Höganäs

Thermal Surfacing
Marine & Offshore Industry Solutions

Höganäs Marine Solutions

Play an Important Protective Role

Marine engine applications need regular maintenance as a result of wear and corrosion. At some point of time, the parts even have to be replaced by new parts.

By applying a protective layer of powder consumable, it is possible to prolong the operating life of new parts and to refurbish worn. Thus, there is a huge potential for cost savings and minimising downtimes. In order to achieve the best results, it is vital to have a thorough knowledge about how to optimise the combination of powder consumable, process and surfacing treatment technique.

Höganäs' product portfolio consists of a wide range of powder consumables suitable for all surfacing techniques. The focus of this brochure is on overlay welding and thermal spraying techniques for reconditioning:

- Advancing overlay welding techniques
- Plasma Transferred Arc Welding (PTAW)
- Laser cladding
- Thermal spraying
- Höganäs powders and services
- Quick guide to Höganäs' powders

Figure 1 Overlay welding of shaft

Advancing Overlay Welding Techniques

Welding techniques for achieving metallic coating layers are characterised by metallurgical bonding to the substrate. It is very important to be able to control the process and minimise coating dilution by the substrate. This ensures the coating layer surface achieves the specific properties required.

For overlay welding, coating layer thickness can vary a lot depending on the technique but it should always achieve the thickness and chemical composition required. Care must be taken to avoid excessive substrate temperatures which can lead to deformation and other undesirable effects.

Why use advanced overlay welding techniques?

Conventional overlay welding techniques such as Metal Inert Gas (MIG/GMAG), Tungsten Inert Gas (TIG) and Submerged Arc Welding (SAW) have been and are still being successfully applied to a wide range of applications. However, a series of drawbacks, mainly associated with their high heat input to the workpiece, can compromise the result or prohibit their use in some cases.

Advanced overlay welding techniques such as Plasma Transferred Arc Welding (PTAW) and laser cladding provide excellent opportunities to improve production and reconditioning capabilities, reduce costs and enhance reliability.

Wear and corrosion

There are many forms of wear, from abrasive and adhesive to erosive that occur in the maritime environment. Metal to metal wear that occurs between valves and valve seats is one example. Typically these surfaces are coated to extend the service interval. Höganäs' wear laboratory supports our efforts to supply high wear resistant materials.

Applications working in corrosive environments, for instance tail shafts that come in contact with sea water, require particular protection. A non-porous coating layer without defects or cracks, deposited with a material with excellent corrosion resistance, can significantly minimise the risk of corrosion. The general influence of the alloying content on corrosion resistance is illustrated in Figure 2. Pitting corrosion is of particular interest in sea water environments. The performance of a Co-based material (2528-00) is compared to a typical stainless steel (316L) in Figure 3.

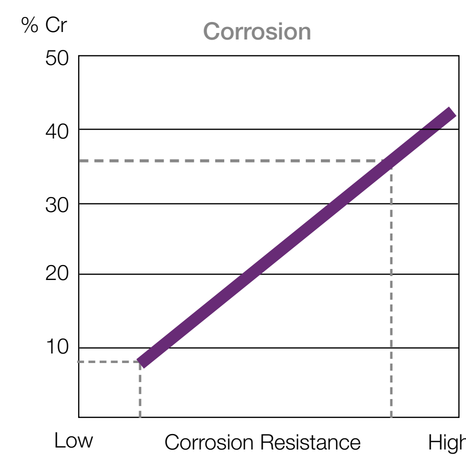


Figure 2 Ni, Cr, Mo and Cu improve corrosion resistance, C and B reduce it.

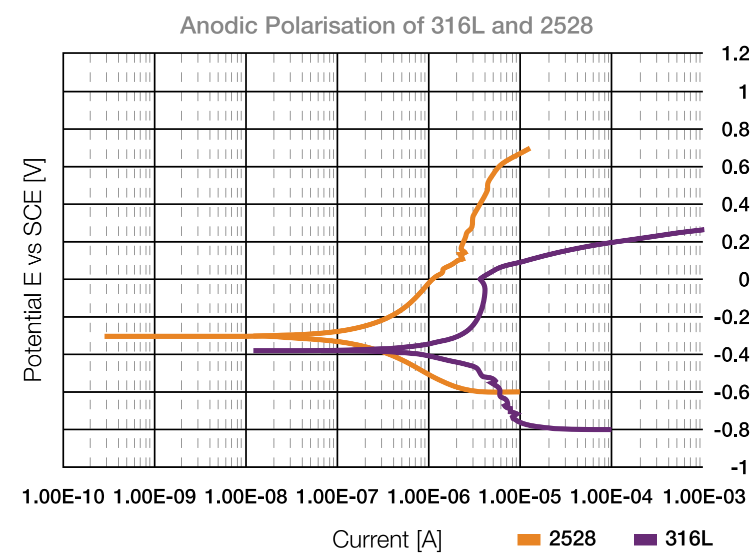


Figure 3 Corrosion data comparison for 316L and 2528 laser cladded depositions.

