

INTECO

Special Melting & Remelting



Product Development

—INTECO—



1973

Electro Slag
Remelting
(ESR)



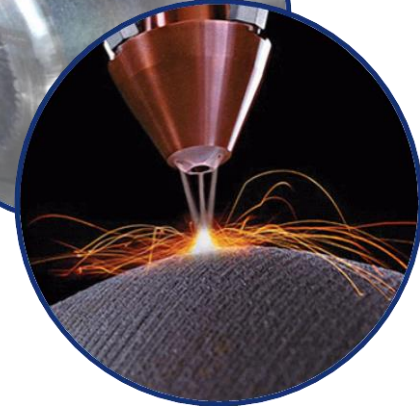
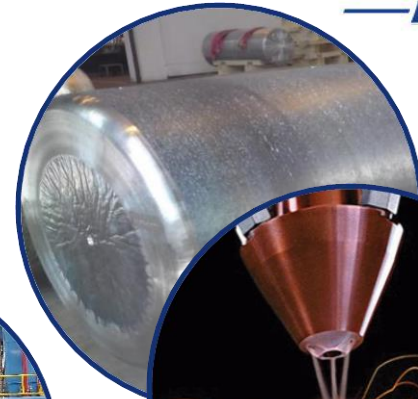
Since 1995

Vacuum Induction
Melting (VIM)
Vacuum Arc Remelting
(VAR)



Since 2010

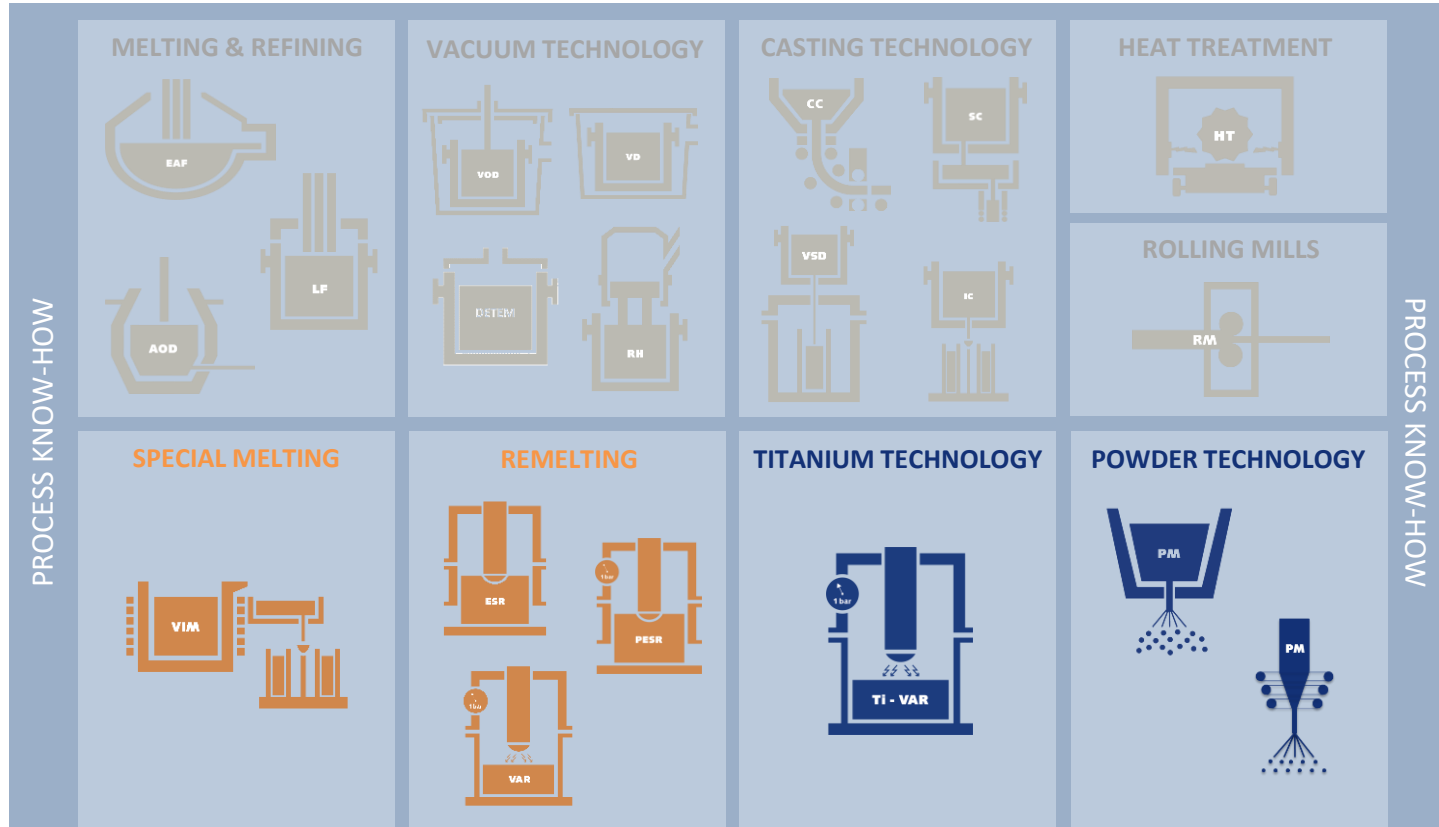
Special Melting and
Remelting Shops
VIM – ESR – VAR



