacing the crack formation has to be reduced by buffer layers	CN 20 Co 50-P, Celsit 21-P, NiCr70Nb-P, A7CN-P, CN 20 Co 50, Celsit 21
Bond layer	Bond layer for thermal spraying	Nibasit Al 5-P

Practical tips regarding hardfacing

Problems	Causes	Countermeasures
Lack of fusion	Welding parameter	Optimization of the welding parameters.
Lack of sidewall fusion	Side walls too steeply, no radius	Flat position with sidewall angle 30 - 45 ° turned with radius of (R 1 - 3).
Dimensional accuracy	Base material delivered ready measured or little record of detailed measures of the base material.	Edge construction (e.g. copper shoe), similar welding material construction, buffering.
Shrinking or distortion	High welding stresses, high welding and intermediate layer temperature, larger number of layers.	Welding positioner, number of layers as less as possible, low welding and intermediate layer temperature (if no cracks).
Crack formation	Very hard welding material, base material with a large C content, low welding and intermediate layer temperature, larger number of layers.	Buffering, base material with a low C content, adjustment of the thermal expansions, high welding and intermediate layer temperature, lower number of layers, suitable welding process.
Hot crack formation	Overheating of the weld pool, high welding and intermediate layer temperature, analytical pollutions, unwanted trace elements.	Prevent overheating, low welding and intermediate layer temperature, no analytical pollutions, no unwanted trace elements.
Pore formation	Overheating of the weld pool, analytical pollutions, unwanted trace elements, flame adjustment, reactions to the gas formation.	No overheating of the weld pool, no analytical pollutions, no unwanted trace elements, optimal flame adjustment, no reactions to the gas formation.
Oxide skin / Slag formation	Base material surface containing scale, oxide and slag creator in the analysis (e.g. Al, Ti), shielding gas not sufficient.	Metallically clean base material surface, no oxide or slag creators in the analysis, more shielding gas.

Our technological department is at your disposal for further information or consultations.

Several engine valves processed by hardfacing with
BÖHLER metal powders and casting rods.



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