LINSPRAY®

High Performance Coating Techniques

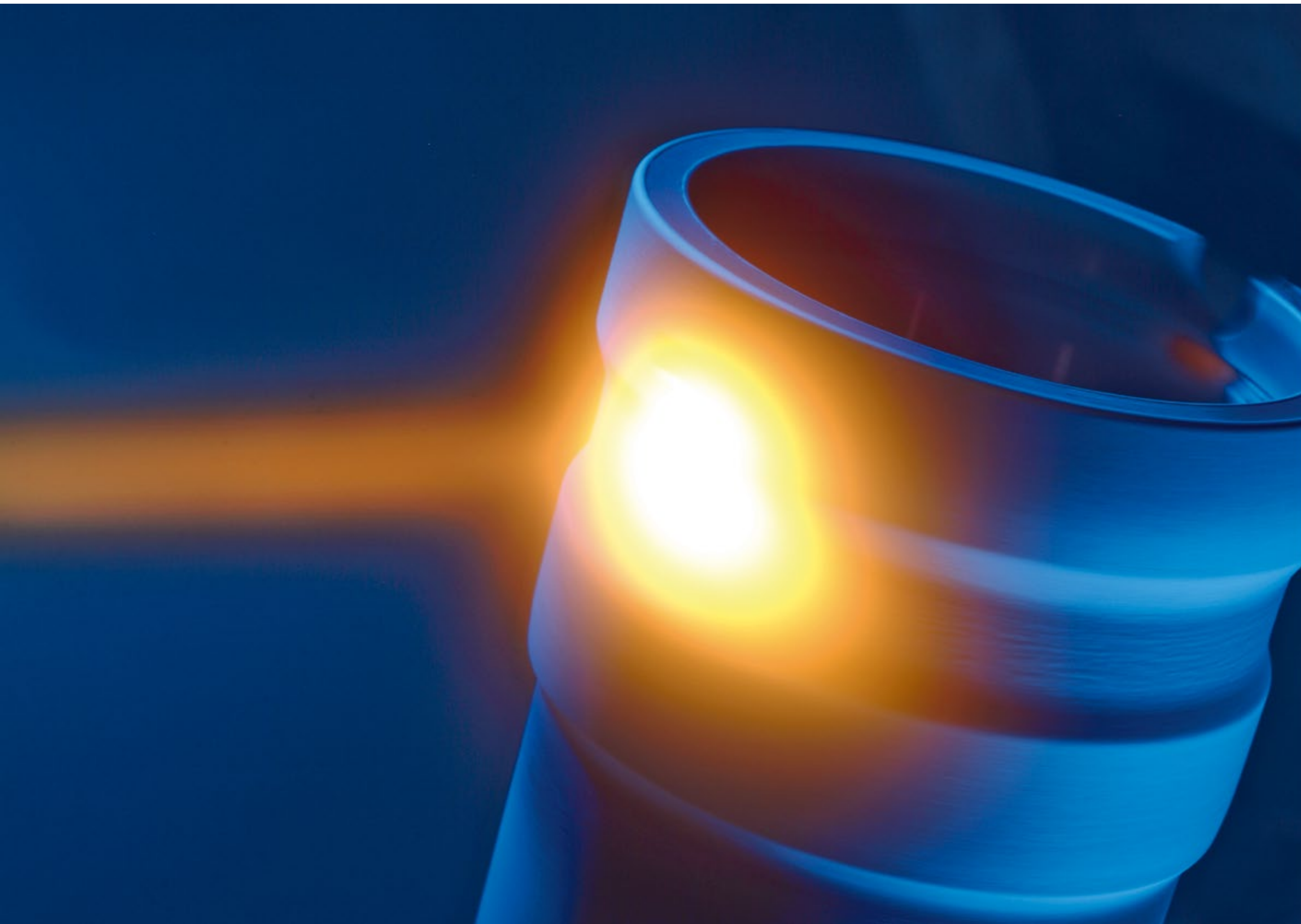
Contents

Introduction

Our customers are constantly seeking new ways of improving the quality and productivity of their coating techniques.

From anti-corrosion coating to improved wear performance, thermal spray provides the perfect combination of high quality and cost effectiveness.

BOC prides itself in being able to offer the right coating solution using the ideal gas supply concept to deliver what its customers need.



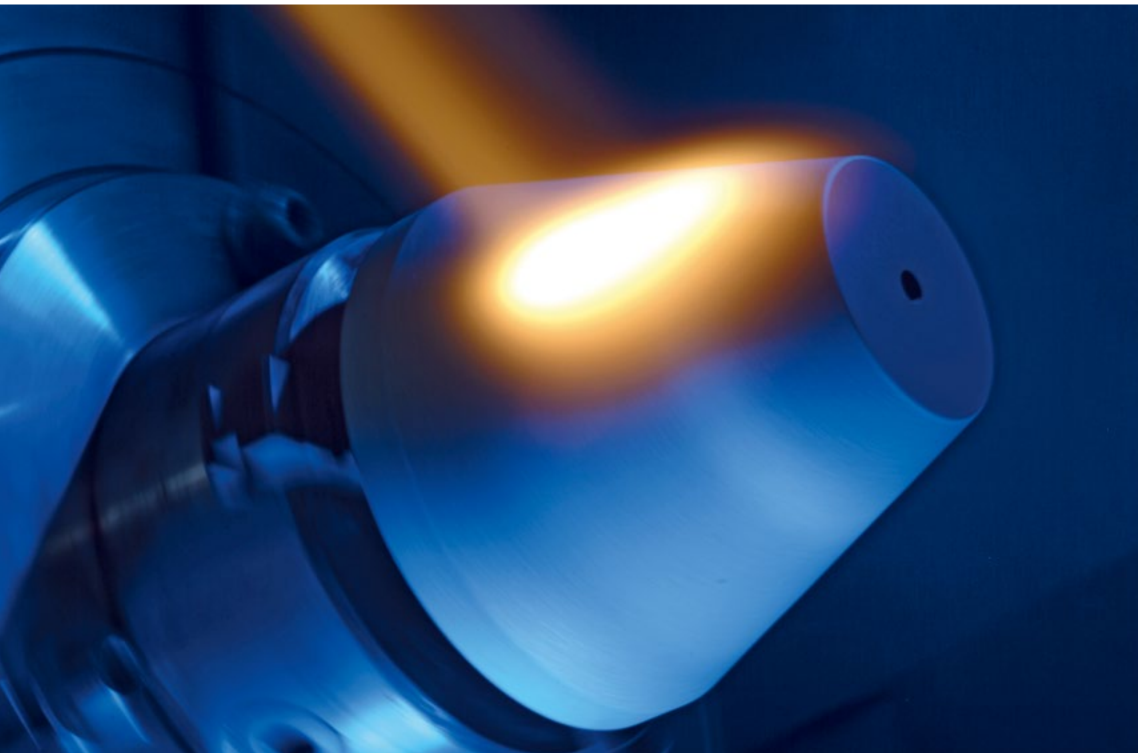
LINSPRAY Thermal Spraying
Industrial Gases for Higher Efficiency and Better Quality

