INTECO

WE ARE SPECIAL METALLURGY

CONTENTS

DEAR READER!

Thank you for your interest in INTECO – the following pages of this brochure are dedicated to present you a brief insight into our special melting technology as well as equipment features and design criteria. As the company foundation of INTECO in 1973 was closely connected with the special metallurgical process of electro slag remelting, the production technologies for high demanding steels and complex alloys have always been our core business and the origin of all our expansion activities in the past decades.

INTECO is proud to be nowadays the worldwide leader in metallurgical process technology and related equipment offering controlled melting, remelting, atomization and solidification processes for special steels, super alloys as well as titanium and its alloys.

INTECO – over the last decades – has performed significant and internationally well recognized developments and has successfully put into operation all respective and relevant production processes such as …

- Vacuum induction melting (VIM)
- Electro slag remelting (ESR)
- Vacuum arc remelting (VAR)
- Titanium production (Ti)
- Powder technology (PM)

Merging process technology and supply of the related equipment, together with our clear focus on the continuous improvement of existing as well as the development of new technologies represents our sustainable strategy.

We do hope that this brochure acquaints you with our broad product portfolio including some of our unique innovations and we would like to draw your attention to various key projects which we were able to execute together with our esteemed customers. We understand our mission to serve you with our know-how and the best tailor made designed equipment and technology possible and to challenge ourselves every single day to continuously improve us, our services and products.

Ultimately, it´s all about you and we would like to cordially express our thanks to you, our valued clients and customers, who supported INTECO with your trust and faith to achieve what is reported in this brochure.

Dr. Harald Holzgruber
- INTECO Holding -

Ing. Roland Kristl
- Managing Director -

Patrick Mild
- Managing Director -

ABOUT INTECO

WHO WE ARE...

Starting out as a consulting company for the special steel industry, INTECO has grown to the only single source supplier worldwide that offers all production processes for metal treatment. Since more than 90% of our equipment and services are exported, INTECO is a global player represented by local agents and/or subsidiaries to market and service the products worldwide. Together, we form a fully dedicated team of highly skilled employees eager to plan or modernize a steel plant according to our customers' requirements.

WHAT WE DO...

During the last decades, INTECO has grown to a reputable provider of customer specific solutions for the specialty steel industry. The competence in engineering, management services and technology transfer as well as a strong customer dedication was and is the key to success for our customers. This is again the driver for INTECO to further develop the service and product portfolio in the future to further strengthen the leadership in metallurgical process technology and equipment for melting, refining, casting, remelting, solidification and atomization for high performance steels, super alloys and titanium.

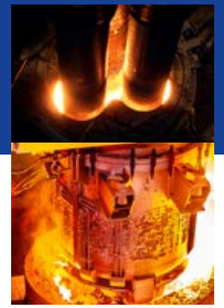
WHAT WE AIM FOR...

We aim for innovation to constantly improve quality of the final product as well as making metal production safer, easier and more efficient. Research and development in process technology and plant design is therefore the key to success, and success for us means to deliver an excellent performance to our customers. Continuous improvements of processes and operating techniques as well as design of systems and components are carried out as a result of our comprehensive R&D activities. Within our R&D process, we make sure that customer requirements as well as innovations triggered by our experienced staff will be pursued in a structured way.

Leadership in metallurgical process technology and equipment for ...

Melting

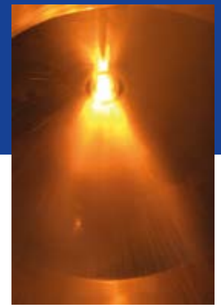
Refining



Casting

Remelting

Atomization



... high performance steels, superalloys and titanium.

PROJECT AND TECHNOLOGY CONSULTING

_Pre-investment studies

Important aspects of such consultancy assignments may involve new greenfield projects, project expansion or retrofit programs, process route evaluation as well as independent assessments and appraisals for financing purposes. Such consultancy starts with a conceptual study and may continue up to full range investigations including a basic engineering.

_Engineering

INTECO provides preliminary, basic and detailed engineering for entire plants including mechanical and electrical engineering as well as automation. All mechanical engineering design work is carried out by modern and state-of-the-art 3D CAD systems. All engineering services are executed in-house at INTECO. INTECO's design is tailor made for the aimed application and is of "single source" from "one hand", i.e. the individual units, components and systems are designed in a manner to support overall objectives set-forth for the entire performance of the whole system.

_Project & construction management

During 50 years of operation, INTECO has executed a number of EPCM, EPC and turn key projects worldwide. INTECO's engineers are specialized in assisting its customers in regard to project management for new plants as well as revamping of existing operations.

_Technology transfer

For all production processes within the product portfolio, INTECO supplies the relevant know-how and technology, from raw material to the finished products with a focus on productivity and efficiency increase as well as quality improvement. During fact finding studies, areas for improvement are identified, cost reduction potentials evaluated and targets mutually agreed. By preparing the know-how documentation, the relevant technology is documented in detail and implemented during technical assistance by INTECO's experts on site as well as training of operating staff.

_Lifecycle services

INTECO provides all major lifecycle services for our equipment such as:

- Remote Support and Service Level Agreements
- Preventive Maintenance Packages
- Spare Part supply
- System upgrades and retrofits

INTEGRATED MANAGEMENT SYSTEM

Since its foundation, INTECO has always focused on the quality aspects of its products and services. The quality management system of INTECO has been continuously and progressively developed and since many years we are ISO 9001 certified by an internationally recognized organization.