Now & Future

Powder Metallurgy
and Titanium
Technologies

Product Portfolio - Special Metallurgy



PROCESS KNOW-HOW

PROCESS KNOW-HOW

*Leadership in metallurgical process technology and equipment for **melting, refining, casting, atomization and solidification** of*

- *High Performance Steels*
- *Super-Alloys*
- *Titanium*



We are quality



Special Melting and Remelting Shops

Vacuum Induction Melting (VIM)

Special Melting and Remelting shops in operation



SeAH CSS

8t VIM



4t ESR



8t ESR



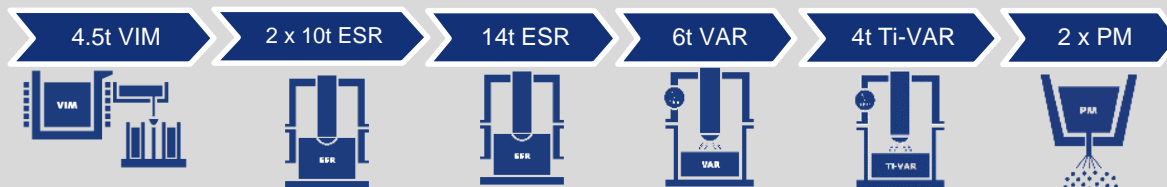
8t VAR



Production managed by ...



Special Melting and Remelting shops in operation



Production managed by ...



