

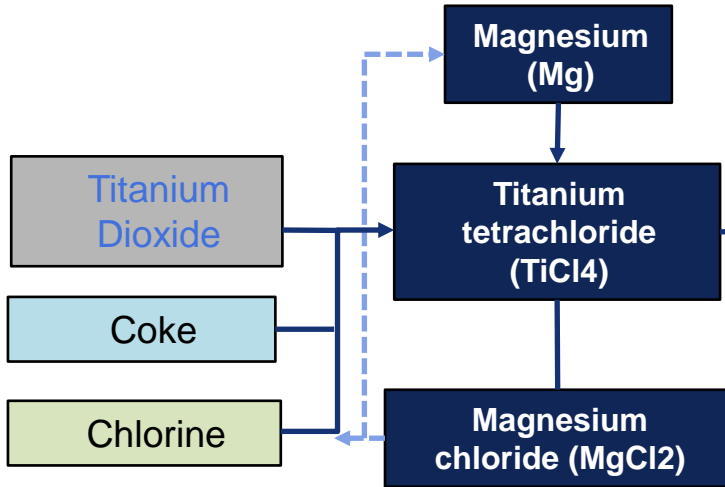


WE ARE
INTECO

**Focus on Titanium
Technologies**

TITANIUM PRODUCTION TECHNOLOGIES SCOPE OF SUPPLY AND SERVICES

KROLL PROCESS



WEIGHING/ BLENDING

REMELTING PROCESS

ELECTRODE PREPERATION

Ti SCRAP

Ti SPONGE

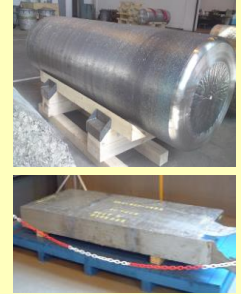
Alloy
material

Vacuum Arc
Remelting
(VAR)

Cold hearth
Melting

Ingots,
Slabs

Hot working
(e.g. Forging,
Rolling)



TITANIUM PRODUCTION TECHNOLOGIES SCOPE OF SUPPLY AND SERVICES



- **More than 15 years of experience as premium supplier in the titanium industry**
- **Feasibility, Conceptual, Basic and Detailed Engineering Studies** for Titanium Production lines
- **Project and Technology consulting** for entire Titanium Production Lines
- Supply of Titanium **VAR, Skull Melting Furnaces and auxiliaries**
- Customized **Process and Production Management Systems (IMAS)** for Titanium Production Lines
- **Know How Transfer** for entire Titanium Production Lines (From selections of raw material up to aerospace certification)



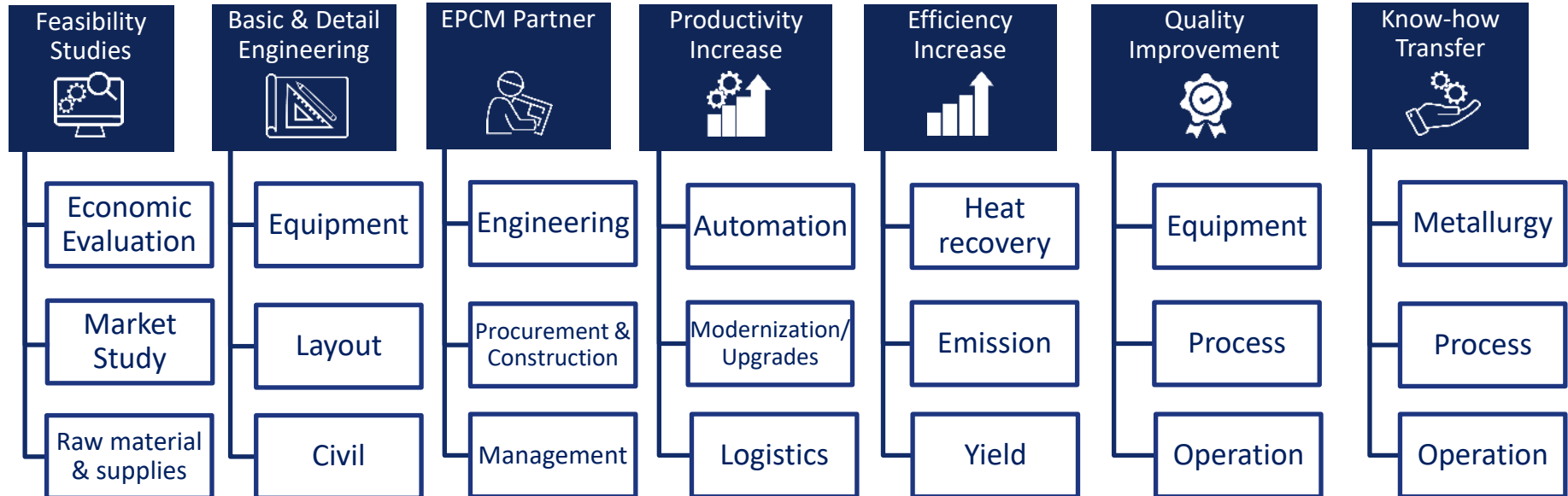
PROJECT & TECHNOLOGY CONSULTING



PROJECT & TECHNOLOGY CONSULTING



melting&casting **INTECO** *technologies*



| INTECO 360° SERVICE

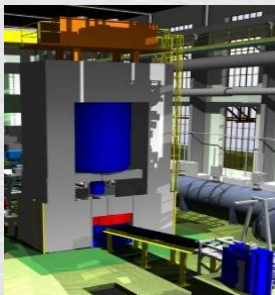


PROCESS KNOW HOW FOR ENTIRE Ti-PRODUCTION ROUTE

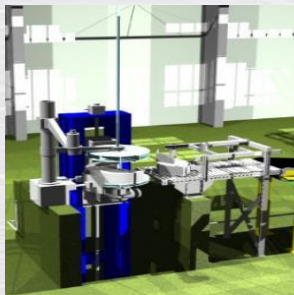
SPONGE / VAR Route



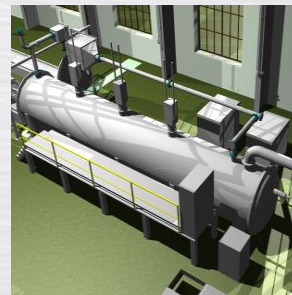
1) Weighing & Blending



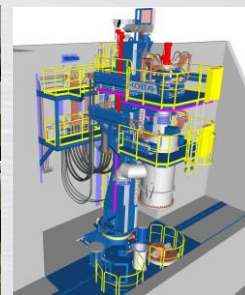
2) Compacting



3) Electrode Assembly



4) Electrode Welding



5) VAR (2-3x)



6) Final Machining

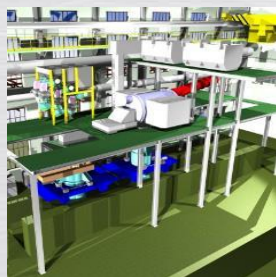
Process flow Covered by INTECO Equipment and Process & Production management system



EB / SM Route

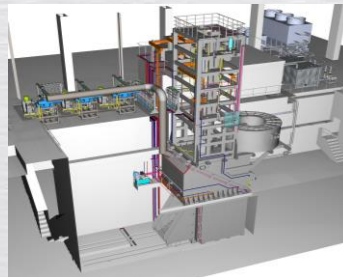


1) Weighing & Blending

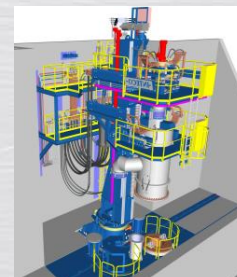


2) Feeding & EB Melting

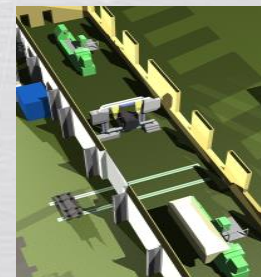
OR



2+3) SM Melting / Casting



4) VAR (1-2x, Optional)



4) Final Machining

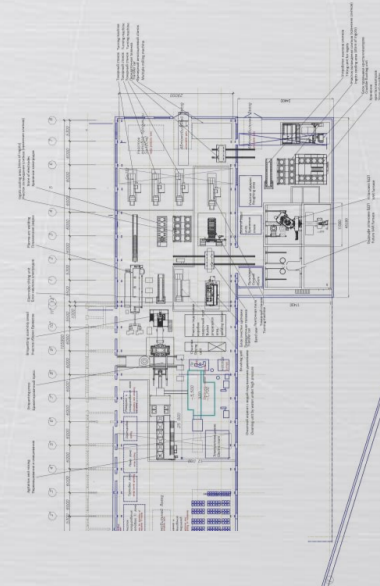
PROJECT AND TECHNOLOGY CONSULTING – PRE-PROJECT PHASE

Scope of supply and service covered during the pre-project phase:



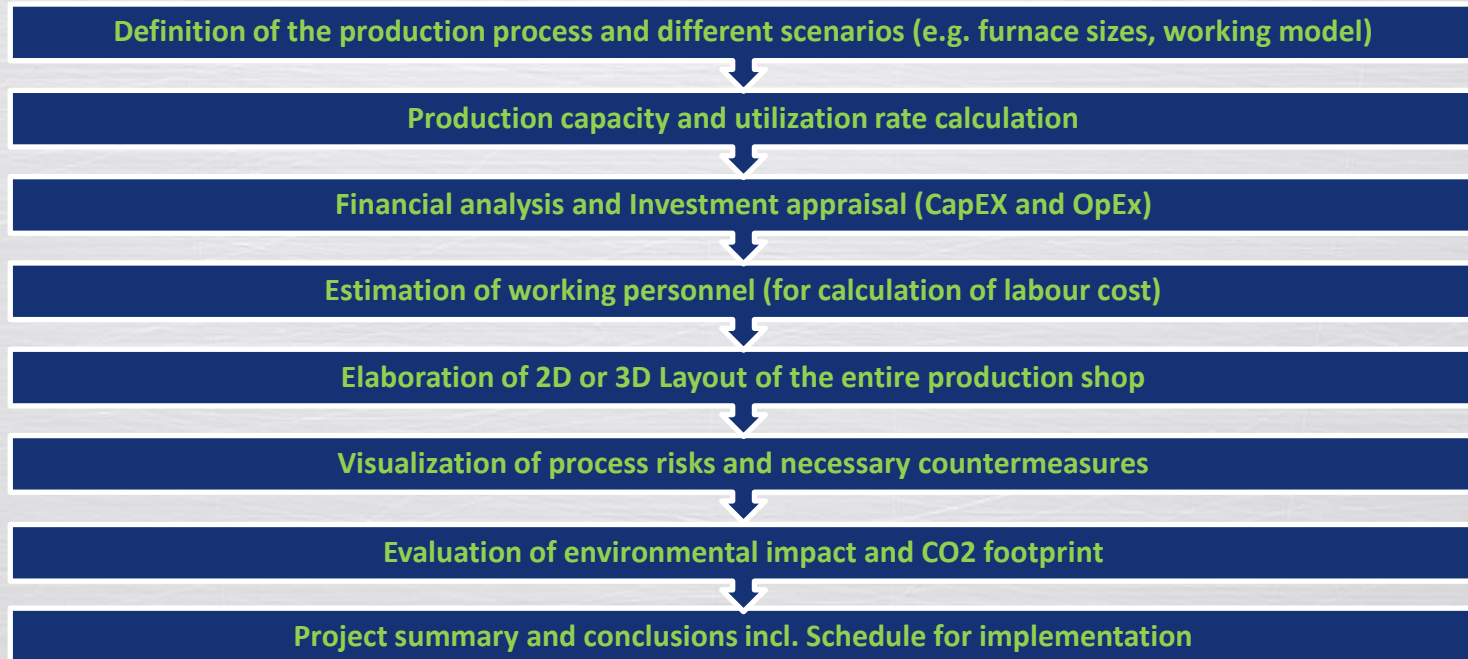
Pre-
Project
Phase

- Market study
- **Pre-investment study**
 - Process design in cooperation with client's experts
 - General description of process
 - Specification of equipment & elaboration of equipment list
 - Plant layout and definition of ideal process flow
 - Basic data for Steel Structure and civil works (incl. room list)
 - Determination of media consumption and personnel requirement (for OPEX calculation)
 - Estimation of investment costs (CAPEX)