PTAW

PTAW enables a metallic bonding with the base material with minimal dilution of the substrate (recommended 5-15%). A collimated stream of gas in the plasma state (20 000K) provides the heat required to melt the filler and substrate materials. The gas, typically Argon, is excited inside the welding torch by flowing through an arc formed between a tungsten electrode and a water-cooled copper nozzle.

With the aid of a potential difference between the torch and the substrate, the excited gas is driven to the substrate. Powder filler metal is provided coaxially with the nozzle where it is preheated by the plasma gas and flows to the melt pool on the surface of the base material. Shielding gas is also provided coaxially for the protection of the molten materials.

Figure 4 Marine valve seat (left) and valve (right). Photo courtesy of Abanqobi Spares, South Africa.

Applications

Marine exhaust valve spindles/seats | Co-based hardfacing alloys and Ni-based super alloys are widely used by OEM part manufacturers and reconditioning centres.

Marine valve seats | For applications requiring excellent corrosion and wear resistance, such as valves operating at high temperatures and requiring metal-to-metal sealing.

Pipes and pumping system parts | The lower dilution levels of PTAW offer a good alternative to TIG with hotwire filler material feed.

Main benefits:

- High energy concentration and low heat input to substrate
- Reduced residual stress and distortion
- Low hydrogen technique compared to SAW
- Excellent control of welding bead geometry
- Good process repeatability
- Easy CNC integration
- Suitable with a wide range of filler metals such as cobalt-, nickel-, and iron-based materials as well as carbide cermets

PTAW and Laser cladding grades

Powder grade	Particle size µm	C %	Co %	Cr %	Mn %	Si %	B %	Ni %	Mo %	Fe %	W %	Others %
Nickel-base												
625	53-150	≤ 0.03	-	21.5	-	0.40	-	Bal.	9.0	1.4	-	Nb = 3.8
718	53-150	< 0.04	Max 1.0	18.0	-	Max 0.35	-	Bal.	3.0	19.0	-	Al = 0.3 Ti = 0.9 Nb = 5.1
1540-00	53-150	0.25	-	7.5	-	3.5	1.6	Bal.	-	2.5	-	-
1550-00	53-150	0.45	-	11.0	-	3.9	2.3	Bal.	-	2.9	-	-
Cobalt-base												
2528-00	53-150	0.25	Bal.	27.0	-	1.0	-	2.8	5.5	1.5	-	-
2537-00	53-150	1.1	Bal.	28.5	-	1.0	-	1.5	-	1.5	4.4	-
2537-10	53-150	1.3	Bal.	28.5	-	1.0	-	1.5	-	1.5	4.4	-
2541-00	53-150	1.4	Bal.	28.5	-	1.1	-	1.5	-	1.0	8.0	-
Iron-base												
316L	53-150	≤ 0.03	-	17.0	1.5	0.8	-	12.0	2.5	Bal.	-	-
420S	53-150	0.25	-	13.0	1.2	0.5	-	<1.0	-	Bal.	-	-
410L	53-150	≤ 0.03	-	12.5	0.1	0.5	-	-	-	Bal.	-	-
3533-00	53-150	1.75	-	28.0	0.8	1.3	-	16.0	4.5	Bal.	-	-
3533-10	53-150	2.1	-	28.0	1.0	1.2	-	11.5	5.5	Bal.	-	-

Laser Cladding

Laser cladding, a process currently gaining momentum, achieves minimal dilution (< 5%) by precisely controlling thermal input. Minimal heat input to the part gives higher welding quality and efficiency. To melt the substrate and filler metals, a high power laser beam is used. This allows a higher energy concentration in comparison to an arc.

All injected energy is confined within a small spot with no diffusion due to convection from hot gas or electromagnetic forces taking place. The filler metal can be added by pre-placing on the workpiece and welded afterwards. Another option is to inject it in the form of powder during welding in a single stage process.