Special Melting and Remelting shops in operation



9t VIM



45t ESR



11t VAR

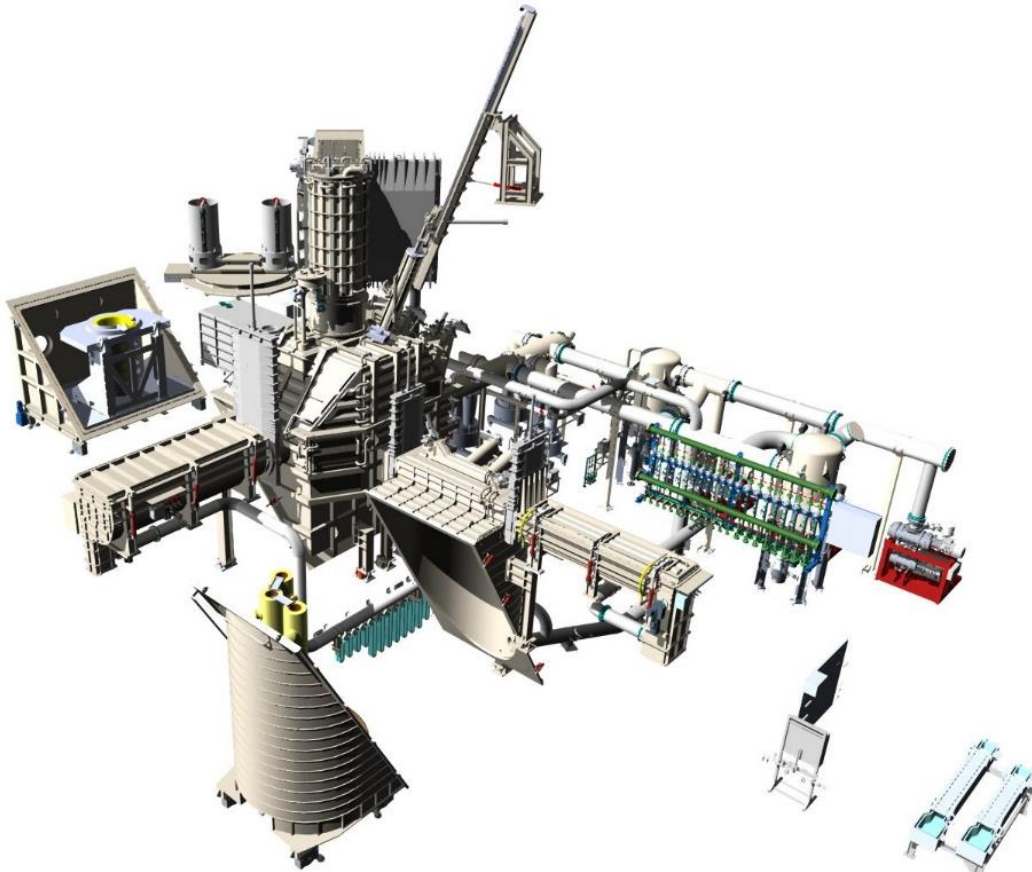


Production managed by ...



**CONFIDENTIAL
CUSTOMER**

VIM – Multichamber Furnace Design



Design aspects for state of the art VIM plants:

- Modular **multi-chamber design** with small chamber volumes (diagonal split design) for highest operational flexibility
- Movable melt chamber bottom for **best accessibility** for crucible cleaning, cold charging, relining and maintenance
- **Highly efficient vacuum system** adjustable to process needs
- All process related **vacuum valves** are of **vertical design**
- **Shortest tundish** design for reduced heat losses and risk of nozzle freezing as well as low operational costs for tundish relining

5t VIM – Furnace, Ruspolymet, Russia



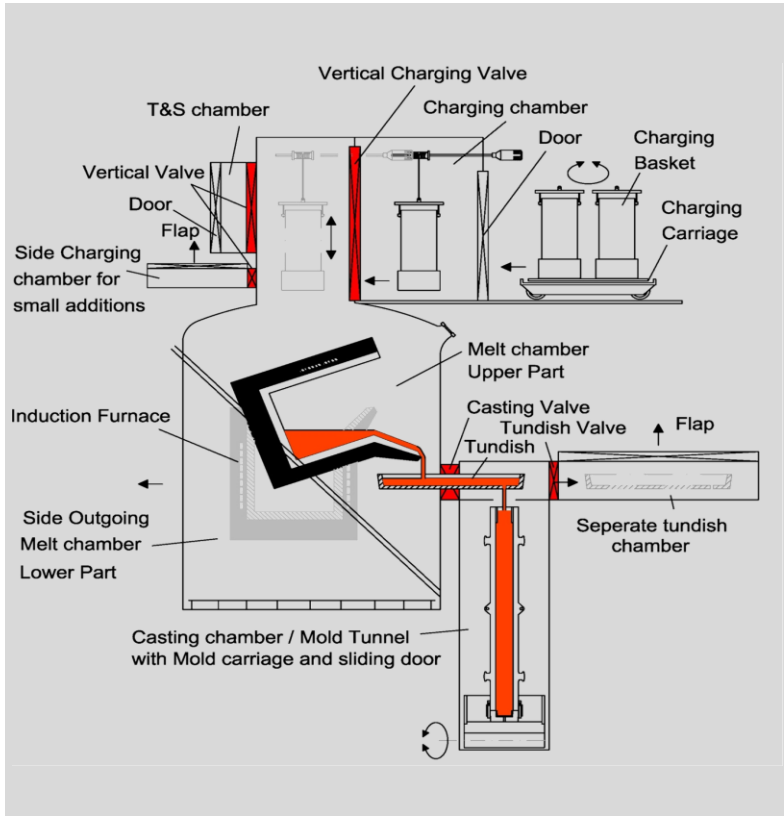
Operational Benefits - VIM



Benefits of VIM:

