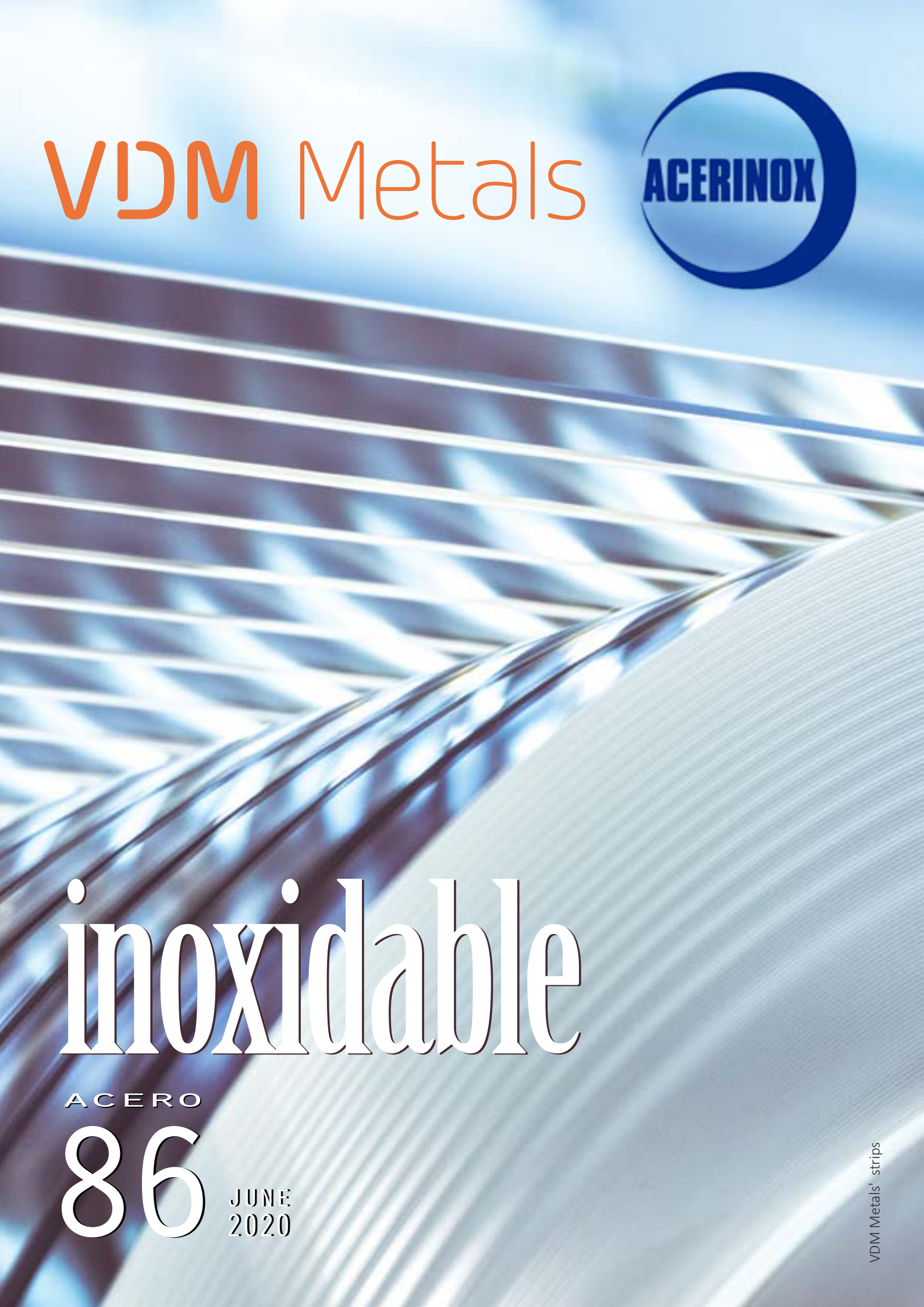
VDM Metals

ACERINOX

inoxidable

ACERO
86
JUNE
2020



VDM Metals' strips

editorial

Dear friends,

With this new issue of our magazine we would like to accompany you in these still difficult times experienced by our society. First of all, we wish that you, your families and friends keep well and stay safe, and also that the companies where you carry out your activities can return to complete normality soonest.

As you may understand, during these months it has not been possible to maintain the usual way of working, especially with travels and face to face meetings. So that, instead of dedicating this issue to different technical articles and applications of stainless steels, we have found very appropriate to prepare this Special Edition as presentation of VDM Metals, the company which has been incorporated since last March 2020 to the Acerinox Group, once the corresponding required approvals have been obtained from EU, USA, and Taiwan authorities.

Acerinox celebrates this year the 50th anniversary of its foundation, and it´s at present a Spanish-based multinational, among the main world leaders in its sector. This recent incorporation of VDM Metals strengthens the group for its joint participation and expansion in the most demanding new markets, a double reason for celebration.

More and more new technologies are being developed for critical applications subjected to extreme conditions of aggressive media, pressure or temperature changes, which require the use of special high-alloy steels for their good operation and long service life. Most of them, intended for projects in various sectors, such as the oil and gas industry -especially offshore installations-, seawater desalination plants, chemical and pharmaceutical process industries, automobile, aerospace and aviation industries, the energy sector, as well as special applications such as marine scrubbers, medical and surgical instruments, and numerous others combining the use of standard stainless steels with super austenitic, super duplex stainless steels and other special high alloy metal materials.

Acerinox and VDM Metals will now be able to share a wide range of products and knowledge that allow them to collaborate together on highly demanding projects and applications.

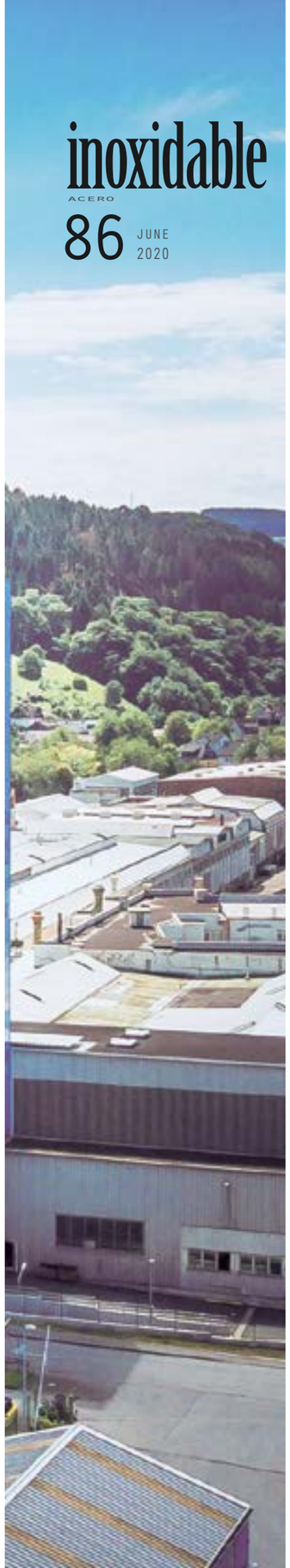
Hoping that you will find the content of these pages useful and interesting, we just would like to offer those readers, who do not have direct contact with VDM Metals yet, the possibility of using the technical enquiry button located at our website, so that you can send any queries about special steels and alloys. We will gladly send it to the corresponding department of VDM Metals where you can receive the answer from and easily establish a first contact.

Kind regards to all of you.

José Carlos Valencia Díaz
Marketing Director of Acerinox, S.A.
Secretary of the Board of Directors of Cedinox

VDM's headquarter as well as the strip and wire production are located in Werdohl, a city of 19,000 inhabitants in the Western part of Germany.