Thermal spraying has become increasingly important, both in the manufacturing of new parts and in the repair of existing parts. With increasing demands on component anti-wear and anti corrosion protection, thermal spray is often the coating method of choice. Its primary advantages are:

- Numerous combinations of base material and coating material are possible
- High quality materials can be used to improve the properties of the base material in a cost effective way
- The flexibility of thermal spraying means that high-grade worn parts can be repaired keeping costs and downtime to a minimum

There are a number of different thermal spray processes. Each has its own unique set of advantages which means that the correct choice of process is important to achieve the required finished properties.

Similarly, the choice of gas and supply system is critical to achieving the most effective coating process.



Choosing the Right Process
Balancing Quality and Efficiency

Flame spraying with wire or rod

In wire or rod flame spraying, the spray material is continuously melted in the center of an oxy-acetylene flame. With the aid of an atomizing gas such as compressed air or nitrogen, the droplet-shaped spray particles are discharged from the melting zone and propelled onto the prepared workpiece surface.

Flame spraying with wire is a widely applied method with a very high coating quality standard. In the automotive industry, for example, several hundred tons of molybdenum, per year, are used to coat gear selector forks, synchronizing rings or piston rings.

Gases for flame spraying with wire or rod

Acetylene-oxygen
Hydrogen-oxygen
Propane-oxygen
Propylene-oxygen
Atomizing gas: e.g. air, nitrogen

Flame spraying with powder

In powder flame spraying, the spray material in powder form is melted or fused in an oxy-acetylene flame and propelled onto the prepared workpiece surface with the aid of expanding combustion gases. If necessary, an additional gas (e.g. nitrogen) can be used to accelerate the powder particles. The range of spray powders available is enormous, comprising well over 350 different types.

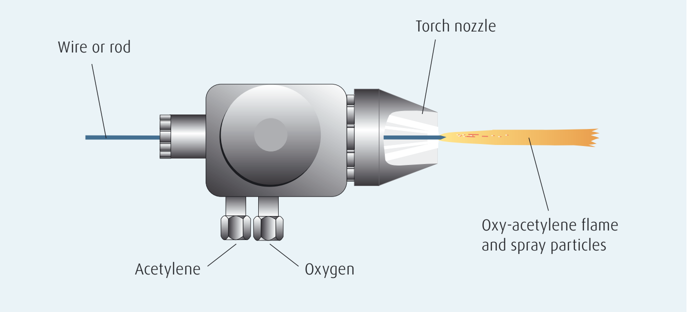
Powders are classified as self-fluxing and self-adhering. Self-fluxing powders normally require additional thermal post-treatment. In most cases, this "fusing" step is carried out using oxy-acetylene torches, which are extremely well-suited to this task.

The adhesion of the spray coating to the base material is greatly enhanced by the heat treatment, rendering it impervious to gases and liquids.

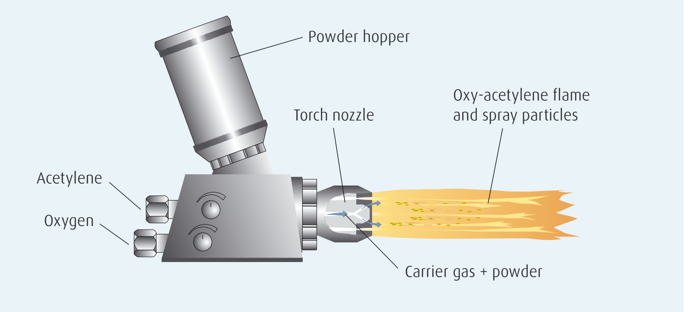
Applications include shaft sleeves, roll-table rollers, bearing seats, ventilating fans, extruder screw rotors.

