11-13 September / Eylül 2014
TÜYAP Fair, Convention & Congress Center, İstanbul
7th International Ankiros Foundry Congress
7. Uluslararası Ankiros Döküm Kongresi

«Vacuum Investment Casting, Furnace Concepts Tailored To Market Requirements»

«Vakumlu Hassas Döküm, Pazarın İhtiyaçlarına Uygun Fırın Tipleri»

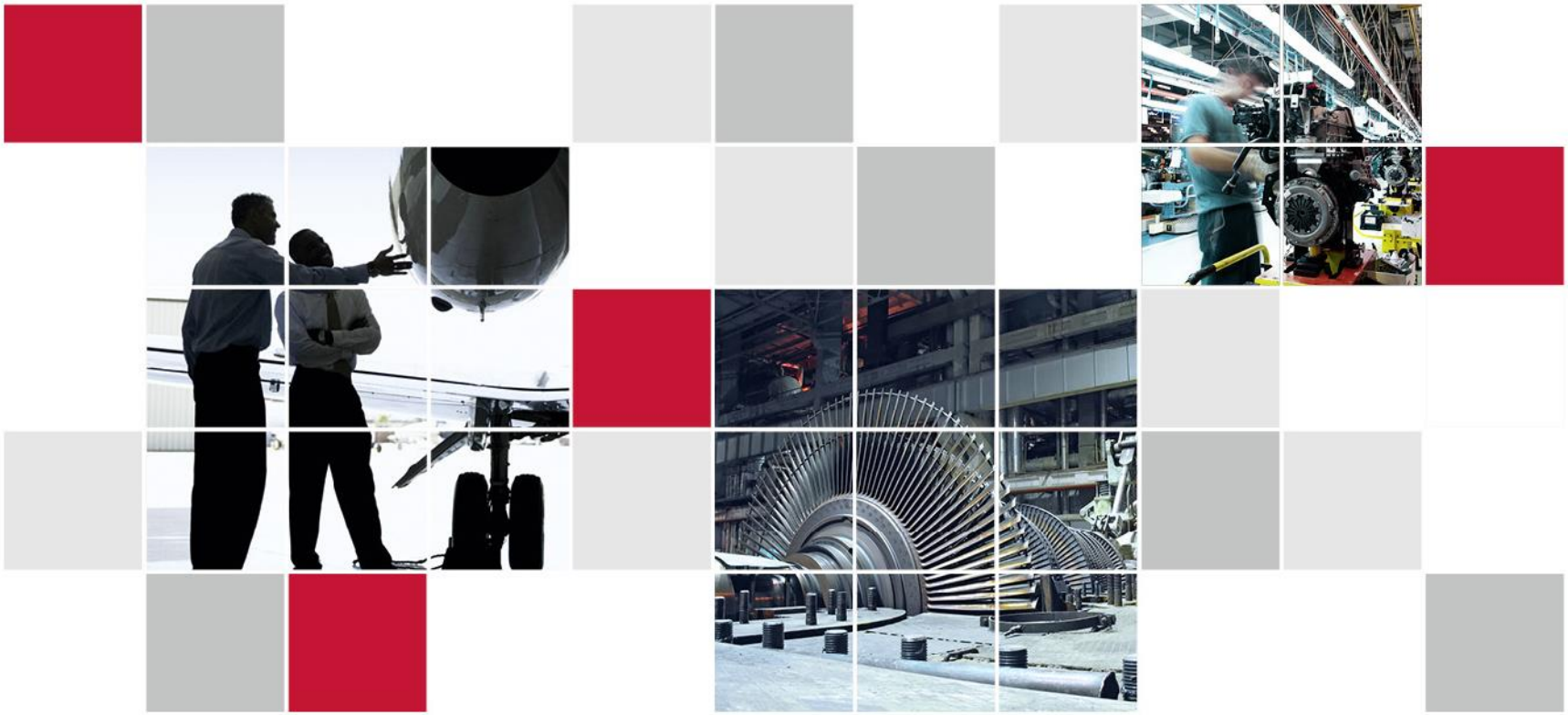
Ulrich Betz
(ALD Vacuum, Meta-Mak Met. Mak. Müm.)