inoxidable
ACERO
86 JUNE 2020

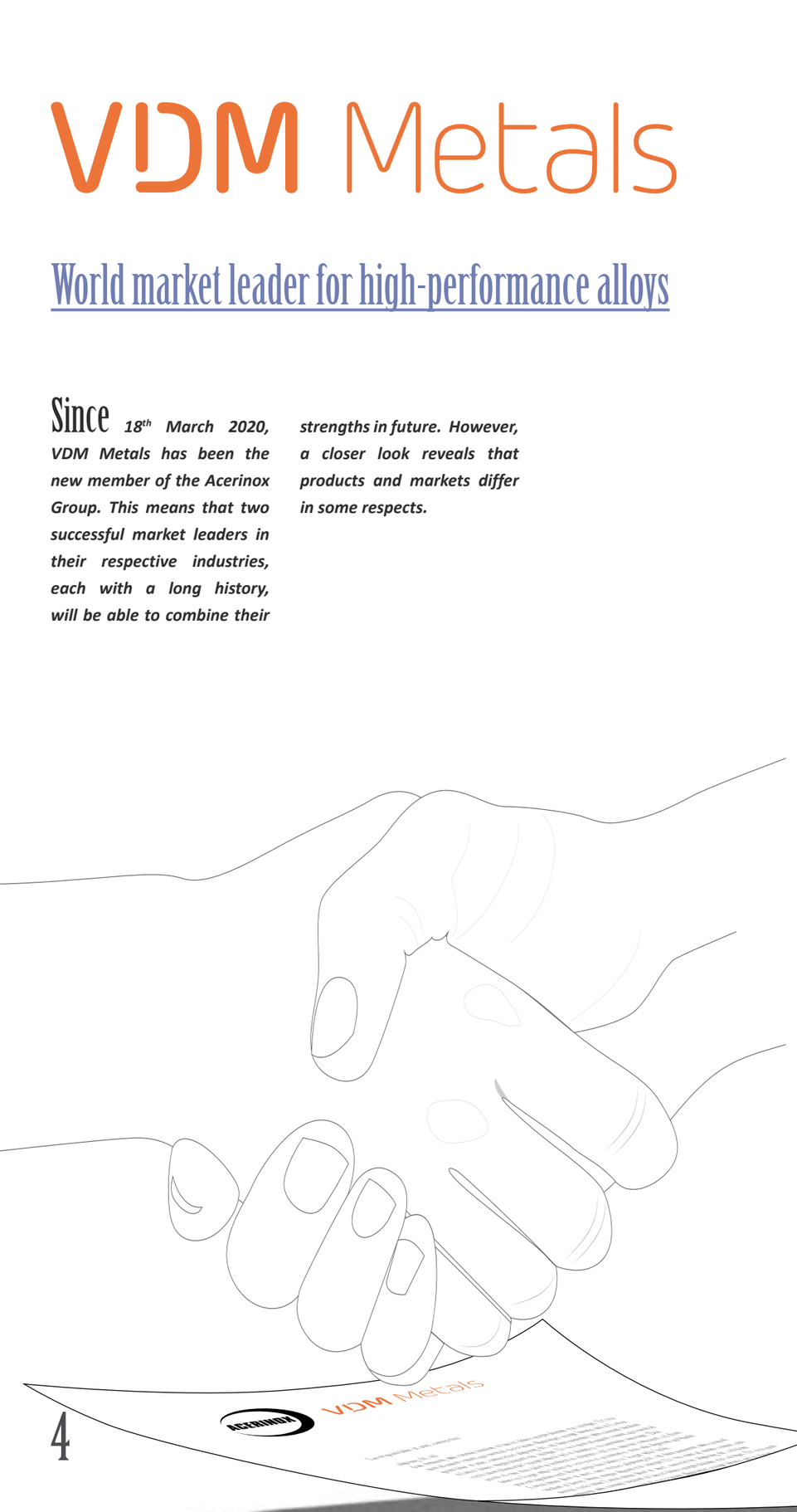


Created and designed by Cedinox, Spanish Stainless Steel Development Association, Santiago de Compostela, 100, 28035 Madrid, Spain. Contact: T 34 91 3985231/2
cedinox@acerinox.com / www.cedinox.es

VDM Metals

World market leader for high-performance alloys

Since ***18th March 2020, VDM Metals has been the new member of the Acerinox Group. This means that two successful market leaders in their respective industries, each with a long history, will be able to combine their strengths in future. However, a closer look reveals that products and markets differ in some respects.***



VDM Metals is the world market and innovation leader in metallic high-performance alloys for mission-critical applications. The Group operates seven production sites, five in Germany and two in the United States, and includes twelve subsidiaries and four service centres around the globe. VDM Metals employs 2,000 people worldwide.

Broad portfolio, broad customer base

In comparison to carbon steel and standard stainless steel, the majority of VDM Metals' products is nickel-based, with additions of other, partly rarely used alloying elements such as chromium, molybdenum, copper, aluminium, yttrium, hafnium etc. The portfolio of more than 100 materials includes corrosion resistant alloys, high-temperature alloys, superalloys, electrical resistance alloys, soft-magnetic alloys and low-expansion alloys. The product forms offered include both long and flat products – rod, bar and wire as well as strip and plate. In 2017, VDM furthermore started the development and production of nickel and cobalt-chromium powder materials for additive manufacturing. The market for this kind of materials is comparably small – globally 350,000 tons.

VDM Metals' materials are not always visible at first sight, but used in critical parts enabling functionality. Customers are mainly from the oil and gas industry, chemical process industry, power generation, green technologies, auto-motive sector, aerospace industry and electronics and electrical engineering. Besides its classical business, VDM operates a small trading and engineering business for copper and aluminium products manufactured externally, called Engineered Solutions.

Strong manufacturing base

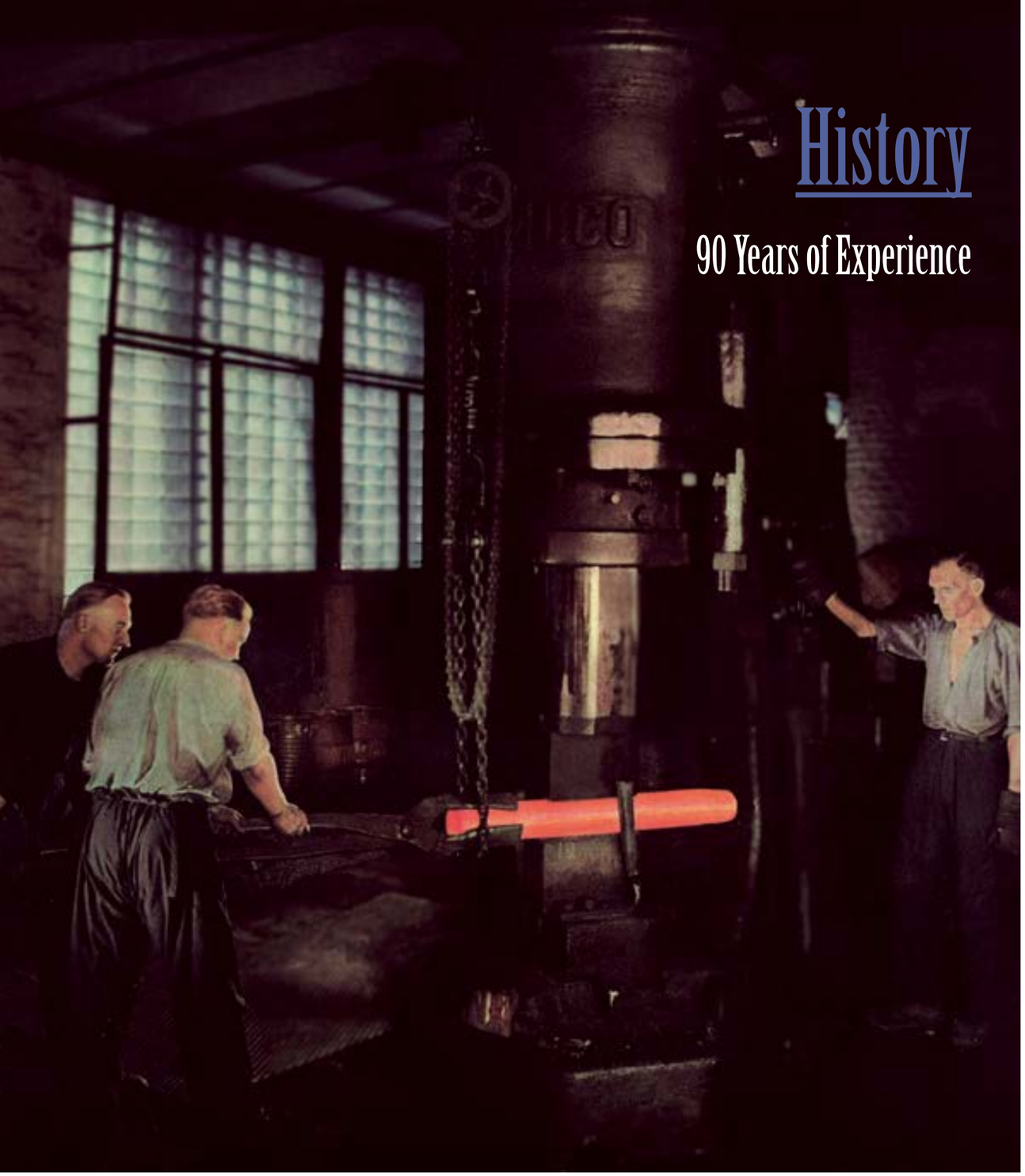
The majority of important production steps is carried out on the company's own equipment. VDM's biggest melting shop is situated in Unna, Germany. Further processing is carried out in Duisburg and Siegen, Altena, Werdohl and also in Unna. Besides its German production facilities, VDM operates two plants in the United States. At Florham Park, New Jersey, VDM Metals USA runs a melting shop and in Reno, Nevada, rods, bars and shapes/profiles are rolled. During the last financial year, the monthly production average of all production sites was approximately 2,300 tons of flat products and 1,300 tons of long product. In total, approximately 42,000 tons of material were shipped to customers throughout the year, representing a worldwide market share of 12%. The Group achieved a revenue from sales of 852 Mio €, amongst others, which resulted in 97 Mio € adjusted EBITDA.