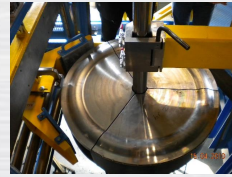
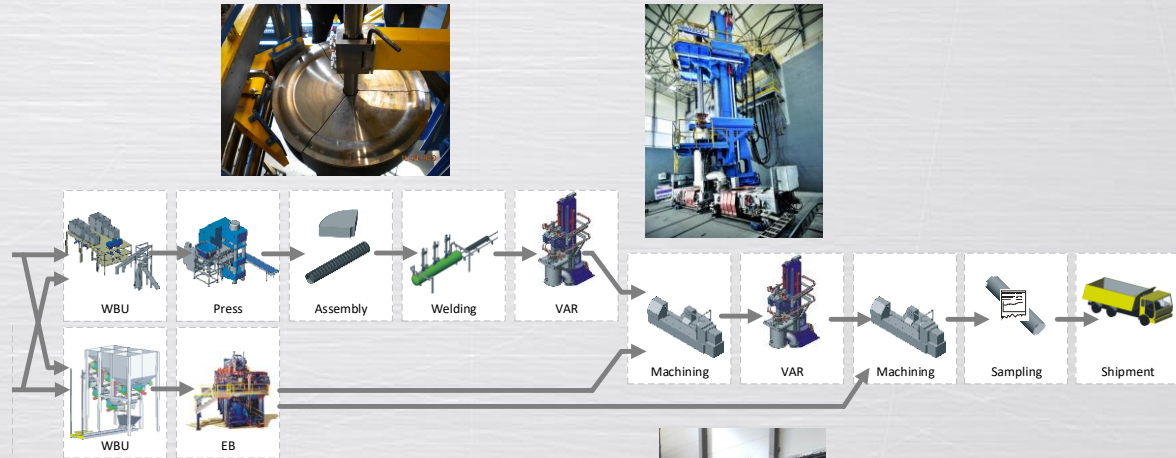
PRE-INVESTMENT STUDY

- A pre-investment study is intended **to provide a sound basis for a serious decision-making** and consideration of a possible investment in a new production plant, which is **to cover both current and future needs** and includes the following:



PRE-INVESTMENT STUDY

- The study is covering the entire production route, from raw materials to the final ingot

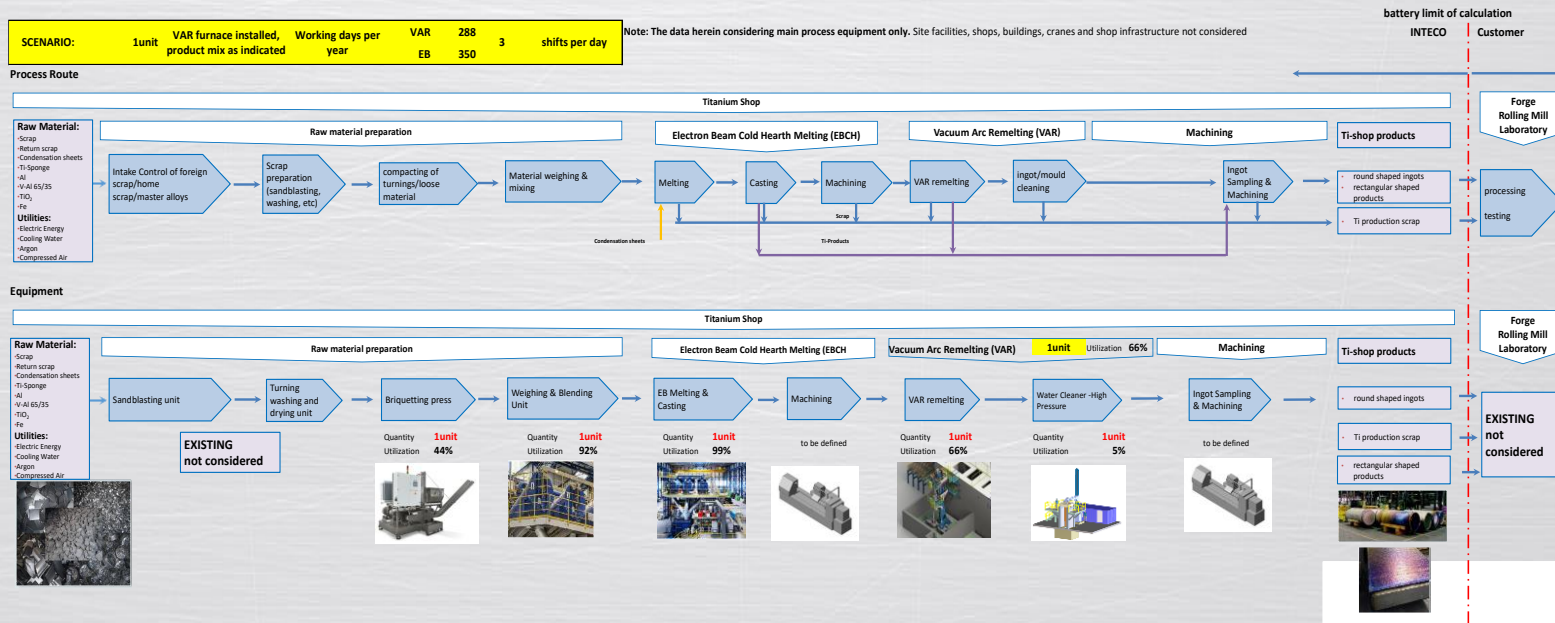


DEFINITION OF PRODUCTION PROCESS

- Definition of the **most suitable ingot dimensions** as forging / rolling mill feedstock according to customer requirements
- Definition of the **best fitting process route to fulfil customer requirements** considering single, double, and triple melted products (ingot and/or slab)
 - VAR + VAR + (VAR) and / or
 - EB + VAR + (VAR) and / or
 - VASM + VAR + (VAR)
- **Definition of the optimum VAR- electrode ingot configuration** schedule based on sponge electrode preparation, EB- or VASM-production
- **Definition of raw material specification** for feeding the different production routes
- **Definition of the best fitting main production and auxiliary equipment** to produce the required grades and quality
- **Definition of multiple production scenario's (max. 5)** to visualize **process risks** of different business cases such as product dimensions and Ti-grades and qualities as well as the product mix for different annual target production figures

CAPACITY & YIELD CALCULATION

- Calculation of **production capacity and utilization rate** for all main and auxiliary plants involved, considering the various process scenarios (EB, VAR, SM)
- **Yield calculation of the whole Titanium melt shop** up to delivery of raw ingots to the forge shop and estimation of forge shop yield losses.

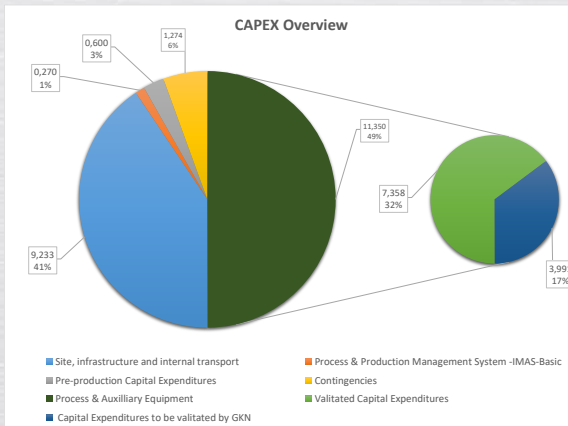


FINANCIAL ANALYSIS AND INVESTMENT APPRAISAL- CapEx



- Estimation of the necessary **CAPEX for the main process and auxiliary equipment** and recommendation of further CAPEX positions to be considered by the customer for each scenario.
- Summary of all calculated CAPEX-figures** in an overview table as an Excel file, allowing the customer to fill-in the respective local costs for the infrastructure and process buildings for each scenario.

Class of Estimate	Purpose	Accuracy	Level of Project Completion
Class 5 Order of Magnitude Estimate	Concept Screening	Low Range = -20 to -50%	0 – 2%
		High Range = 30 to 100%	
Class 4 Study Estimate	Preliminary Study	Low Range = -15 to -30%	1 – 15%
		High Range = 20 to 50%	
Class 3 Definitive Estimate	Budgeting	Low Range = -10 to -20%	10 – 40%
		High Range = 10 to 30%	
Class 2 Detailed Estimate	Control Estimate or Bid Preparation	Low Range = -5 to -15%	30 – 70%
		High Range = 5 to 15%	
Class 1 Check Estimate	Tender	Low Range = -3 to -10%	50 – 100%
		High Range = 3 to 10%	



A.	CAPEX - site, infrastructure, production-shops, office- & auxiliary buildings, main process equipment and auxiliary equipment	Qty	Unit Cost	Unit Cost	Taxes & Duties	Transport DAP	Erection Costs	Supervision Erection & Start-up	Subtotal Cost	Subtotal Cost	TOTAL COST
			Mio EUR	Mio EUR	Mio EUR	Mio EUR	Mio EUR	Mio EUR	Mio EUR	Mio EUR	Mio EUR
1.	Site and infrastructure	1		3,547	0.000	0.000	0.355	0.000	4.001		4.001
1.1	Site for TIFaIn-Plant	1		0.918	0.000	0.000	0.000	0.000	1.010		1.010
1.2	Weighing bridge - 18m3.5m including foundations	1		0.045	0.000	0.000	0.000	0.004	0.054		0.054
1.3	Office & Social - Building incl. Laboratory and control room - 3 floor	1		2.176	0.000	0.014	0.218	0.004	2.464		2.464
1.4	Aux. Bldg for Maintenance workshop and storage room	1		0.408	0.000	0.000	0.041	0.000	0.473		0.473
2.	Technical Building with Main Utility Systems	1		1.488	0.000	0.021	0.150	0.128	1.888		2.007
2.1	Electrical Substation building - 1 floor-3 rooms incl. Photo voltaic system	1		1.187	0.000	0.021	0.105	0.084	1.397		1.397
2.2	Argon Supply System	1		0.080	0.000	0.000	0.008	0.004	0.092		0.092
2.3	Nitrogen Supply System - used as protective gas and mechanical purpose (replacement of compressed air)	1		0.081	0.000	0.000	0.008	0.004	0.093		0.093
2.4	Water System	1		0.200	0.000	0.004	0.020	0.014	0.240		0.240
2.5	Emergency Water & Fire Fighting System	1		0.200	0.000	0.004	0.020	0.014	0.240		0.240
3.	Process Buildings - Production Shop 1 - Material Handling and Melting - Production Shop 2 - Flake Processing	1		2.075	0.000	0.004	0.227	0.017	2.323		2.323
4.	Internal Transport	1		0.200	0.000	0.000	0.000	0.000	0.200		0.200
5.	Process & Auxiliary Equipment	1		0.258	0.000	0.000	0.000	0.001	0.260		0.260
5.1	Incoming goods inspection area	1		0.088	0.000	0.000	0.000	0.000	0.088		0.088
5.2	Pre-screwing unit for Transition raw materials	1		0.246	0.000	0.000	0.004	0.016	0.266		0.266
5.3	Pre-screwing press for Transition scrap / chips / sponge	1		0.276	0.000	0.000	0.007	0.028	0.311		0.311
5.4	Filling station for iron pipes / Transition Cobble / Manganesa flake	1		0.016	0.000	0.000	0.000	0.001	0.021		0.021
5.5	TIFaIn- Material handling system	1		0.000	0.000	0.014	0.000	0.000	0.028		0.028
5.6	Flake center plant	1		4.400	4.000	0.000	0.280	0.460	5.140		5.140
5.7	SAFETY Living Monitoring System for 5.6	1		0.104	0.100	0.004	0.004	0.018	0.218		0.218
5.8	Tools and tacks for induction furnace reeling incl. electrical bus or bar	1		0.110	0.100	0.000	0.003	0.010	0.123		0.123
5.9	1,000kg VM-melting incl. Set of Power leads and power port, cables with 50kg VM -melting incl. 5.8	1		0.114	0.000	0.000	0.000	0.000	0.114		0.114
5.10	Transport Container, 600, stainless steel for storing and transferring of flake and pig iron material	19		0.020	0.020	0.001	0.007	0.004	0.068		0.068
5.11	Handling Tools for 600 Transport Container incl. Dosing unit	2		0.040	0.040	0.000	0.000	0.000	0.080		0.080
5.12	Crushing and milling unit	1		0.280	0.000	0.006	0.028	0.020	0.334		0.334
5.16	Double deck sieving station 425µm 50µm	1		0.472	0.000	0.007	0.034	0.027	0.540		0.540
5.17	Blending station	1		0.680	0.000	0.012	0.058	0.044	0.794		0.794
5.18	Compacting press area	1		1.275	0.000	0.009	0.043	0.034	1.361		1.361
5.19	Tank filling and assembly area	1		0.100	0.100	0.000	0.010	0.004	0.120		0.120
5.20	Packing & Dispatch area	1		0.030	0.000	0.000	0.000	0.001	0.031		0.031
5.21	Bag House Filter No.1 - 15.000m³/h	1		0.200	0.200	0.000	0.004	0.016	0.240		0.240
5.22	Bag House Filter No.2 - 2.000m³/h - ATEX	1		0.200	0.200	0.000	0.004	0.020	0.240		0.240
6.	Process & Production Management System -IMAS-Basic	1		0.200	0.200	0.000	0.000	0.000	0.200		0.270
Subtotal A											20,853
5.	Contingencies	5.0%		1,043	0.000	0.000	0.000	0.000	1,043		1,251
Total - A - EQUIPMENT											22,104
B. Pre-production Capital Expenditures											
B.1	Upfront Engineering for TIFaIn-production Plant										0,200
B.2	Supervision of equipment erection & commissioning <i>included within</i>										0,200
B.3	Production Know How Package for the material handling and melting Shop										0,200
B.3	Production Know How Package for the flake processing Shop - <i>not considered (GKN)</i>										0,200
B.4	production assistance during start-up phase										0,100
B.5	Permit & civil engineering (site & shops) - <i>not considered (GKN)</i>										0,100
B.6	Site & Construction management - <i>not considered (GKN)</i>										0,100
B.7	Build up of personnel, Training of staff & Labour- <i>not considered (GKN)</i>										0,100
Total -B- Pre-production Capital Expenditures											0,600
GRAND TOTAL CAPEX (Total A+B)											22,704
Depreciation period - to be verified by GKN											10 years
											depreciation per year