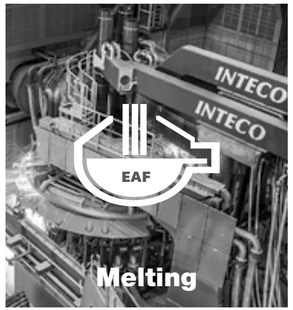
In this context our quality management system covers all business processes like (but not limited to):

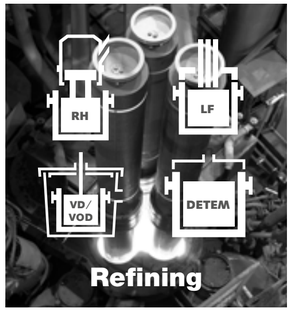
- Preparation of commercial and technical proposals
- Contract management
- All kind of engineering
- Procurement
- Marking and traceability
- Manufacturing
- Inspection, testing and corrective actions, if neccessary
- Quality inspection of components to be supplied by the buyer
- Packaging and expediting
- Erection and commissioning
- Performance testing
- Training and after sales services

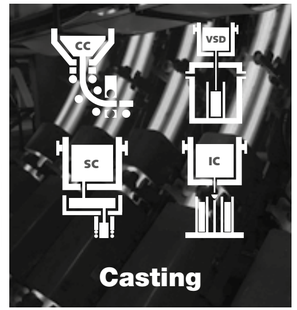
All these processes are performed according to standard procedures and regulations as well as are subject to various systematic and random inspections, testing, controls and internal audits. The quality management (QM) department is responsible for the documentation of the QM-system and its effectiveness.

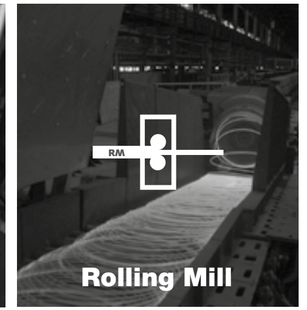
INTECO has been certified in the areas of safety and health in accordance with the standard DIN ISO 45001:2018 since 2013. The aim of this certification is to guarantee each employee a healthy and safe working environment, no matter if the employee is at the office or at a customer's plant site.

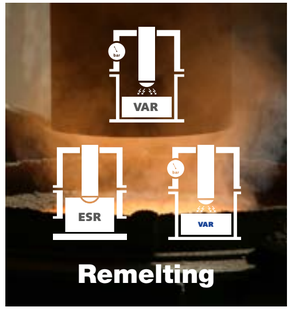
IMAS DIGITALIZATION AND INDUSTRY 4.0

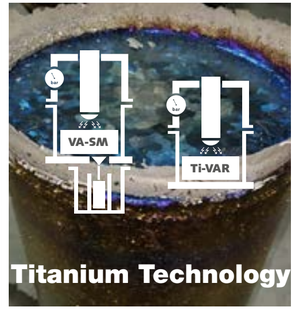












PROCESS KNOW-HOW & CONSULTING

HISTORY AND VISION

Our competence in engineering, technology transfer and ongoing research and development activities as well as a strong customer dedication was, is and will be the key to success for our customers. This is the driving force for INTECO to continuously serve our clients and to further develop our technologies.

1973

Electro slag remelting (ESR)

since 1995

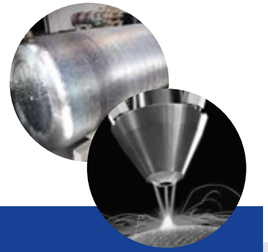
Vacuum induction melting (VIM)

Vacuum arc remelting (VAR)

since 2010

Special melting and remelting shops

VIM – ESR – VAR



now & future

Powder metallurgy (PM)

Titanium technologies (Ti)

DID YOU KNOW THAT...

...INTECO was founded as an **in**ternational **te**chnical **co**nsulting company based on the electro slag remelting technology in 1973

…INTECO is the only company providing detailed process know-how and equipment supply for all special metallurgical processes

...INTECO supplies entire special melting and remelting shops consisting of VIM, ESR and VAR furnaces

...INTECO developed, engineered and supplied the biggest ESR furnaces in the world

...INTECO has provided the complete engineering and process know-how for an entire titanium production line

...INTECO is a premium supplier for Ti-VARs and skull melters

...INTECO has started the activities in the metal powder industry already 35 years ago

...INTECO has delivered state-of-the-art technology for the production of metal powders

…INTECO provides a holistic production management system (IMAS) covering all special metallurgical processing routes

…INTECO has an exclusive cooperation with the Montanuniversity Leoben in the field of process simulation of ESR and (Ti)-VAR

VACUUM INDUCTION MELTING (VIM)

Introduction

The vacuum induction melting (VIM) process was established as the most important primary vacuum melting technique for todays industrial production of high performance special steels and super alloys for most demanding applications. Depending on the final application, VIM produced ingots are often used as electrodes in electro slag remelting (ESR) and/or vacuum arc remelting (VAR) processes.

Melting in vacuum has a long history of over 100 years, beginning in the 1920's after induction furnaces were introduced. During the early sixties larger industrial VIM furnaces were designed for melting increasing quantities of high-temperature super alloys and ultra-high strength steels required by rapidly growing aerospace programs. The subsequent decades have led to a consolidation of the vacuum melting industry with different furnace designs and technical advances in operation for economic production of high-performance materials.

Today, the VIM process is carried out entirely under vacuum or controlled inert gas atmosphere including all operation sequences of charging, melting, alloying, sampling, temperature control, pouring and solidification.

The INTECO VIM furnace has been developed as a multi-chamber design, providing innovative advantages in terms of vacuum performance, melting procedure, casting method and plant ergonomics which enables our customers to reliably produce high end materials in a most modern and economic way.