Many orders are project related, in particular in the oil and gas industry. The project business means offering customized solutions, including close customer contacts, consulting and a lot of advice regarding the right choice of materials and further processing in order to achieve the best results for a long and stable service life of the customers' projects. Shipments over long distances (worldwide) are standard. VDM only starts purchasing of raw materials and production after order clearance. Thus, standard delivery times are between eight and 20 weeks, in some cases even longer. However, approximately 10% of orders are distributed via Service Centres, with shorter delivery times, as a matter of course.

Quality and innovation are key

Customers expect premium quality. This is why quality control and quality management play a crucial role in VDM Metals' production processes. VDM holds various institutional and customer approvals, which are needed to deliver materials into critical applications such as pressure vessels or rotating turbine parts. The Group's track record of 62 material patents demonstrates another key strength. Thanks to long-term experience, material science and application know-how VDM Metals has developed into the innovation leader within the market. To continue this road, innovation is the foundation for VDM's future success. Co-operation with leading research institutions and close co-operation with customers on product development and improvement are indispensable to execute this strategy.

Acerinox-VDM moving forward together



History

90 Years of Experience

A great deal of handwork – open die forging process at VDM in 1955

VDM ***Metals can look back on a corporate history of almost 90 years. In August 1930, a number of medium-sized family enterprises, including Carl Berg of Werdohl, 1853 and Basse & Selve of Altena, 1869 merged to form Vereinigte Deutsche Metallwerke AG (VDM).***

VDM Metals

Materials for the future.

The enterprise thus founded was a manufacturer of non-ferrous metals with a large portfolio of semi-finished products – from plates to tubes to bearings. Initially the focus was on copper and brass, but later aluminium, stainless steel and nickel alloys gained importance. The company's headquarters was in Frankfurt am Main for many years, while its production locations included Altena and Werdohl, Duisburg, Cologne, Mainz, Nuremburg and Frankfurt am Main. The founding of VDM was a necessary step towards concentration in Germany's semi-finished goods industry, hardly hidden by the global economic crisis.

During the years of the Third Reich, the production focused on materials for the arms industry, particularly aviation. Parts of the company became state-owned, at least indirect.

By the end of the war, production was in almost complete ruin. Nevertheless, in only a few years after the end of the Second World War, VDM had risen to become one of the largest manufacturers of semi-finished and finished metal products, supported by its shareholder, the metal trading conglomerate Metallgesellschaft AG. However, since the mid-sixties, the company steadily lost market shares what finally led to job losses and shutdowns of production sites until as late as the mid-eighties.

Focus on nickel materials

The nickel alloys segment proved to be an exception – some of VDM's plants had successfully focused on the development and production of these alloys since the seventies. In 1972, the melting shop for nickel alloys and special alloys opened in Unna, where it still operates today. For VDM, developing its own nickel alloys and concentrating on its core competence of melting and casting provided the opportunity to grow into a leading specialised supplier selling worldwide. This development took place during the seventies and eighties, hand in hand with the setting up and expansion of sales subsidiaries, for example in Asia. On October 1, 1987, the nickel division with locations in Unna, Werdohl and Altena was spun off as VDM Nickel-Technologie AG. Just one year later, Krupp Stahl AG took over one third, and later 100% of the shares of the new company.

Expansion in the United States

In the United States, VDM has been represented with a sales subsidiary from the beginning of the seventies. The purchase of Precision Rolled Products (PRP) in 1990, a company with operating production sites in Florham Park, New Jersey, and Reno, Nevada, enabled VDM to access the important aerospace market of the United States. Today's VDM Metals USA specializes in melting and processing long products in high-alloy materials for non-rotating parts used in the aerospace industry. It also serves the plant construction and oilfield equipment market segments.

A short trip to Finland and back

After 23 years at Krupp and later Thyssenkurpp, the Finnish Outokumpu Group took over VDM as part of ThyssenKrupp's stainless steel unit Inoxum in December 2012. In 2013, Outokumpu announced its intention to sell VDM back to ThyssenKrupp. For the time period between March 2014 and July 2015, VDM returned to ThyssenKrupp Group now trading under the name VDM Metals. The new name clearly emphasized the company's heritage and the strong ties to the metals business. Back then, VDM Metals also developed and introduced its current corporate branding very successfully. In August 2015, the private equity firm Lindsay Goldberg LLC acquired VDM Metals from ThyssenKrupp. The following years were characterized by withdrawal from non-profitable parts of the business and stringent and efficient development of the core business, including a sustainable increase in production output and thoughtful investments in machines and in people. To summarize, Acerinox acquired nothing less than a world market leader in good shape with decades of experience, well equipped and ready to take the next steps in a eventful and rich history to enable further growth.

High-performance materials

Nickel, cobalt and zirconium materials and a wide range of special stainless steels, all that and more can be found in VDM Metals' product portfolio. Each one of VDM's alloys is characterized by a unique combination of properties, depending on the chemical composition and the manufacturing process.

VDM powder

The majority of VDM's products is nickel-based – this means the nickel content varies between 30 percent and more than 99 percent. VDM Metals' customers place greatest importance on the materials' corrosion resistance, mechanical strength or physical properties. The materials are offered as plate, sheet and strip, rolled, forged or drawn bar, billet, wire and welding wire. Engineered products like forged shafts, cut parts, and special long shapes are also available in many cases. For customers in the additive manufacturing market, VDM Metals offers a selection of powder materials in a wide range of particle fractions.

Peeled bar being transported

Corrosion-resistant alloys

Corrosive media such as sea water, acids, alkali and salt solutions create a rough and aggressive environment in many fields of application, where the materials used will need to possess an above average service life stability. Corrosion-resistant alloys of VDM Metals are successfully used in refineries, in the production of phosphoric acid, phosphate fertilizer, sulphuric acid, nitric acid, in oxidizing and reducing media, acetic acid, salt production, chlorine, caustic soda, vinyl chloride monomer (VCM), plastics production, synthesis of organic compounds and pharmaceutical products. In offshore engineering these materials are found in production tubing, drill stems, pipe claddings, umbilicals for oil production, seawater pipes, condensers and coolers.

As colourful and various as the applications are the alloys that can be used. VDM's portfolio includes iron-based materials with "only" 25 percent nickel like VDM® Alloy 926, nickel-based alloys with a nickel content of 30 to 40 percent like VDM® Alloy 31, VDM Alloy 31 Plus® and VDM® Alloy 825, and classical nickel-chromium-molybdenum alloys with up to 70 percent nickel as VDM® Alloy 59, VDM® Alloy 2120, VDM® Alloy C-276 and VDM® Alloy 625. A selection of nickel-copper (VDM® Alloy 400, VDM® Alloy K-500), copper-nickel alloys and commercially pure nickel alloys (containing more than 99 percent nickel) completes the portfolio.

Besides classical nickel alloys and special stainless steels, VDM Metals offers zirconium plates for use in corrosive environments. Zirconium owes its excellent corrosion resistance to a passivating oxide layer which forms very quickly on the surface. This layer makes the material resistant to practically all organic acids and alkaline solutions as well as to mineral acids. In addition, it is self-healing when in contact with aqueous media.

The right material selection is highly depending on the customers' process parameters – this is why VDM Metals usually delivers individual and professional technical customer advice on top of first-class materials.

Bars, ready for shipment to the customer, in Unna

Plates in VDM® Alloy 825 that can be further processed into cladded pipes

High-temperature alloys

Key industry components are often exposed to high and highest temperatures. Their construction requires the use of innovative high-temperature alloys. These materials have found a wide range of applications not only in industrial furnaces and heat treatment plants, but they are also used as a substrate material for heavily stressed metallic catalysts. Other typical applications are radiant tubes, combustion hoods, hood-type furnaces, controlled atmosphere annealing furnaces, continuous annealing furnaces, ventilators and fans, rotary kilns, and also oil and gas burners.

VDM® Alloy 602 CA, developed by VDM Metals, can be used at service temperatures of up to 1,200°C, for example. The portfolio of high-temperature materials furthermore includes other nickel-based materials known from industrial furnace construction like VDM® Alloy 120, VDM® Alloy 600 and 600 H, as well as iron-based special stainless grades like VDM® Alloy 310 S, 314 L, VDM® Alloy 800 and 800 H. Like mentioned before, the right material selection is depending on the respective process parameters.

Superalloys

Superalloys are high-strength nickel or cobalt-based alloys that are, on the one hand, used in environments with significantly elevated temperatures, but on the other hand also in extremely corrosive atmospheres. The driving forces in the development of these materials were the increasingly higher requirements of the aviation industry, caused by higher temperatures inside the turbines.

Alloy 718 has been the most important material for turbine construction for decades. Other nickel-based materials to mention are VDM® Alloy C-263 and VDM® Alloy X for turbine and VDM® Alloy 80 A for automotive engine construction. Cobalt-based alloys like VDM® Alloy 25 and VDM® Alloy 188 maintain their excellent high-temperature strength up to ca. 1,000°C and above; they also possess outstanding oxidation resistance due to their chromium content. These

VDM® Alloy C-276 is one of the VDM´s stardard grades

characteristics are especially well suited for use in highly corrosive environments. Common areas of application are turbines, both stationary as well as in aircraft.