Gases for flame spraying with powder

Acetylene-oxygen
Hydrogen-oxygen
Propane-oxygen
Propylene-oxygen
Carrier gas: e.g. nitrogen, argon, oxygen



Thermal energy: max. 3,160 °C   Kinetic energy: up to 200 m/s   Deposition rate: 6–8 kg/h



Thermal energy: max. 3,160 °C   Kinetic energy: up to 50 m/s   Deposition rate: 1–6 kg/h

Flame spraying with plastics

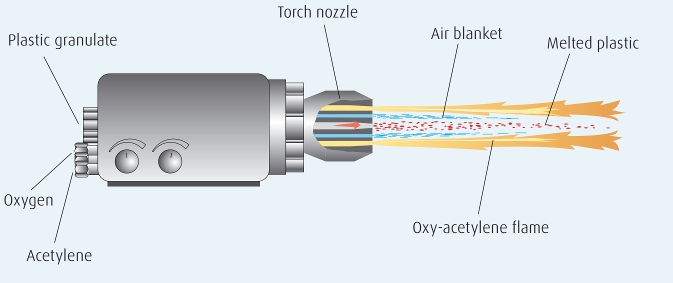
In flame spraying with plastics, the plastic coating material does not come into direct contact with the oxy-acetylene flame. A powder-feed nozzle is located in the center of the flame spray gun. This is surrounded by two ring-shaped nozzle outlets, the inner ring being for air or an inert gas and the outer ring for the thermal energy source, i.e. the oxy-acetylene flame.

The plastic coating material is therefore not melted directly by the flame, but by the heated air and radiation heat. The mobility of flame spraying with plastics, e.g. its use on-site, makes it increasingly versatile in its application.

Applications include every kind of railing, feed-through pipes in walls, drinking-water tanks, garden furniture, swimming-pool markings, and the coating of recycled plastic components.

Gases for flame spraying with plastics

Acetylene-oxygen
Carrier gas: e.g. nitrogen, argon



Thermal energy: max. 3,160 °C Kinetic energy: up to 30 m/s Deposition rate: 2–4 kg/h

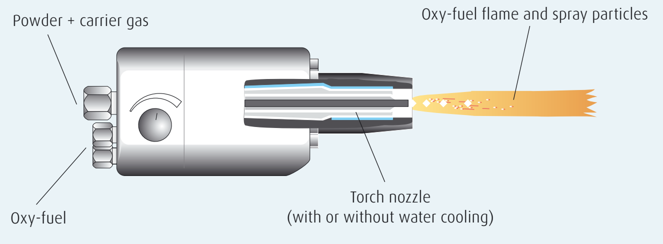
High velocity oxy-fuel spraying (HVOF)

High velocity oxy-fuel spraying involves a continuous gas combustion under high pressure in a combustion chamber. The spray material, in powder form, is fed into the central axis of the chamber. The high pressure of the oxyfuel gas mixture produced in the combustion chamber – and in the expansion nozzle which is usually located downstream of the chamber – in turn produces the desired high flow velocity in the gas jet. In this way, the spray particles are accelerated to high velocities, leading to exceptionally dense spray coatings with excellent adhesion. Due to the sufficient but moderate heat input, the spray material undergoes only slight metallurgical changes as a result of the spray process, e.g. minimal formation of mixed carbides. With this method, extremely thin coatings with a high dimensional accuracy can be produced.

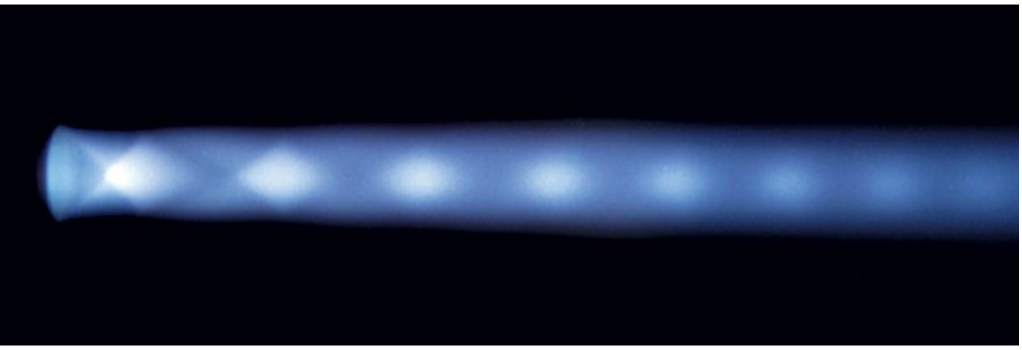
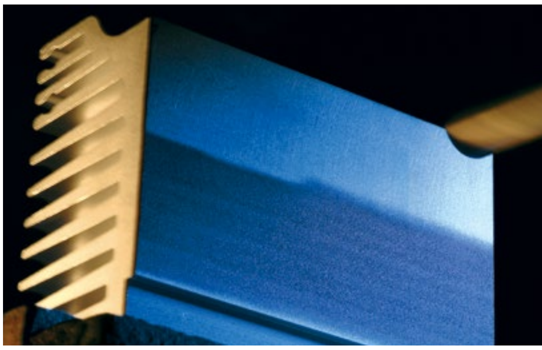
Applications include sliding surfaces of steam irons, rollers for the photographic industry, machine parts for the petrochemical and chemical industry, e.g. pumps, slides, ball valves, mechanical sealings, Kaplan blades, every kind of anti-wear protection, also in connection with anti-corrosion protection, electrically insulating coatings (oxides).

Gases for high velocity oxy-fuel spraying

Ethene-oxygen
Propane-oxygen
Propylene-oxygen
Hydrogen-oxygen
Acetylene-oxygen
Carrier gas: e.g. nitrogen, argon



Thermal energy: max. 3,160 °C Kinetic energy: up to 550 m/s Deposition rate: 2–8 kg/h

Shock diamonds in high velocity oxy-fuel spraying (left).
Optimal heat dissipation provided by cold-sprayed copper coating (right).

Cold spraying

In cold spraying, the kinetic energy, i.e. the particle velocity, is increased and the thermal energy reduced. In this way it is possible to produce spray coatings which are virtually free of oxides. This new development became known under the name CGDM (Cold Gas Dynamic Spray Method).