FINANCIAL ANALYSIS AND INVESTMENT APPRAISAL- OpEx



- Calculation of the **annual raw material and utility consumption figures** as well as process scrap based on the production capacity calculation such as:
 - Raw material (Sponge, Master alloys, scrap..)
 - Argon
 - Nitrogen
 - Compressed air
 - Cooling water / Emergency water
- Electrical power supply requirements:
 - Melt power supply
 - Low voltage supply
 - Emergency power supply
- Environmental protection:
 - Estimation of emissions (Noise, vaporous emissions, Process exhaust gas)
 - Wastewater
 - Estimation of residual materials
 - Estimation of transportation to and from the production plant
 - Estimation of approx. CO2 – footprint (“Scope 2”)

SCENARIO		1	2	3	4	5	6	7	8
Furnace Body Heat size [kg]		500							
Mode of operation		Figures for start-up (conservative)				Figures for full production (progressive)			
yearly net production hours depending on working model [h/year]		5.400		7.634		5.400		7.634	
Casting speed [kg/min]		30	50	30	50	30	50	30	50
Note:	Cost / Unit	Total annual costs							
Raw materials									
Iron cathode	1.239€/t	0,89Mio€	0,96Mio€	1,27Mio€	1,36Mio€	1,43Mio€	1,66Mio€	2,04Mio€	2,28Mio€
Titanium Sponge	8.000€/t	3,09Mio€	3,33Mio€	4,39Mio€	4,69Mio€	4,96Mio€	5,54Mio€	7,06Mio€	7,87Mio€
Titanium scrap	8.000€/t	3,09Mio€	3,33Mio€	4,39Mio€	4,69Mio€	4,96Mio€	5,54Mio€	7,06Mio€	7,87Mio€
Manganese-electrolyte	3.451€/t	0,32Mio€	0,35Mio€	0,46Mio€	0,49Mio€	0,52Mio€	0,58Mio€	0,74Mio€	0,82Mio€
Binding material for Blending	500€/t	0,01Mio€	0,01Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,03Mio€	0,03Mio€	0,03Mio€
Subtotal Raw Materials	7,41Mio€	7,94Mio€	10,52Mio€	11,26Mio€	11,89Mio€	13,29Mio€	16,92Mio€	18,88Mio€	
Consumables & Utilities									
Refractories for VIM-furnace and tundish	4.500€/t	1,21Mio€	1,30Mio€	1,73Mio€	1,84Mio€	0,60Mio€	0,67Mio€	0,86Mio€	0,95Mio€
Temperature and Sampling probes for VIM-furnace	1.50€/pcs	0,01Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,03Mio€	0,03Mio€	0,04Mio€
Empty 84,5 Litre Bottles to be filled	300€/pcs	0,76Mio€	0,81Mio€	1,08Mio€	1,16Mio€	1,25Mio€	1,40Mio€	1,78Mio€	1,99Mio€
Utilities									
Electric Energy									
Subtotal Electric Energy	0.10€/kWh	0,28Mio€	0,29Mio€	0,40Mio€	0,41Mio€	0,43Mio€	0,43Mio€	0,59Mio€	0,61Mio€
possible electric energy savings if PV-Array is Installed	-0.10€/kWh	-0,03Mio€	-0,03Mio€	-0,03Mio€	-0,03Mio€	-0,03Mio€	-0,03Mio€	-0,03Mio€	-0,03Mio€
Total electric Energy-including PV-unit	0.10€/kWh	0,25Mio€	0,26Mio€	0,37Mio€	0,38Mio€	0,40Mio€	0,40Mio€	0,55Mio€	0,58Mio€
Argon	1.90€/Nm³	0,18Mio€	0,19Mio€	0,26Mio€	0,27Mio€	0,29Mio€	0,32Mio€	0,41Mio€	0,45Mio€
Nitrogen	0.37€/Nm³	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€	0,02Mio€
Compressed Air (replaced by Nitrogen)	0.03€/Nm³								
Natural Gas (not required)	0.40€/Nm³								
City Water	1.30€/m³	0,002Mio€	0,002Mio€	0,002Mio€	0,002Mio€	0,002Mio€	0,002Mio€	0,002Mio€	0,002Mio€
Subtotal Consumables & Utilities	2,43Mio€	2,59Mio€	3,47Mio€	3,69Mio€	2,66Mio€	2,83Mio€	3,66Mio€	4,04Mio€	
Waste Disposal									
TiFeMn-Scrap considered as sold	-1.500€/t	-0,12Mio€	-0,13Mio€	-0,17Mio€	-0,18Mio€	-0,09Mio€	-0,10Mio€	-0,12Mio€	-0,12Mio€
Solid Wastes (Refractories, pallets, drums, big bags)	500€/t	0,15Mio€	0,16Mio€	0,21Mio€	0,22Mio€	0,09Mio€	0,10Mio€	0,12Mio€	0,14Mio€
Bag House Dust	1.000€/t	0,001Mio€	0,002Mio€	0,002Mio€	0,002Mio€	0,001Mio€	0,001Mio€	0,001Mio€	0,001Mio€
Liquid Wastes	-0,5€/t	0,00Mio€	0,00Mio€	0,00Mio€	0,00Mio€	0,00Mio€	0,00Mio€	0,00Mio€	0,00Mio€
Subtotal Waste Disposal	0,03Mio€	0,03Mio€	0,05Mio€	0,05Mio€	0,00Mio€	0,00Mio€	0,00Mio€	-0,01Mio€	
Transport									
Transport - No of Trucks - for incoming goods	1.500€/truck	0,16Mio€	0,17Mio€	0,23Mio€	0,24Mio€	0,26Mio€	0,29Mio€	0,36Mio€	0,41Mio€
Transport - No of Trucks - for outgoing goods (wastes not considered)	1.500€/truck	0,05Mio€	0,06Mio€	0,08Mio€	0,08Mio€	0,09Mio€	0,10Mio€	0,12Mio€	0,14Mio€
Subtotal Transport	0,21Mio€	0,23Mio€	0,30Mio€	0,32Mio€	0,34Mio€	0,38Mio€	0,49Mio€	0,54Mio€	
Personnel	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€	0,823Mio€
SUBTOTAL - COSTS		10,9Mio€	11,6Mio€	15,2Mio€	16,1Mio€	15,6Mio€	17,3Mio€	21,9Mio€	24,3Mio€
Note:	Revenue / Unit	Total annual revenues							
Product Revenues									
TiFeMn-Powder	8.000€/t	4,91Mio€	5,26Mio€	6,97Mio€	7,46Mio€	8,08Mio€	9,03Mio€	11,50Mio€	12,83Mio€
TiFeMn-Discs filled into bottles	8.000€/t	5,11Mio€	5,47Mio€	7,25Mio€	7,76Mio€	8,41Mio€	9,40Mio€	11,97Mio€	13,36Mio€
TiFeMn-undersized material - considered as a sellable product	3.500€/t	0,99Mio€	1,06Mio€	1,41Mio€	1,51Mio€	1,63Mio€	1,82Mio€	2,32Mio€	2,59Mio€
Subtotal REVENUES		11,0Mio€	11,8Mio€	15,6Mio€	16,7Mio€	18,1Mio€	20,2Mio€	25,8Mio€	28,8Mio€
GRAND TOTAL CONTRIBUTION MARGIN		0,1Mio€	0,2Mio€	0,5Mio€	0,6Mio€	2,5Mio€	2,9Mio€	3,9Mio€	4,5Mio€
Depreciation based on a period of 10 Years (to be covered by Cash)	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€	-2.270Mio€
GRAND TOTAL CASH FLOW		-2,2Mio€	-2,1Mio€	-1,8Mio€	-1,7Mio€	0,3Mio€	0,5Mio€	1,5Mio€	2,1Mio€

IDENTIFICATION OF PROCESS RISKS AND NECESSARY COUNTERMEASURES

- **Identification of any process risks** together with the customer and **definition of possible countermeasures.**
- When defining the process route known and identified risks are already taken into account and countermeasures can be taken.

AVAILABILITY OF RAW MATERIAL / SCRAP ON THE MARKET

INFLUENCE OF CONTAMINATED RAW MATERIAL ON PRODUCT QUALITY

SHORTCOMINGS AND BOTTLENECKS IN PRODUCTION ROUTE

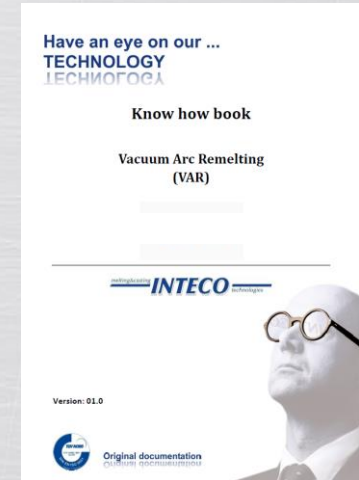
IDEAL PROCESS PARAMATER

PROJECT AND TECHNOLOGY CONSULTING – PROJECT PHASE

Scope of supply and service covered during project phase:

Project
Phase

- Preparation of tender documents and evaluation
- Basic and detail engineering
- Implementation of equipment and plant automation system
- Implementation of integrated production flow with optimized interfaces and T.O.P's
- Raw material administration, handling and storage concept
- Electrode design for various grades (octagonal shape / round shape)
- Holistic know- how documentation (“Know How Book”)
- Theoretical Training at INTECO HQ
- Ingot calculation concept depending on raw materials
- Concept for first melt treatment and final ingot analysis
- Production planning concept



PROJECT AND TECHNOLOGY CONSULTING – START-UP PHASE

Scope of supply and service covered during production start up phase:

Start-
Up
Phase

- Technical assistance on site during erection, cold and hot commissioning
- Practical Training during Commissioning at customer's site
- Provision of Melt recipes
- Definition of "Cook Book" and implementation into daily production routine
- Fine-tuning of process parameters
- Concept for increased manufacturing depth for semi-finished products made out of CP grades and alloy grades
- Concept for quality safety system and quality handbook
- Support for supplier certification by aerospace end users



PROJECT AND TECHNOLOGY CONSULTING – PRODUCTION PHASE

Scope of supply and service covered during production phase:

Production Phase

- Definition of production concept and on-site support during the implementation of new production processes and new material grades
- Provision of instructions for detailed melt recipes (not covered in the initial Know How documentation) for a defined period.
- Provision of “in-house” support and quick trouble shooting for a defined period by means of remote service free of charge
- Customer has the right to receive any new information on developments in the field of titanium production done by INTECO at first hand
- Joint R&D projects, publications, etc. can be discussed on a case-to-case basis but are basically envisaged and desired
- Plant assessment in regular intervals
- Best practice of economical and cost-effective production
- Support for continuous quality improvement



Ti - PRODUCTION PLANT AT UKTMP

—INTECO—



- Ti Production plant at UKTMP /Kazakhstan:12.000 t/y capacity target with large diameter ingots > 700 mm diameter
- INTECO provided the complete Know-how and operational experience along the complete production route including successful certification for the aerospace industry



Production managed by...