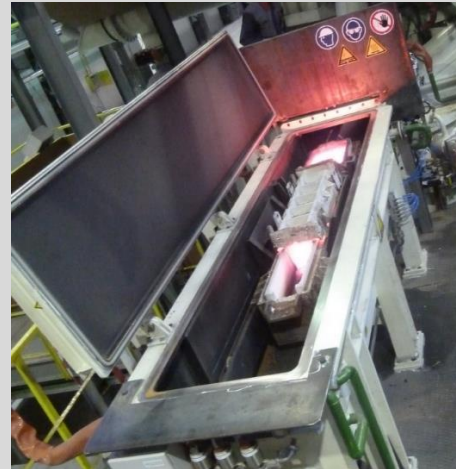
- Melting, refining, alloying and casting under vacuum
- Controlled addition of high reactive elements
- Close tolerance achievable for various alloying elements such as Al, Ti, Nb, Zr, etc.
- Reduction of gas content (H, N, O) and removal of undesirable trace elements

Shortest possible tundish design



Short Tundish Design:

- Pouring in tundish axis direction
- Reduced heat losses and risk of nozzle freezing
- Low metal superheat for casting
- Quick and effective preheating
- Low operational costs for tundish relining
- Clean casting procedure and low amount of skull



Chemical composition of VIM electrodes



440mm dia. VIM ingot IN718



250mm dia. VIM ingot 80A

Analysis done in a certified laboratory at Böhler

Chemical Laboratories		BÖHLER EDELSTAHL	
<small>BÖHLER Edelstahl GmbH & Co KG, P.O. Box 98, A-8805 Kapfenberg, Austria</small>			
Name of Sample:	IN600 VIM-BOTTOM	Name of Sample:	IN600 VIM-TOP
Sam. Descr.:	Stück	Sam. Descr.:	Stück
parameter	value	parameter	value
Carbon	0,070	Carbon	0,075
Silicon	0,10	Silicon	0,10
Manganese	0,29	Manganese	0,31
Phosphorus	< 0,005	Phosphorus	< 0,005
Sulfur	0,0006	Sulfur	0,0007
Chromium	15,43	Chromium	15,57
Molybdenum	< 0,02	Molybdenum	< 0,02
Nickel	76,57	Nickel	76,42
Vanadium	< 0,02	Vanadium	< 0,02
Tungsten	< 0,05	Tungsten	< 0,05
Copper	< 0,02	Copper	< 0,02
Cobalt	0,09	Cobalt	0,09
Titanium	< 0,02	Titanium	< 0,02
Aluminium	0,23	Aluminium	0,24
Niobium	< 0,02	Niobium	< 0,02
Hydrogen	1,2	Hydrogen	1,9
Boron	0,0039	Boron	0,0052
Iron	7,19	Iron	7,14
Nitrogen	< 0,0004	Nitrogen	< 0,0004
Tantalum	< 0,02	Tantalum	< 0,02
Oxygen	0,0008	Oxygen	0,0009
Arsenic	< 0,005	Arsenic	< 0,005
Tin	< 0,005	Tin	< 0,005
Zirconium	< 0,005	Zirconium	< 0,005
Antimony	< 0,005	Antimony	< 0,005

Achievable quality:

- Smooth surface formation without any cracks due to **correct casting parameters**
- **Lowest gas contents** achievable due to reliable vacuum system
- Lowest sulfur content due to **correct raw material selection**
- Practically **no deviation in chemical composition** from bottom to top
- Soft annealing if required to adjust the correct hardness value

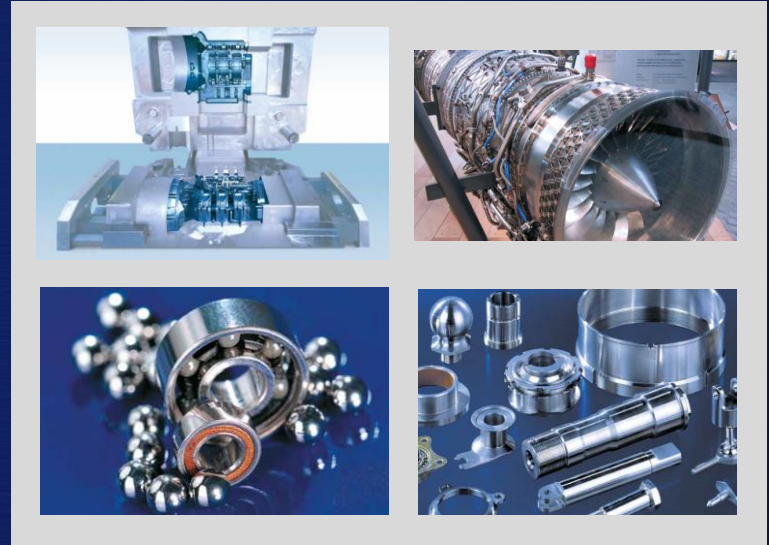


Preconditions for the subsequent remelting operation

Subsequent processes in production route...