7.Oturum: Süreçler ve Kontrol
7th Session: Process and Control

Oturum Başkanı/Session Chairman: Mustafa Akyürek (Anadolu Döküm San. Tic. A.Ş.)

Saturday Afternoon

Vacuum Investment Casting - Furnace Concepts tailored to Market Requirements



ANKIROS 2014 - 12th INTERNATIONAL IRON-STEEL AND FOUNDRY TECHNOLOGY, MACHINERY AND PRODUCTS TRADE FAIR

Vacuum Investment Casting – Furnace Concepts tailored to Market Requirement
Overview

- Vacuum Metallurgy
- Vacuum Induction Melting – Investment Casting (VIM-IC) Processes
- VIM-IC Furnaces for Melting of Ni/Co based Superalloys
- Cold Wall Induction and Vacuum Arc Scull Melting Furnaces for Melting of Reactive Alloys

Overview Vacuum Metallurgy

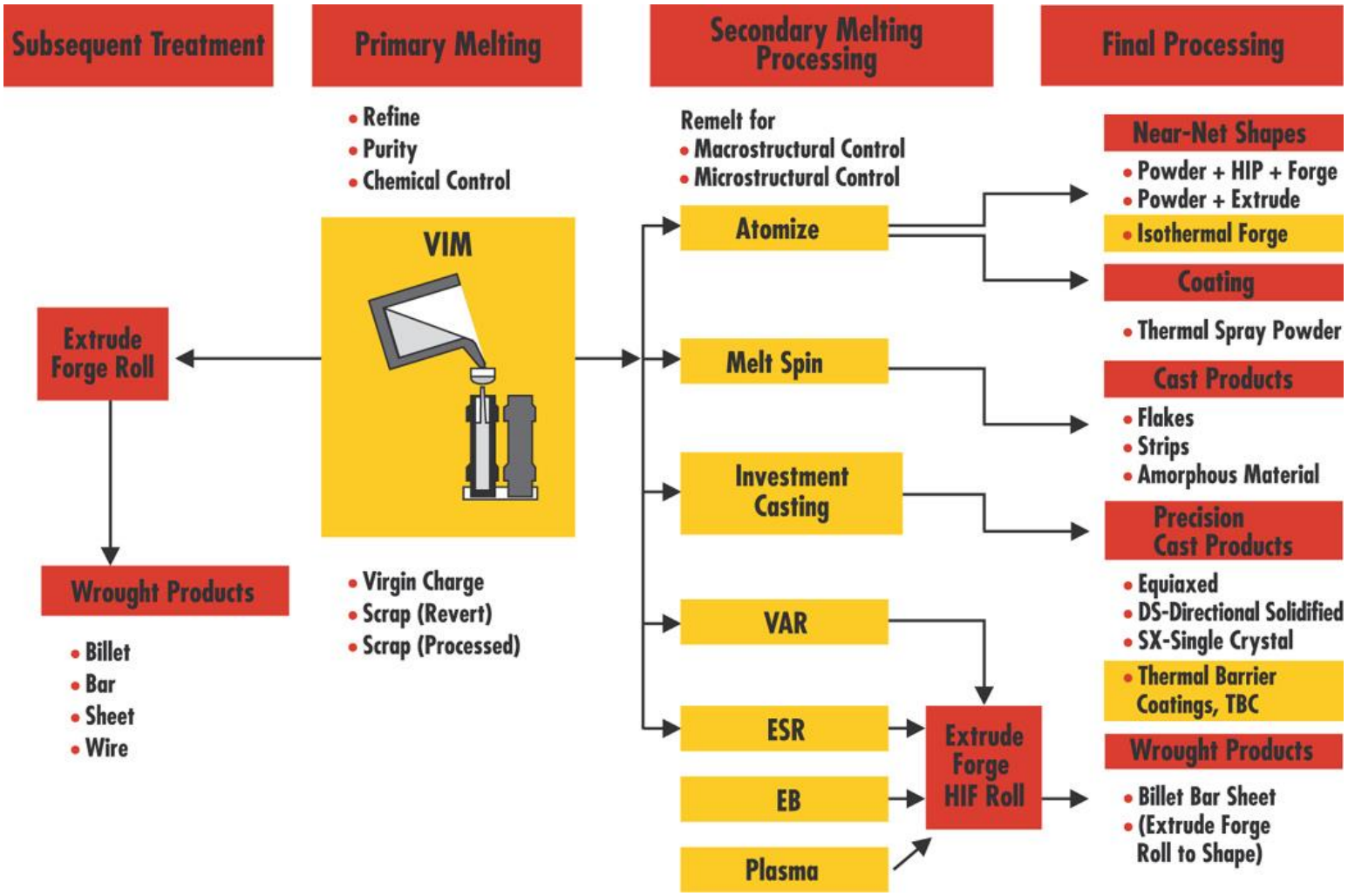


Fig. 1 Processing routes for superalloys and high quality stells

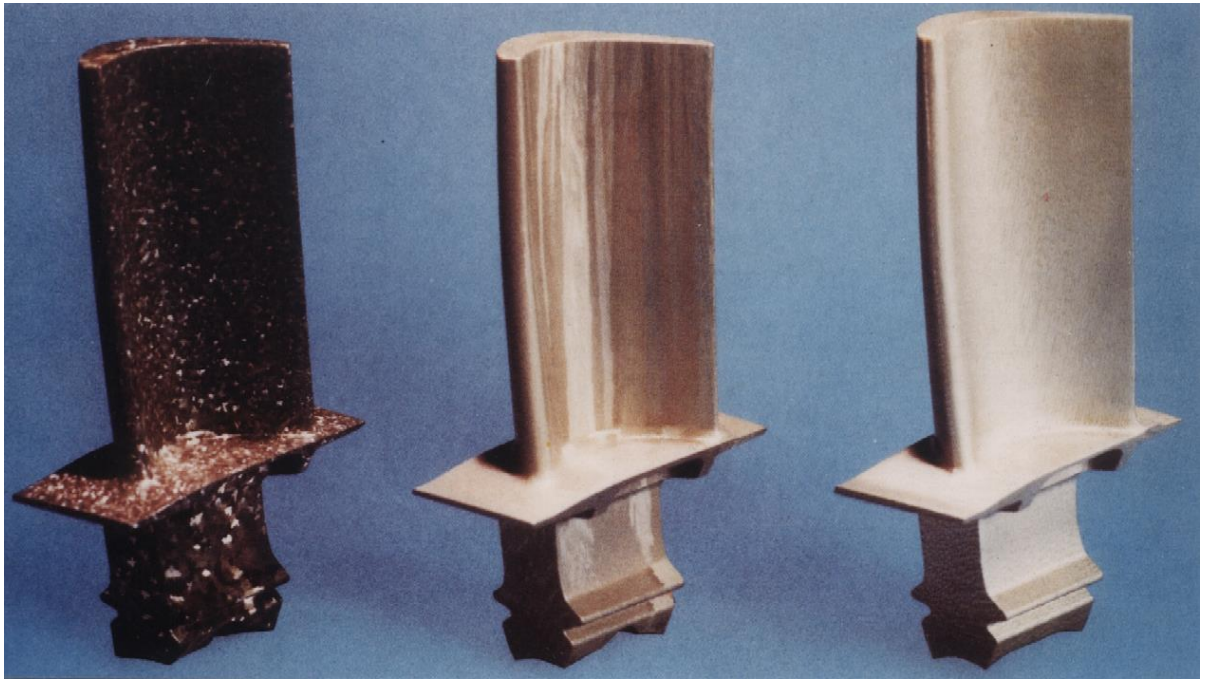
“Vacuum Induction Melting - Investment Casting”
VIM-IC Process

The VIM-IC process is the primary process for the production of complex near net-shape components. During the VIM-IC process melting and casting of the Ni/Co-based superalloys is done under vacuum or controlled atmosphere and finally the material is poured into a ceramic molds, which gives the cast part already the near net shape.