Resistance alloys

Resistance alloys are characterized by relatively high and/or constant specific electrical resistance values. The materials spectrum ranges from austenitic nickel-iron-chromium alloys like VDM® Alloy HT 60 to copper-nickel alloys like VDM® Konstantan, to aluminum-containing ferritic chrome steels like VDM® Aluchrom Y. Resistance alloys are mostly found in the electronics industry as specialty wires or as brake and starting resistors for electric drive system. In addition, they are used wherever electrical energy is converted into heat, as in ceramic hobs, toasters or coffee machines. Resistance materials made by VDM Metals are usually available as strip or wire.

Soft magnetic alloys

Soft magnetic materials are characterized by high magnetic conductivity (permeability) and have a long application tradition in electrical engineering. VDM Metals has been producing soft magnetic iron-nickel alloys for many years in the form of toroidal tape cores, transducers, transformers, heat shields and as yokes and armatures of relays. The nickel-iron alloys group with a high nickel content, which contains VDM® MAG 75 and VDM® MAG 7904, is characterized by a high permeability and low coercive force. VDM® MAG 50 and VDM® MAG 53, with a nickel content of 50 percent both lie in a region of maximum saturation polarization but low permeability. Resistance materials made by VDM Metals are usually available as strip, and also further processed into magnetic cores.

Controlled expansion alloys

Our controlled expansion alloys like VDM® Alloy 36 or VDM® Alloy 42 provide constant low rates of thermal expansion up to temperatures approaching 350°C. The thermal coefficient of expansion of the latter one matches that of soft glass, for example. As a result, it is used for glass-sealing applications. Furthermore, these materials possess good ductility and toughness, as well as good mechanical properties and a low propensity to fatigue at low temperatures.

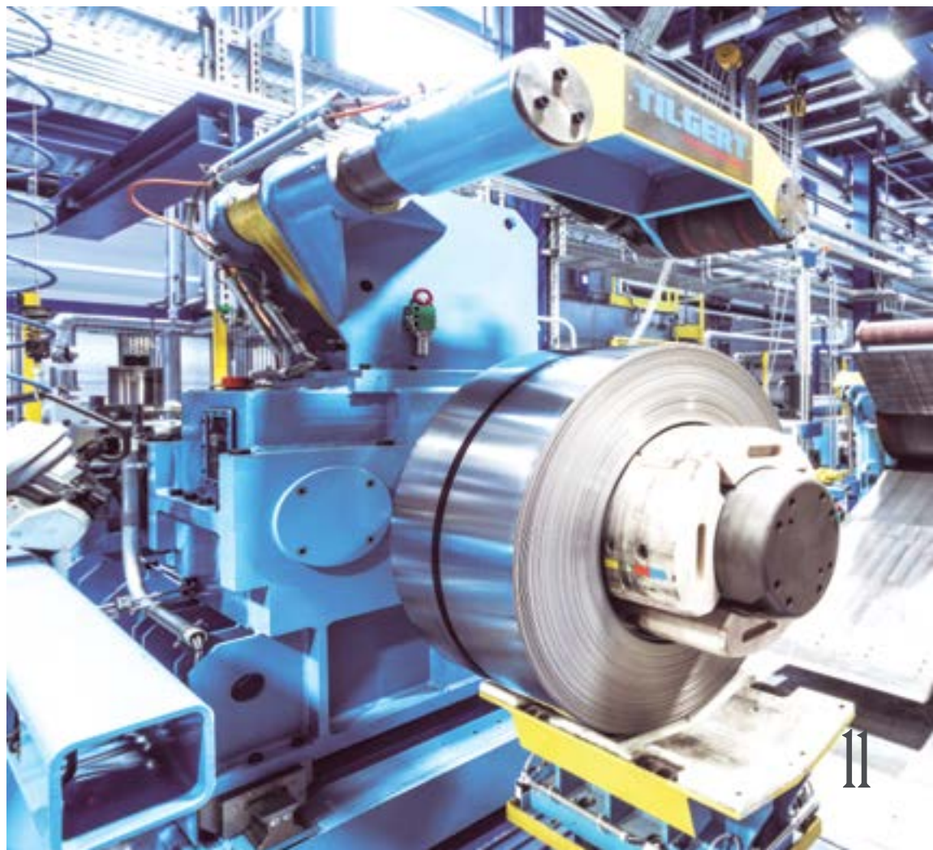
Powder materials

As modern production methods, generative manufacturing processes are becoming part and parcel of industry nowadays. This requires high quality materials as powder. Our product portfolio comprises cobalt-chromium alloys (e.g. VDM® Powder CoCr Mp1), corrosion resistant alloys (e.g. VDM® Powder 625), superalloys (e.g. VDM® Powder 780) and special stainless steels (e.g. VDM® Powder 926 L).

Spark plug alloys

Wires for the production of spark plugs and glow plugs are an additional field of activity for VDM Metals. The small, but tailored portfolio includes nickel-based materials that are alloyed with other elements like manganese and silicon.

Annealed strip, produced in Werdohl



VDM Metals

Strip can be rolled down to ultra-thin foil with only 0.02 mm thickness

Electrodes for welding nickel alloys

VDM produces forged, rolled and drawn bars

Strip is available in various dimensions

(Welding) Wire is delivered on different spool types

VDM Metals offers more than 100 alloys in various shapes and dimensions.

Hot-rolled **plates** and **sheets** are available in 3 to 100 mm thickness and cold-rolled sheets in 1 to 8 mm thickness, depending on the alloy. The maximum width is 2,500 mm and the maximum length 12,000 mm.

Cold-rolled/ strip is available in width between 4 and 750 mm and – depending on the alloy – can be rolled down to foil with only 0.02 mm thickness. Coil inside diameters vary between 300 and 600 mm.

Forged, rolled or drawn **rods and bars** are available in standard sizes between 6 to 600 mm diameter and up to 12,000 mm length (applies only to rolled bars between 6 and 125 mm diameter). Additionally, VDM Metals offers a range of rolled rectangular bars and special shapes/profiles.

Wires made by VDM Metals are available in the following product shapes: rolled wire in diameters of 5.5 mm to 16 mm, drawn wire in diameters of 1.5 mm to 12 mm, fine wire in diameters of 0.10 mm to 1.50 mm and flat wire with minimum cross-section of 0.04 x 0.20 mm and max. cross-section of 2.50 x 6.00 mm. Furthermore, wire electrodes and welding wires in diameters of 0.6 to 3.2 mm, welding rods in diameters from 1.6 to 4 mm and core wires in diameters from 2 to 5 mm are available.

Powder is available with particle size distributions of 10 to 53 and 53 to 150 µm.

Numerous fields of application

Hot, ***corrosive, in any case challenging environments – this is where nickel, cobalt and zirconium alloys as well as special stainless steels made by VDM Metals are usually used.***

The chemical process industry represents one of VDM's strongest customer industries. Materials can be found in many processes – from acid production to pressure vessel construction and from synthesis of organic compounds to industrial furnace construction. In many plants, the operating temperatures exceed several hundred degrees Celsius. Even in these harsh conditions nickel alloys and special stainless grades manufactured by VDM Metals have proven their resistance to pitting and crevice corrosion, intergranular corrosion or metal dusting. Many process owners in neighbouring industries like energy and environmental engineering face similar challenges – and use the same materials.

Typical alloys used in the chemical process industry are:

VDM® Nickel 200 (2.4060 / 2.4066 / UNS N02200)

VDM® Alloy 31 Plus (2.4692)

VDM® Alloy 2120 MoN (2.4700 / UNS N06058)

VDM® Alloy 59 (2.4605 / UNS N06059)

VDM® Alloy 602 CA (2.4633 / UNS N06025)

VDM® Alloy 625 (2.4856 / UNS N06625)

VDM® Alloy C-276 (2.4819 / UNS N10276)

VDM® Alloy 699 XA (2.4842 / UNS N06699)

Apart from electric vehicles, the trend in today's automotive industry is towards ever more powerful engines with smaller engine displacement. It is the stated goal of downsizing to reduce fuel consumption while lowering the emission of pollutants at the same time. The design of these turbocharged engines results in higher exhaust temperatures, which entails greater requirements for the design of the components and the materials used. As a result, the service life of the engines depends on both the design as well as the materials used. Here VDM Metals has recourse to a wide variety of materials that fulfil the diverse requirements within different sections in the automobile. These include e.g. high temperatures, creep resistance, load alternation, corrosion resistance or wear resistance.

The following alloys are typically used in automotive manufacturing:

VDM® Alloy 80 A (2.4952/UNS N07080)

VDM Alloy 602 CA® (2.4633/ UNS N06025)

VDM® Alloy 718 (2.4668/UNS N07718)

VDM® Alloy 751 (2.4694/UNS N07751)

VDM Alloy 788 A® (2.4959)

VDM® Alloy C-263 (2.4650/ UNS N07263)

VDM® Alloy C-264 (2.4750)

NiSiAlY Hf (2.4133)

The oil and gas industry is another key market for VDM's materials. Crude oil and natural gas are organic mixtures with widely varying composition, depending on their deposits. The standard components of crude oil include hydrocarbons and sulphur, oxygen and nitrogen compounds. Natural gas consists of such gases as methane, ethane and propane and likewise contains other secondary constituents such as sulphuric acid. Again, resistance to pitting, crevice and stress corrosion is therefore one of the most important characteristics of materials used in the oil and gas production.