Our technology – Your advantage

- Modular multi-chamber design with small chamber volumes for highest operational flexibility and reliability
- Diagonal split design for melting and casting chamber for best access and safety
- Movable melt chamber bottom for best accessibility for crucible cleaning, cold charging, relining and maintenance
- Highly efficient vacuum system adjustable to process needs (reduced pump-down time)
- All process related vacuum valves are of vertical design (unaffected by dirt and heat radiation)
- Shortest tundish design for reduced heat losses and risk of nozzle freezing as well as low operational costs for tundish relining
- Automated tilt pouring system for smaller sized systems
- Tailor made ergonomic design to meet customer specific requirements
- Holistic process and production management system (IMAS) including cost optimized alloy calculation

Process and technology

Vacuum induction melting (VIM) was developed as a primary melting method suitable for isolating the molten metal bath from the atmosphere. The exclusion of an oxygen/nitrogen containing environment enables melting of alloys containing reactive elements while ensuring good compositional control. The independent control of temperature and pressure combined with the ability to stir and back-pressure with inert gas provides a high degree of control over the melt composition. Unrefined virgin materials can be melted and superheated under vacuum to remove oxygen and nitrogen as well as volatile trace elements. Even though melting in the absence of oxygen and nitrogen results in improved micro cleanliness over air melted material, VIM melted material is most often cast into electrodes which are further refined by electro slag remelting (ESR) or vacuum arc remelting (VAR). Alternatively, the refined charge may be cast into small diameter ingots for use as a master alloy in the investment casting industry with no further refining steps required. The most important objective of the VIM process is to produce material having a consistent primary chemistry from heat to heat.

VIM multi-chamber furnace design for utmost flexibility

Variations

- Single- or multi-chamber design
- Modular side charging chamber, trace alloy chamber and temperature and sampling manipulator
- Casting chamber in mould tunnel or turn table design for ingots and barstick production
- Bottom and/or top pouring
- Casting under vacuum, inert gas and atmosphere
- Hot crucible exchange and transfer
- Separate sintering position
- Casting speed control
- Heat sizes from lab scale up to 30t

Nowadays, VIM furnaces are designed for single heat sizes of up to 30t. A **multi-chamber design** allows to feature VIM furnaces with separate chambers enabling a fully automatic temperature measuring and sampling procedure, addition of small alloying materials or addition of raw material separately from the main charging operation. This modular design enables small chamber volumes, providing highest operational flexibility with a highly effective vacuum system adjustable to the process needs. A **short tundish design** allows low melt superheat and reduced risk of nozzle freezing as well as low operational costs for tundish relining. INTECO's VIM furnaces are designed for best accessibility by means of a **split diagonal design** of the melt and casting chamber. The **vertical design of all process related vacuum valves** ensures highest lifetime and reduced maintenance efforts.

Even though the VIM process and the related equipment has reached industrial maturity, INTECO focuses on **new solutions for customers with specific requirements** regarding VIM technology. Ultimately the **latest technology** with a high degree of automation paired with **in-depth process** know how relating to the raw material selection, correct temperature and pressure settings and fine adjustment of the chemical composition leads to a stable melting, refining, homogenization and casting of VIM ingots.

Therefore, ingots produced via vacuum induction melting ensure consistent product quality providing perfect semi-finished products for a subsequent remelting operation.

Ni-base ingot after stripping

References

Customer	Type / Format	
voestalpine Stahl Donawitz GmbH Austria	Lab-scale vacuum induction furnace Turnkey project, engineering and supply of a lab-scale VIM furnace, temperature and sampling manipulator, late charging and alloying, overpressure melting, precision pour control, instrumented mould functionality, ergonomic design for highest operation convenience	
SeAH CSS South Korea	8t vacuum induction furnace Engineering and supply of a 8t VIM providing electrodes for the subsequent remelting processes, latest state of the art control systems in combination with a production management system (IMAS) covering the entire special melting and remelting shop	
Ruspolymet Russia	2 x 5t vacuum induction furnaces Engineering and supply of a 5t VIM Most modern design for an optimized production of ingots/electrodes either to be forged or processed in subsequent remelting processes (i.e. ESR and VAR)	
BGH Lippendorf Germany	11t vacuum induction furnace Modernization of the existing VIM- furnace supplied by INTECO in the ninties, increasing of the melt capacity, equipped with a new control system and implementation of a production management system (IMAS)	

ELECTRO SLAG REMELTING (ESR)

Introduction

Electro slag remelting (ESR) is still one of the most important technologies in the production of steels and super alloys of highest demand for various applications. Starting from the very beginning when ESR was used only as a desulphurization step in the late sixties, the ESR process gained increased importance for achieving superior ingot quality with respect to segregation level, cleanliness and solidification structure.

Nowadays, the ESR process has already reached industrial maturity and is used for the refinement and quality enhancement of ingots with a variety of different plant concepts. Due to the nature of the ESR process and its complexity, a lot of research and new developments has been carried out over the last decades, resulting in newly developed technologies, plant concepts and designs.

Based on INTECO's long term experience in electro slag remelting and our continuous focus on further developments, a wide range of remelting technologies has been developed satisfying today's market requirements. Today, INTECO is in the position to offer tailor-made solutions with the related production technologies for all applications, meeting our customers' expectations with respect to product quality and process stability.

Our technology – Your advantage

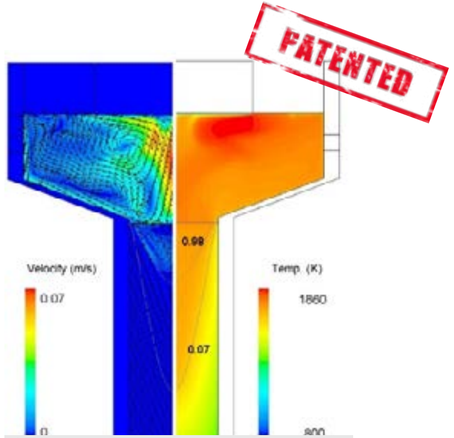
- Newly developed protective gas system for lowest gas consumption (N_2, Ar)
- Coaxial high current loop to achieve superior ingot quality
- Weighing system and XY-adjustment for precise control of the remelting parameters
- In-depth process know how and highly sophisticated process control for superior product quality
- Highest yield due to optimized starting and hot topping procedures
- Comprehensive process simulation model exclusively developed with the Universtity for Metallurgy in Leoben
- All necessary auxiliary equipment (stub welding, alloy and slag dosing) available from one single supplier
- Tailor made ergonomic design for best accessibility and easy maintenance
- Holistic process and production management system (IMAS) for overall recipe management, data storage and definition of key performance parameters