The solidification structure of the casting can be adjusted to be equiaxed (E) or, through the use of an additional mold heater, directionally solidified (DS) or single crystal (SC).

Solidification Processes

Equiaxed Solidification = E > Vacuum Induction Melting - Investment Casting VIM-IC E
Directional Solidification = DS > Vacuum Induction Melting - Investment Casting VIM-IC DS/SC
Single Crystal Solidification= SC > Vacuum Induction Melting - Investment Casting VIM-IC DS/SC



Equiaxed (E) Solidification

Directional Solidification Multi Crystal (DS)

Directional Solidification Single Crystal (SC)

Fig. 2 Solidification processes and respective furnace types

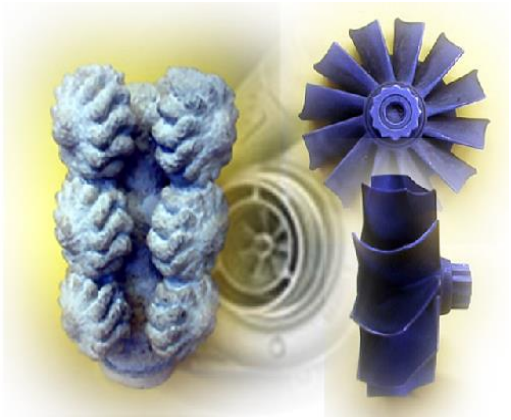
General Requirements for Melting and Casting of Ni/Co-based Superalloys

- Melting must be done under vacuum in order to avoid any reaction between the melt and Oxygen and Nitrogen because these reactions would degrade the material properties
  > multichamber furnaces are required, which allow to load the mold and the charging material as well as melt temperature measurements without breaking the vacuum in the main process chamber
- Typical operation vacuum is in the 10-3 mbar range
- For the equiaxed process fast evacuation times of the mold chamber are required in order to limit the temperature losses of the mold during the transfer of the preheating furnace in the pouring position
- For the improvement of the mold filling conditions the pouring speed must be adjustable and an exact pouring of the material into the center of the mold pour cup is necessary

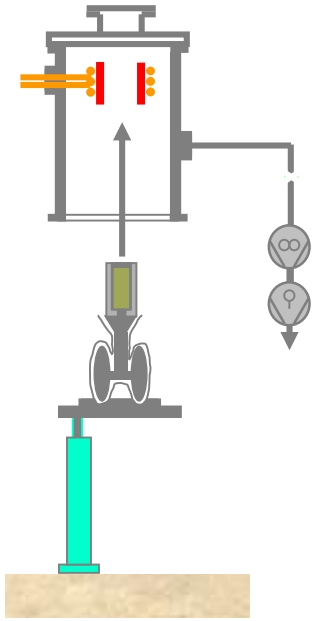
Furnaces for the Production of Turbocharger Impellers

- Low value product “Impeller” requires simple and cost effective production furnace > single chamber furnace VIM-IC 1 E-BP

Product



Furnace Type



Main Technical Data	
Cast Weight:	5-12 kg
Max. Mold Dia.:	400 mm
Max. Mold Height:	500 mm

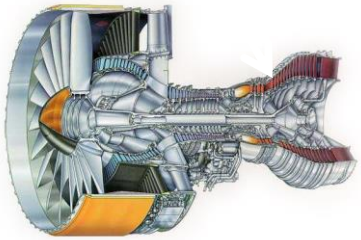
Vertical Furnace for the Production of small and medium size Blades, Vanes and Structural Parts for Gas Turbines

- For cast weights up to 200kg and/or mold sizes up to diameter 1000mm x height 1200mm usually vertical furnaces are used