Typical alloys used in the oil and gas industry are:

VDM® Alloy 31 (1.4562 / UNS N08031)

VDM® Alloy 718 CTP (2.4668 / UNS N07718)

VDM® Alloy 625 (2.4856 / UNS N06625)

VDM® Alloy 825 (2.4858 / UNS N08825)

VDM® Alloy 825 CTP (2.4861 / UNS N08827)

VDM® Alloy 400 (2.4360 / UNS N04400)

VDM Alloy K-500 (2.4375 / UNS N05500)

VDM® Alloy 926 (1.4529 / UNS N08926)

The development of nickel and cobalt alloys was closely intertwined with the history of modern aerospace and turbine construction. Many of the alloys used in aerospace belong to the group known as superalloys. These alloys combine extreme temperature resistance with strong anticorrosive properties – stability at high temperatures, high creep strength, good fatigue behaviour, slow crack propagation, toughness and resistance to high-temperature oxidation comprise the critical properties and features of this group of materials. The production of materials to aerospace quality represents the ultimate discipline of materials manufacturing.

Commonly used aerospace alloys are:

VDM® Alloy 718 (2.4668 / UNS N07718)

VDM® Alloy 780 (2.4960 /-)

VDM® Alloy 625 (2.4856 / UNS N06625)

VDM® Alloy 75 (2.4951 / UNS N06075)

VDM® Alloy 188 (2.4683 / UNS R30188)

VDM® Alloy 36 (1.3912 / UNS K93600 / UNS K63603)

Our daily lives are made easier by a wealth of electronic devices – including VDM materials. The main areas of technical application are supported by the electrical, magnetic and thermophysical properties of these alloys. Resistance materials, expansion alloys and soft magnetic materials have many applications in household appliances like hair dryers, electronic motor controls, instrument transformers or current leakage circuit breakers, in the poles of electric motors, transformers, shieldings or as yokes and armatures in relays.

Alloys typically used in electronics and electrical engineering are:

VDM® Alloy 29-18 (1.3981 / UNS K94610)

VDM® Alloy 42 (1.3917 / UNS N94100)

VDM® MAG 50 (1.3922 / 1.3927 / UNS K94840)

VDM® MAG 75 (2.4501 / UNS N14076)

VDM® MAG 7904 (2.4545 / UNS N14080)

VDM® Alloy HT 70 (2.4658 / UNS N06008)

VDM Konstantan® (2.0842 / UNS C72150)

VDM® Aluchrom Y Hf (1.4767 / UNS K92500)

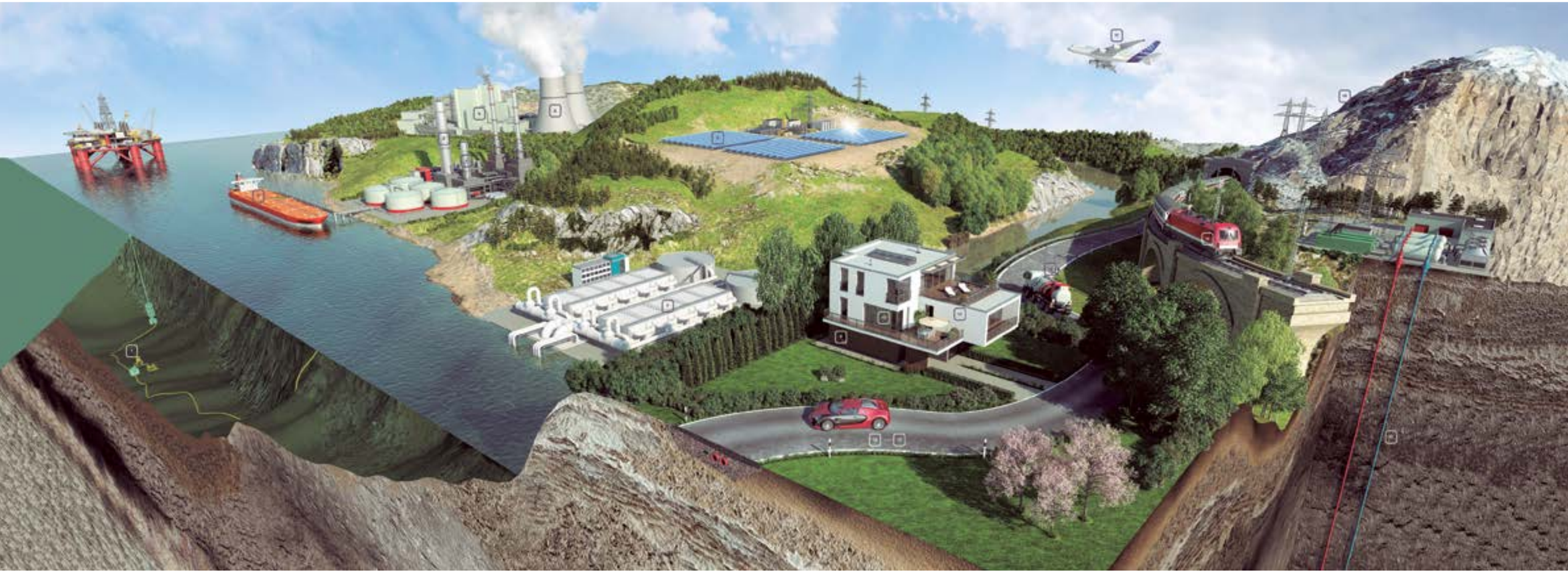
Last but not least, VDM Metals' iron, nickel and cobalt alloys are sought-after materials in medical engineering technology and in the design of medical examination equipment because of their special properties. Rods and strip, for example, are processed into deep-drawn parts with applications in MRI scanners or X-ray equipment. Surgical instruments are made of special stainless steels. Soft-magnetic alloys are suitable for magnetic shielding.

And powder materials like VDM® Powder CoCr F75 are intended for the additive manufacturing of medical implants and prostheses.

The world of VDM Metals

VDM Metals

Materials for the future.



1. Oil and gas production.
2. Marine scrubbers.
3. Refineries.
4. Chemical process industry (CPI).
5. Power plants.
6. Flue gas desulfurization.
7. Seawater handling.
8. Solar thermal power.
9. Burners in gas heating systems.
10. Energy-saving fluorescent lamps.
11. Household appliances.
12. Spark plugs and glow plugs.
13. Engines and exhaust systems.
14. Piezo electric injectors.
15. Catalytic converters.
16. Tank trucks.
17. Aircraft.
18. Electric locomotives.
19. High-voltage power lines.
20. Geothermal energy.

VDM Metals' material are indespensable in a wide range of mission-critical applications.

VDM Metals

1. Oil and gas production.

Supply and control lines on the depths of the seafloor: whether it's salty water millions of years old, sulphurous sediments or, of course, crude oil – our materials ensure their reliable and eco-friendly extraction.

2. Marine scrubbers.

In order to comply with international regulations, many vessels rely on marine scrubbers that filter their exhaust gases from sulfur oxides. As construction material of choice, corrosion-resistant materials made by VDM Metals contribute to clean air and less pollution.

3. Refineries.

Distillation columns separate crude oil into various high-grade products. Alloys from VDM Metals protect tanks and piping systems from the highly aggressive mixtures at temperatures up to 400°C.

4. Chemical process industry (CPI).

Packaging, cable sheathing and varnishes are often based on acrylic and acetic acid. Zirconium tanks and piping systems are protected against these aggressive substances by means of a self-passivating oxide layer.

5. Power plants.

Up to 700°C and extremely high pressures up to 350 bar: only high-performance alloys like VDM's can enduringly resist such a continuous inferno in power plants; and strongly boost their overall efficiency as they do so.

6. Flue gas desulfuritazion.

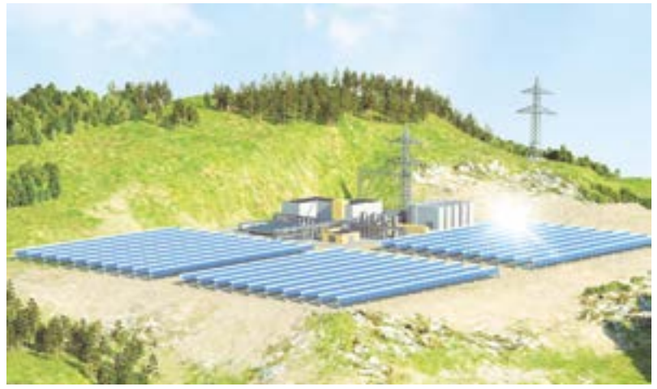
The scrubber section in flue gas desulfurization plants: temperature fluctuations, acids, salty dust. VDM creates materials to withstand it all. They have been cleaning the air that way for more than 30 years now.

7. Seawater handling.

In many industrial applications seawater is used thanks to its virtually unlimited availability – for example in heat exchangers. Alloys from VDM Metals ensure the corrosion resistance required in seawater handling.