Variations

- Short collar mould plants with retractable base plate
- Static mould plants with or without electrode exchange technology
- Combined static / collar mould plants
- Pressure ESR plants (up to 40 bar)
- ESR plants for hollow and rectangular ingot production
- Patented electro slag rapid remelting (ESRR®) for billet production
- Labscale ESR furnace
- Large sized ESR furnaces (ingot weight up to 250t)
- Patented current conductive mould (CCM®) technology for segregation prone alloys

Process and technology

Electro slag remelting (ESR) is a secondary refining process in which an already solidified ingot (electrode) is immersed in a molten slag which is contained within a water-cooled copper crucible. The slag is maintained in its liquid state by passing an electric current through the electrode and the ingot/crucible. The temperature of the slag is kept above the liquidus temperature of the electrode and the molten electrode droplets fall through the slag, undergoing chemical refinement and accumulating in the crucible to form an ingot below the slag. The ingot solidifies progressively in an upward direction. The major benefits of the ESR process are the production of a solid ingot free from porosity and with smooth surface appearance, homogeneous microstructure and an improvement in cleanliness as non-metallic inclusions are removed when passing through the slag layer.



Computational fluid dynamic simulation of the electro slag rapid remelting process (ESRR®)

Ni-base ingot produced in static mould ESR operation

Nowadays, ESR ingots can be produced from lab scale sizes up to a weight of 250t with ingot diameters ranging from 60mm to 2.600mm. Depending on the application of the finished product and the availability of the required electrode formats, a wide range of plant concepts is readily available to apply the ESR technology in the production of steels and super alloys. For near net-shape sized billets the so called **Electro Slag Rapid Remelting Technology (ESRR®)** process was developed, where a billet is produced from a larger sized electrode. The billet can then directly be rolled without any forging step in between. Apart from the typical static mould ESR furnace, in which one electrode is remelted to produce one ingot, other technologies exist providing more flexibility regarding ingot and electrode dimensions. By taking several small sized electrodes and by applying the **electrode change technology**, ingots in different lengths and diameters can be produced in either short collar or static mould operation. When applying elevated positive pressure during the remelting operation, ingots with increased nitrogen content can be produced by means of the **Pressurized ESR technology**.

To keep pace with the times and due to the close relationship with our customers, INTECO as the world market leader in ESR technologies has highest interest in further developments, concentrating on new applications such as the production of hollow ESR ingots or to extend the limits of the standard ESR process for special alloys and applications. For producing segregation prone alloys in big dimensions the so called **Electro Slag Current Conductive Mould Technology (CCM®)** has been developed. A special focus also lies on further improvements of existing technologies. Therefore, high efforts in the field of process simulation, process control and new design features are made in order to increase process stability and efficiency of already existing technologies.

References

Customer	Type / Format	
Forgiatura A. Vienna Italy	Biggest protective gas ESR in the world, highly sophisticated process control to guarantee perfect quality over the entire ingot length, special developed starting and hot topping procedure for highest yield	
Uddeholms AB Sweden	30t static mould ESR furnaces Highest productivity and plant availability, new developed protective gas concept for lowest consumption of nitrogen and argon	
BGH Lippendorf Germany	25t combined ESR furnace Maximum flexibility due to split power design and combined static and short collar mould production, production of different ingot dimensions by applying the electrode change technology	
Ugitech France	Electro slag rapid remelting plant Near net shaped production of billets with ESR quality in a semi-continuous process, most precise weighing system for precise controlling of the remelting parameters	

VACUUM ARC REMELTING (VAR)

Introduction

The strict quality requirements of end users such as the aerospace industry calls for a metallurgical refining process that enhances the product quality to the highest level. The vacuum arc remelting (VAR) process has been developed in the 1950's with the aim of satisfying these increased demands on certain material properties of the final product.

Today, the VAR process is used for refining a broad variety of materials such as various steels as well as different nickel or cobalt base super alloys. Because the VAR process is carried out under inert conditions (i.e. vacuum) and with controlled solidification conditions, the remelted ingot is of superior cleanliness and lowest residual gas content.

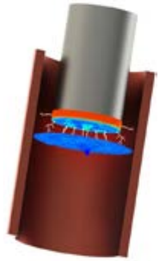
Based on INTECO's long-term experience and know how in the field of vacuum metallurgy as well as sophisticated control systems for remelting systems, a wide range of well-proven and specialized solutions in VAR technology can be offered to our customers meeting the highest standards.

Variations

- VAR for steels, super alloys and reactive materials
- From lab-scale to 30t ingot weight and more
- Partial pressure remelting for minimization of evaporation losses
- Helium cooling system for improved heat transfer between mold wall and ingot
- Automatic adjustment controller
- Patented combined ESR/VAR concept

Our technology – Your advantage

- Coaxial furnace design with defined current path for highest reproducibility
- Sophisticated drip short analysis functionality (IDRIP®)
- Horizontal XY adjustment of the electrode in the crucible for maintaining a constant gap during the remelting process
- Optimized weighing system for accurate control of the remelting parameter
- Tailor made ergonomic design for best accessibility and easy maintenance
- Comprehensive process simulation model exclusively developed with the University of Leoben for Metallurgy
- Holistic Process and production management system (IMAS) for overall recipe management, data storage and definition of key performance parameters



Computational Fluid Dynamic Simulation of argon filling of the VAR furnace

Ni-base ingot produced in VAR operation

Process and technology

Vacuum arc remelting (VAR) is a secondary refining process in which an electric arc is struck between the bottom surface of a solid electrode and the top molten pool surface of a solidifying ingot. Melting takes place in a water-cooled copper crucible under low partial pressure. As the molten metal droplets are released from the tip of the electrode, they are exposed to the vacuum environment resulting in the removal of residual gases and volatile elements. This degassing process is highly effective due to the high surface area of the fine metal droplets compared to their volume. As the droplets accumulate in the crucible, solidification occurs progressively in an upward direction. Since the VAR process can be steadily operated at low melt rates and can use auxiliary helium gas to enhance ingot cooling, the tendency for freckle formation is less compared to equivalently sized ESR ingots. On the other hand, low melt rates can increase the possibility of white spot formation, thus attention has to be paid to the electrode/ingot filling ratio (electrode area/ingot area) and the lower limit for the melt rate. Electrode/ingot concentricity is crucial to avoid arcing between the electrode and the crucible.