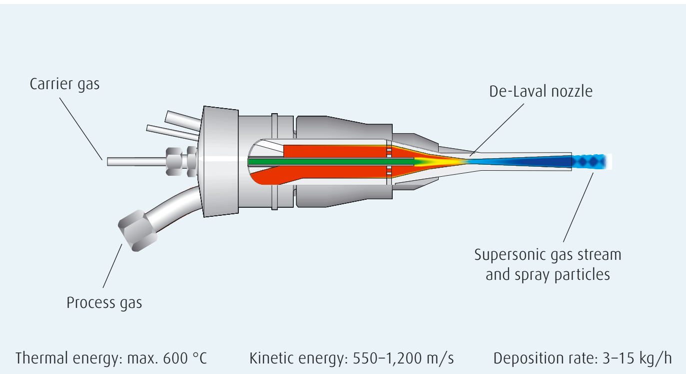
By means of a gas jet heated to approx. 600 °C at a corresponding pressure, the spray material is accelerated to > 1000 m/s and brought to the surface to be coated as a continuous spray jet. The particle jet can be focused on cross-sections of 1.5 x 2.5 up to 7 x 12 mm.
The deposition rate is 3 to 15 kg/h.

Laboratory investigations show that cold spray coatings have extremely high bond strengths and are exceptionally dense. Whereas with traditional thermal spray processes, the powder in the spray process must be heated to above its melting temperature, the cold spray process requires a powder temperature of only a few hundred degrees. The oxidation of the spray material and the oxide content of the sprayed coating are therefore reduced considerably. Coated substrates reveal no material changes due to thermal influence.

Applications include automobile industry, anti-corrosion protection and electronics, for example.

Gases for cold spraying

Nitrogen
Helium or nitrogen/helium mixtures



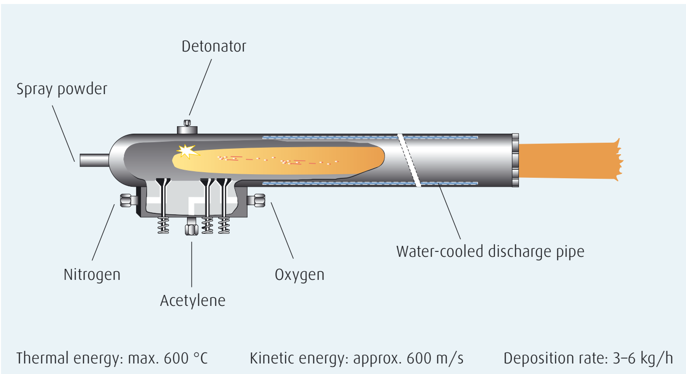
Detonation flame spraying (shock-wave flame spraying)

Detonation flame spraying is an intermittent spray process. The so-called detonation gun consists of a discharge pipe with a combustion chamber at one end. A mixture of acetylene, oxygen and spray powder is fed into the chamber and detonated using a spark. The shock wave produced in the pipe accelerates the spray particles. These are then heated at the front of the flame and propelled at high speed in a focused jet onto the prepared workpiece surface. After each detonation, the combustion chamber and the pipe are purged with nitrogen. The very high quality standard of these spray coatings generally justifies the higher costs involved in this process.

Applications include pump plungers in gas compressors and pumps, rotors in steam turbines, gas compressors or expansion turbines, and in papermaking machinery, the rolls used in wet areas of the production process and calender rolls.

Gases for detonation flame spraying

Acetylene-oxygen
Acetylene-propylene-oxygen
Carrier/purging gas: e.g. nitrogen, argon, oxygen



Plasma spraying

In plasma spraying, the spray material, in powder form, is melted by a plasma jet in or outside the spray gun and propelled onto the workpiece surface. The plasma is produced by an arc which is constricted and burns in argon, helium, nitrogen, hydrogen or their mixtures. This causes the gases to dissociate and ionize; they attain high discharge velocities and, on recombination, transfer their thermal energy to the spray particles.

The arc is not transferred, i.e. it burns inside the spray gun between a centered electrode (cathode) and the water-cooled spray nozzle forming the anode. The process is applied in a normal atmosphere, in a shroud gas stream, i.e. inert atmosphere (e.g. argon), in a vacuum and under water. A high-velocity plasma can also be produced by means of a specially shaped nozzle attachment.

Applications include the aerospace industry (e.g. turbine blades and abradable surfaces), medical technology (implants) and thermal barrier coatings.

Gases for plasma spraying

Argon, nitrogen, helium, hydrogen or their mixtures
Carrier gas: e.g. nitrogen, argon

Arc spraying

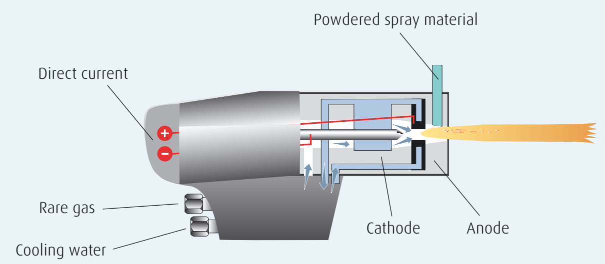
In arc spraying, two similar or different types of spray material in wire form are melted off in an arc and propelled onto the prepared workpiece surface by means of an atomizing gas, e.g. compressed air. Arc spraying is a high-performance wire spraying process in which only electrically conductive coating materials can be used, however.

When using nitrogen, argon or nitrogen-oxygen mixtures as the atomizing gas, oxidation of the materials can largely be prevented, respectively, specific coating properties can be achieved.