8. Solar thermal power.

Sunlight heats the carrier fluid in absorber tubes to as high as 400°C. Here VDM materials protect the vacuum between the glass tube and the metal pipe – thanks to their precisely tailored expansion behaviour.



Electronics & electrical industries

9. Burners in gas heating systems.

Modern gas heating systems generate lots of heat from very little gas. VDM's high-temperature resistant alloys ensure prime efficiency over a long service life.

10. Energy-saving fluorescent lamps.

Energy-saving lamps are eco-friendly – as long as they remain sealed. When heated, VDM's materials expand at exactly the same rate as the ceramic bulb socket. So current – but no air – reaches the noble gas.

11. Household appliances.

In toasters, ceramic hobs, hairdryers and wherever the going gets hot: protective oxide layers on filaments made from our alloys ensure trouble-free operation throughout a long service life.

Automotive Industry

12. Spark plugs and glow plugs.

No combustion engine can run without a spark plug or a glow plug – or without wires like those from VDM. They provide reliable and efficient ignition in central electrodes and glow plugs.

13. Engines and exhaust systems.

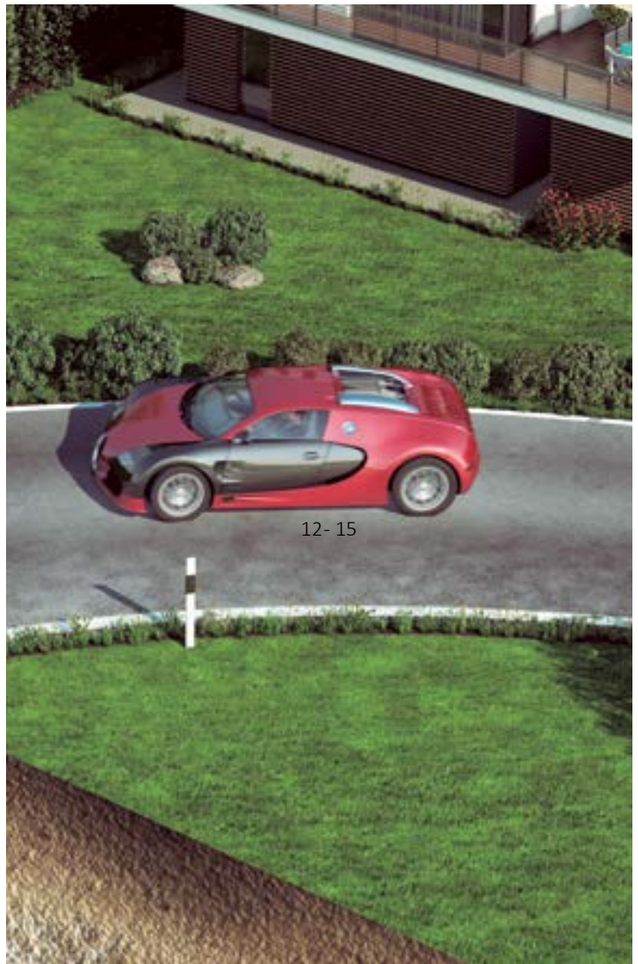
Turbo chargers make engines lighter and more fuel-efficient – but also much hotter. With the high-temperature alloys VDM supports more eco-friendly vehicle construction.

14. Piezo electric injectors.

Piezo electric injectors in diesel engines allow faster and more precise timing control. Made from VDM's materials, they reduce fuel consumption while maintaining the level of engine performance.

15. Catalytic converters.

Catalytic converters made from extremely thin foils: short warm-up phases for immediate function, low exhaust back pressure for full engine performance – and high-temperature alloys for a long service life.



16. Tank trucks.

Acids and bases, often at high temperatures: the transportation of these products requires tanks with the highest possible corrosion resistance. VDM Metals supplies the materials it takes.

Aerospace Industry

17. Aircraft.

Jet engines have to cope with very challenging conditions – thermal stress, corrosion, long hours of operation. Superalloys have proven their strength in these hot environments more than once. “Have a safe trip” – with materials produced by VDM Metals.

18. Electric locomotives.

Overhead lines carrying 15,000 Volt: too much for the starting phase. Starting resistors from VDM alloys reduce the charge and make for a gentle start to your journey.

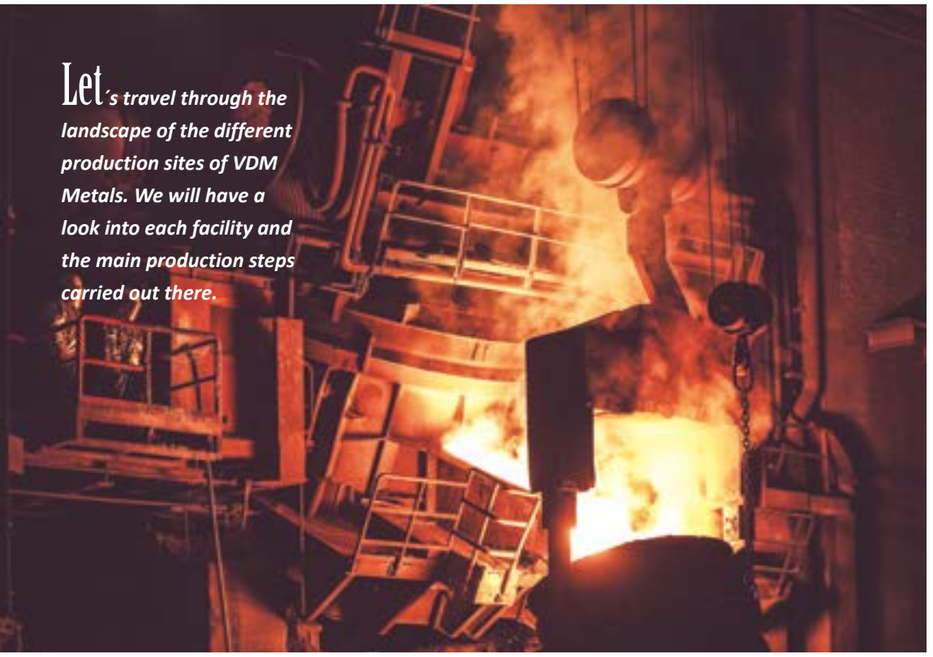
19. High-voltage power lines.

As the charge increases, high-voltage cables heat up and can begin to sag badly. But not when they are made from VDM's materials: they transport current safely and even improve the line efficiency.

20. Geothermal energy.

The deeper, the hotter and often also the saltier: the challenges in sourcing geothermal energy are extreme. Tubes made from VDM's corrosion resistant nickel alloys bring this energy to the surface – safely and continuously.

Production network



Let's travel through the landscape of the different production sites of VDM Metals. We will have a look into each facility and the main production steps carried out there.

VDM factory in Unna, city of Germany

Unna

Over 470 employees work at VDM Metals in Unna, near Dortmund. The melting and casting shop construction started in 1972 with a 15 MW Electric Arc Furnace of 30 tons capacity, and a Vacuum Oxygen Decarburization plant, designed to produce nickel based materials. In the 1990s, melting shop was extended by 3 induction furnaces, with a capacity of 16 tons each, and a vacuum degassing ladle furnace. In contrast to carbon steel or stainless steel mills, ingot casting in different shapes and dimensions is widely used at VDM Metals, as these serve as feed material for remelting or forging operations, for example. Alternatively, casting takes place in a vertical continuous caster where slabs up to 16 tons weight are produced.

Since 2003 VDM Metals also operates a 20 tons vacuum induction melting (VIM) furnace. Alloys produced here satisfy the most challenging demands in terms of analysis precision. Gases and trace elements are virtually removed. VIM ingots also serve as pre-material for remelting, which enhances homogeneity and purity of the materials. In Unna, 2 vacuum arc remelting (VAR) and 7 electro slag remelting (ESR) furnaces are available. Ingots and slabs produced are either processed on-site into forgings or bars, or carried to other sites for further processing.

Here in Unna, VDM Metals operates a 45 MN open die forging press, constructed in 2007, which uses 2 rail-bound manipulators and receives its feedstock from certified heating and reheating furnaces. Bars, billets and semi-finished products are made following precise procedures. The maximum ingot weight is 60 tons, an interesting option for toll manufacturing.

Heat treatment is another crucial production step, as this process determines the mechanical properties of a metallic alloy such as hardness, strength, toughness, ductility, and elasticity. Following cooling, forged bars of up to 7,500 mm length can be heat treated at up to 1,250°C in a NADCAP certified annealing furnace. At Unna site, forged bars with a diameter >120 mm are machined using advanced rotary turning or peeling equipment. To ensure optimum quality, various testing facilities are available, including ultrasonic testing as per DIN, EN, ASME and NADCAP.

Since 2017, powder is produced in Unna as well in a standardized production process. A vacuum inert gas atomization plant (VIGA) forms the core of the powder manufacturing facilities. VDM's high-purity powder is produced by means of vacuum induction melting and inert gas atomization. The steps of powder production are precisely coordinated to each other as they affect the composition and purity of the powder.