In order to ensure stable and reproducible VAR operation, utmost attention has to be paid to provide a steady melt rate and a close and constant gap between the electrode and the liquid metal pool surface. The gap is controlled utilizing the **drip short frequency** which corresponds to the amount and characteristics of droplet releases and bridge formations between the electrode and the melt pool in a certain period of time. By using INTECOs self-developed control concepts and state of the art measuring devices **(IDRIP)**, a constant arc length can be obtained. The shape and depth of the liquid metal pool during the process is the driving force for assuring a segregation free ingot. INTECO's **well-proven control concept** combined with **long term metallurgical experience** keep the liquid metal pool shallow and constant over the entire ingot length. A perfectly aligned electrode is needed to maintain the pool shape symmetrically to ensure constant solidification patterns.

Today VAR ingots can be produced from lab-scale sizes up to a weight of 30t and even more. Typical features applied in Vacuum Arc Remelting are partial pressure remelting during the production of high manganese containing grades and helium cooling for a better heat transfer resulting in shallow liquid metal pools for highly segregation prone alloys. Although the VAR process has already reached industrial maturity, INTECO is continuously working on the **improvement of existing technologies** and control concepts as well as the **development of new features** to keep our customers at the top of this industry.

References

Customer	Type / Format	
DAYE Special Steel China	1 x 6t and 1 x 25t vacuum arc remelting plant VAR furnace for remelting steels and super alloys up to an ingot weight of approx. 6t respectively 25t, partial pressure and helium cooing possible, equipped with INTECO's self-developed IDRIP	
BGH Lippendorf Germany	12t vacuum arc remelting VAR furnace for remelting steels and super alloys up to an ingot weight of approximately 12t, partial pressure and helium cooling possible, equipped with INTECO's self-developed IDRIP	
ATI Allvac USA	Combined ESR/VAR Furnaces Combined furnace with one melt station for ESR and one melt station for VAR, equipped with all state-of-the-art features, furnace designed to remelt titanium as well	
Breitenfeld Edelstahl AG Austria	20t vacuum arc remelting plant Production of different ingot sizes up to 20t, partial pressure remelting and helium cooling for highest product quality possible	

TITANIUM PRODUCTION (Ti)

Introduction

Today, about 80% of the titanium produce worldwide is applied in the aerospace industry and 20% by non-aerospace industries such as metal finishing, chemical processing, consumer products and medical implants. The conversion of purified titanium sponge into commercially pure titanium or titanium alloys involves several processes with multiple processing steps and can nowadays be realized via two independent production routes.

In the VAR or sponge route, titanium sponge is mixed with various alloy additions in a dedicated weighing and blending unit. This mixture is then pressed into compacts and welded together in a vacuum plasma welding process forming a sponge electrode. This electrode is then subsequently remelted two to three times in a water-cooled copper crucible in a Vacuum Arc Remelting process. After the VAR process, the ingot is subsequently processed by hot deformation into mill products such as bar, billet, wire, tubing, plate and sheet by conventional forging and rolling processes. Beside the classical VAR production line, the cold hearth remelting route is applied for direct melting, refining and casting of raw materials such as scrap, sponge and alloying elements into titanium ingots and slabs. Here the loose raw materials are continuously fed into a cold hearth remelting furnace where they are melted by high-energy electron beam guns. After casting and solidification, the produced ingots may optionally be vacuum arc remelted or conventionally processed by forging or rolling. A variant of the cold hearth technology is the skull melting process where an electrode and other raw materials are melted in a in a water-cooled copper crucible. After the melting, the crucible is tilted and the liquid melt is directly casted into moulds for ingots, slabs or investment cast parts.

With more than 15 years of experience as premium supplier serving the titanium industry, INTECO offers various technologies and equipment as well as the complete production know-how for different titanium production lines for individual demands of its customers.

Our technology – Your advantage

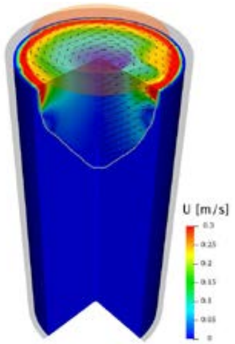
- Experience in the engineering and commissioning of entire titanium production shops from raw material to finished ingots
- Long term operational experience and know-how of full scale titanium production plants including certification for the aerospace industry
- Supply of newly developed titanium VAR (I-Ti VAR) based on well proven and in-house developed VAR technology
- Supply of Skull melting furnaces (I-Ti VA SM) based on a revolutionary new design concept
- Customized Process and Production Management System (IMAS) for titanium production lines
- Advanced process modelling as the key tool for a better understanding and process optimization resulting in reduced start-up times

Available Equipment & Technology

- Sponge - VAR and cold hearth titanium production routes
- Entire production lines or single units
- Ti VAR plants from lab scale up to 17t ingot weight with different design concepts of VAR in terms of productivity
- VAR skull melting furnace with pouring weight from 250kg up to 1.700kg for high recycling rates

Process and technology

The vacuum arc remelting of titanium is a core technology for producing titanium with high demand on purity and quality. The remelting of titanium in principle is very similar to the VAR remelting of steel and nickel based alloys but with different aspects dedicated to the process control and the plant design itself. Usually higher melt rates are applied for titanium resulting in increased melt power and cooling capacities. Based on INTECO´s long-lasting experience in the field of vacuum arc remelting of steels and super-alloys, INTECO has developed a new and innovative furnace concept for titanium remelting which features all state-of the art characteristics. An arc centralisation system and newly designed lock valve ensure highest operator safety and plant productivity. Furthermore, a comprehensive process simulation model has been exclusively developed with the University of Leoben to provide further insights into this complex remelting process allowing our customers to enhance their process know how and optimize their entire production.



