

ŽOLLERN

Solid metals. Fine solutions.

Investment Casting

High-
performance
components



The ZOLLERN Group

ZOLLERN is one of the pioneers in the metal industry. At several locations in Europe, North America and Asia, 2,000 employees develop, produce and service a wide range of high-quality metal products. ZOLLERN supplies sophisticated solutions for a wide range of applications with its business areas of drive technology, investment casting, sand casting and forging as well as steel profiles.

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Demanding investment castings

First class products for the high-end sector



Laucherthal, Germany



Soest, Germany



Maia-Vermoin, Portugal



Pecica-Arad, Romania



Ravne na Koroškem, Slovenia

ZOLLERN-Feinguss produces sophisticated investment castings at its headquarters in Laucherthal, Germany and other locations in Soest (Germany), Slovenia, Romania and Portugal. The vertical range of manufacture extends from the master smelter to ready-to-install, highly sophisticated investment castings, including mechanical processing, surface finishing and assembly. ZOLLERN's experienced specialists cast almost any standardised alloy. Even non-standardised special alloys are created according to customer requirements or modified using existing alloys.

The investment casting process is suitable for developing components using rapid prototyping and offers economical solutions in small, medium and large series.

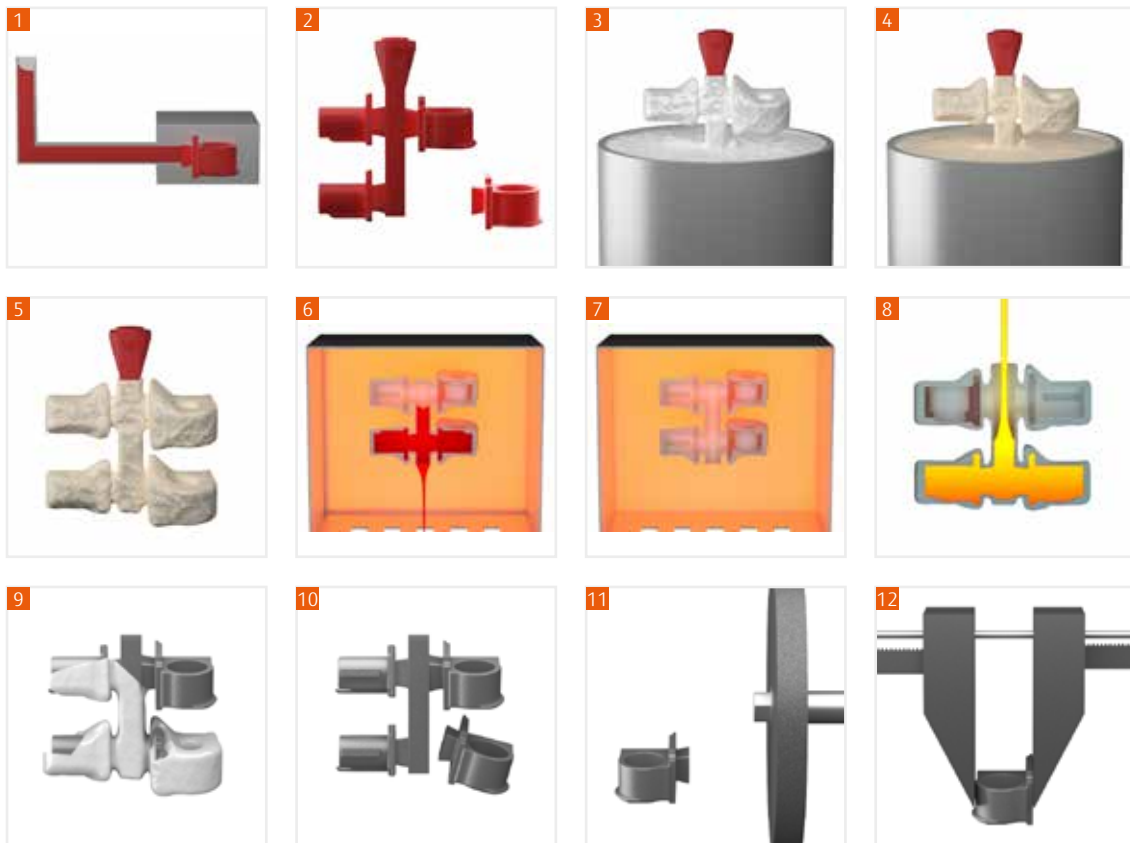
ZOLLERN combines different technologies, such as open casting, vacuum induction, low-pressure casting and SOPHIA®-casting under one roof. ZOLLERN offers the best technical and economical solution for various application-specific requirements.