VDM factory in Duisburg, city of Germany

Altena

Altena is a small city 30 km south of Dortmund, famous for its XII century castle. VDM's production site is also of rich history. Today, approximately 420 employees work at Altena, including the corporate divisions Research and Development and Quality Assurance. Hot-rolled and forged bars with <120 mm diameter are produced, up to 12,000 mm length. As in Unna, state-of-the-art NADCAP and AMS approved heat treatment furnaces are available. The bars are machined with modern peeling and grinding machines, commissioned in 2013. A 60-ton drawing bench is available for the manufacture of cold-drawn precision bars.

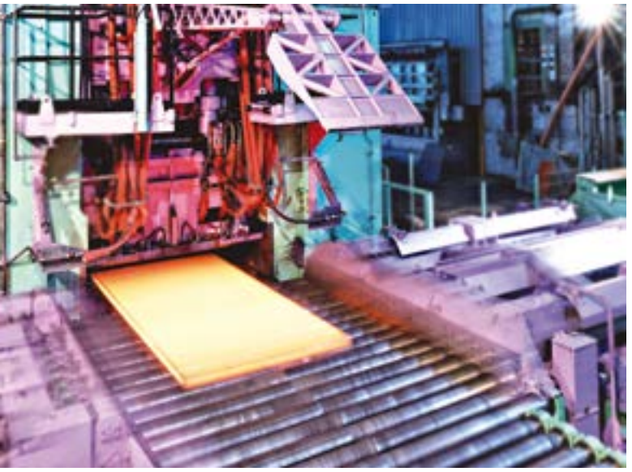
Altena is also the home turf of VDM's sheet production. The maximum length of plates and sheets is 12,000 mm. While the hot-rolling of plates is performed in Siegen, all following production steps are carried out here. Again, the heat treatment is of major importance when it comes to mechanical product characteristics. A continuous roller type annealing furnace that can process sheets in widths up to 3,200 mm and up to 70 mm thickness is available, including an advanced water quenching unit. Facilities for finishing steps such as shot blasting, leveling, pickling, grinding and cutting are also available. The cold rolling of sheets can be processed on a Sendzimir reversing mill that can process hot-rolled sheets to cold-rolled sheets in widths up to 2,500 mm. Ultrasonic testing ensures a high quality of the finished products.

As quality is a leading priority, VDM Metals operates different laboratories to control product properties. In Altena, metallography, mechanical properties and corrosion behaviour is tested. Furthermore, the Welding Technology Centre of Excellence is also located here.

VDM factory in Altena, city of Germany

Duisburg

VDM Metals operates a two high hot rolling mill with a 40 MN rolling force, including auxiliary equipment such as quenching baths, integrated in the plant of Thyssenkrupp. Ingots cast in Unna are hot formed into slabs here. On site, 15 standard pit furnaces, 3 large pit furnaces as well as 2 holding furnaces are available. After delivery, the ingots to be rolled are heated initially up to 1,250°C and then rolled. The rolled slabs are 300-2,000 mm width and 80-600 mm thick. The maximum weight is 25 tons. A hydraulic cutter with a shearing pressure of up to 30 MN and the capacity to separate scrap is likewise available, as is a laser measuring system that is used to measure thicknesses and widths. Furthermore, the slab heads and ends are cropped after rolling, which means they are cut off. Against the background of the large capacity of the mill, not only VDM's products are processed here, but also bronze, brass, titanium, copper, aluminum, carbon and stainless steels for third party producers.



VDM factory in Siegen, city of Germany

Siegen

In Siegen, 80 km south of Dortmund and 75 km east of Cologne, 75 employees are working at VDM Metals' four high hot rolling mill for plates. The mill was originally designed as cold rolling mill in 1957, and converted into a hot rolling mill in the 1970s. VDM acquired the plant from Krupp in 2000 and modernized it 2013. Today, plates with a width of up to 2,600 mm and a length of up to 13,000 mm can be processed to hot rolled sheets with a thickness of min. 3 mm. Three gas powered heating furnaces, state-of-the-art cutting facilities and an integrated IMS measuring system secure smooth operations: The mill gets its feed material (slabs) from Unna or Duisburg, and once hot rolled, the sheets are transported to Altena for finishing.

Werdohl

More than 700 employees work here, at the headquarters of VDM Metals, in different corporate functions, strip and wire production or VDM's European Service Center. The plant was commissioned in 1860, when one of the predecessor companies, Kugel & Berg, started production.

The strip mill gets its feed material from one partner's hot rolling mills, where slabs from Unna and Duisburg are processed into hot rolled strip. After arriving in Werdohl, the hot rolled strip is blasted and pickled to remove the black oxide layer that has formed during the hot forming process. Wet grinding is performed to improve the surface. For cold rolling, VDM Metals operates a four high mill to produce 0.2 to 5 mm thick strips and a six high roll stand with CVC roll shifting for the manufacture of strips with a thickness of 0.1 to 5 mm.

A brand new and globally unique vertical bright annealing line, which only started operation in 2019, is available to perform heat treatment at 800 to 1,230°C. The plant includes a degreasing unit, an integrated heat recovery and its own hydrogen production system. Leveling, slitting and cutting equipment is available for finishing operations to meet customer specifications. In addition to strip, VDM Metals also produces foil up to 20 micrometers thickness at the Werdohl site with a special 20 high foil rolling mill. Furthermore, VDM Metals manufactures toroidal strip cores and precision engineering parts.

Like the strip mill, the wire mill receives its feed material from a hot rolling partner. Three stationary annealing furnaces for hot rolled wire are available for optional vacuum or shielding gas heat treatments. Via draw peeling the wire can be processed with a max infeed diameter of 16 mm. Stationary coating, degreasing and pickling equipment is also available. Six dry drawing lines can be used to produce wire of 0.7 to 7.5 mm diameter and 21 wet drawing lines to produce wire of 0.15 to 2 mm diameter. 13 continuous annealing furnaces, four of them double-chamber furnaces, are used to perform heat treatment. Auxiliary equipment can be used to produce welding wire and welding electrodes. Furthermore, VDM Metals is specialized in the manufacture of wire for spark and glow plugs.

Different laboratory facilities are located in Werdohl to assure premium quality, such as the chemical laboratory or the testing centre for wire, including ultrasonic testing and metallography.

VDM factory Werdohl, city of Germany

VDM Metals

VDM Metals USA

The headquarters is located in Florham Park, New Jersey, an hour west of New York City. The plant was built in the 1960's by the specialty metals company Wilbur B. Driver, and later became a part of Precision Rolled Products, a company that was acquired by VDM in 1990. At Florham Park, VDM Metals USA operates a melting shop equipped with a VIM furnace and three ESR furnaces. Furthermore, a Birdsboro two high single stand hot rolling mill is available, which recently was successfully upgraded to produce round material. Four natural gas fired furnaces heat the material for rolling, and a batch furnace is available for heat treatment. The Florham Park lab is NADCAP accredited and performs comprehensive quality analyses. All administrative functions are concentrated in Florham Park. It is the centre for import and handling of all product manufactured by VDM Germany and sold across the continental United States.

The second plant of VDM Metals USA is located in Reno, Nevada. The facility was built in 1978 by Precision Rolled Products. Before acquiring the melt shop in Florham Park, the feed material was purchased externally. Today, receiving its feed material either from Florham Park or Unna, the Reno plant manufactures flat, round, and square long products as well as special shapes, mainly for the aerospace industry. The rolling is performed on either a 10" or a 14" hand mill. Heat treatment is carried out by a tip up annealing furnace with 10 x 1,8 m work zone. Equipment for centerless grinding, peeling and cutting is also available. As a matter of course, the Reno plant is also equipped with state-of-the-art lab and testing facilities and is certified to Pratt & Whitney standards.

VDM Metals USA employs more than 100 people at each of its US locations.

Service Centers

Reliable ***delivery of small quantities at short notice around the globe – this encapsulates the challenge and task of VDM Metals' Service Centers.***

All VDM Service Centers are connected to each other to assure short delivery times. They are equipped with state-of-the art machinery for tailor-made cuts: VDM commands Trumpf laser jet units and Ridder water jet units for professional cutting and handling. Small orders are welcome and materials for spare parts are usually on stock. Needless to say, that VDM's material experts are available to advise on questions of material selection and processing.

Current set-up in Europe, Asia (Korea / China) and Australia

In 2002, VDM's Service Center Europe opened in Werdohl, Germany. Since then it has grown continuously, both in size and in the range of services offered and products on stock, always keeping up with customer demands. The 7,000 square meter Service Center has a versatile portfolio of materials on stock and is able to offer a comprehensive range of services and add on work options at their manufacturing plant. The portfolio includes heating element wires, welding fillers, sheets, rods and forged billets. The services include cutting of sheet, also in more complex forms and individually processed (laser and waterjet cutting) and cutting of rods and billets. Products are offered to customers across Europe and the Middle East.

In 2008, VDM Metals opened its first Service Center in Asia. Today it is located in Nantong, near Shanghai. Here as well, the Service Center is a storage facility with a comprehensive range of products and add-on processing services capabilities. In October 2016, VDM Metals opened a second Service Center in Asia, which is located in the Gimje free trading zone in Korea. VDM supplies the entire Asian region, except China, from Korea.