The vacuum arc skull melting process was developed for the production of castings using a regular consumable electrode (e.g. from VAR) to melt scrap and other raw materials in a water-cooled copper crucible under vacuum atmosphere. Homogenization of the chemical composition as well as refining the melt from refractories and impurities is obtained by a long soaking time of the liquid metal and the heavier particles remaining in the skull. The process can provide either ingots, slabs or investment cast parts (single or double melt) which may optionally be vacuum arc re-melted or subsequently processed. INTECO´s revolutionary and innovative Skull Melter design features two different casting techniques combined in one plant by using either static casting to provide ingots, slabs or dynamic casting for investment cast parts. Recycling rates of up to 100% can be achieved by a sophisticated titanium scrap addition unit.

In addition to the supply of single equipment, INTECO can provide the complete process and production know how for entire titanium production lines. Starting from a feasibility and pre-investment study to overall definition of equipment and engineering as well as commissioning, INTECO can act as a technology partner and support the customer in product certification such as needed for the aerospace industry. Furthermore, INTECO has developed a sophisticated production management system (IMAS) covering the entire process route including pre-defined procedures and ultimately an operator independent and repeatable process.

References

Customer	Type / Format	
Chongqing Kingsley Titanium Technology Co. Ltd. China	17t titanium vacuum arc remelting plant Titanium VAR furnace consisting of one furnace head and one meltstation for remelting titanium up to an ingot weight of 17t (second melt station can be installed at a later stage), partial pressure and inert gas cooling possible.	
Ruspolymet Russia	4t titanium production plant Basic engineering for a new titanium production plant designed for an annual production of 500.000t including the supply of a 4t Ti-VAR	
Shaanxi Tiancheng Aerospace China	Two 10t, one 12t & one 17t Ti-VAR Engineering and supply of two 10t, one 12t and another 17t titanium-VAR plant for ingots up to 1130mm diameter to one of the most modern Ti-production plants in China	
Baoji Yaguang Machinery China	Vacuum arc cold hearth skull melting and casting Titanium VAR skull-melting furnace designed for melting and subsequent casting of max. 1200kg of titanium and titanium alloys, newly developed furnace concept combines static casting with investment cast products (dynamic casting) with high recycling rates of scrap	

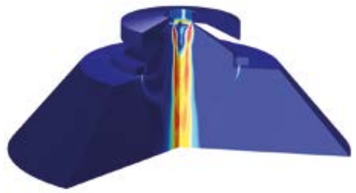
POWDER TECHNOLOGY (PM)

Introduction

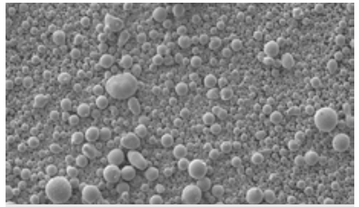
Over the last century, commercial production of various metal powders has seen exceptional growth with wide ranging applications in a myriad of different industries such as the press- and sinter (P&S) industry, the hot isostatic pressing (HIP) industry as well as in newly emerging and high demanding industries like metal injection molding (MIM) and metal additive manufacturing (AM). All of these industries have different requirements on the metal powders and in turn on the powder production technology. Todays commercially available gas atomization systems were developed in the 1980's and mainly intended for use in industries such as HIP or P&S. The originally intended process for these powder batches may not require the same high quality as for powders used in newer processes and as such their performance in an AM process may not be adequate or as expected. Focusing on these newly emerging powder specifications and requirements, INTECO has developed the „next generation" gas atomization system, combining innovative developments in atomization technology and in-depth process know-how. Today, INTECO offers a wide range of newly developed technologies for the production of metal powders for various steels, nickel and cobalt superalloys, meeting today's requirements with respect to cost, quality and yield.

Our technology – Your advantage

- „Next-Generation" gas atomization technology for superalloys, steels and cobalt based materials
- Melting under vacuum, inert gas or atmospheric conditions
- Automated tilt pouring for optimized atomization conditions
- Anti-satelliting technology for high powder flowability and sphericity
- Powder recycling system for utilization of revert and used powders
- Multifunctional charging system for late charging, alloying, sampling and temperature measurement enabling sophisticated alloy development
- Highly effective tundish, nozzle and gas heating systems for highest process consistency and flexibility
- Optimized tundish and gas nozzle design for highest powder cleanliness and production yield
- Easy maintenance and cleaning for quick and reliable change of grades
- Industry's first holistic process and production management system (IMAS) covering the complete powder production process



Simulation of gas flow for close-coupled gas atomization (VIGA)



Gas Atomized Tool Steel Metal Powder (HSS/ESH)

Process and technology

The gas atomization process has become the dominant industrial technology for the production of spherical metal powders of various metals and alloys. Depending on the material to be atomized, melting of the raw material can be carried out under atmosphere, inert gas or vacuum, either in a ceramic crucible or via crucible free processes. During the atomization process, the liquid metal stream is disintegrated by the impact of the high-energy gas flow into fine liquid droplets, which then solidify and cool in flight inside the atomization chamber. The spherical powder particles that are formed are collected at the bottom of the atomization tower and conveyed pneumatically to a cyclone separator. Here the separated powder is collected in the powder canister below the cyclone and the gas is exhausted out from the top of the cyclone into a filter station. Depending on the material as well as the desired field of application, the powder specification dictates the atomization system design which is governed by cost, throughput and quality.