Applications

Critical shafts and engine parts | Welding with minimal distortions allows the processing of critical parts such as propeller shafts, crankshafts, pump shafts, camshafts, piston rods, crosshead pins, etc.

Turbomachinery | In-situ laser cladding allows fast and cost-efficient repair of low pressure blades of steam turbines. Small turbo rotors can be repaired without distortion.

Other parts | Local repairs can be made on cast iron parts, such as expensive cylinder cover castings, and pump impellers at minimum cost and post machining.

The lower dilution of laser achieves the correct material chemistry after 1 layer with 1 mm height. The MIG/GMAG process requires 3 layers and 8 mm (see Figure 5).

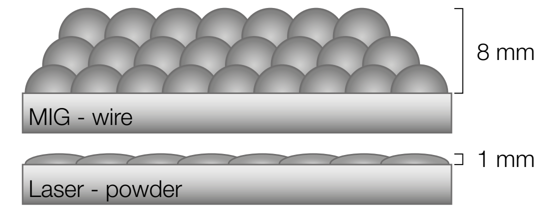


Figure 5 Laser cladding requires less machining than MIG/GMAG to reach final dimensions after deposition. This is due to the bead form or shape and the overlap.

Main benefits:

- Minimum distortion and residual stress in reconditioned parts
- Very low dilution levels (<5%) with very fine overlay thicknesses
- Impeccable control of welding bead geometry and overlay thickness attainable
- Local processing capability
- Deposition rates up to more than 12 kg/h
- Good fusion between substrate and filler materials
- Excellent mechanical properties

Powder grade	Hardness HRC	Hardness HV_{30}	Melting range (°C)	Thermal expansion co-efficient (10^{-6}/°C)	Hall flow (sec/50g)	Density (g/cm^3)	Recommended use /Features/Comments
Nickel-base							
625		200*	1290-1350	15.6 (20-800°C)	14.2	8.4	IN 625 [1)]
718		240*	1200-1300	16.0 (25-800°C)	15.5	-	IN 718 [1)]
1540-00	40*		1010-1140	14.4 (25-600°C)	15.4	8.1	
1550-00	52*		1000-1110	13.6 (20-600°C)	15.4	7.9	
Cobalt-base							
2528-00		340*	1185-1385	15.6 (20-800°C)	15.7	8.3	Stellite 21 [2)]
2537-00	41*	480	1285-1375	15.6 (20-800°C)	15.8	8.3	Stellite 6 [2)]
2537-10	43*		1285-1375	15.6 (20-800°C)	15.8	8.3	Stellite 6 [2)]
2541-00	44*		1280-1315	15.2 (20-800°C)	16.4	8.5	Stellite 12 [2)]
Iron-base							
316L		160*	1375-1430	19.5 (20-800°C)	16.4	7.9	316L [3)]
420S	55*			-	-	-	
410L		220*	1480-1530	-	14.5	-	416L [3)]
3533-00	33*		1220-1320	-	15.0	7.8	
3533-10	42*		-	16.1 (25-800°C)	14.8	7.7	

* Value measured after PTAW

Thermal Spraying

Thermal spraying includes techniques where a hot filler material, is sprayed with high velocity against the workpiece to create an overlay. Many applications in the marine industry are repaired by the available techniques described below.

Flame Spray

By utilising combustible gas such as hydrogen, acetylene, propane and natural gas, the flame spray process creates the energy required to soften the coating material. The semi-molten particles flatten under impact and interlock with the base material and with each other to form a mechanical bond.

To form a dense coating strongly adhered to the substrate, spraying is typically followed by a fusing process. This can be achieved by passing a gas torch over the deposit at about 1000°C or by heating in a furnace with controlled atmosphere.

Applications

- Restoration of various parts, for example bearing journals and rotor shaft sealing areas.

Plasma Spray

This method employs a technique essentially similar to flame spraying. It differs in that the flame comprises an electrically excited plasma of high velocity and temperature (≈15 000K). This permits a denser coating (95-98%). Deposition rates are from 2–8 kg/hour, and surfacing thickness from 0.1–2.5 mm.