The Service Center in Australia was already established in 1981. It takes care of customers in Australia and New Zealand. The product portfolio consists of sheets, plates, bars, drawn wires and welding consumables from VDM production, but also products produced externally, like tubes and pipes. Processing facilities and value added services are offered as well.

Flexibility and customer focus: Quick adaption to customers' needs

During the past years, the stock and service program was more and more adapted to the needs of engineering companies. As a result, VDM Metals even delivers complete construction kits to fabricators for particular industries, including serially numbered cut parts and the corresponding filler metals. By nesting, VDM takes care of the best material outcome and realizes the necessary cuts. The scrap metal cycle is managed automatically during production. During the process all cut parts are marked or engraved, and packed in sets according to the engineering customers' construction plans, so these kits can be assembled easily on site. VDM Metals is therefore not only concerned with questions of material resistance but also with the economic procedure to help the customer. A win-win situation.

Service Center Online Shop

Only for its Service Center products, VDM Metals offers a 24/7 online shop. Customers can easily check the availability of certain materials and inventories, send inquiries around the clock and get access to special offers.

Check it out on:

www.vdm-metals.com/shop

New alloys and new applications

Many *pioneering inventions have made VDM Metals the global innovation leader in nickel alloys and special stainless steels in recent years. More than 300 national patents for over 60 inventions are proof of this. VDM's goal is to defend and expand this leading position – together with its customers.*

At VDM Metals, materials capable of withstanding extreme conditions and corrosive media are developed. How well they perform depends on their chemical composition and production process. These may be surprisingly simple or highly complex, but in every case VDM's solutions are the fruit of intensive research and development work in which nothing is left to chance.

Co-operative approach

Since VDM's development cycles generally last several years, forward-looking planning is essential. VDM Metals is currently already developing the materials that will shape the market in the next ten years. Starting in the planning phase, VDM Metals works closely with its customers. The technical exchange is very important. In discussions with its customers, VDM's experts regularly get to know where materials reach their limits or what challenges new technologies bring with them.

In the area of research and development VDM basically distinguishes between two approaches – the further development of existing materials or the development of new materials.

- VDM® Alloy 825 CTP, for example, is based on the well-known Alloy 825, and is specifically intended for use in seawater environments in the oil and gas industry.
- VDM Alloy 31 Plus® is another such development. The aim of the development was to improve processing properties, the basis being the well-known Alloy 31.
- The new high-temperature alloy VDM® Alloy C-264 was designed to address a very specific deformation problem in an automotive application.
- VDM® Alloy 699 XA is a new material solution for the well-known corrosion phenomenon of metal dusting.
- VDM® Alloy 780 is a new superalloy with increased temperature resistance, designed for the use in aircraft engines.

Once the initial series of tests has been successful, the large-scale tests in production is scheduled. From the melt to the semi-finished product – the entire process is accompanied by VDM's R&D experts. Together with production, the optimal production plans and production routes are being developed.

The material development as such is accompanied by calculation models regarding melting, remelting and casting, forging and rolling, solidification of microstructure, just to name a few. The properties are examined in VDM's own laboratories or external facilities. In the corrosion laboratory, material samples are exposed to defined corrosive media, for example, at room temperature and elevated temperatures. Of course, the mechanical and physical properties of the materials are also examined in detail.

The aim of VDM Metals' research is not just to develop new materials, but also to sound out hidden performance potentials in market-proven alloys which the company can then qualify for new applications.

Weldability counts

For many customers it is very important that the materials are easy to process. For this reason, VDM Metals has set up a dedicated Welding Technology Center of Excellence. Here, the appropriate welding filler materials are developed and tested. Once VDM has developed a new sheet or strip material, the subject of joint welding plays a central role. The team's task is then to develop and qualify welding wire or electrodes for the various welding processes. Traditionally, overlay welding is of great importance for our oil and gas customers. Here, too, the R&D team ensures that VDM materials can be used in the required product forms in various processes without any weld ends.

The latest challenge: Additive manufacturing

VDM's latest product form is powder for additive manufacturing processes. VDM Metals offers well-known nickel alloys in powder form, but also alloys that have so far been outside VDM's classic semi-finished product portfolio. The development process focuses more strongly on the properties of the end product. In addition to the size and shape of the powder particles, flow ability plays a decisive role.

As innovation leadership is a strong differentiation strategy, VDM Metals works closely together with leading research institutes around the globe to commercialize new technologies, at present in more than 50 dedicated projects. These co-operations have been successful with an outcome of several hundred registered patents.

Tests and analysis of material properties take place in VDM´s laboratories, like the Chemistry Lab in Werdohl

Testing of mechanical properties (tensile strength) at the wire division

Welding materials and welding technology center

VDM ***Metals has been involved in welding and welding materials since the end of the 1960s. In Europe, VDM Metals was one of the first producers of nickel alloys and has naturally been concerned with their further processing and weldability. In doing so, the company had two aspects in mind: firstly, to offer customers the best possible solutions for further processing of the materials and, secondly, to demonstrate the advantages of nickel alloys also in welding processing by providing the necessary service.***

VDM Metals initially began to produce welding materials for other suppliers and companies and did not make any appearance itself in the market. It was not until 2008 that it decided to operate under its own name. Since then VDM Metals has built up a very good reputation by continuously expanding its product portfolio and services in the field of welding materials. The portfolio now includes TIG rods, welding wire, wire electrodes, core wire as well as strip electrodes and strip for flux cored wire. The company is continuously researching to expand its portfolio in order to meet the demands of new welding processes and production techniques.

Changing market requirements

To keep up with the changing requirements of the market, the technologies and capacities have also been expanded accordingly over the years. For example, it was recognized that the market for oil and gas production would undergo lasting changes – an increasing demand for corrosion-resistant coated pipes was to be expected. Consequently, VDM Metals has added the weld cladding variant to its product range. In overlay welding, an existing pipe made of unalloyed or low-alloyed steel is coated on the inside with several layers of a corrosion-resistant material in an automated welding process. VDM Metals, has optimized the materials for these requirements and qualified them for the process.

A new filler metal is tested

Concentrated expertise: Welding Technology Centre of Excellence.

The Welding Technology Centre of Excellence is located at the Altena site and part of the Research and Development division. On the one hand, the centre is busy with the development of welding filler materials for the further processing of nickel materials. For this purpose, new developments are made, but also the optimization of already existing welding consumables. In addition, the team is dealing with the qualification of existing materials for new applications, as illustrated by the example of clad welding.

Focused of Customer Service

On the other hand, the Welding Technology Centre of Excellence offers a comprehensive service for customers. Together with the sales department, actual needs and challenges of customers are analyzed and solutions developed. There are many factors that influence the result of the welding process. High demands on the welding filler materials are common to the various welding processes. The material must be easy to process to ensure a smooth and faultless process. If, for example, the customer has a problem with the automated welding process, the experts of the Welding Technology Centre of Excellence will visit a production plant or a construction site at the customer's premises in order to better understand the issue and recommend appropriate measures. Customer training courses and workshops are also offered. Here, customers are familiarized, for example, with new welding processes or instructed in the processing of a new material.

Cladding is a major field of application

Modern equipment to keep up with developments

The center is equipped with a multi-welding machine and a welding robot to perform the different types of welding and to test the behavior of the materials under realistic conditions. The multi-welding machine is used for classic welding processes such as TIG or gas-shielded welding. The robot is used for the Cold-Metal-Transfer-Welding process (CMT) as well as for Wire Arc Additive Manufacturing (WAAM), an important key technology in modern production engineering. Since the welding process takes place over a long period of time, the demands on the welding materials are very high. In the center, the materials are qualified for this new area of application.

The welding technology center has access to the quality laboratories for the necessary tests, for example to test mechanical properties, breaking strength, etc. An X-ray apparatus is also used to test invisible structures, irregularities or defects in the structure of a welding material under development.

Strong ties With Spain

In ***Spain, VDM Metals traditionally delivers the majority of materials to customers from the chemical process industry; these account for 68 percent of all shipments.***

The electronics and electrical engineering industries follow with 28 percent share. Furthermore, some strong partnerships could be established during the past years:

Recently, VDM Metals obtained the approval to deliver 10'' bars in VDM® Alloy 718 for turbine discs from ITP Aero, headquartered in Zamudio, Bizkaia.

ITP Aero is a world leading company within its market, currently the ninth largest aircraft engine and components company in the world by revenue. ITP Aero includes among its activities the design, research and development, manufacturing and casting, assembly and testing of aeronautical modules and engines. It also provides MRO services for a wide range of engines for regional airlines, business aviation, helicopters, industrial and defense applications. Currently, VDM Metals is working on further approvals for additional bar sizes.

Another current co-operation is the exclusive manufacture of seamless tubes made of VDM® Alloy 699 XA by Tubacex. VDM® Alloy 699 XA is a brand new high-temperature alloy for metal dusting applications in chemical and petrochemical processes. Tubacex' headquarters is located in Llodio, Álava, where it also has industrial facilities.

www.cedinox.es