For high speed steel (HSS) powder the raw material is melted under atmosphere and subsequently transferred to a tundish located on top of the atomization chamber. The melt in the tundish is covered by a slag which helps to avoid contact with the surrounding atmosphere and which collects oxidic impurities. Nitrogen gas is used as the atomization medium. Due to the strong relationship between melt cleanliness and the mechanical properties of the final product, large tundishes with up to 20t capacity are used to ensure sufficient separation of non-metallic inclusions of the melt before atomization. This separation process requires a suitable tundish heating system in order to maintain the heat in the melt and prevent nozzle freezing during atomization. For such applications, INTECO's patented electro slag heating (ESH) system has become the state-of-the-art technology to ensure highest melt cleanliness and powder quality. For demanding steel qualities with limited carbon contents, this technology has been further developed and is offered as electro plasma heating (EPH) with no contact of graphite electrodes with the melt.

For superalloy powder melting is carried out in a ceramic crucible under vacuum or inert gas in order to prevent the melt from oxidation. After melting and alloying (if required), the melt is automatically poured into a preheated tundish, from which the melt flows into the close-coupled gas nozzle where it is atomized by the high-pressure argon gas. Because the tundish volume is several times smaller than the melting unit, constant filling of the tundish is required to achieve a steady gas to metal ratio. In order to ensure highest consistency during the whole atomization process, INTECO has developed a sophisticated and innovative control system, where the complete atomization process from melting, pouring and atomization is completely automated, controlled and logged. This, together with an innovative gas nozzle design and related in-depth process know-how, led to the development of INTECO's "next-generation" atomization system for the production of tailor-made superalloy powders for the application in highly demanding industries like additive manufacturing.

References

Customer	Type / Format	
Tiangong China	China's first PM production line for HIP powders, consisting of an 8t inert gas atomization system	
MIMETE s.r.l. Italy	Vacuum inert gas atomization system Automated tilt-pouring, gas heating, tundish heating, powder recycling system, INTECO Metals Application Suite (IMAS)	
Ruspolymet Russia	Powder production plant Two independent production lines consisting of one vacuum inert gas atomization system for AM and one ESH heated inert gas atomization system for tool steels and HIP applications	
Erasteel Sweden	Electro slag heating plant for HSS-metal powder production with argon stirring system	

INTECO METALS APPLICATION SUITE (IMAS)

Introduction

Industrial production of high performance materials requires precise tracking and transparency of all production steps to ensure highest reproducibility for high-demanding industries such as the aerospace industry. Starting from the very beginning with simple manual data logging in excel sheets or printed melt logs the first basic database systems (Level 2 systems) were developed. As the requirements on data storage and the amount of data continuously increased over the years, the potential of these systems was already on the limit.

Modern production management systems require vertical and horizontal integration of all production processes and shall cover not only process tracking and reporting but also include planning and optimization tools for the entire production route which are necessary to meet customer and end-user specific requirements.

INTECO as a world leading supplier for specialized production technologies offers a powerful process and production management solution called *"INTECO Metals Application Suite (IMAS)"*. IMAS was developed to combine several levels of automation and is intended to close the gap between machine data (Level 1) and the enterprise IT landscape (Level 4). State-of-the-art software development combined with the process know-how of INTECO are the fundamentals of IMAS.

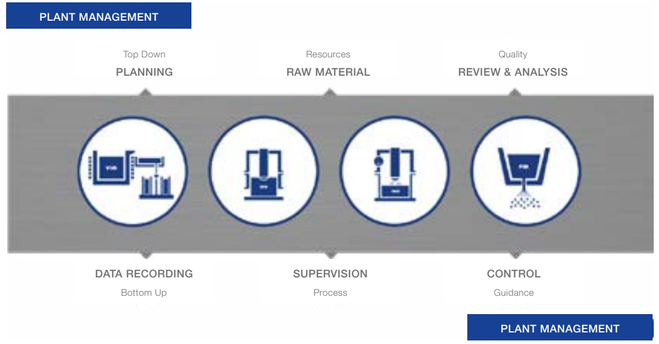
Our technology – Your advantage

- Quality improvement due to standardized and centralized know-how
- Modular design
- Online production monitoring and supervision
- Data processing and analysis for continuous know-how improvement
- Seamless integration into any existing IT landscape
- Low to high operator guidance
- Highest availability and reliability due to modular state-of-the-art software development
- Easy-to-use operation interface dedicated to office and pulpit operations
- Production reporting from detailed melt report to monthly recaps
- Business intelligence integration for advanced analytics

Process and Technology

INTECO Metals Application Suite (IMAS) was designed as a flexible framework in contrast to a single developed application. It is designed to cover all special metallurgical processes under one roof, which makes IMAS to an holistic application suite.

The integrated automation concept of INTECO covers the following functionalities:



(1) Plant Management and Supervisory Functionalities
On top of all processes within the production plant is the superior plant management application. The plant management unites all the process automation apps under one roof. The major responsibilities are the overall production planning, raw material distribution as well as review and analyses to close the cycle at the end of production.

(2) Shop floor Integration for Production and Auxiliary Equipment
These modules are responsible for data recording, supervision and control. The process automation apps are designed for operators at the pulpit to provide bottom-up process guidance, allowing operation personnel to observe all recorded sensor-data in real-time. Moreover, IMAS provides instant information and alarms, based on which the operators can control and steer the process just-in-time.

In order to achieve highest flexibility together with a maximum in reliability, IMAS was developed based on the latest technology and developments with respect to its software architecture, fulfilling all requirements for **Industry 4.0.** The latest generation of IMAS breaks with old software paradigms like monolithic applications or client/server infrastructure. Instead, the IMAS framework follows the microservice concept to ensure scalability in modern steel shops. By the use of Microsoft® technology stack and C# as development language, a consistent and state-of-the-art software architecture and development framework is ensured. The distributed architecture of the latest IMAS generation allows not only to cover all individual customer specific processes, but also to **interact bi-directional with any existing IT landscape** in an extremely flexible way. Whatever ERP/Level 4 system is in place, a dedicated communication agent will do the job.