Products

Cast Parts for Industrial Gas Turbines

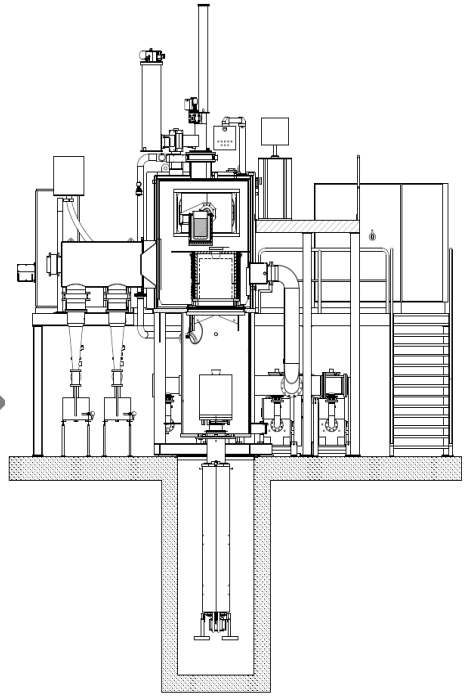
Cast Parts for "Flying" Gas Turbines



Blades, Vanes and Smaller Structural Parts for Gas Turbines

Orthopaedic Implants

Furnace Type VIM-IC 5-20 E/DS/SC



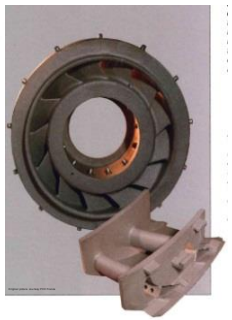
Typical Furnace Data

Cast Weight:	25-200 kg
Mold Dia.:	200-1000 mm
Mold Height:	300-1200 mm

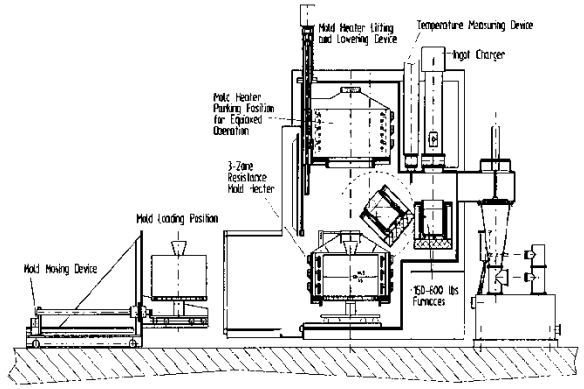
Horizontal Furnace for the Production of Large Blades, Vanes and Structural Parts for Gas Turbines

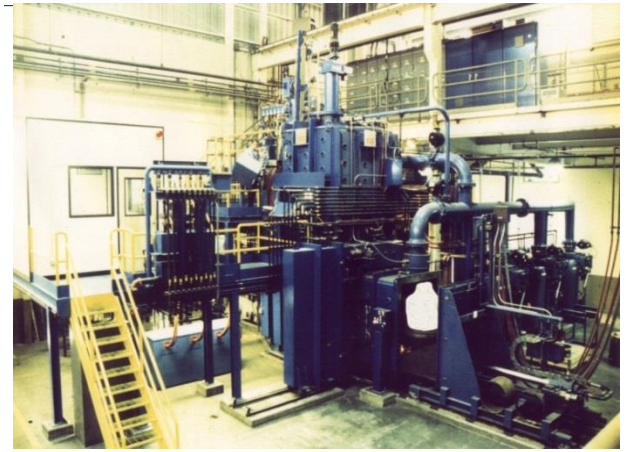
- For cast weights above 200kg and large mold sizes usually horizontal furnaces are used

Product



Furnace Type VIM-IC 20-60 E/DS/SC





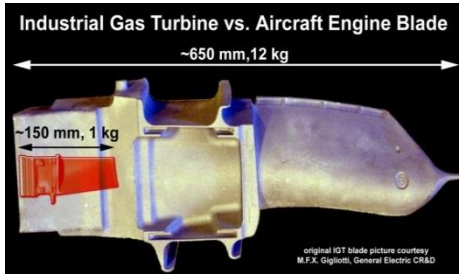
Typical Furnace Data

Cast Weight:	200-500 kg
Mold Dia.:	800-1800 mm
Mold Height:	800-1500 mm

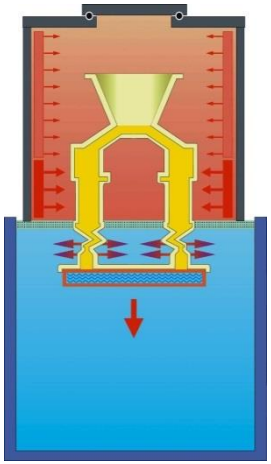
Liquid Metal Cooling Furnaces for the Production of Large DS/SC Components