Improvements of material quality by means of Remelting via ESR and VAR:

- › Improved **solidification structure** and consequently better **forgeability**
- › **Prevention of Macro- and Microsegregation** in the ingot
- › Homogeneous Distribution of remaining **Non-metallic inclusions** within the ingot
- › Further **reduction of gas content and undesired trace elements** during VAR process
- › Improvements in regard to **shrinkage cavities**



Electro Slag Remelting (ESR)

Benefits and Design Aspects - ESR

Benefits of ESR:

- Improved **cleanliness level** due to refining with slag
- **Minimization of segregations**
- **Slow directional solidification**
- **Complete dense ingot without porosities**

Design aspects for state of the art ESR furnaces:

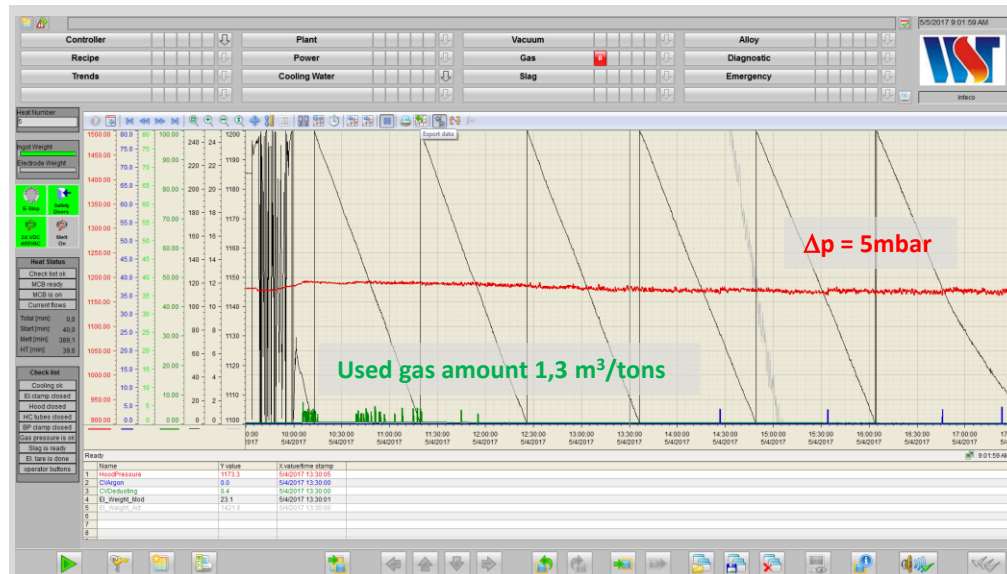
- **Coaxial high current line** to minimize electro magnetic stirring within the slag and metal bath
- **Weighing system** and **XY-adjustment** for precise control of the remelting parameters
- Sophisticated **control system** (close control of melt rate and electrode immersion depth)
- Vacuum tight furnace design and **protective gas operation** for lowest hydrogen pick up and highest cleanliness requirements



Protective Gas Operation



- High cleanliness level of ESR ingot
- Minimized hydrogen pick up
- Close control of analysis from bottom to top of ingot