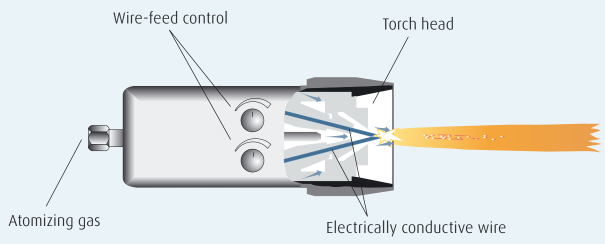
Applications include large-area coating of vessels, anti-corrosion protection, bond coatings, cylinder liners, etc.

Gases for arc spraying

Atomizing gas: e.g. nitrogen, argon, oxygen or their mixtures



Thermal energy: up to 20,000 K Kinetic energy: up to 450 m/s Deposition rate: 4–8 kg/h



Thermal energy: > 4,000 °C Kinetic energy: > 150 m/s Deposition rate: 8–20 kg/h

Selecting the individual gases for the spray process is crucial for the production of optimal coating properties (left). Arc Spraying of a guide roll (right).

PTA – plasma transferred arc surfacing with powder

In the PTA process, the surface of the workpiece is surface melted. A high-density plasma arc serves as the heat source and the metal powder as the surfacing material. The arc is formed between a non-consumable electrode and the workpiece. The plasma is generated in a plasma gas (e.g. argon, helium or argon-helium mixtures) between the central tungsten electrode (-) and the water-cooled anode block (+) in the transferred arc. The powder is supplied to the torch by means of a carrier gas, heated in the plasma jet and deposited on the workpiece surface where it melts completely in the melt pool on the substrate.

The entire process takes place in the atmosphere of a shroud gas (e.g. argon or an argon-hydrogen mixture).

The PTA process facilitates a minimal mixing of base and coating material (5–10 %), a small heat-affected zone, a high deposition rate (up to 20 kg/h), a true metallurgical bond between the substrate and the coating – and thus extremely dense coatings – and the flexible use of alloys. The surfacing powders most frequently used can be classified as nickel-base, cobalt-base and iron-base alloys.

Applications include the coating of a wide variety of base materials, e.g. low-alloyed steel, stainless steel, cast iron, bronze, nickel-base super-alloys.

Gases for PTA

Argon, helium, hydrogen or their mixtures

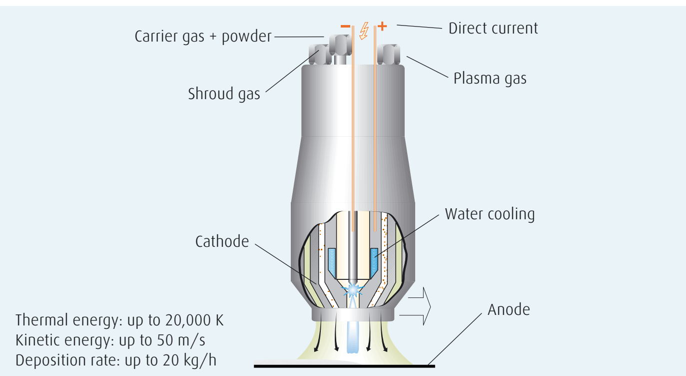
Laser spraying

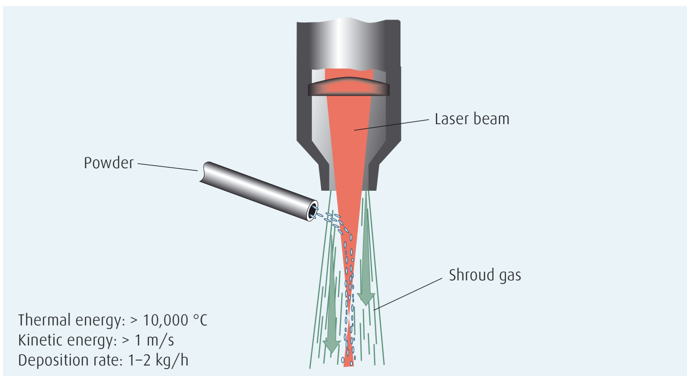
In laser spraying, a powdered spray material is fed into a laser beam via a suitable powder nozzle. By means of laser radiation, both the powder and a minimal proportion of the base material surface (micro-zone) are melted and the spray material and the base material are metallurgically bonded. A shroud gas serves to protect the melt pool.

One application for laser spraying is the partial coating of stamping, bending and cutting tools.

Gases for Laser Spraying

Laser gases: carbon dioxide, nitrogen, helium
Working gases: argon, oxygen
Carrier gas: e.g. nitrogen, argon






115

Across All Market Sectors
A Range of Thermal Spraying Applications

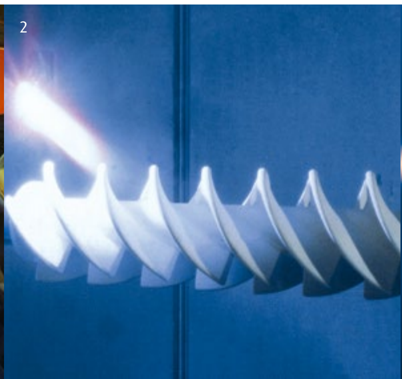
Market sectors

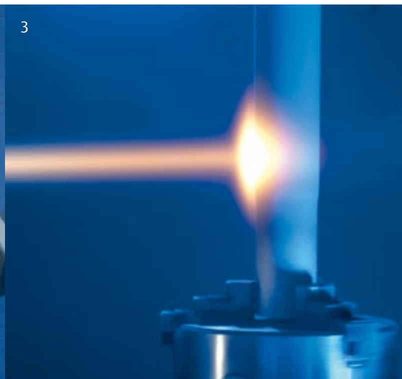
- Medical engineering
- Nuclear power plants
- Chemical plants
- Plastics industry
- Pump industry
- Metalworking industry
- Foundries
- Smelting plants
- Steel industry
- Extrusion plants
- Wire industry
- Automotive industry
- Aerospace industry (1)
- Energy and water supply/ utilities
- Ship building
- Glass industry
- Manufacturing industry
- Agricultural machinery
- Petroleum industry
- Mining
- Offshore technique
- Paper industry
- Printing industry
- Textile industry
- Electrical industry
- Electronics
- Household appliances (4)
- Sports industry