- In order to achieve acceptable process conditions resp. high thermal gradients for the production of large DS/SC components advanced processes are required > Liquid Metal Cooling (LMC)

Products



Furnace Type VIM-IC 5-20 DS/SC/LMC



Main technical data:

Casting weight:	50-150 kg
Mold Dia.:	800-1000 mm
Mold Height:	800-1500 mm

Melting and Casting of Reactive Materials

- Due to the high reactivity of these materials ceramic-free, water-cooled cupper crucibles must be used in order to avoid reaction between the crucible and the melt.

- For the vacuum investment casting of Ti-alloys in production scale the following furnace types are used :

  LEICOMELT (Leybold Induction Cold Melting)

  and

  VAR-SM (Vacuum Arc Remelting-Scull Melting) furnace.

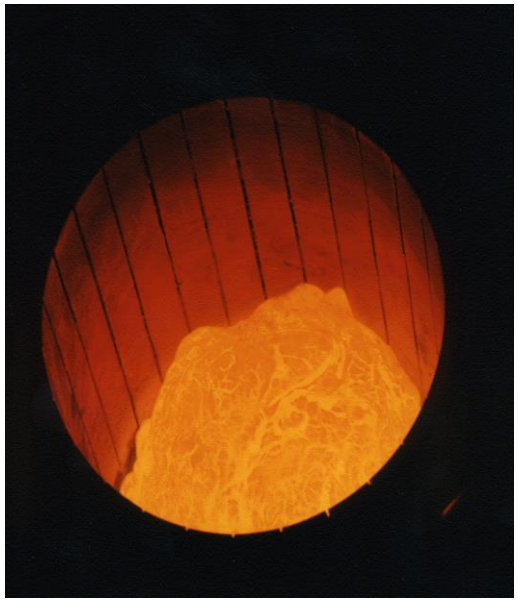
- Typical Materials to be melted:
  Ti-alloys
  TiAl
  Zirconium-alloys
  Memory shape alloys (Ni-Ti)

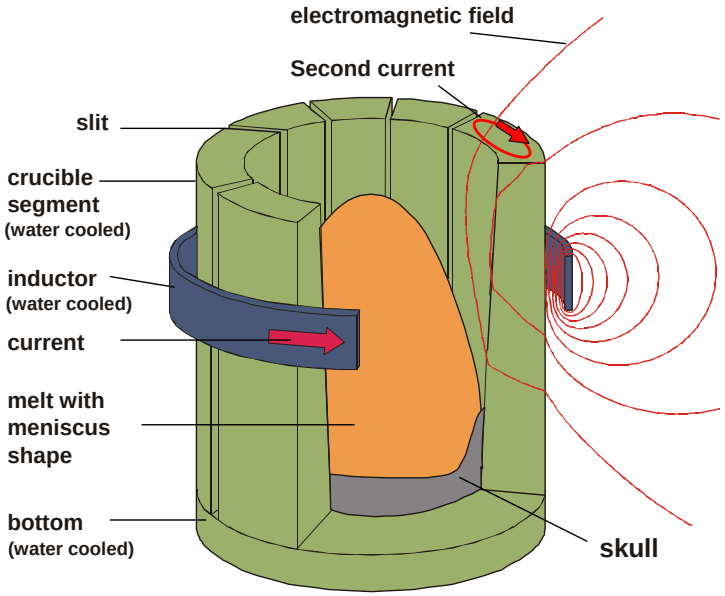
Melting and Casting of Ti-alloys

- The alloys are highly reactive and must be melted under vacuum or inertgas in a water-cooled Cu-Crucible
- Conventional Ti-alloys (Ti-6Al-4V) can be cast into “cold” molds
- TiAL-alloys must be cast into “hot” molds
- Centrifugal casting is in many cases required
- Typical operation vacuum is in the 10^{-2} mbar range
- High safety standards including remote control must be applied due to risk of contact between molten material and water