Investment casting

A precision process with tremendous design freedom

Investment casting is casting in one-piece ceramic shell moulds. This eliminates the mould and model divisions that are common in sand casting as well as the inaccuracies and burrs that this causes.

In investment casting, the model is melted out and is thus lost. The process is described by the following manufacturing steps.



1 A wax model is required for each casting. The models are produced by injection moulding in tools made of soft metal alloys, aluminium or steel.

2 The models are glued together to form a »casting cluster«. This means that the casting system is created. Several models or only one model can be glued to form the »casting cluster«.

3 to 5 By dipping the »casting cluster« into a ceramic slurry several times with subsequent sanding, models (after drying and possibly chemical hardening) receive a 6 to 10 mm thick refractory ceramic shell.

6 and 7 After the mould material dries and sets, the wax models are melted out and the moulds are fired at temperatures up to 1,100°C.

8 The casting is made by pouring into hot moulds. By filling even fine details of the mould, a dense casting is created.

9 to 11 After cooling down and knocking out, the poured castings are separated from the moulds, processed and tested.

12 Quality inspection

Investment casting is a very economical exact or precision casting process. On the one hand, ever larger castings are being precision cast, while on the other hand (super) alloys that are increasingly difficult to melt are being precision cast. Due to its economic advantages, investment casting is increasingly being considered in value-analytical comparisons. Investment casting enables optimum design like no other casting process.

Technical solutions are often achieved by means of precision casting design, which are otherwise not possible at all or at least not so inexpensively.

Selection of materials

A tremendous variety of materials is available, such as case-hardening steels, creep-resistant, heat-resistant and high-temperature alloys, wear-, corrosion- and soft magnetic materials. ZOLLERN can cover almost all application areas. Detailed information can be found in ZOLLERN's alloy catalogue.

Surface finish

The castings cast without burrs have an excellent surface and in many cases do not require further machining, except for the production of the fitting dimensions.

Unit weights

Depending on the manufacturing process, unit weights of up to 100 kg are produced.

Advantages

- Virtually unlimited design freedom
- Large selection of alloys
- Precision casting process with high dimensional accuracy
- Near contour casting (near net shape)
- Representation of difficult inner contours by means of ceramic cores
- High surface quality





Investment Casting Aerospace

In many areas of aviation,
investment castings from ZOLLERN
ensure reliable technical functions.

Applications

- Turbine:
Guide and rotor blades, heat shields
- Structure and flight control:
Landing flap profiles and receptacles, drive housing, electronic housing, fuel and hydraulic housing
- Equipment:
Fittings, locking bolts, brackets, hinges, handles, pump housing
- Aerospace:
Housing for optical, electronic and fuel systems

Materials, weight spectrum

- Steel, max. 20 kg
- Aluminium, up to 1,400 mm x 900 mm x 600 mm, max. 120 kg
- Super alloys conventional solidification, max. 25 kg
- Super alloys directional (DS) and monocrystalline solidification (SX), max. 4 kg

ZOLLERN Technologies

- Open casting
- Low pressure die casting
- VIM - Vacuum casting

Special processes

- SOPHIA® process for high-strength, thin-walled aluminium components
- Laboratory equipment for Single Crystal (SX), Directional Solidification (DS) and Equiax (CC) casting

Stress and casting simulation ensure optimised process engineering and maximum economic efficiency



Courtesy of UTC Aerospace Systems,
designed by UTAS-Propeller Systems -
RATIER - FIGEAC®



Investment Casting

Vehicle construction

Investment cast components convince in the automotive industry with their enormous performance capability. For example, the small, powerful turbine wheels made of Inconel perform over 300,000 revolutions per minute while withstanding temperatures of 1000°C and more.

Applications

- Turbocharger components: turbine wheels, valve discs, vanes or wheel carriers, electronic boxes, levers, brackets and planet carriers

Materials, weight spectrum

- Steel alloys
- Vacuum alloys or superalloys, including MAR and INCONEL

Components from a few grammes up to 60 kg are possible.