High Velocity Oxygen Fuel (HVOF)

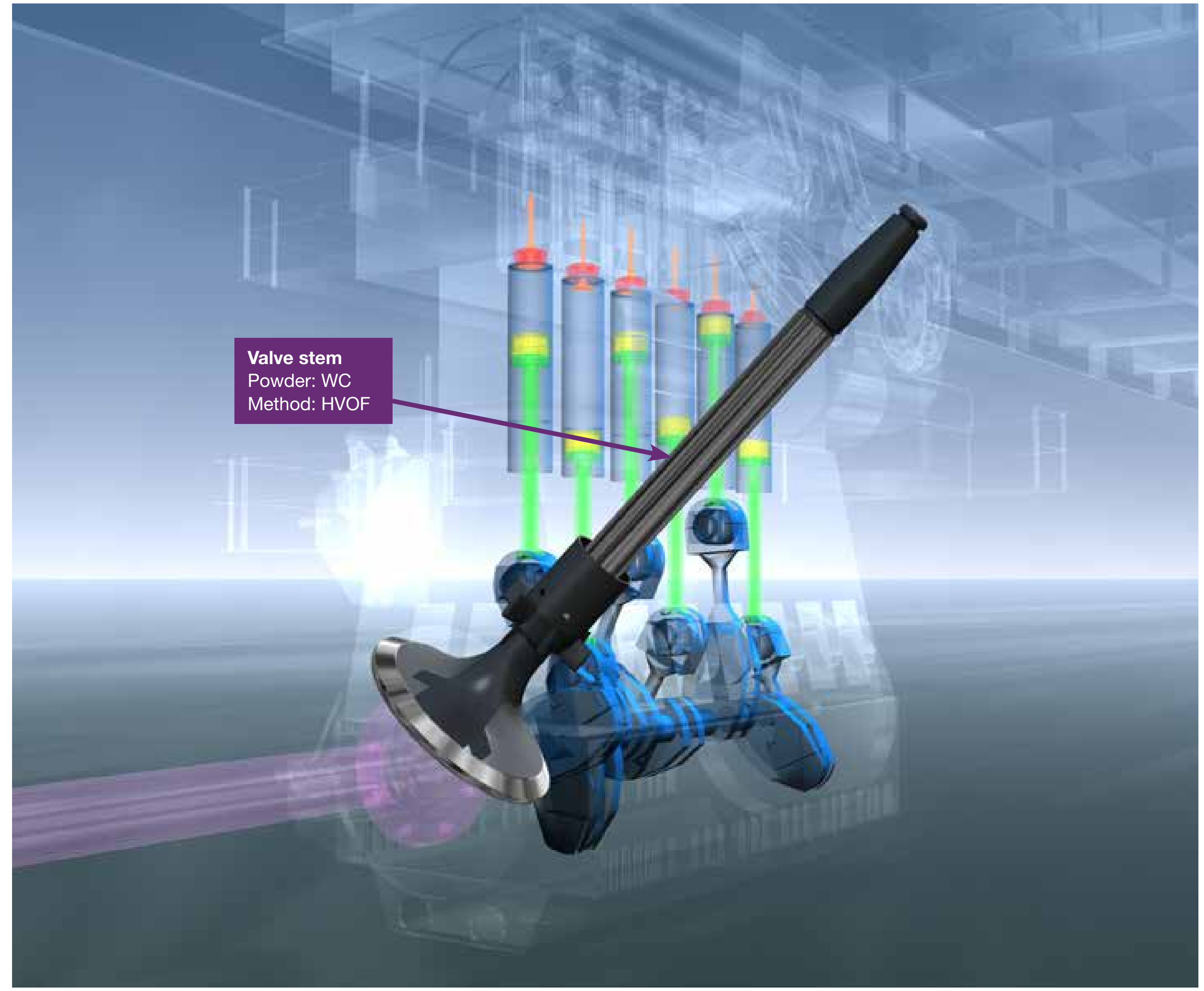
HVOF is a thermal spraying process using high gas velocity. Fuel and oxygen is combined to create rapidly expanding combustion gases inside a specially designed combustion nozzle. At speeds around 5 Mach, the powder filler metal is accelerated through the flame. In most HVOF systems, the transient time of particles within the flame is such that they do not melt.

The melting process is supported by the plasticising of particles as they collide with the substrate. This feature is particularly useful when applying carbide cermets where the carbide particles should remain below melting temperatures and retain their properties.

The high collision velocities allow for very dense (<0.5 % porosity) and uniform coatings with excellent adhesion, wear and corrosion properties.