IMAS does not only care about real-time operational data, it also provides comprehensive archiving functionality and long-term storage of any process related data. Current researches in **big data** and **machine learning** will further improve operator guidance and processes with advanced analytics. Researches in deep learning technology, also known as **artificial intelligence**, will make IMAS capable of decision recommending or even making.

References

Customer	Type / Format	
SeAH CSS South Korea	IMAS – Professional Covering the entire special melting and remelting shop consisting of 8t VIM, 4t ESR, 8t ESR and 8t VAR for the production of super alloys	
BGH Lippendorf Germany	IMAS – Professional Covering the entire special melting and remelting shop consisting of 11t VIM, 10t P-ESR, 11t VAR	
Ruspolymet Russia	IMAS – Professional Covering the entire special melting and remelting shop consisting of 2 x 5t VIM, 1x10t ESR, 2x14t ESR and 2 x 6t VAR with the expansion of the system to include Ti-VAR and the powder metallurgy production	
UKTMP Kazachstan	IMAS – process management system First process automation for an entire titanium melt shop	

SELECTED CUSTOMERS

BÖHLER · CARPENTER · UDDEHOLM · HAYNES International · Acciaierie Valbruna · voestalpine ONE STEP AHEAD. · JAPAN CASTING & FORGING CORPORATION · Schmiedewerke Gröditz GmbH - seit 1779 - Edelstahl · sij | metal ravne · SeAH Steel Corp. · LSW · KIND&CO EDELSTAHLWERKE · UGITECH Providing special steel solutions · aperam · FOMAS GROUP · TCAE · 中国第二重型机械集团公司 CHINA NATIONAL ERZHONG GROUP CO. · 富順特殊鋼有限公司 FUSHUN SPECIAL STEEL · BGH · saarstahl · 大冶特殊鋼股份有限公司 DAYE SPECIAL STEEL CO.,LTD · ERASTEEL · Deutsche Edelstahlwerke · RUSPOLYMET · VDM Metals · saarschmiede Freiformschmiede · ASIL CELIK · GMTC 榮剛材料科技股份有限公司 GLORIA MATERIAL TECHNOLOGY CORP. · thyssenkrupp · nunki steel · Breitenfelc Edelstahl · TAEWOONG · TG TIANGONG INTERNATIONAL · ArcelorMittal · KALYANI · MIMETE · TISCO 太原钢铁(集团)有限公司

RUSPOLYMET, RUSSIA

2 x 5t VIM · 2 x 10t ESR · 14t ESR · 2 x 6t VAR · 4t Ti-VAR · 2 x PM

Production managed by ... IMAS INTECO Metals Application Suite

CONFIDENTIAL CUSTOMER, ASIA

9t VIM → 45t ESR → 11t VAR

Production managed by ...

IMAS INTECO Metals Application Suite

CHANGWON SPECIAL STEEL SOUTH KOREA

8t VIM → 4t ESR → 8t ESR → 2 x 8t VAR

Production managed by ...

IMAS INTECO Metals Application Suite

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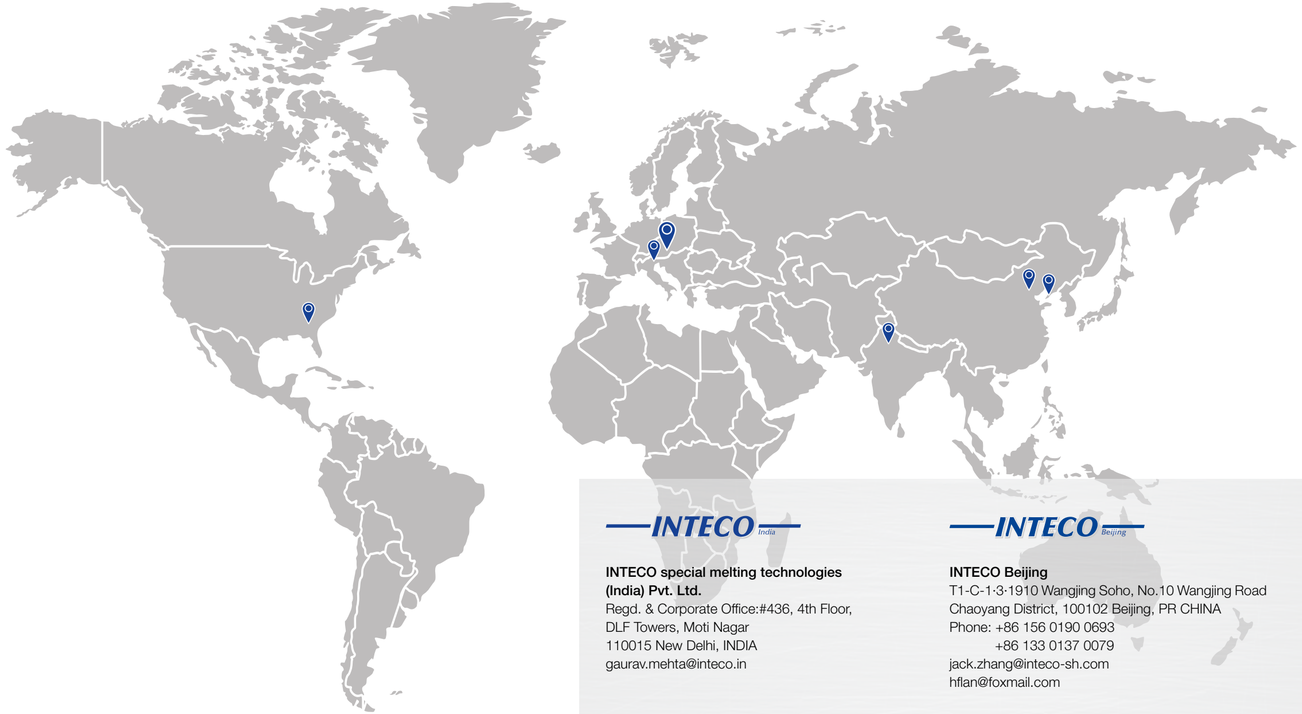

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