ZOLLERN Technologies

- Open casting
- Penny/VIM vacuum casting



With a diameter from 20 to 120 mm, the ZOLLERN turbine wheel performs at temperatures of more than 1,000°C at more than 300,000 rpm. For full power and an agile driving feeling at the highest level.



Investment Casting

Industrial components

medical technology

mechanical engineering

In high-performance mechanical engineering, investment castings can withstand particularly high dynamic loads. The diversity of materials and freedom of design in investment casting is also appreciated in medical technology, where knee implants are made from cobalt-based alloys, for example. The heat resistance of the materials used also plays an important role as turbine blades in gas turbines.



The highest quality implants are manufactured by investment casting from superalloys. Femoral and tibial elements for knee joints in particular are an area with a future for ZOLLERN, also in the USA and China.

Applications

- Energy:
Industrial gas turbine, pump housing, electronics housing, guide blades,
- Medical technology:
Implants, Instruments
- Mechanical engineering:
Housing, brackets, valves, fittings, screw conveyors, chain links, fan wheels
- Measuring technology



Materials, weight spectrum

- More than 500 materials, also according to customer specification
- Openly potted alloys
up to 180 kg melting weight
- Vacuum alloys
up to 90 kg melting weight and a component size up to (HxØ) 750 mm x 600 mm



ZOLLERN Technologies

- Open casting
- Low pressure die casting
- Vacuum casting

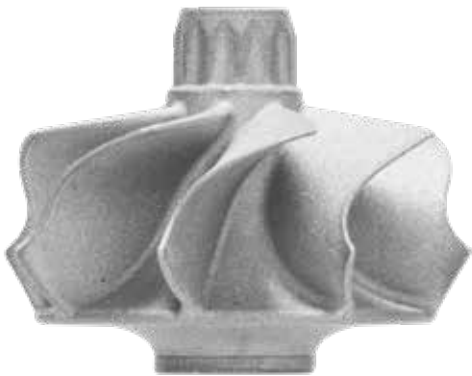
The appropriate procedure for every requirement

Vacuum investment casting

There are two different technologies for vacuum investment casting. On the one hand the Penny technology and on the other hand the vacuum induction process using a VIM system (Vacuum Induction Melting). Due to their chemical composition, in particular the content of oxygen affine elements, high-temperature resistant materials must be melted and cast in a vacuum.

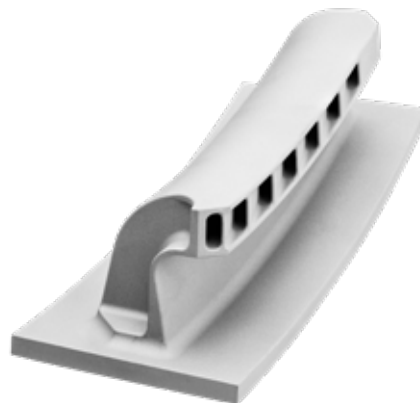
The vacuum casting process also offers the advantage of a very good degree of purity and, due to the special process technology,

offers the possibility of targeted grain refinement on the castings. The workflow at the melting stations is automated except for loading and unloading. Only vacuum remelt alloys are used as starting materials for superalloys.



Penny technology

A vacuum induction furnace is used as a tandem system for melting and casting under vacuum. This system is designed for the serial production of smaller investment castings. It is adapted to the use of preheated ceramic shell moulds produced by the lost wax process. Melting takes place in an oxide ceramic disposable crucible. Casting takes place automatically through bottom casting after melting through a thin metal plate which closes the casting opening in the crucible bottom during melting. The metal plate is of the same type as the cast alloy. The crucible is either made of oxide ceramic fibre material or is an integral part of the casting mould. The system operates in the vacuum range up to 10^{-2} mbar. Components with a diameter of approximately 250 mm and a maximum height of 300 mm can be manufactured in this way.



VIM technology

The molten mass weight of the VIM system is approximately 100 kg. The system is designed for a melting bath temperature of up to 1,700 °C. The vacuum range is $\leq 5 \times 10^{-4}$ mbar. Components with a diameter of 600 mm and a height of 600 mm can be manufactured.