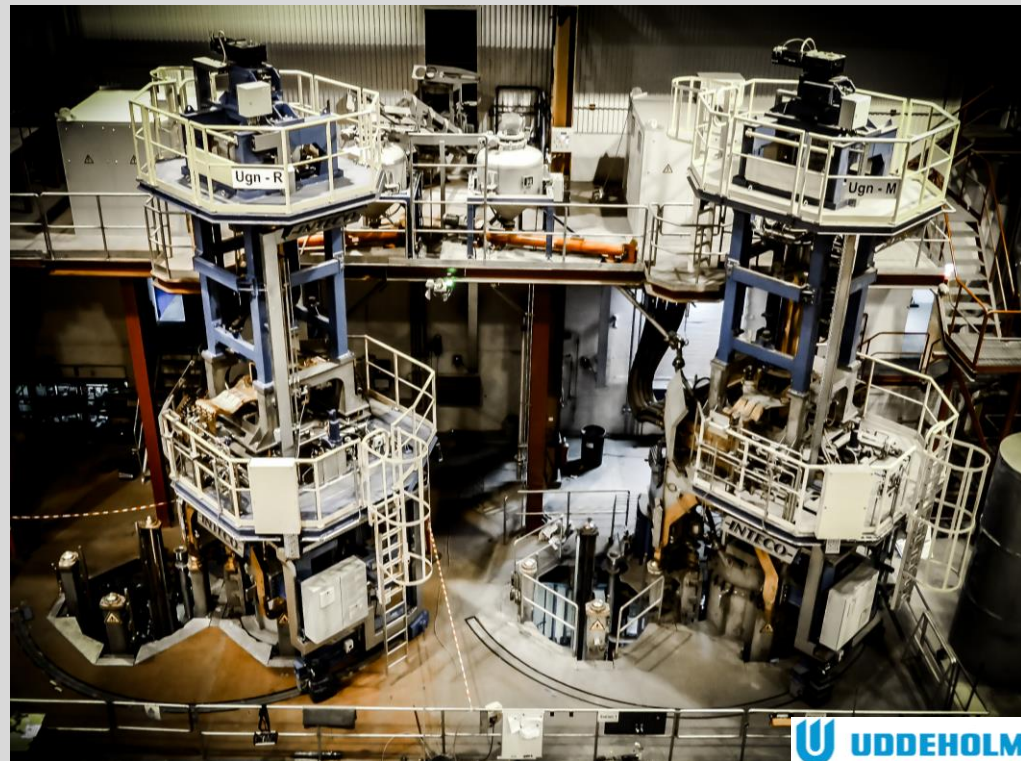
Due to maintaining a **predefined overpressure** by a **controlled gas regulation** a reliable protective atmosphere by using **lowest consumption of gas** can be ensured.

Additionally a **pre-evacuation of the furnace** before melt start ensures perfect preconditions.