IMAS INTECO
Metals Application Suite

Ti - PRODUCTION PLANT AT POSUK



- Integration of a holistic process management system (IMAS) for an Electron Beam furnace production route at POSUK /Kazakhstan

IMAS - INTECO Metals Application Suite

MASTER DATA RESOURCES PRODUCTION QUALITY Administration

Overview Customer Order Status WBSU Campaigns Planning Cookbook

Stabs WBUs

UNBEKANNT

Tab2

115

215

ID: Last Modified: Modified By: 1.1 07/10/2019 10:06 imas@posuk.kz

Number: Grade: Status: Product Minimum Weight, kg: Product Maximum Weight, kg: Maximum Allowed Chip Percentage: 51 Tab2 0 0

Percentage of Chips to consider: []

Material Management

Available Stocks

LOT NUMBER	MATERIAL	AMOUNT	RESERVED	O	C	N	H	FE
13229	As13	380.00	0.00	39.82				2.68-05
13228	As13	500.00	0.00	39.75				3E-05
3331	Sp023	34,728.00	0.00	0.028	0.003	0.002		0.02
3332	Sp015	5,847.00	2,830.00	0.001	0.009	0.003		0.027
3333	Sp015	5,466.00	0.00	0.028	0.003	0.002		0.066
Ch05-01	Chps	11,300.00	0.00	0.03	0.003	0.004	0.005	0.034
Ch01-01	Chps	11,300.00	0.00	0.025	0.003	0.004	0.005	0.034

Batches

MATERIAL LOT	MATERIAL NAME	SLOS	WEIGHT, KG
3332	Sp015	1	2030 kg
TOTAL CAPS			2030 kg

Chemistry

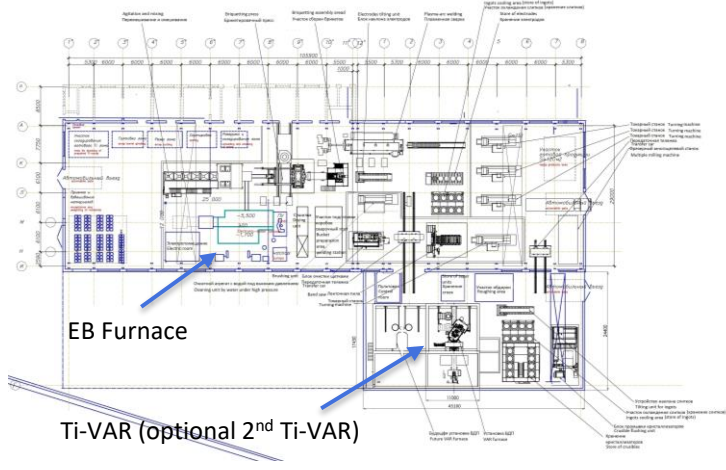
NAME	MIN	MAX	CALC
Al			
C	0.080	0.003	
Cr			
Ca			
Fe	0.15	0.03	
H	0.010		
Mg			
Mn			
Mo			
N	0.0300	0.0030	
Ni		0.01	
O	0.1000	0.1500	0.0200
Si		0.00	
Ti		99.8000	
V			
Zr			

Production managed by...



Ti - PRODUCTION PLANT AT RUSPOLYMET

—INTECO—



- RUSPOLYMET / Russia 3.000 t/y capacity target with small diameter ingots and < 700 mm diameter
- INTECO provided Know-how and operational experience for a Sponge / VAR line as well as EB / VAR line
- INTECO supplied also a 4t Titanium VAR plant



RUSPOLYMET 

TITANIUM VACUUM ARC REMELTING



TITANIUM VACUUM ARC REMELTING



Design aspects for INTECO's I-Ti-VAR furnaces:

- **Coaxial furnace design** with defined current path for highest reproducibility
- **Horizontal XY adjustment of the electrode** in the crucible for maintaining a constant gap with the possibility of automatic adjustment during the remelting process
- **Inert gas system** between crucible and ingot for improved heat transfer resulting in shallow liquid metal pools for highly segregation prone alloys
- **Partial pressure remelting** results in the elimination or minimization of the vaporization of elements like Mn, Cu or Sn as well as a flatter metal pool and improved structure
- **Stirring coil system** including visualization of arc location increasing the safety and the stabilization of the arc
- **Optimized weighing system** for precise control of the remelting parameter ($\leq 0,1\%$ overall accuracy)
- Plant designed **ready for Ampere Scientific's VAR-metric™ & VAR-control™** system to be easily implemented
- **Holistic process and production management system (IMAS)**



INTECO's Ti – VAR DESIGN CONCEPTS



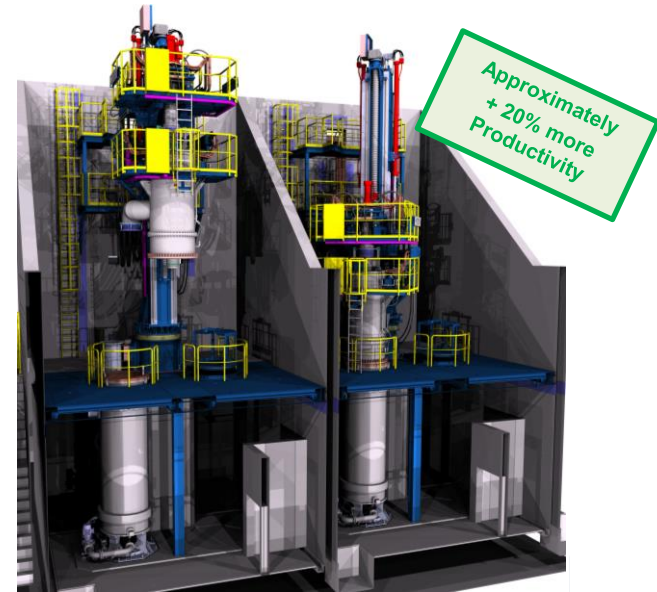
“One head two station” Concept

- One Furnace head
- Two Melt-stations
- Two Lock valves to increase productivity



“Two head two station” Concept

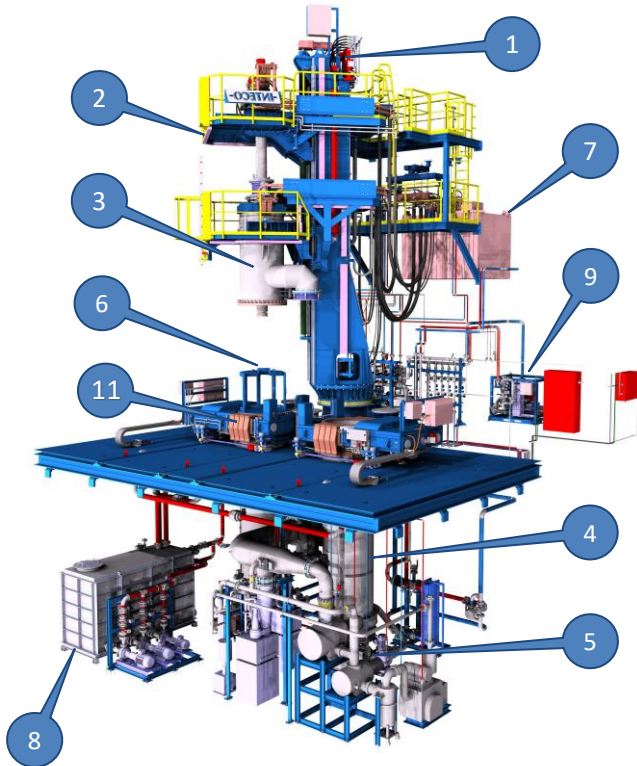
- Two furnace heads (completely separated)
- One Melt-station per furnace head
- Increased productivity through separate plant accessibility



INTECO's TI – VAR MAIN PLANT COMPONENTS



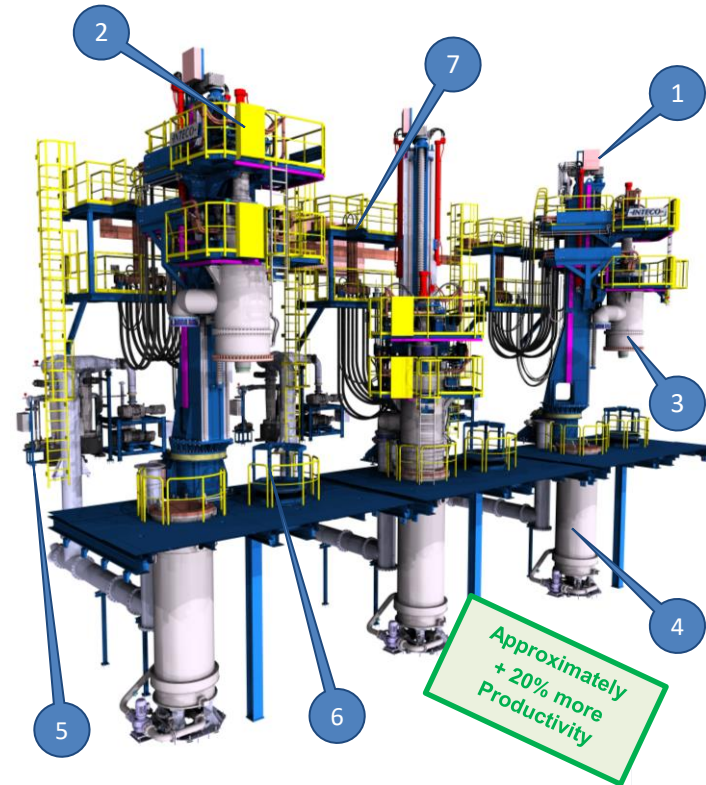
“One head two station” Concept



The main plant components at INTECO's I-Ti VAR plants are:

- 1) Furnace head
- 2) Electrode carriage
- 3) Hood carriage
- 4) Melt station
- 5) Vacuum system
- 6) Stub unloading unit
- 7) Melt power supply system
- 8) Cooling water supply system
- 9) Internal cooling water system
- 10) Hydraulic system
- 11) Lock valves
(Only at 1H2S concept)

“Two head two station” Concept (1 Optional)



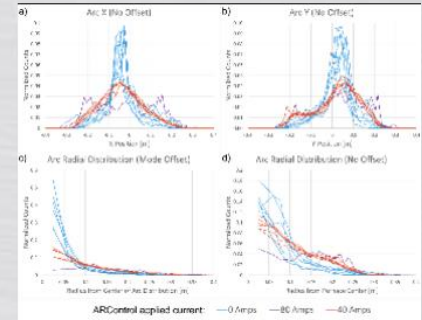
VARmetric™ AND ARControl™



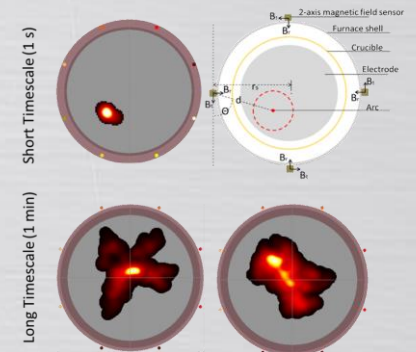
Amper Scientific

INTECO

- Studies have shown the **positive effect of transverse magnetic fields** on the arc stabilization respectively the predictability of the position of the arc
- **The heat flux will be tailored** which has a **direct effect on the shape of the melt pool**:
 - Decreasing of liquid pool depth
 - Decreasing of Splashing to crucible wall
 - Eliminates off-normal arc conditions / states
- **AMEPERE SCIENTIFIC** has developed the new cutting-edge technology VARmetric™ AND ARControl™ system which can be applied at steel and Titanium VAR furnaces
- **INTECO VAR's** are **designed ready** for the AMPERE SCIENTIFIC System to be implemented easily



Statistics on the distribution of the arcs without (blue) and with (red) ARControl



Visualization of Arc Position Sensing (VARmetric)

INTECO's Ti – VAR SELECTED REFERENCES



RUSPOLYMET

Russia 2016

Engineering and Supply of one 4t VAR plant for ingots up to 2700 mm length and 700 mm diameter for Steels and Super alloys.



CHONGQING KINGSLEY Titanium Technology Co., Ltd China 2017

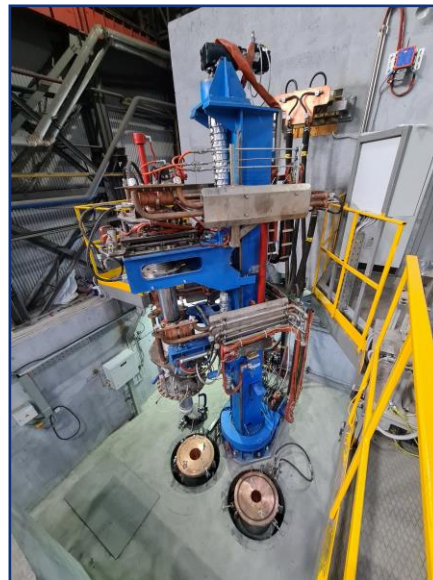
Engineering and Supply of one 17t Titanium-VAR plant for ingots up to 1100 mm diameter to be installed in a completely new Titanium Production Plant.



INTECO's Ti – VAR SELECTED REFERENCES



ALLVAC
USA, 2007
Engineering and Supply of one lab-protective Gas ESR- VAR plant for ingots up to 1450 mm length and 250 mm diameter.



CONFIDENTIAL CUSTOMER
Russia 2019
Engineering and Supply of one lab-protective Gas ESR- VAR plant for ingots up to 1450 mm length and 250 mm diameter.