In a partially double-walled and water-cooled melting chamber, the alloy is melted in a ceramic crucible via an induction field. The crucible is tilted via a computer-controlled, servomotor-supported tilting curve for optimum mould shell filling.



Aluminium investment casting SOPHIA® process

- With the computer-controlled, directional solidification in the SOPHIA® process, high-strength mechanical material properties are achieved that go far beyond the standard values. The SOPHIA® process is particularly suitable for the lightweight design.
- Prototypes and series can be developed and manufactured within a very short time using the SOPHIA® PROCESS. The virtually unlimited freedom of design for bionic and topologically-optimised components in series quality is another advantage of the special process.



Open investment casting conventional

Conventional open investment casting is characterised by an almost unlimited selection of different alloys.

In this procedure, the casting cluster is poured off manually in an oxygenated environment.

The mould filling is controlled manually via the pouring speed.

A component weight of up to 100 kg is feasible.



Open investment casting roll-over technology

Before the casting process, the ceramic shell is mounted upside down on the melting furnace.

After melting the alloy, the furnace rotates 180 degrees in a few seconds. The mould is filled accordingly quickly.

The casting process takes place under an inert gas bell in order to eliminate the influence of oxygen.

Low pressure investment casting process

The main difference between the low-pressure investment casting process and conventional casting and the SOPHIA® PROCESS is that the mould filling can be controlled and the molten mass can be cast against gravity at low pressure.

Processes

Shaping the world



Wax injection

When producing the wax model, wax is pressed into a tool that depicts the shape of the subsequent casting as a negative. After curing, the wax model is removed. The tool is designed as a manual aluminium or steel automatic tool, depending on the planned series quantity. Very complex internal geometries, which cannot be reproduced by the tool, can be realised by a water-soluble wax core. This is dissolved again in a water bath after the wax model has been injected.

Cluster assembly

Individual components are adhered to a casting system and form a model cluster. Depending on the size of the wax models or the subsequent components, a model cluster consists of a few up to hundreds of wax models. The model cluster is then immersed in a cleaning medium to prepare the surface for the ceramic process.



Ceramic

To produce the subsequent casting mould, the wax cluster is coated with a stable and diffusion-open ceramic. This is usually done automatically by robots. Several layers are built up by alternately dipping into a ceramic slurry, then sanding and drying. This process takes several days.



Melting off

In an autoclave, the wax in the ceramic is melted out by means of steam and increased pressure. Hence the name »lost wax process«. The wax model is lost and the ceramic shell takes over the shaping of the product. Melted wax can be recycled and reused for the sprue system.

Firing

The subsequent firing gives the ceramic mould the necessary stability to withstand the casting pressure and thermal influences during casting.



Casting/Finishing

The casting clusters are brought up to temperature in the furnace, removed manually or by a robot and fed to the casting system. For open-cast steel alloys, the casting process only takes a few seconds or minutes. For alloys that require a vacuum to be melted, the cycle time may exceed 30 minutes.

Rework

The ceramic is removed from the casting cluster. Various technologies are available for this purpose, such as sandblasting or vibration systems. The casting system is separated from the component and then the remaining sprues on the component are brought into the final contour through grinding.



Finished part machining

The investment casting process enables the component to be manufactured in near net shape so that machining is only required in areas that require special tolerances.



Quality assurance

Quality assurance takes place during the individual processes as well as at the end of the process chain. The quality tests are determined depending on the requirements of the component, the industry or the customer. A separate accredited laboratory is available for metallurgical investigations.



Certified processes. First class quality.

ZOLLERN products are marked by high quality. In addition to the strict quality assurance of the individual products, the ZOLLERN management system is certified according to the international standards ISO 9001 and ISO TS 16949. Environmental and energy management in accordance with ISO 14001 and ISO 50001 is also a certified standard that is applied on a daily basis.

- At ZOLLERN, error prevention takes priority over error correction. The goal is zero defects in the sense of complete fulfilment of customer requirements.
- The work at ZOLLERN is accompanied by continuous improvement of the processes, the organisational structure and ultimately the products and services. In addition to continuous further development in the relevant areas, the company suggestion scheme also makes an important contribution to this.
- Employee orientation, training and further education and optimum working conditions are important components of the corporate policy at ZOLLERN – so that top performances are achieved in national and worldwide markets today and tomorrow and so that resources and the environment are conserved at the same time.