Applications

- Hydraulic piston rods
- Two-stroke engine piston rods
- Exhaust valve stems



Plasma and HVOF spraying grades

Powder grade	Particle size µm	C %	Co %	Cr %	Mn %	Si %	B %	Ni %	Mo %	Fe %	W %	Others %
Nickel-base												
1660-02	20-53	0.75	-	14.8	-	4.3	3.1	Bal.	-	3.7	-	-
1660-02+WC	20-53	-	-	-	-	-	-	-	-	-	-	-
Cobalt-base												
2628-02	20-53	0.25	Bal.	27.0	-	0.9	-	2.5	5.5	1.5	-	-
2637-02	20-53	1.1	Bal.	28.5	-	1.0	-	1.5	-	1.5	4.4	-
Iron-base												
316L	20-53	≤ 0.03	-	17.0	1.5	0.8	-	12.0	2.5	Bal.	-	-
3650-02	20-53	1.75	-	28.0	0.8	1.3	-	16.0	4.5	Bal.	-	-

Powder grade	Hardness HRC	Hardness HV_{30}	Melting range (°C)	Hall flow (sec/50g)	Density (g/cm³)	Recommended use /Features/Comments
Nickel-base						
1660-02		780*	970-1200	12.6	7.7	
1660-02+WC			-	-	-	
Cobalt-base						
2628-02		300**	1185-1385	11.5	-	Stellite 21 [2)]
2637-02		380*	1275-1375	11.6	-	Stellite 6 [2)]
Iron-base						
316L		160**	1275-1430	13.0	7.9	316L [3)]
3650-02		500**	1220-1320	13.1	7.8	

* Indicative value
** Measured value

Höganäs Powders

Recommendations for overlay welding and thermal spray

Höganäs manufactures a wide range of metallic materials with a proven track record including the compositions required for marine and offshore applications. These are available in a range of particle size intervals to function in all equipment brands.

It is important to choose the right powder grade, chemical composition and hardness etc., but also the right particle size range. Our powder grades have seven main standard sieve ranges (see Figure 6).

Choice of material

Classification society rules specify the material suitable for each application. Based on these recommendations a range of materials can be seen on page 11.

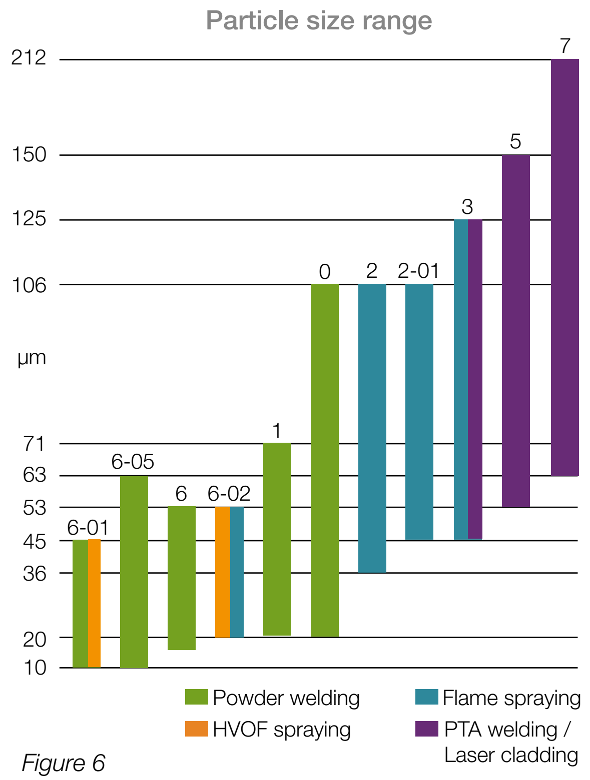


Figure 6

Recommended Storage Conditions

- Bottles should be tightly sealed at all times during storage
- Opened bottles must be resealed immediately after use
- Bottles should be stored in clean and dry conditions at all times
- Storage temperatures of 15-25°C are considered optimum

Important

Shake bottles well before use. No large and fast temperature changes should occur during storage as this will cause humidity inside the cap even when it is sealed.

If for some reason the powder moisture content has increased this can be lowered by drying. Dry the powder at 80°C (max 100°C) for one hour. Preferably under rotation for best effect.

Services

Independent consulting service for laser cladding may be requested for choice and enabling of equipment, staff training and as a speaking partner – request quote.

Classification societies may require the preparation of welding coupons that will be used for the construction of specimens for mechanical testing. As a technical service, we can provide customers with coupon evaluation – request quote.