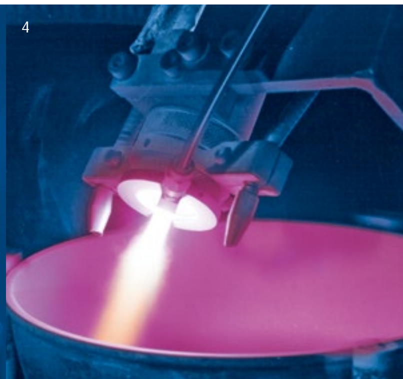
Range of applications

- Anti-wear protection (2)
- Anti-corrosion protection
- Thermal barriers
- Attrition
- Particle erosion
- Particle abrasion/wear debris
- Electrical conductivity
- Electrical resistance
- High-temperature protection
- Reject recovery
- Bearing coatings
- Chemical loads
- Oxidizing atmosphere
- Resistance to galling
- Decorative coatings
- Abrasion surfaces/sealing
- Special applications such as sprayed foreign bodies
- Reconstruction of dimensions (maintenance) (3)
- Reproduction of dimensions (maintenance)
- Coatings with special material properties (e.g. catalytic, surface-active and surface-passive, etc.)


1


2

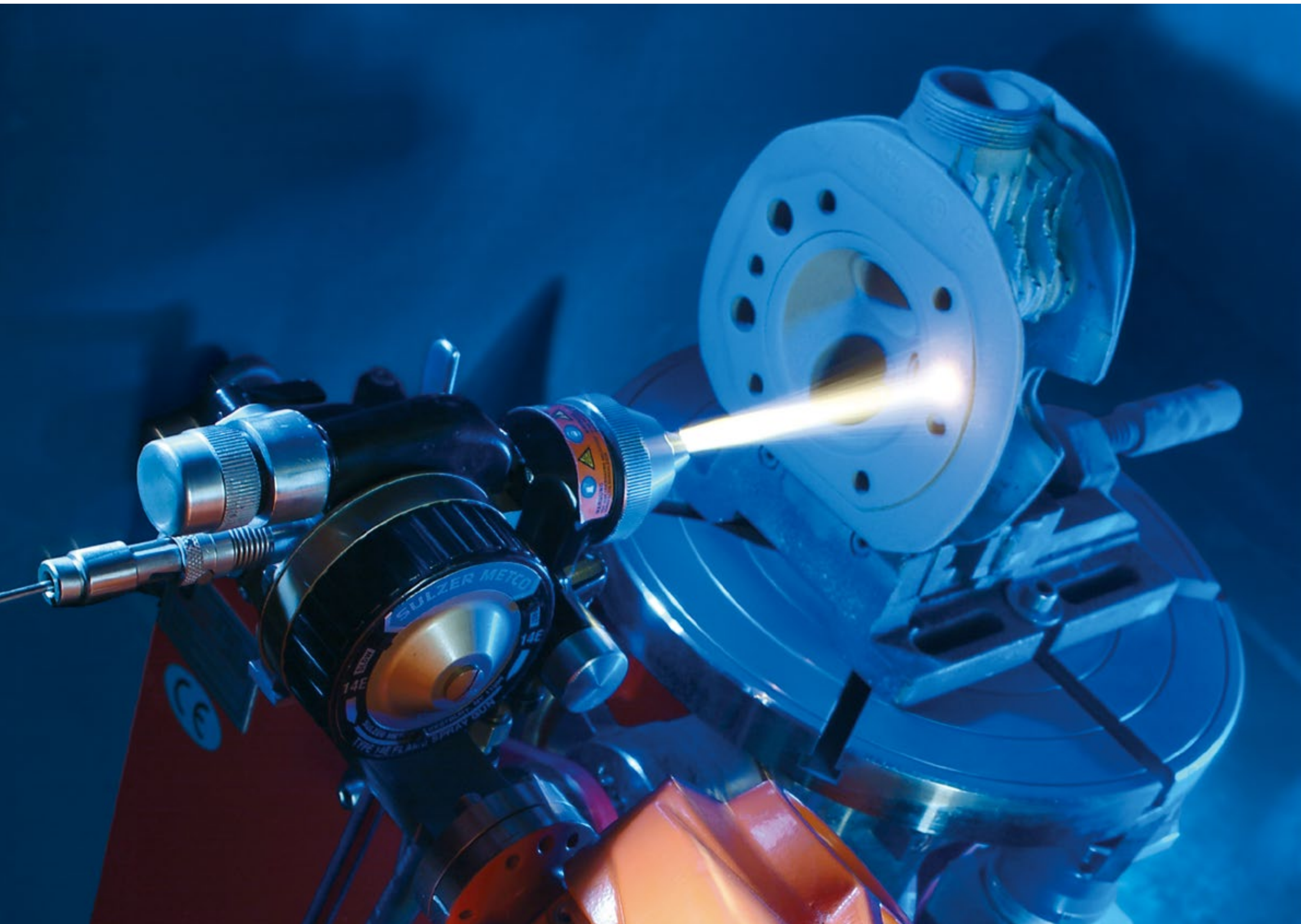

3


4

Range of Spray Materials

- Alloyed steels
- Low-alloyed steels
- Molybdenum
- Babbitt metal
- Zinc
- Aluminum
- Iron, nickel cobalt and stainless steel
- Monel metal
- Carbon steel
- Exothermic material
- Self-fluxing alloys
- Non-ferrous metals
- Brazing materials
- Carbides (tungsten-carbide, chrome-carbide)
- Ceramic oxides (chromium-oxide, aluminum-oxide, zirconium-oxide)
- Tungsten, tantalum and molybdenum
- Plastics