Quality assurance and material testing

ZOLLERN uses a variety of methods and instruments to ensure product quality. Material tests are certified according to DIN EN 10204 and accompany the entire manufacturing process.

Testing of mechanical and technological properties

- Tensile testing machines
- Hardness testing devices for all standards
- Fully automatic small load hardness tester
- Notched bar impact test

Metallographic testing

- Laboratory for sample preparation, such as hot embedding and preparation of microsections
- Various macroscopes and microscopes enable precise material examination

Determination of the chemical composition

- Spectral analysis
- Chemical analysis

Geometry and surface roughness testing

- Measuring machines, optical, tactile and digital
- Roughness testing devices

Straightness and torsion testing

- Measuring tables, measuring bridges in various lengths and protractors

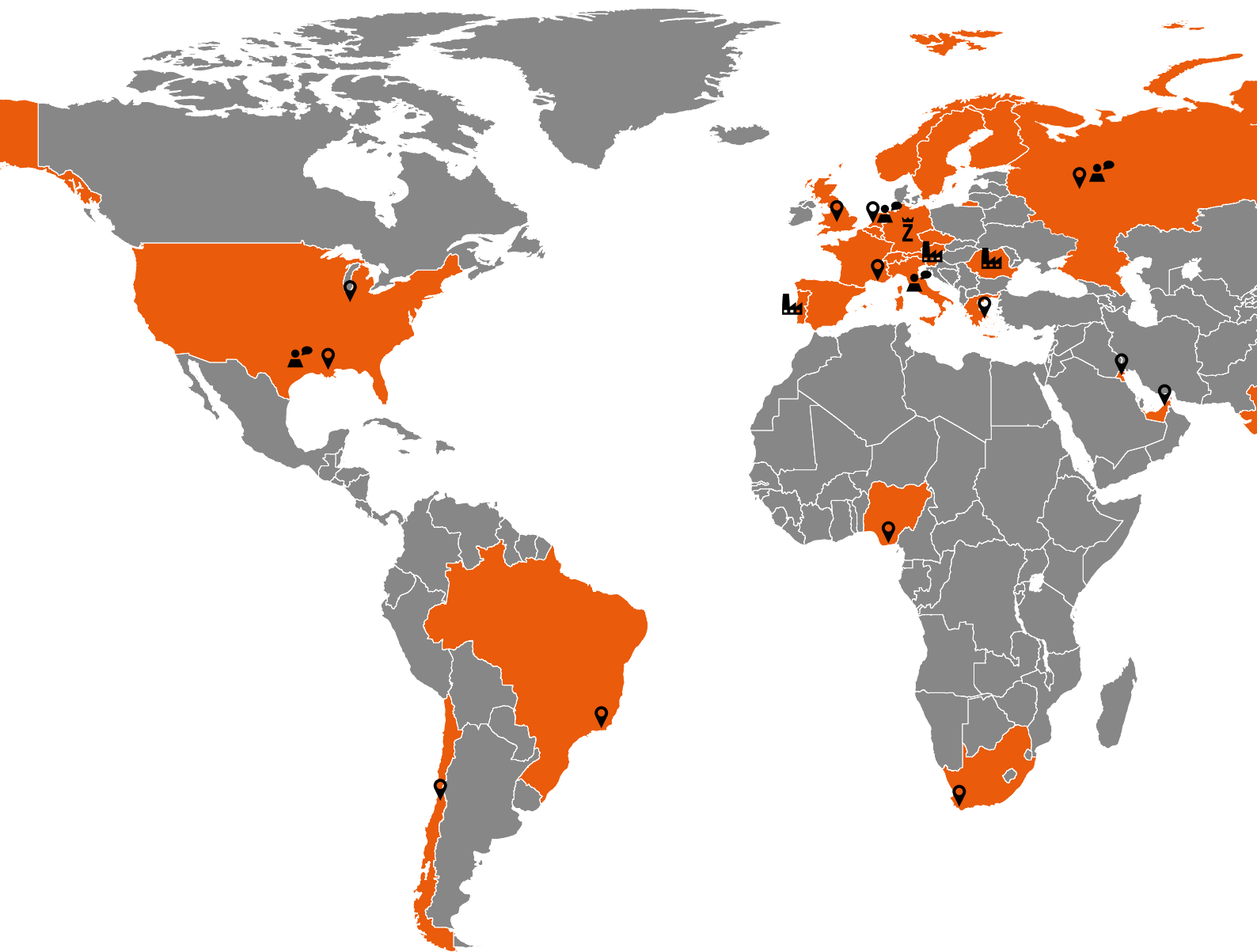
Further development of heat treatment, determination of tempering temperatures