ESR Furnaces in operation



Newly developed ESR-Static mold concept



| 30t ESR-Breitenfeld, Austria

—INTECO—



Breitenfeld
Edelstahl



45 years of Electrode Exchange Technology



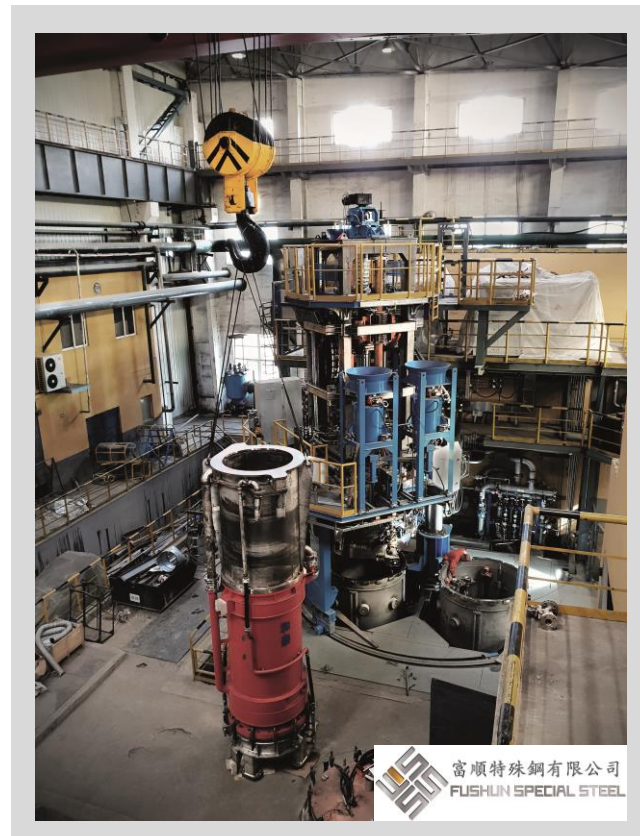
Breitenfeld
Edelstahl

ESRR[©] Furnaces

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Pressurized ESR furnaces





Supersized ESR plants

INTECO BIG ESR plants-already in operation

—INTECO—



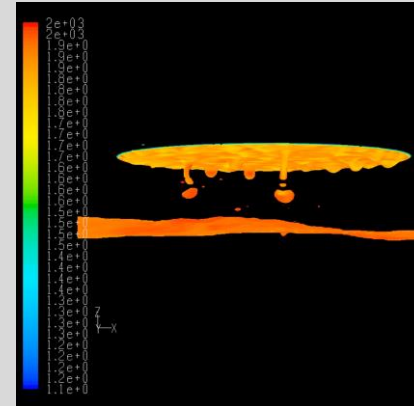
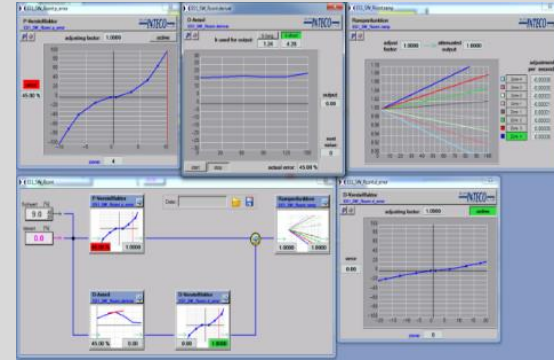
150t ESR Plant, Erzhong, China



From Zero to Hero...



Research and Process Development:





Vacuum Arc Remelting (VAR)

Benefits and Design Aspects - VAR

Benefits of VAR:

- Improved cleanliness level
- Minimization of segregations
- Slow directional solidification
- Reduction of gas content (Hydrogen, Oxygen and Nitrogen)

Design aspects for state of the art VAR furnaces:

- Coaxial furnace design with defined current path
- horizontal **XY-adjustment** of the electrode within the crucible to maintain a constant gap with the possibility of automatic adjustment during remelting
- **Partial pressure remelting** and **helium cooling** possible for precise control of chemical composition and better heat transfer conditions
- **Precise weighing system** for accurate control of remelting parameters
- Sophisticated **control system** (close control of melt rate and arc gap)

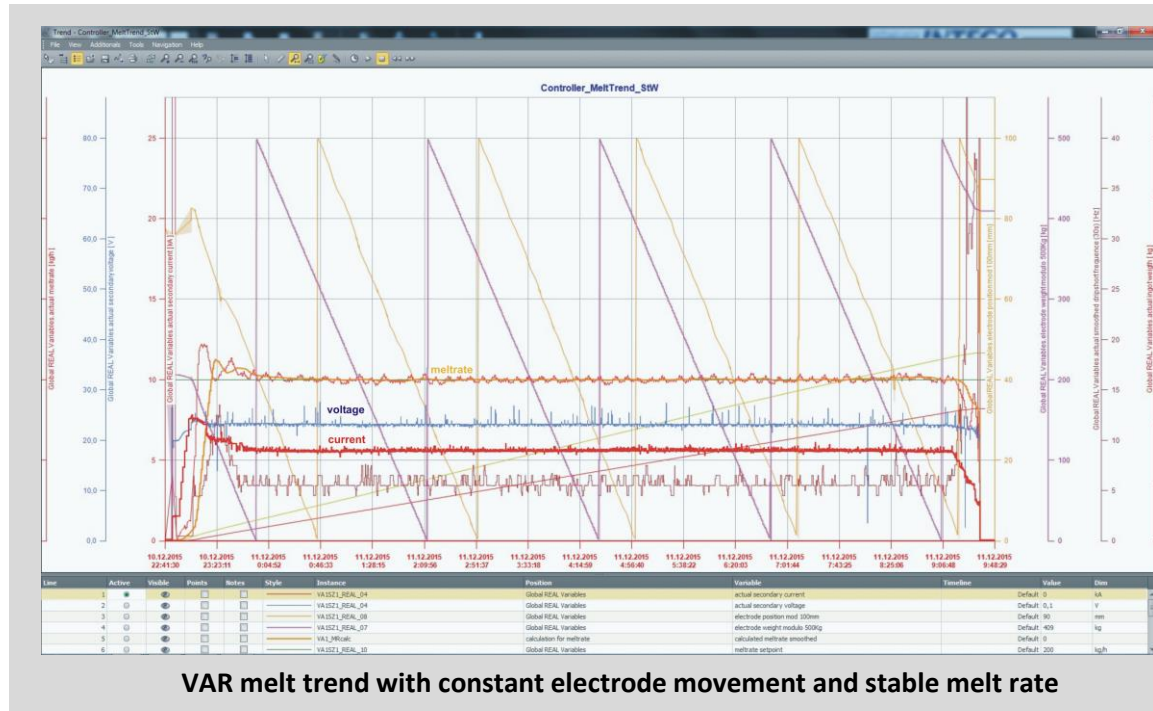


Control of the VAR process - IREC + IDRIP



INTECO Remelting Controller (IREC®) and INTECO Drip short controller (IDRIP):