XIANYIANG Titanium Industry Co., Ltd
China 2018
Engineering and Supply of one 12t Titanium-VAR plant for ingots up to 930 mm diameter to be installed in a completely new Titanium Production Plant



INTECO's Ti – VAR SELECTED REFERENCES

—INTECO—



XIANYANG Titanium Industry Co., Ltd

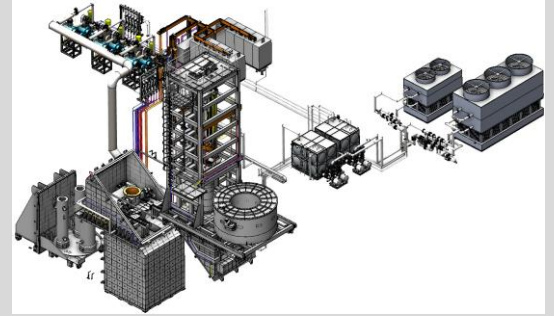
China 2022

Engineering and Supply of two 12t Titanium-VAR plant for ingots

up to 930 mm diameter and one 17t Titanium-VAR plant for ingots

up to 1140 mm

TITANIUM
VACUUM ARC
COLD HEARTH
SKULL MELTING FURNACE (VA CH SM)



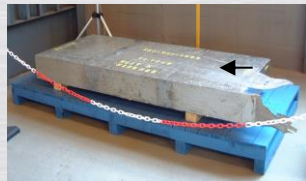
Ti-VA CH SKULL MELTING FURNACE

- Comparable to other melting and casting processes, the Skull Melting process has the following main advantages:

- Very good product homogeneity
- Very low amount of inclusions
- Very good cleanliness level
- Low operational costs
- Lower investment costs
- Possibility of investment casting



Skull (For reference)



Casted slab (For reference)

Comparison Criteria	Comparison of industrial scale Titanium Melting & Casting Processes			
	VAR	VA SM / CHR Option*	EB / CHR Option*	PAM / CHR Option*
Titanium Grade	CP & Alloy	CP & Alloy	mainly CP / Alloy Option	mainly Alloy / CP Option
Feedstock	Mainly Ti Sponge in form of large compacts , Small Scale Scrap up to 25 %** Master Alloys, Elemental Alloys	Mainly Ti scrap in form of small compacts to bulky pieces up to 100 %, Ti Sponge Master Alloys, Elemental Alloys	Mainly Ti CP scrap small compacts up to 100 %, Optional bulky pieces/electrodes via bar feeder, Ti Sponge Master Alloys, Elemental Alloys	Mainly Ti alloy scrap small compacts up to 100 %, Optional bulky pieces/electrodes via bar feeder, Ti Sponge Master Alloys, Elemental Alloys
Applied Melt Cycles	Double Melted	Single or Double Melted***	Single Melted***	Single Melted***
Product Shape	Ingot	Ingot /Slab / IC Parts	Ingot /Slab	Ingot /Slab
Product Dimension	400 -1150 mm dia 3500 mm length	400 mm -800 mm dia / cross section 3500 mm length	400 mm -1150 mm dia /cross section 5000 mm length	400 mm -1150 mm dia /cross section 5000 mm length
Product Weight	2t up to 17 t	0.5t up to 10 t	2t up to 20 t	2t up to 20 t
Product Homogeneity	good	very good	good	good
Inclusions (LDI/HDI)	low	very low	very low	low
Macro Structure	Remelted = directional soldification	Cast= equiaxed	Remelted = directional soldification	Remelted = directional soldification
Macro Segregation Effects	yes	yes	no	yes
Cleanliness	good	very good	very good	good
Product Surface	smooth directly forgeable	smooth directly forgeable	smooth directly forgeable	not smooth not directly forgeable
Energy Efficiency	approx. 0.7	approx. 0.7	approx. 0.7	approx. 0.45
Process Condition	Vacuum Process	Vacuum Process	Vacuum Process	Argon / He Atmosphere Process
Operation Cost	lowest	low	higher	highest
Investment Cost	low	mid	high	highest

* CHR = Cold Hearth Refining

** loose chips integrated in large compacts

*** Compliance with AMS /ASTM standards requires min. 2x melted for Alloy e.g. by a VAR process

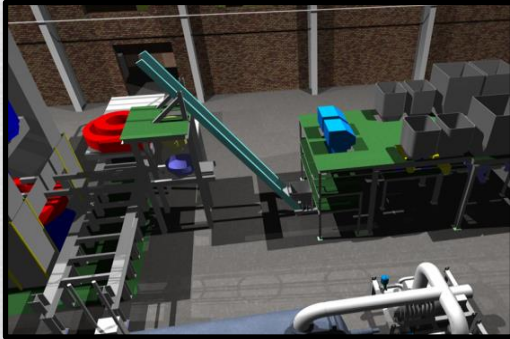
Ti-VA CH SKULL MELTING TECHNOLOGY

TYPICAL PROCESS FLOW



1

Scrap management:
Sorting, weighing
and blending



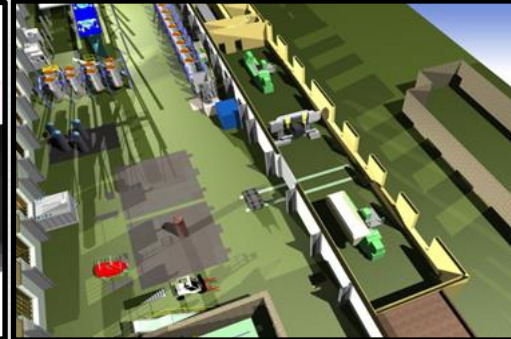
2

Skull melting and
casting process
(static or dynamic)



3

Subsequent
Treatment of casted
product



4

Re-melting in
VAR plant
(Optional)



Process flow Covered by INTECO Equipment and Process & Production management system



INTECO's TI VA CH SKULL MELTER

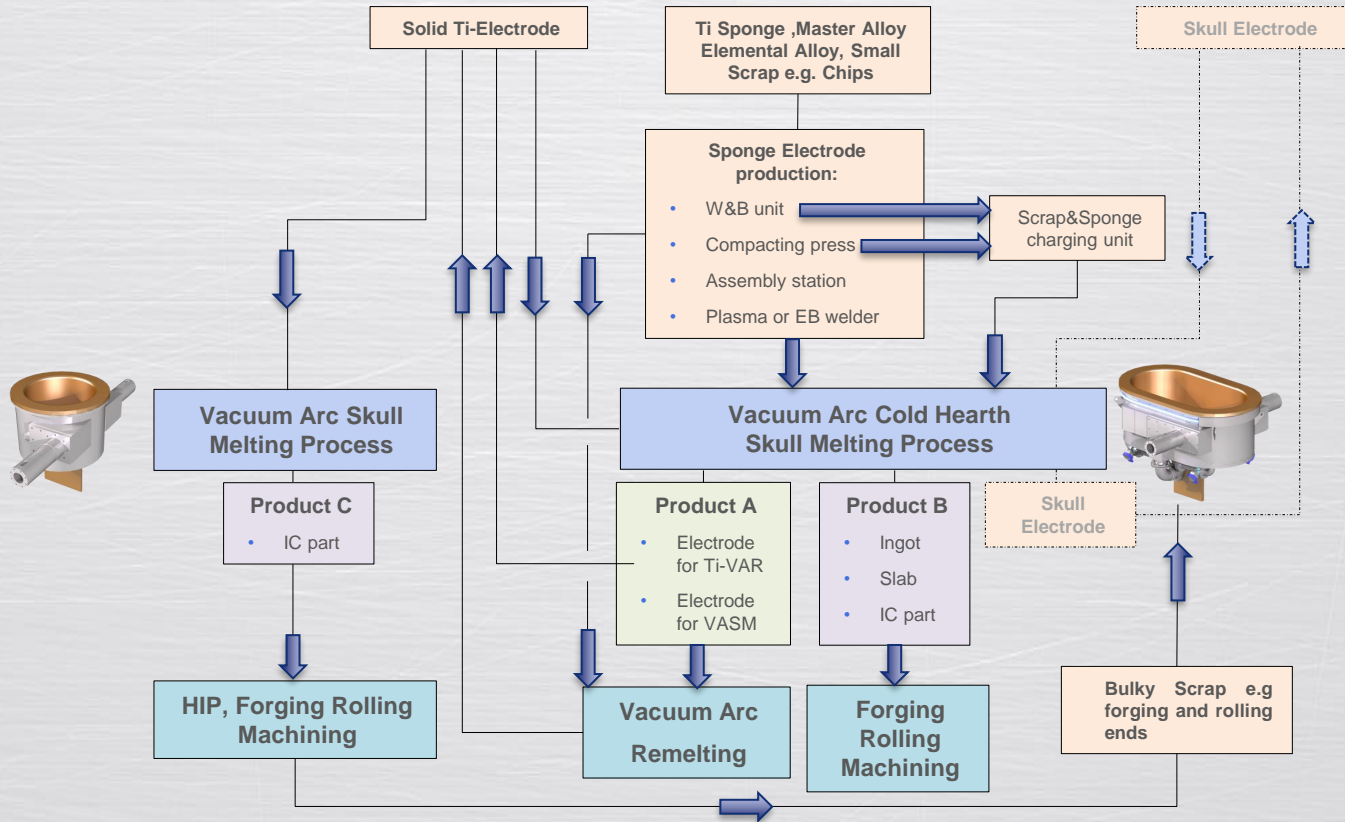


- **Combination of three melting techniques:**
 - Standard Skull Melter (Round crucible)
 - Cold Skull Melting (Double round, oval crucible)
 - Skull Electrode Melting (Using the skull as electrode)
- **Two Titanium casting techniques are combined** in one plant (static/dynamic) to provide either ingots, slabs or investment cast parts
- **Flexible feedstock** ranging from classical VAR electrodes up to 100 % scrap per cast in case of Skull Electrode melting
- Can be used as **primary melter** (electrode feedstock) for VAR furnaces **or final melting & casting plant** for investment castings using VAR / EB / PAM electrodes
- **Agglomerate / scrap feeding** is also provided without breaking the vacuum during the melting cycle

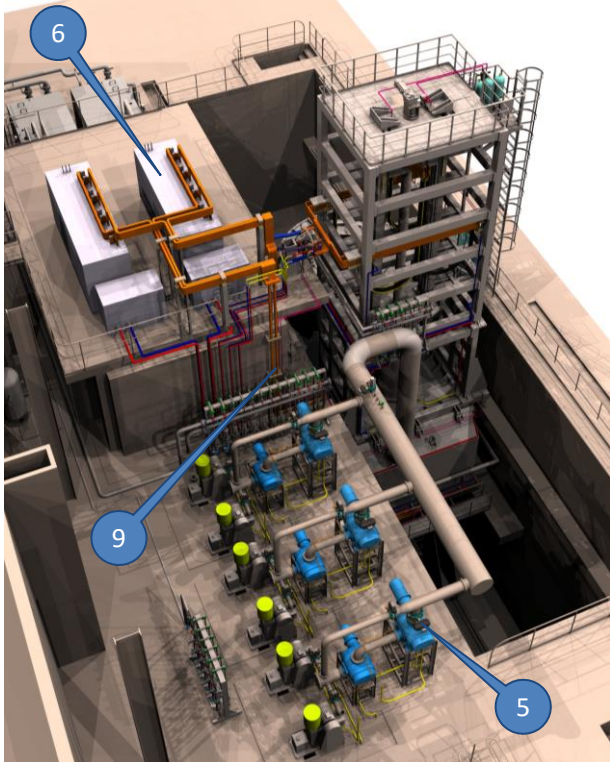
—INTECO—	INTECO's VA Skull Melter Types					
	Unit	1400X	1000X	750X	500X	250X
Cast weight - Standard Skull Melter (Round Crucible)	[kg]	1400	1000	750	500	250
Cast weight - Cold Skull Melter (Double Round Crucible)	[kg]	2500	1350	1100	850	550
Electrode max. dia	[mm]	800	660	600	480	390
Electrode min. dia (For round crucible)	[mm]	660	610	590	360	250
Melt power supply - Skull Melter	[kA]	54	44	40	26	20
Melt power supply - Cold Skull Melter	[kA]	60	50	46	30	24