- Laboratory furnaces

Non-destructive testing methods

- Crack testing according to the eddy current principle and magnetic particle principle
- Ultrasonic tests
- Tests for confusion

3 continents,
13 locations,
2,000 people.





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Service partner

ZOLLERN-Drive technology

Gearboxes

- Wheel and track drives from 100,000 Nm to 2,300,000 Nm
- Slewing gears from 1,000 Nm to 1,550,000 Nm
- Plug-in winch drive gears from 1,000 Nm to 2,500,000 Nm
- Industrial gears from 1,000 Nm to 4,000,000 Nm
- Tunnel boring gears up to 3,000,000 Nm
- Sugar mill gears 550,000 Nm to 6,300,000 Nm
- Gearbox combinations up to 5,000,000 Nm (planetary gears, spur gears, bevel-helical gear units, helical-worm gear units)
- Electrical drive systems

Winches

- Free fall winches for free fall weights up to 60 t
- Rope winches with planetary gearboxes for lifting or pulling forces up to 265 t (at the rope drum)
- Winch systems, application-specific complete systems as plug and play solutions

Direct drive systems

- Torque motor kits, outer diameter up to 2,200 mm, torque up to 60,000 Nm
- Synchronous motors kits
- Standard synchronous motor assemblies from 80 to 400 kW
- Special motors (synchronous/asynchronous) according to customer specifications

Hydrostatic bearing systems

- Hydrostatic spindles
- Hydrostatic guides
- Hydrostatic bearings

Rotary tables

- Hydrostatic rotary tables with diameters up to 4,000 mm
- Aerostatic rotatry tables with diameters up to 2,000 mm
- Rotary tables with roller bearings with diameters up to 3,000 mm

Automation

- Linear axes (payload up to 10,000 kg)
- Telescopic axes (payload up to 1,600 kg)
- Line and area gantries (nominal stroke up to 50 m)
- Plant and system solutions (turnkey)



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ZOLLERN investment casting

Investment casting

- Complex components according to the lost wax process
- Open cast steel alloys
up to 180 kg casting weight, max. 760 x 500 mm
- Vacuum cast superalloys
up to 90 kg casting weight, max. 600 x 600 mm
- Low-pressure cast aluminium
up to 130 kg casting weight, max. 800 x 600 mm
- Vacuum DS/SX directional solidified components
up to 4 kg, max. 200 mm height
- Solidification characteristics: EQX; DS; SX
- Pre-finished components

ZOLLERN sand casting and forging

Sand casting and other casting processes

- Complex single pieces and small series, also finish machined
- Unit weights up to 2t in steel and 8t in copper alloys
- Patternless forming by milling the moulding material and printed sand cores
- Production according to EN, DIN, WL, AMS, ASTM and other national standards

Forgings

- Complex single pieces and small series made of copper and copper alloys, also finish machined
- Forgings up to 3t/pc, also in special dimensions
- Round and flat bars, discs, thick-walled rings and bushings
- Rings up to 2.5 m diameter
- Die pressed parts up to 15 kg
- Special extruded copper profiles with graded conductivity
- Production according to EN, DIN, WL, AMS, ASTM and other national standards

ZOLLERN Steel profiles

Special profiles and finished parts

- Profile types: hot rolled, cold rolled, cold drawn, induction hardened up to 64 HRC
- Profile cross sections from 5 mm² to 7,650 mm² (40 g/m to 60 kg/m)
- Surface roughness: from Rz 5 µm, dimensional tolerances from 20 µm
- Mechanical properties, optimally adapted to the application
- Machined and ready-to-install components from steel profiles

Plain bearing technology

Together with Miba AG, ZOLLERN is actively part of a joint venture for plain bearing technology (www.miba.com)

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