- Precise melt rate and gap (VAR) calculation algorithm
- Maintaining a constant gap between electrode tip and liquid metal bath by means of Drip short or voltage control
- The dripshort frequency is measured with an oscilloscope and compared with the setpoint → IDRIP



VAR Results

Surface formation of IN718 in dependency of the ingot size



360mm dia. IN718



500mm dia. IN718



720mm dia. IN718

Surface quality:

- Bigger dimensions as in ESR are feasible
- Due to **low melt rates** the surface needs to be conditioned after remelting in certain cases
- **Constant gap between electrode and liquid metal bath** ensures perfect remelting conditions
- **Well adjusted starting curve** resulting in highest yield of the bottom part of the ingot
- **Controlled hot topping procedure** (power as well as melt rate controlled possible) resulting in a complete dense top part of the ingot

Shown results courtesy of **SeAHcss**

VAR Furnaces in operation



VAR Furnaces in operation



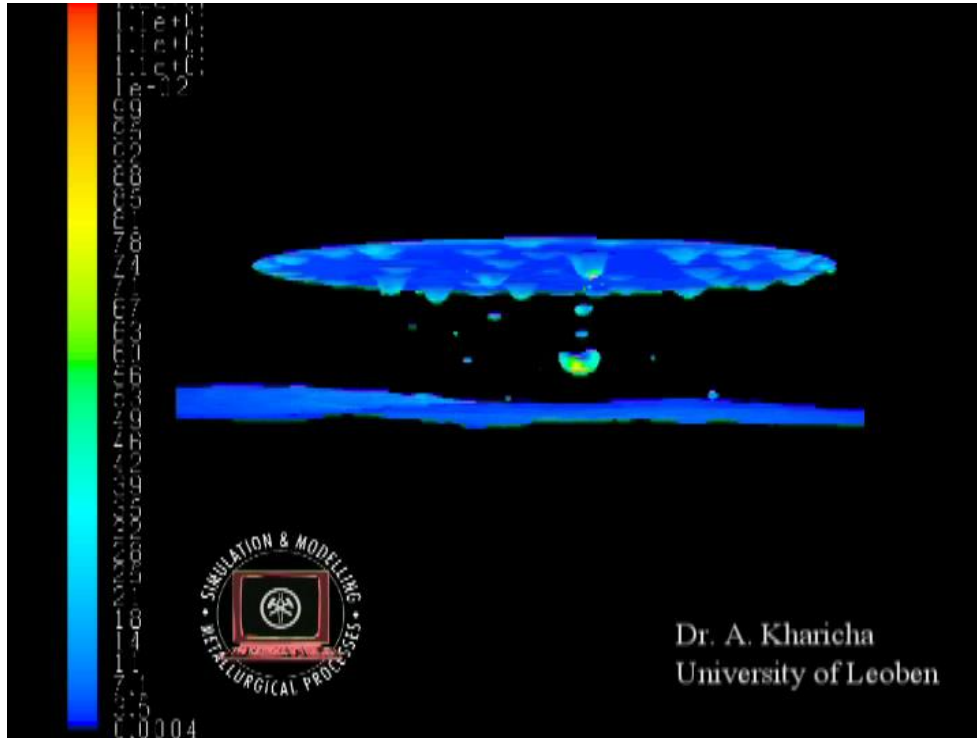
VAR Furnaces in operation

Industrial Scale Multifunctional ESR/VAR Furnace (patent filed with DEW Krefeld)



ESR/VAR Process Simulations Research & Development

—INTECO—



Proposal for the Foundation and Support of a Christian
Doppler Laboratory on

**Metallurgical Applications of
Magnetohydrodynamics**

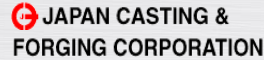
COMING SOON

NEW Project with focus on VAR already
started and continued until 2025

MONTAN
UNIVERSITÄT
WWW.UNILEOBEN.AC.AT


Christian Doppler
Forschungsgesellschaft

Proud to have customers like that...



DISCLAIMER



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