LEICOMELT (Leybold Induction Cold Melting)

- In the Leicomelt furnace the melting energy is introduced into the material by an electromagnetic field
- Revert material up to 100% can be used
- Excellent thermal and chemical homogenization





Products and Furnaces for Melting and Casting of conventional Ti-alloys (e.g.Ti-6Al-4V)

Products

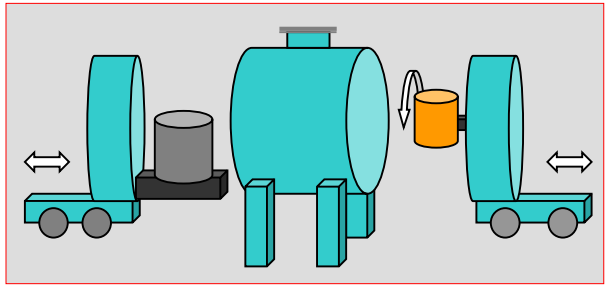
Ti - Golf Clubs

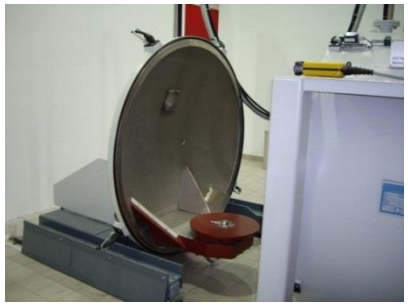
Ti - Orthopedic Implants

TiAl - Turbocharger Impellers

Airframe Parts

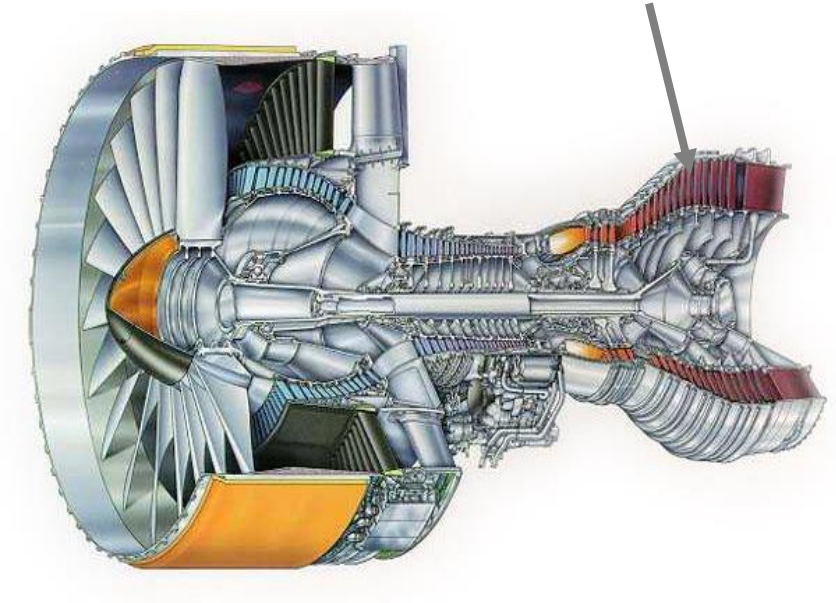
Furnace Type: Single Chamber LEICOMELT 2-40





Typical Furnace Data	
Cast Weight:	5-160 kg Ti-alloys
Mold Dia.:	200-1000 mm
Mold Height:	300-800 mm