INTECO's VA CH SKULL MELTER PROCESS SCHEME

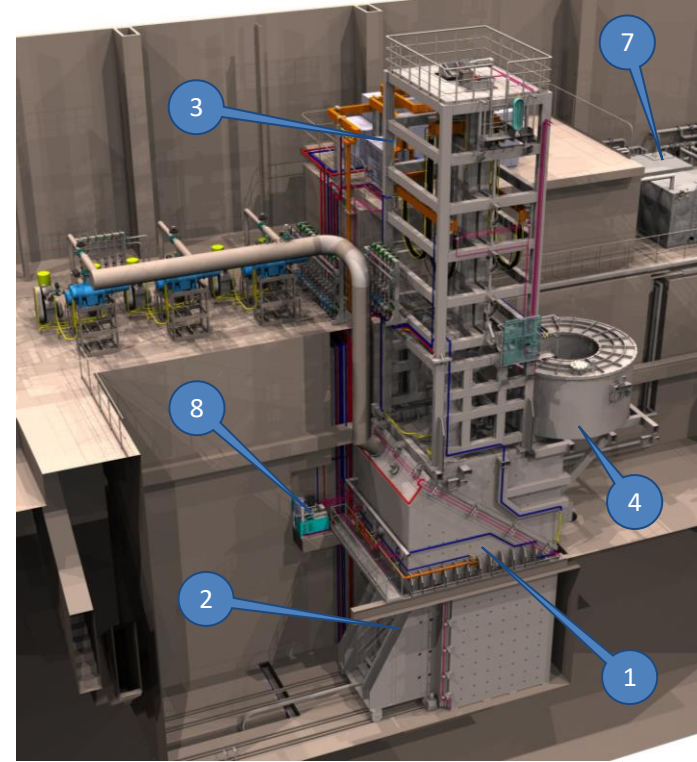


INTECO's Ti-VA CH SKULL MELTING FURNACE —INTECO— DESIGN CONCEPT

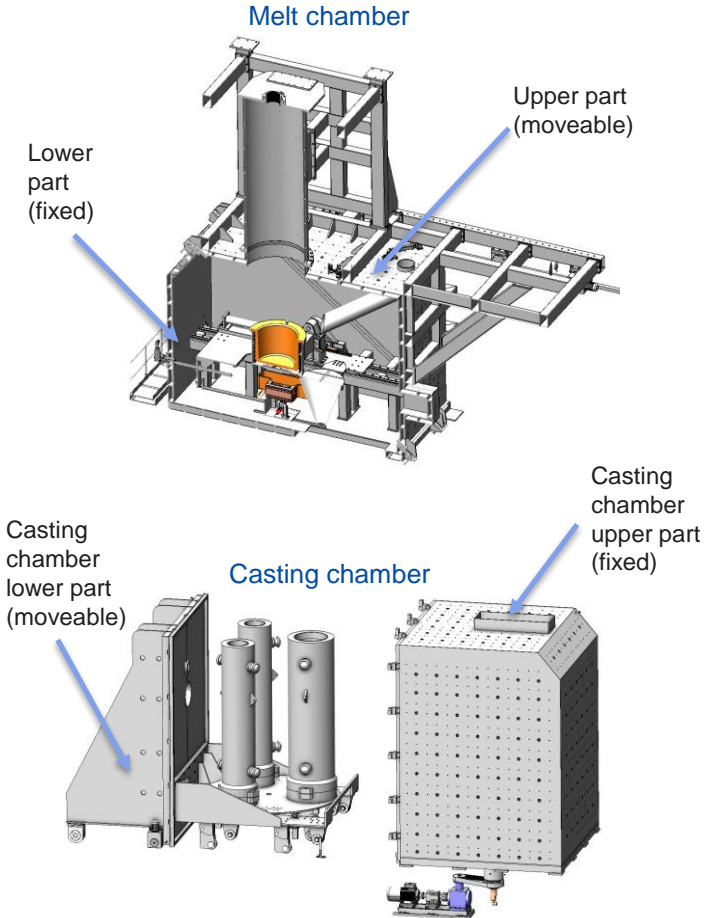
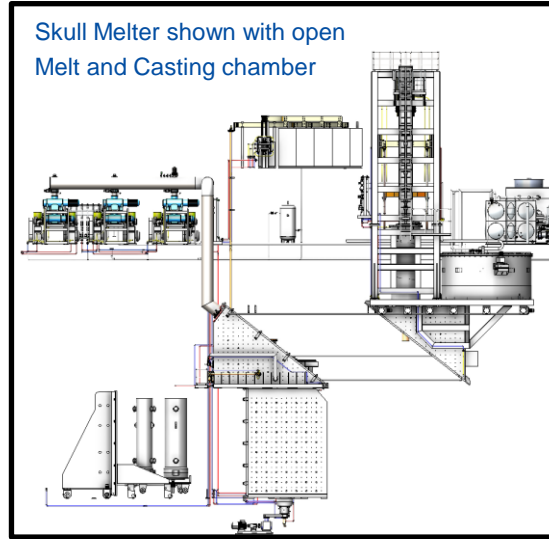
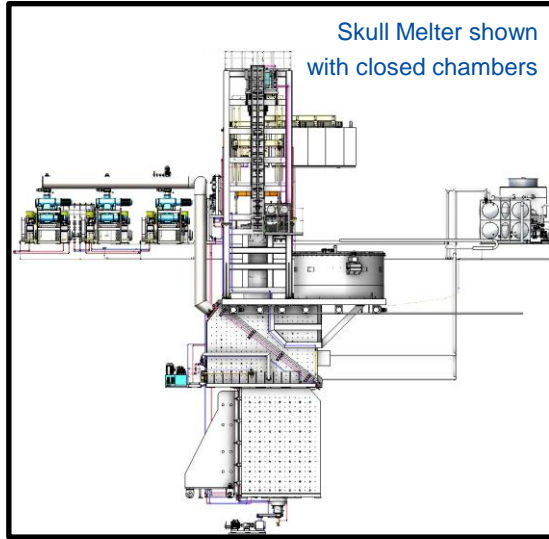


The main plant components at
INTECO's I-Ti Skull Melter plant are:

- 1) Melt chamber
- 2) Casting chamber
- 3) Furnace head
- 4) Revolver charging system
- 5) Vacuum system
- 6) High current line and Melt power supply
- 7) Cooling water supply system
- 8) Hydraulic system
- 9) Inert gas and pneumatic system



INTECO's Ti-VA CH SKULL MELTING FURNACE —INTECO— DESIGN CONCEPT

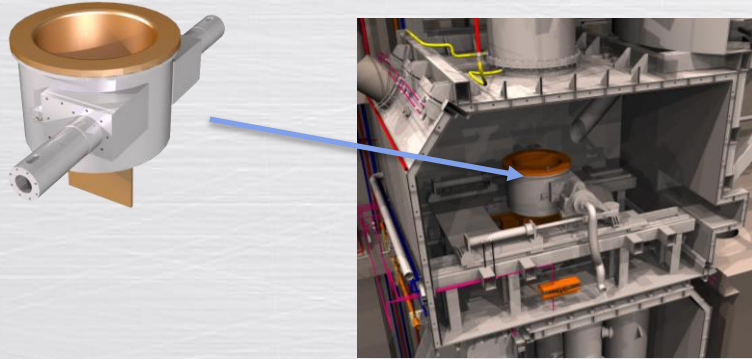


Melt and casting chamber –Split chamber design

- Best accessibility for preparation of melt chamber and crucible as well as maintenance
- Quick loading/unloading of the electrode into the furnace head
- Easy and fast loading and unloading of mold setup into the casting chamber

INTECO's Ti-VA CH SKULL MELTING FURNACE —INTECO— ROUND & OVAL CRUCIBLE

Round crucible



- Used for standard Investment casting (static and dynamic)
- Magnetic stirring coil for maximum process safety and stability
- Fast casting allows reduced remaining skull

Oval crucible



- allows the use of up to 40 % suitably prepared recycled materials to be charged per charge
- higher liquid volumes for metallurgical work and pouring weights
- Magnetic stirring coil for maximum process safety and stability
- Remining Skull can be used as electrode

INTECO's Ti-VA CH SKULL MELTING FURNACE —INTECO—

MAIN ADVANTAGES

- The possibility to use a **double round (oval) cold skull crucible** for increased metallurgical efficiency and cast weight flexibility > 1000 kg (cold skull melting)
- A **feeding system for adding scrap and sponge feedstock / alloying feedstock** to allow economical raw material use and adjustment of the chemical composition of the electrode.
- **Recycling rates up to 100%** can be achieved by producing the own melting electrode.
- **Two Titanium casting techniques** are combined in one plant:
 - **Static casting** for producing ingots, slabs or investment cast parts
 - A rotational cast table with auto balancing system with high balancing accuracy for dynamic casting can be used for **centrifugal casting technique** to achieve advanced product complexity and properties
- **Low energy consumption compared to other cold hearth melting furnaces (approx. 1/3)**
- **Split melt - and casting chamber design** allowing easy access for crucible and casting setup exchange as well as maintenance and cleaning
- **Easy loading and unloading process** of electrode
- **Multicasts** of one electrode for up to 6 casts possible
- **Fully automated crucible tilting/pouring process** and programmable pouring speed
- **Stirring coil system** at copper crucible increasing the safety and the stabilization of the arc
- **Holistic process and production management system (IMAS)**

SELECTED REFERENCES



- **BaoTi Baoji Titanium Industry Co., Ltd.**, in China is one of the biggest Titanium producer in the world
- The **INTECO VACHSM Konzept** has been developed together with **BaoTi**



SELECTED VA CH SM PRODUCTS



CENTRIFUGAL
CASTING



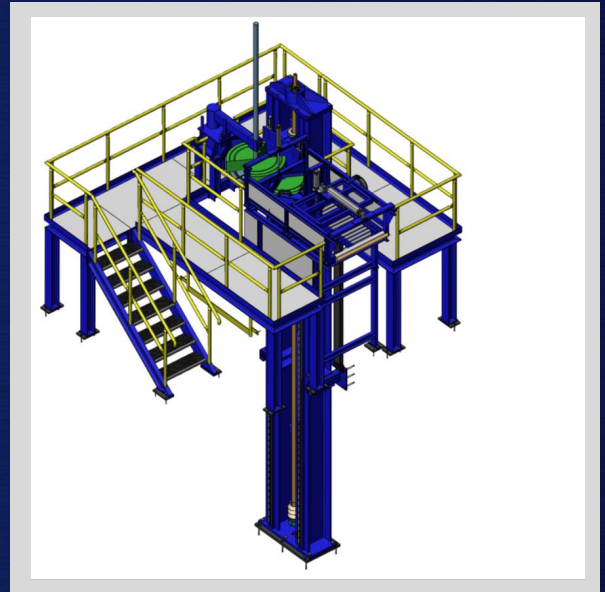
INVESTMENT
CASTING



STATIC CASTING
OF INGOTS / SLABS



AUTOMATED ELECTRODE ASSEMBLY UNIT (EAS)

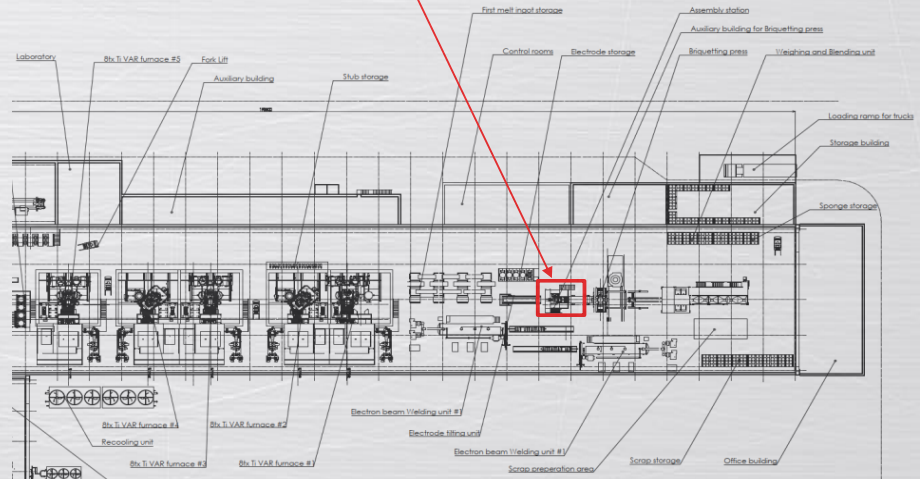
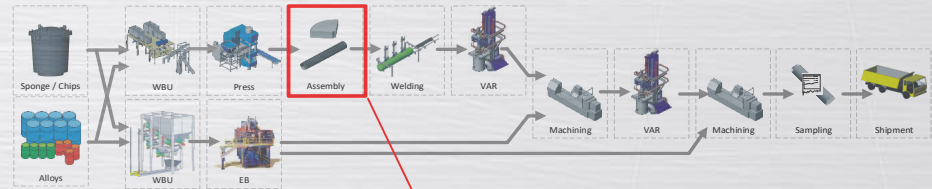