Powder designations

1 6 20 – 1 1
A B C – D E

A: Alloy Base
1 = Nickel (Ni)
2 = Cobalt (Co)
3 = Iron (Fe)
4 = Tungsten Carbide (WC)

B: Standard Particle Size Range
0 = 20 – 106 µm
1 = 20 – 71 µm
2 = 36 – 106 µm
3 = 45 – 125 µm
5 = 53 – 150 µm
6 = 15 – 53 µm
7 = 63 – 212 µm

C: Average Hardness: Rockwell C

D: Chemical Composition
1–9 = modified

E: Particle Size Range
1–9 = modified

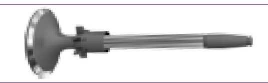
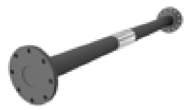
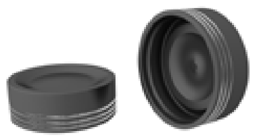
Foot notes

1) Registered trademark Inco Corp.
2) Registered trademark Kennametal Stellite
3) A.I.S.I. standard
4) Spherical particles
5) This sieve is especially designed for HVOF


Schematics of marine engine.

Quick Guide to Höganäs Powder Grades

Marine and offshore applications

Powder	Typical HRC	Typical HV_{30}	Method	Parts	Application
1550-00	52		PTAW or Laser Cladding		Exhaust valve seat region
2537-00	41				
2537-10	43				
2541-00	44				
718		240			Valve bottom surface
316L		160			
625		200			
1660-02 +WC	-	-	HVOF		Valve stem
2537-00	41		PTAW or Laser Cladding		Valve seat
420S	55				
316L		160			
410L		220			
410L		220	PTAW or Laser Cladding		Valve cage
2537-00	41				
2528-00		340	Laser Cladding		Turbo rotor
410L		220			
3533-10	42		Laser Cladding		Hydrolic piston rod Depends on corrosion requirement 2 stroke engine piston rod
625		200			
420S	55				
625		200	PTAW or Laser Cladding		Intermediate shaft
3533-00	33				
316L		160			Final shaft
410L		220			
1540-00[a]	40		Laser Cladding		Piston crown Piston groves 4 stroke engine[a] 2 stroke engine[b]
2537-00[b]	41				

Equipment specific products on request.

Power of Powder®

Metal powder technology has the power to open up a world of possibilities. The inherent properties of metal powders provide unique possibilities to tailor solutions to match your requirements. This is what we call Power of Powder, a concept to constantly widen and grow the range of metal powder applications.
With its leading position in metal powder technology, Höganäs is perfectly placed to help you explore those possibilities as your application project partner.

Höganäs is an independent powder manufacturer providing a full range of surface coating products. A comprehensive choice of high quality powder solutions enhances the potential for surface coating industry applications. Having knowledge about materials, processes, applications and long experience working within the field, Höganäs offers support to enable your success.
To find out how you can apply the Power of Powder, please contact your nearest Höganäs office.

Sweden Höganäs AB
Höganäs
Phone +46 42 33 80 00
info@hoganas.com

Brazil Höganäs Brasil Ltda
Mogi das Cruzes
Phone +55 11 4793 7729
brazil@hoganas.com

China Höganäs (China) Co. Ltd
Shanghai
Phone +86 21 670 010 00
china@hoganas.com

France Höganäs France S.A.S.
Limas
Phone +33 474 02 97 50
france@hoganas.com

Germany Höganäs GmbH
Düsseldorf
Phone +49 211 99 17 80
germany@hoganas.com

India Höganäs India Pvt Ltd
Pune
Phone +91 20 66 03 01 71
india@hoganas.com

Italy Höganäs Italia S.r.l.
Rapallo (Genoa)
Phone +39 0185 23 00 33
italy@hoganas.com

Japan Höganäs Japan K.K.
Tokyo
Phone +81 3 3582 8280
japan@hoganas.com

Rep. of Korea Höganäs Korea Ltd
Seoul
Phone +82 2 511 43 44
korea@hoganas.com

Russia Höganäs East Europe LLC
Saint Petersburg
Phone +7 812 334 25 42
russia@hoganas.com

Spain Höganäs Ibérica S.A.
Madrid
Phone +34 91 708 05 95
spain@hoganas.com

Taiwan Höganäs Taiwan Ltd
Taipei
Phone +886 2 2543 1618
taiwan@hoganas.com

United Kingdom Höganäs (Great Britain) Ltd
Tonbridge, Kent
Phone +44 1732 377 726
uk@hoganas.com

United States North American Höganäs Co.
Hollsopple: PA
Phone +1 814 479 3500
info@nah.com

www.hoganas.com/surface-coating