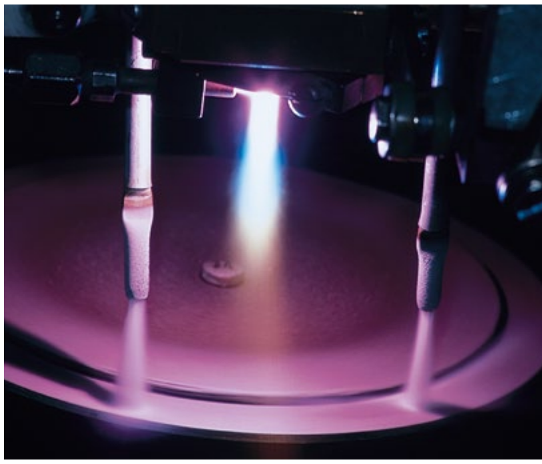
Wire flame spraying of a cylinder head surface.



Against the Heat
Controlled Cooling with Carbon Dioxide (CO_2)

Why is cooling needed in thermal spraying?

Especially with high-energy spray processes, – such as high velocity oxy-fuel spraying or plasma spraying – the heat input in the base material can be extremely high. When coating thin-walled substrates or substrates with very low thermal conductivity, or when using temperature-sensitive coating materials, problems often arise if cooling is not employed. With BOC's CO_2 cooling, coatings can be applied which could hitherto not be controlled.

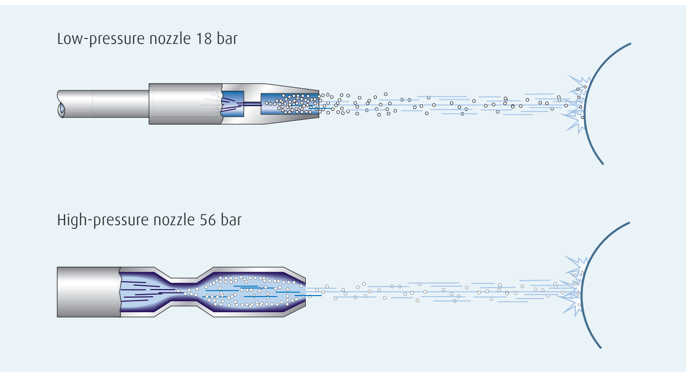


Plasma spraying of abrasion coatings: high quality and reproducibility as a result of CO_2 cooling.

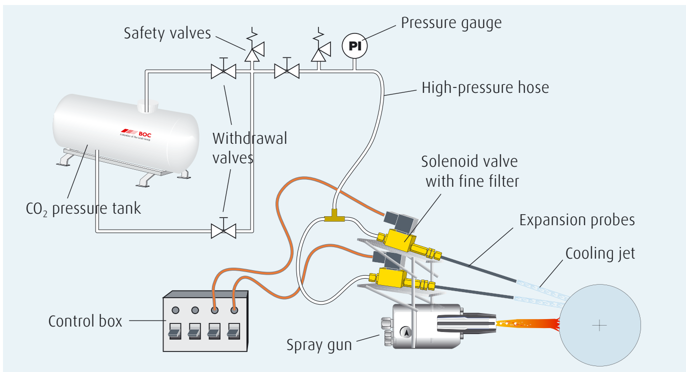
Possible Applications

- Temperature-sensitive substrate materials
  - Heat resistance
  - CFK/titanium/aluminum/magnesium
  - Thin-walled components
  - Low thermal conductivity
- Oxide-sensitive spray materials
  - Minimal metallurgical reaction
  - Low oxidation (copper)
  - Minimal phase transformation (WC Co)
- Differing heat expansion
  - Flaking off of coating
  - Minimal thermal expansion
  - Aluminum coated with Al203

The patented nozzle geometry guarantees the most effective expansion and optimal jet constriction without clogging the nozzle.



The BOC CO_2 cooling system is available as a complete system, including all the necessary operating components.



The thermal spray laboratory at the Linde Group's International R&D Centre where all thermal spray systems can be used.

BOC Service

LINSPRAY software

The LINSPRAY PC program enables the user to archive and administrate spray parameters, materials and company data. Together with the tables already included in the software, LINSPRAY can be expanded to form an extensive database for thermal spray know-how, and assists the user in finding solutions.

Online diagnostic LINSPRAY PFI

Parameter optimization, and subsequent quality assurance and control are of crucial importance in thermal spraying. Here, empirical methods in conjunction with complicated measurements are usually employed. With this in mind, the LINSPRAY PFI (Particle Flux Imaging) diagnostic system was developed. Its special features include economical set-up, easy and reliable operation and a wide range of applications.

The PFI diagnostic method is based on the fact that a characteristic brightness distribution of the carrier medium as well as of the particle flux can be assigned to the different operating conditions of thermal spray processes (e.g. plasma or HVOF). Even small changes to the operating parameters, such as fluctuations in the carrier-gas flow or constant changes to the power input of a plasma torch, can be detected. With the aid of the PFI software, the online image can be compared with a previously loaded reference image, and an error message is displayed if preset boundary values are exceeded.