AUTOMATED ELECTRODE ASSEMBLY UNIT



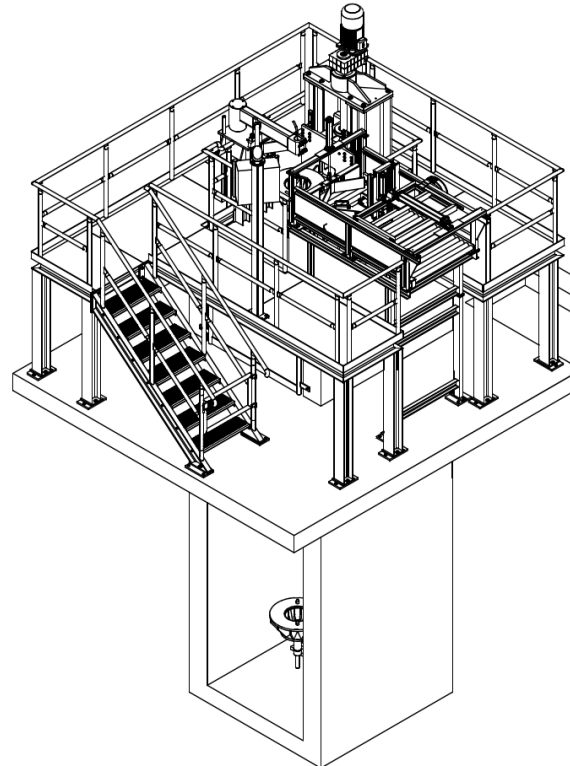
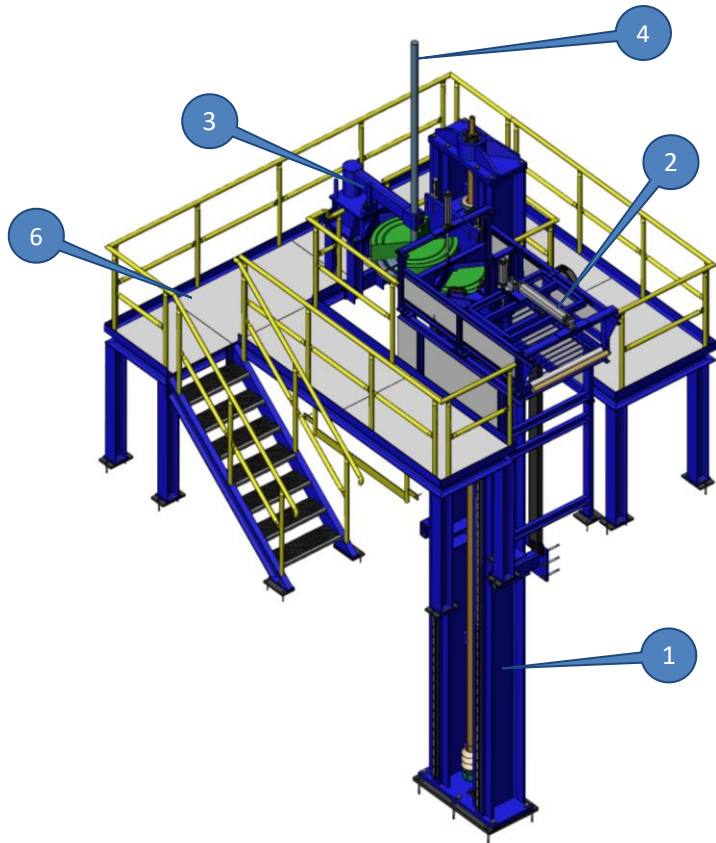
Design aspects for INTECO's Automated electrode assembly unit:

- **Avoiding the bottleneck** of manually assembling of the compacts due to **Automated assembly process**
- **Can be directly integrated in the production workflow** behind the compacting press and before the electrode welding equipment (Plasma or Electron beam).
- **120°, 180° compacts** can be assembled on a tie rod



AUTOMATED ELECTRODE ASSEMBLY UNIT

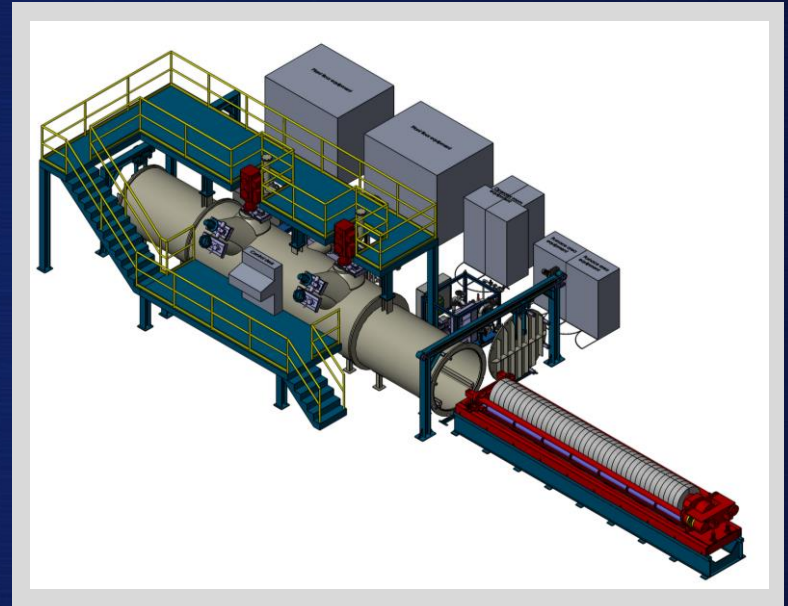
—INTECO—



The main plant components at
INTECO's EAS are:

- 1) Column for electrode drive
- 2) Compact feeding unit
- 3) Supporting arm
- 4) Set of Tie rod assemblies
(Buyer's supply)
- 5) Pneumatic system
- 6) Platforms and walkways
(Buyer's supply)

ELECTRON BEAM WELDING UNIT

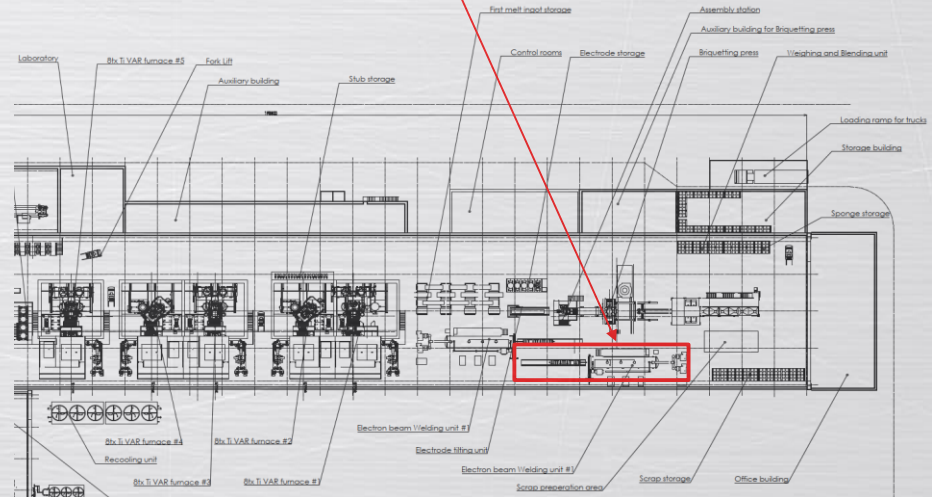
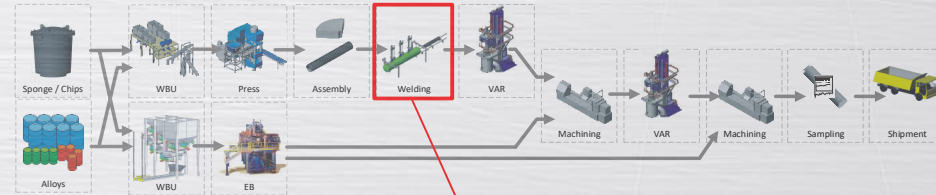


ELECTRON BEAM WELDING UNIT



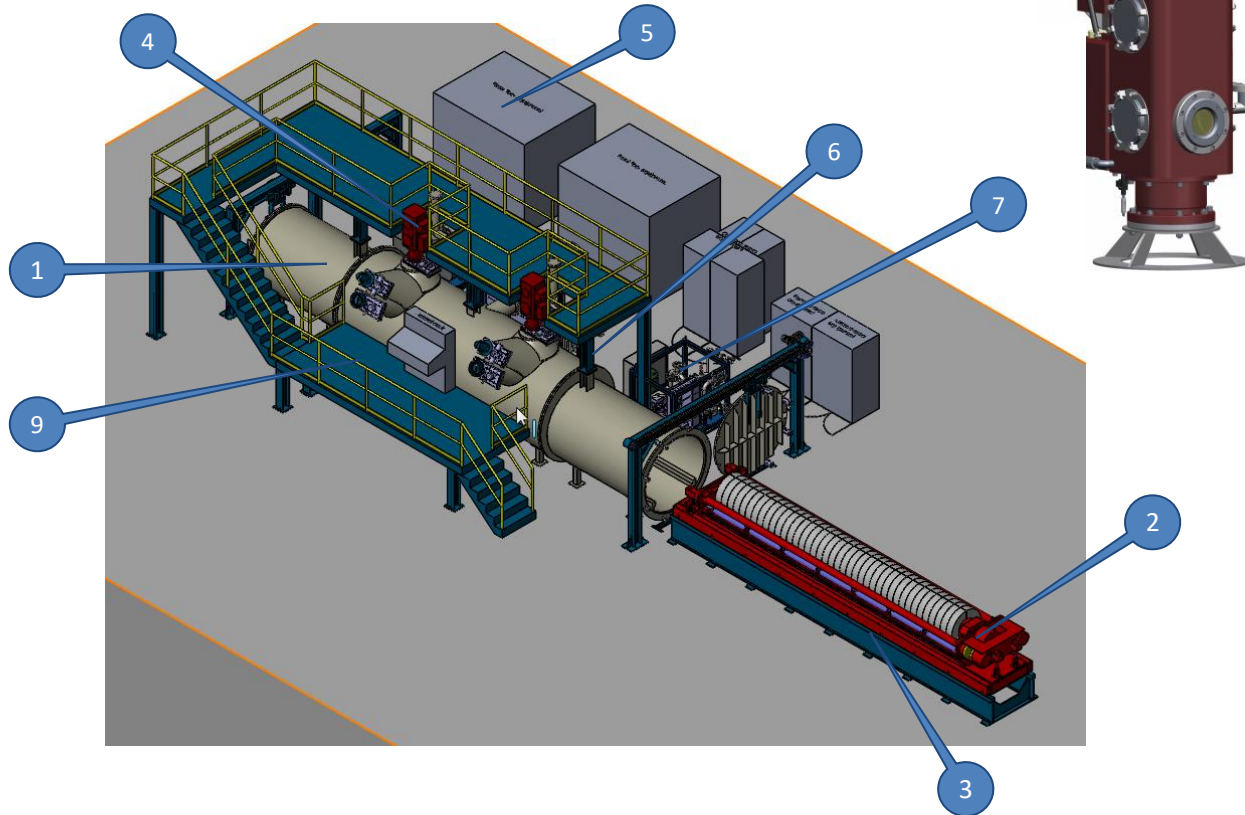
Features of INTECO's Electron Beam Welding Unit

- **Cutting edge Electron Beam technology by VON ARDENNE**
- **Faster welding speed** results in **increased productivity**
- **Higher energy density** and **more precise control of the energy input and energy distribution.**
- **Better quality control of the welding seam** due to the low vacuum pressure during the welding process.
- **Reduction of the process costs by the entire gas costs** compared to plasma welding systems.
- **Possibility of melting ('glazing') the entire cylindrical surface of ingots**, allowing to eliminate surface defects and impurities of first heat ingots after VAR melting **without machining.**
- **High energy efficiency**



ELECTRON BEAM WELDING UNIT

—INTECO—



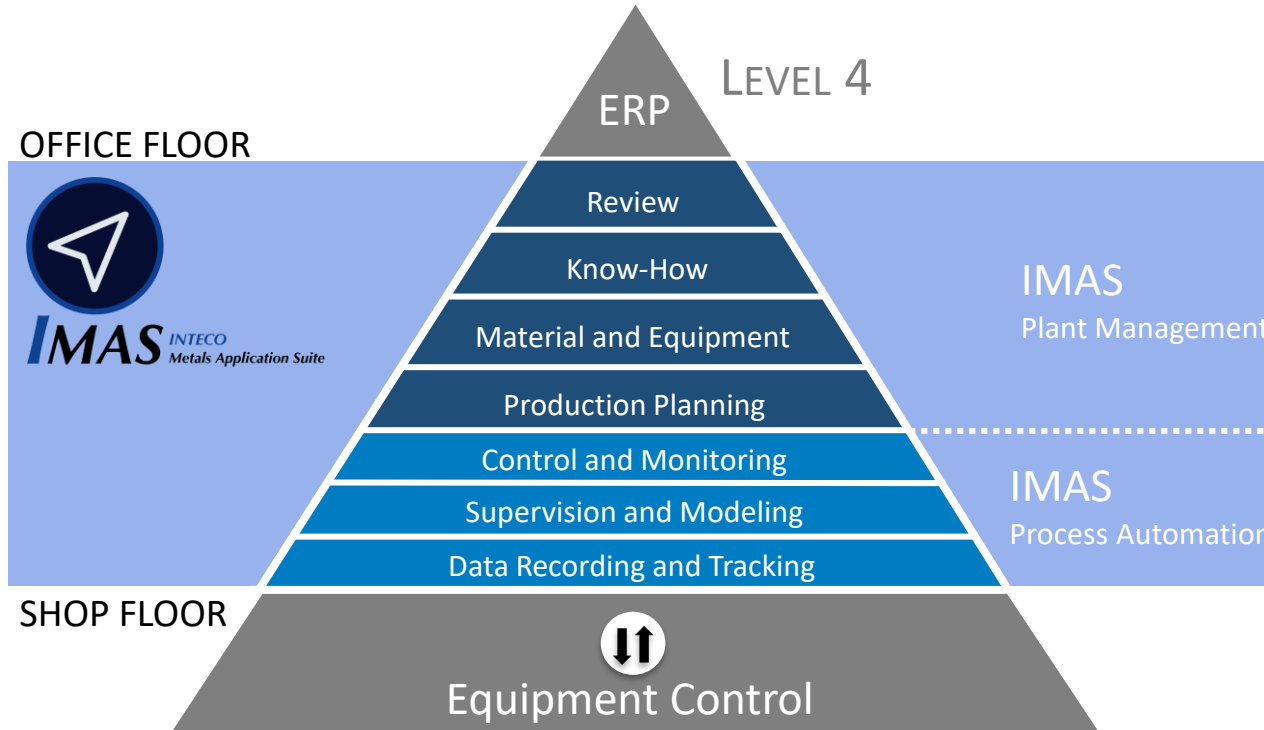
The main plant components at INTECO's EB welding unit are:

- 1) Cylindrical vacuum chamber incl. front and rear end doors
- 2) Mobile carriage incl. tension rod system
- 3) Loading table for mobile carriage
- 4) Electron beam guns
- 5) High voltage power supply and beam guidance system
- 6) Vacuum system
- 7) Closed cooling water system
- 8) Inert gas and pneumatic system
- 9) Steel platform and stairs

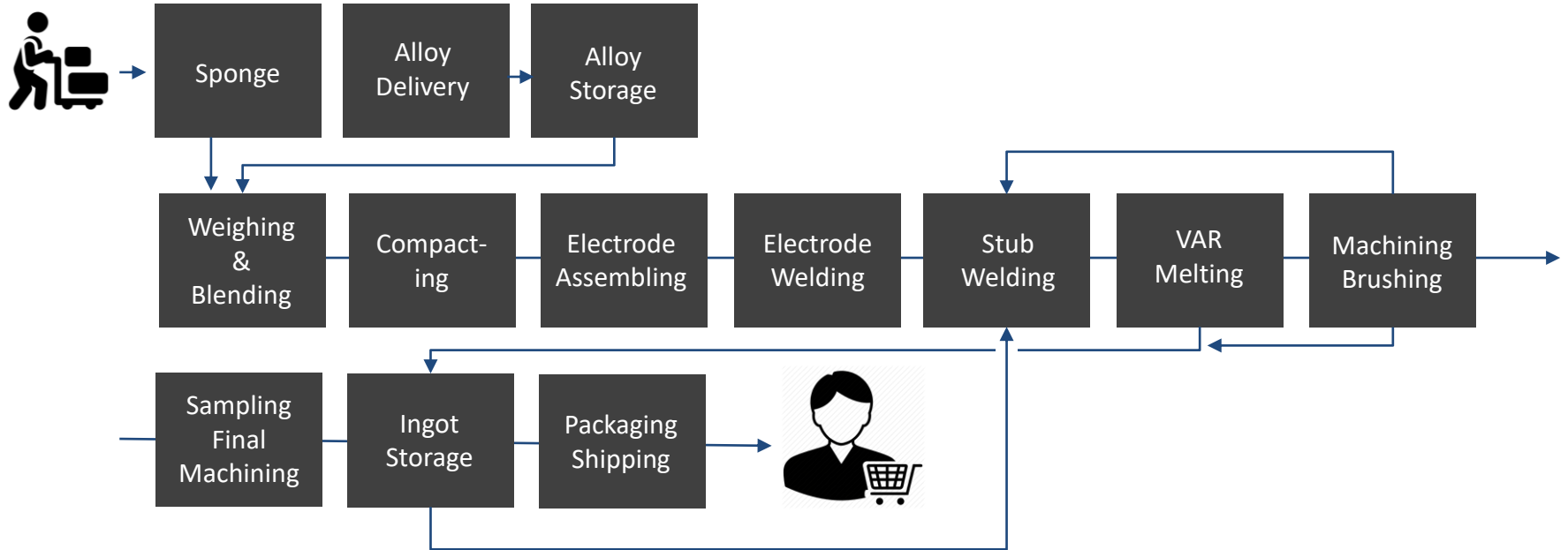
IMAS – PRODUCTION MANAGEMENT SYSTEM



IMAS – PRODUCTION MANAGEMENT SYSTEM



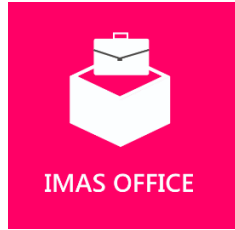
IMAS – IDENTIFYING THE PRODUCTION WORKFLOW



IMAS – ADDITIONAL BENEFITS



IMAS – PRODUCTION MANAGEMENT SYSTEM





Software
System Design Concept



IMAS – PRODUCTION MANAGEMENT SYSTEM OFFICE



IMAS OFFICE

- › Production Planning: *Order management, charge planning, casting setup*
- › Material & Equipment: *Material data, material storage, inventory tracking*
- › Master Data: *Grade management, treatment recipes*
- › Review: *Heat specific data, reports, inventory review*  



IMAS – PRODUCTION MANAGEMENT SYSTEM SHOP



IMAS SHOP

- › Recording: *Process Data Recorder and Visualization App*
- › Modeling: *Holistic and Fundamental Approach of Process Modeling*
- › Supervision: *Visualization of Recipes and Integrated Tracking App*
- › Control: *Static and dynamic Set-Point Control App*



IMAS BENEFITS – QUALITY CONTROL



—INTECO—

- Maintaining and ensuring a **constant quality level** on the entire production route starting **from raw material to the product**
- **Tool for certification processes** (such as aerospace)
- **Documentation** of the production process for your customers (Quality certificate)
- **Standardization** of production processes
- IMAS as a tool to **generate Know-How**
- IMAS as **an important tool** for **start-up companies as well as established companies** in the industry
- IMAS as a **tool to guide the operator through the process** (Independence of the operator skills)
- **Implementation of process models** to guide the production process
- **Utilization of historical production data** to identify and predict production failures
- Tool for **identifying shortcomings and bottlenecks** in the production workflow
- IMAS as a tool to apply a **continuous improvement process**



CONTROLLING

IMAS BENEFITS – COST CONTROL



- Availability of **all necessary information for OPEX** evaluation
- **Stock management incl. lifetime tracking of inventory, tools, consumables and raw material**
- **Time savings** due to **standardized processes**
- **Cost optimized charge calculation** respective production planning (e.g. preferred usage of broken lots)
- Tool for **capacity evaluation**



REDUCTION

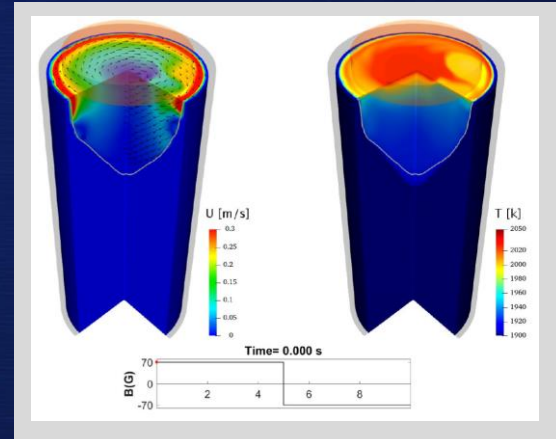
IMAS BENEFITS — PRODUCTION PLANNING



- **One software covering the complete production planning** incl. order scheduling and charge planning
- **Customer specific production planning**
- **Tracking of product** throughout the entire production cycle
- **Bridging the gap from level 1 (shop floor) to overall ERP level**
- **Automatic Key Performance Indicator (KPI) generation**



RESEARCH AND DEVELOPMENT



Ti-VAR PROCESS SIMULATIONS

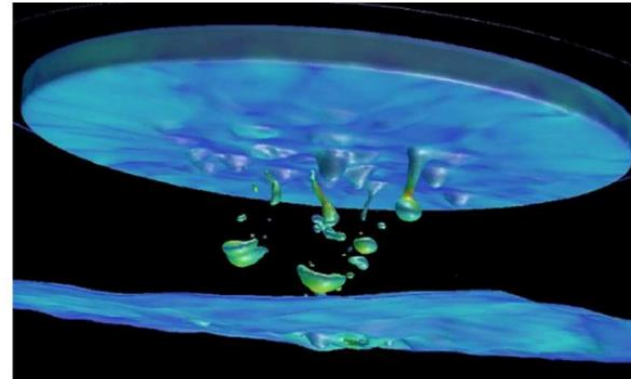
Proposal for the Foundation and Support of a Christian Doppler Laboratory on

Metallurgical Applications of Magnetohydrodynamics

Project with focus on **(Ti) VAR** started in 2018 with a confirmed period until 2025



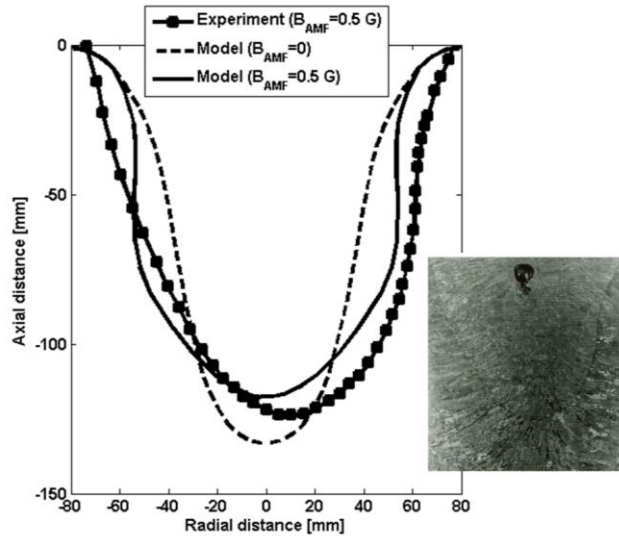
Christian Doppler
Forschungsgesellschaft



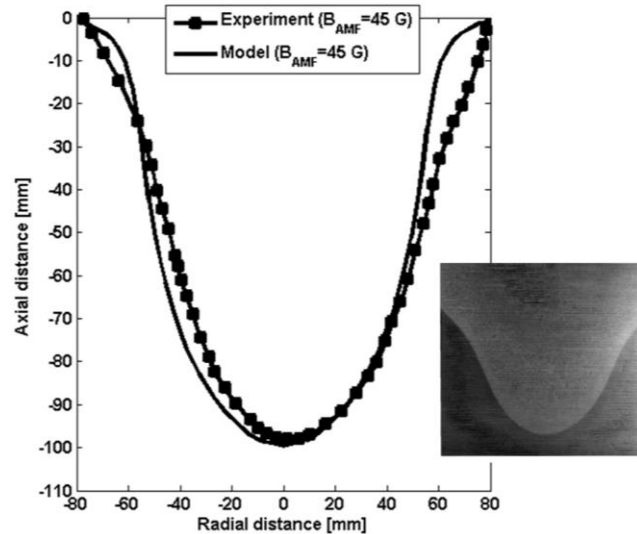
- Process Modelling as the key tool for a better understanding of the process (trouble-shooting, shorter start-up phase, optimized production, yield, etc.)
- Broader knowledge and deeper insights on the process to improve process parameters for a safe and repeatable operation
- Optimized Process control and valuable input for various design issues due to full understanding of the physical phenomena
- Cooperation with Ti-Producers to validate the developed model

VAR PROCESS SIMULATIONS

The model was validated using pool profile for a laboratory scale Ti64-VAR with a diameter of 165 mm considering both earth magnetic field and an axial magnetic field (AMF) through the coil.



AMF = 0.5 G (Earth magnetic field)



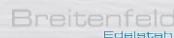
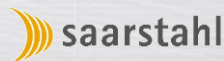
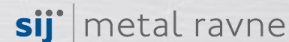
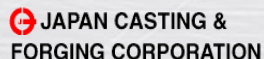
AMF = 45 G



INTECO IS THE RELIABLE PARTNER **—INTECO—** IN THE TITANIUM INDUSTRY....

- ...for **Feasibility-, Conceptual-, Basic- and Detailed Engineering Studies for VAR and Electron Beam / Vacuum Arc Skull Melter Titanium production lines**
- ...for the provision of **Know-how and operational experience** acting as technology **partner** for setting up entire **Titanium Production Lines**
- ...as a supplier of state-of-the-art **Ti-VAR plants** and **related process technology**
- ...as a supplier of **next generation Vacuum Arc Skull melter plants** and **related process technology**
- ... as a supplier of **Production management software** as a holistic digitalization tool to **manage, control** and **optimize the production of Titanium materials** for most demanding industries
- ...for **Ti-VAR Process simulations** as the key tool for a better understanding and process optimization

PROUD TO HAVE CUSTOMERS LIKE THAT..



—INTECO—

Thank You!



| DISCLAIMER

INTECO melting and casting technologies GmbH

Wienerstrasse 25
A-8600 Bruck an der Mur

Tel.: +43 (0)3862 53110 0

Fax: +43 (0)3862 53844

Email: inteco.austria@inteco.at

Contact: Alexander Scheriau / Uwe Haissl

Have an eye on our technology www.inteco.at

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