Melting and Casting of Ti-Al Turbine Blades for Aircraft Engines

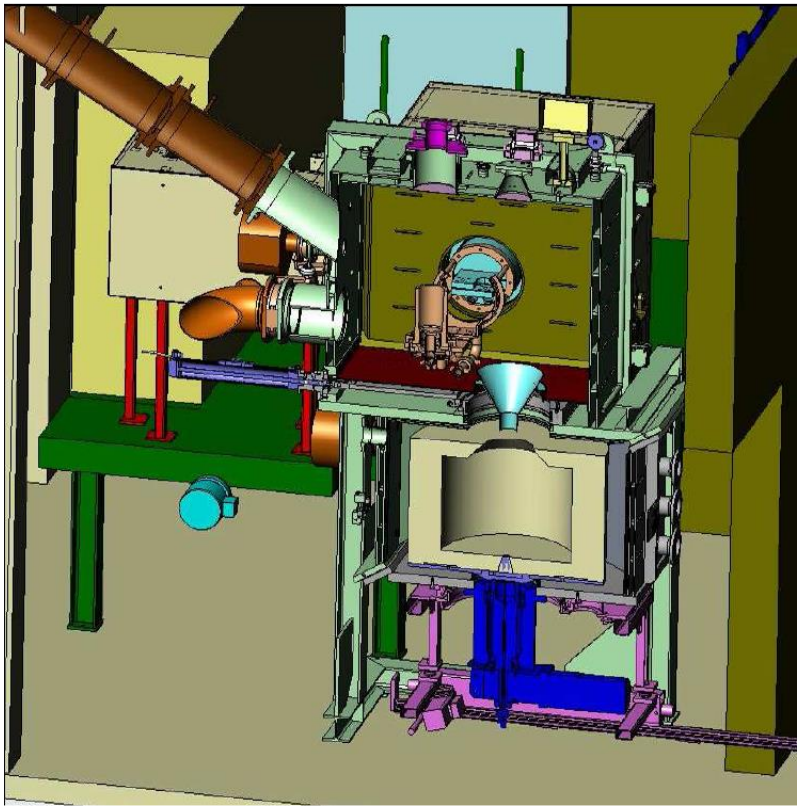


TiAl turbine blades have only 50% of the weight of a super-alloy blade
> weight reduction
> fuel savings

Typical Double Chamber LEICOMELT 5 Furnace for Melting and Casting of TiAl Blades

- Fast lock-in of mold in pouring position (~ 130s)
  > mold remains hot
- Fast lock-out of mold after pouring (~ 130s)
  > excellent control of the component cooling
- Shorter process time > higher productivity

Furnace Capacity: 20 kg
Installed Power: 600 kW

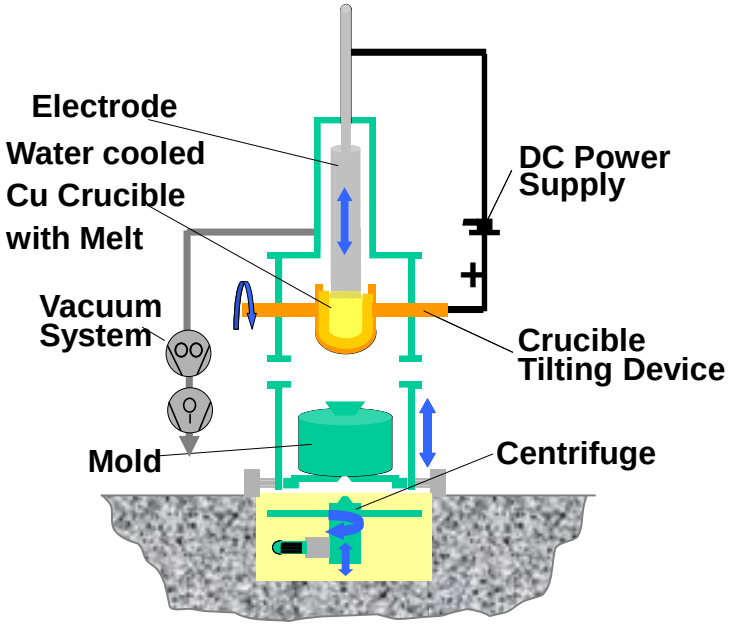


Pouring of a TiAl Alloy

VAR-SM (Vacuum Arc Remelting-Scull Melting furnace.

- In the VAR-SM furnace the melting energy is introduced into the material by an DC Arc between the Electrode and Melt Pool
- The melting efficiency is better compared to the Leicomelt furnace resulting in lower production costs
- An electrode is required
- The VAR-SM is mainly used for larger melt weights

VAR Skull Melter L250 SM



Thank you for your Attention