Further services

- At the Linde Group's International R&D Centre, research into new technologies is carried out and new processes involving gas are developed. Among other things, all the thermal spray systems available can be tested in our own laboratory
- Customer problems are analyzed and solutions devised which are then implemented in the customer's plant under shop-floor conditions
- Close co-operation with leading research institutes. Participation in and sponsorship of research projects in the field of thermal spraying
- Design and construction of optimal gas supply systems
- Development of hardware for the automatic and manual using of self-fluxing powders, e.g. PEA 2 (programmable fusing device)
- Training aids and visual materials such as the films "Flame spraying with acetylene" (awarded a prize by the IIW) and "LINSPRAY high-quality coating"
- Training posters and offprints
- The Linde Group hosts conferences and information events, and provides further opportunities to exchange know-how and experience

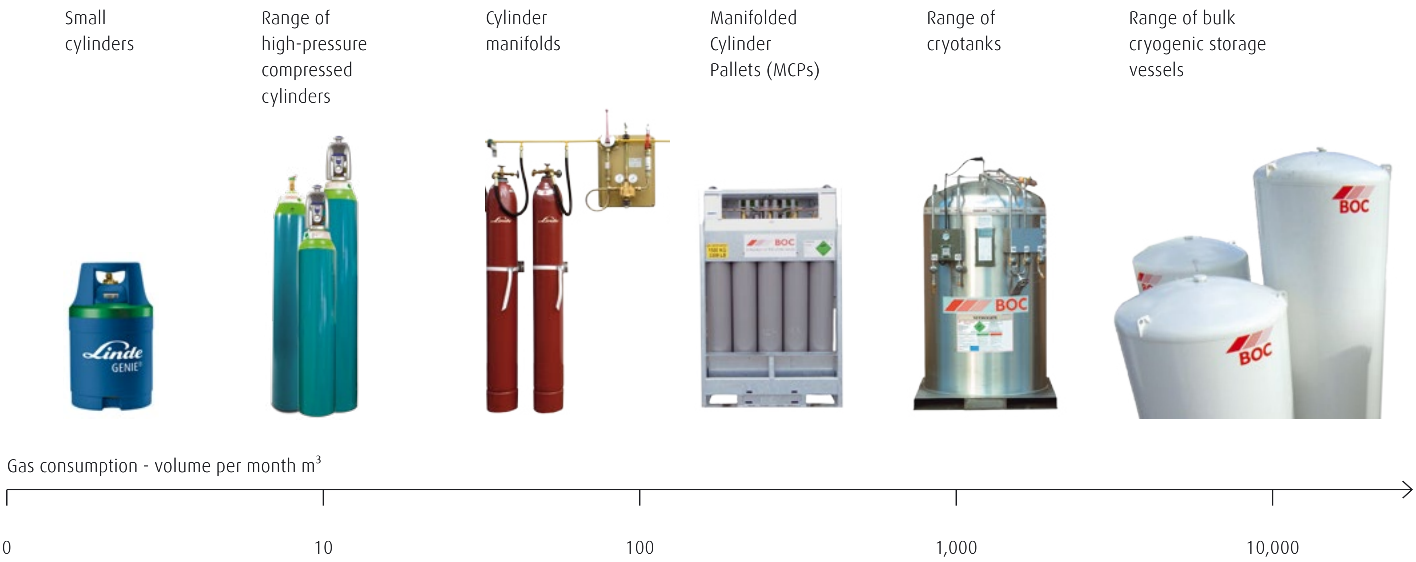
Gas Supply Systems

Your gas supply package can influence your productivity. Frequent handling and changeover of single cylinders can increase non-productive time, reduce your efficiency and ultimately increase your costs.

To optimise your gas efficiency, you need to match your gas supply to your demand. BOC offers a range of products and services that will help to make your business as efficient and productive as possible.

- → Packages tailored to suit your requirements
- → A quick, reliable and flexible service
- → Efficient supply, helping to reduce your gas supply costs
- → Expert advice to enhance your business

Supply mode selection guide for oxygen, nitrogen, argon and carbon dioxide



Industrial gases are used in a wide range of processes and the demand varies according to the different requirements of individual customers. The chart gives an indication of the volume relationship between certain supply methods, but volume is not the only thing you should consider when choosing a supply solution. Pressure and flow rate also need to be considered. BOC can provide all the information you need to help you determine the most appropriate and cost effective gas supply solution.

BOC is a Linde company, the Leading Global Gases and Engineering Business with a Mission to Make the World More Productive

We are the UK and Ireland's largest provider of industrial, medical, and special gases as well as related equipment, engineering services, and solutions to support them.

We produce, package, and distribute thousands of different types of gases to our customers every day. Our unrivalled range includes atmospheric gases, high purity gases and mixtures, refrigerants, and chemicals, for applications as diverse as cooling magnets in hospital MRI scanners to fuelling zero emissions vehicles and much more.

BOC offers tailored supply solutions for every size of customer; our cylinder customers enjoy a nationwide delivery and collection network; bulk customers the reassurance of 24/7 delivery; and for our high-demand customers we offer onsite production or dedicated pipeline supply.

And all of this is backed up by industry leading customer service, expert technical support and best-in-class levels of safety and environmental performance – the basis on which we have earned our reputation as a reliable and trusted partner.

For more information about us please contact us:

BOC Limited
Customer Service Centre,
Priestley Road, Worsley,
Manchester M28 2UT

Tel 0800 111 333
Fax 0800 111 555

custserv@boc.com
boconline.co.uk

BOC Ireland
PO Box 201,
Bluebell, Dublin 12,
Republic of Ireland

Tel 1800 355 255
Fax (0)1 409 1801

irelandsales@boc.com
boconline.ie

BOC/405375/CST/0422

BOC Limited registered office, Forge, 43 Church Street West, Woking, Surrey GU21 6HT, England. Company number 337663 – English Register. Authorised and regulated by the Financial Conduct Authority, register number 715528.
BOC is a company name used by Linde plc and its affiliates. The BOC logo, the BOC word and LINSPRAY® are trademarks or registered trademarks of Linde plc or its affiliates. Copyright © 2010–2022. BOC Ltd.