# General Electric
# Technical call

11/06/2020

# Agenda

## Introduction

O1 – Overview of process capability and capacity

O2 – Raw material

O3 – Hearth melt

O4 – VAR

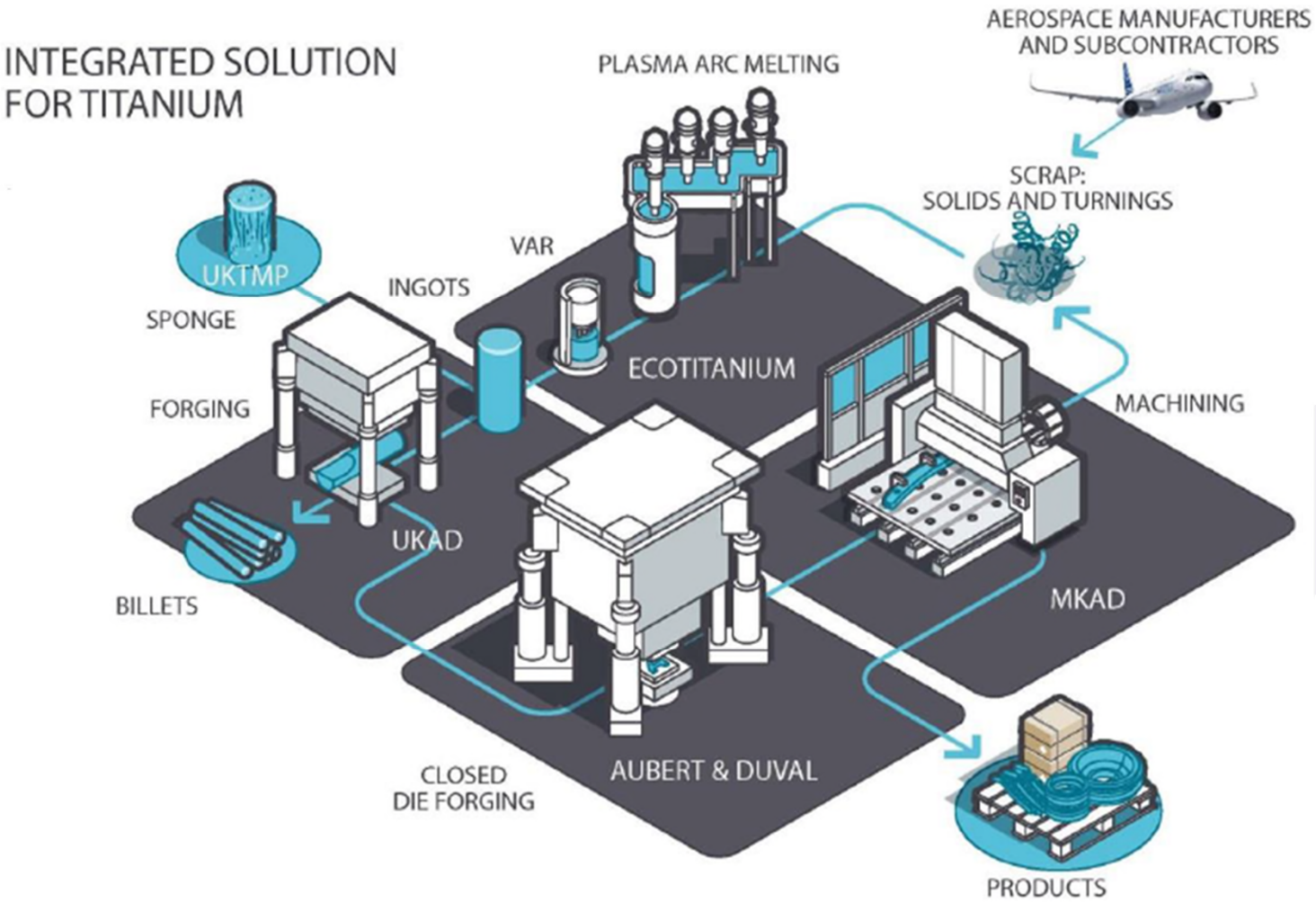
O5 – Conversion

O6 – Inspection

# 01

# Overview of process capability and capacity

# TITANIUM STREAM

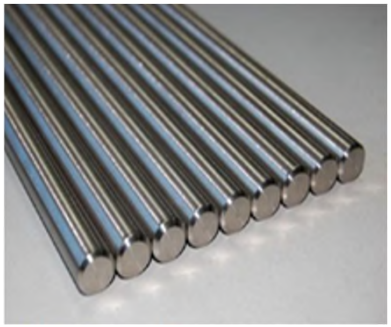


# PRODUCTS AND MARKETS

## OUR PRODUCTS

**Ingots**
from 7 to 10 tons
(6-4 / Cp ingots)

**Blooms and billets**



**Bars, development in progress**


**Closed die-forged** products

## OUR MARKETS AND SOME FINAL PRODUCTS

AEROSPACE

OIL & GAS

DEFENCE

MEDICAL


UKAD

EcoTitanium

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# Grades and markets

- **TI 6-4** — **Airplanes structural parts**
  **Aero Engine fixed parts**
  **Aeronautical Fasteners**
  **Defense**
  **Spatial**
- **TI 6-4 ELI** — **Airplanes structural parts**
  **Medical application**
- **TI 10-2-3** — **Landing gear parts**
- **Grade 2** — **Industrial application**
- **No experience with premium quality**

# Commercial interest in qualifying as a GE PQ titanium supplier

## Development Strategy Aero Engine

Ingot sources available:

- UKTMP from virgin raw material
- EcoTitanium from recycling material

Qualification SQ (Safran) in progress, final and formal approval expected in next weeks.

2018 - 2019:

**TA6V SQ Titanium**

2021 or later

**TA6V PQ Qualification**

2023 - 2025:

**Serial Production of PQ/ DQ TA6V**

2023 onwards :

**Other Alloys Development according to customer opportunities and needs**

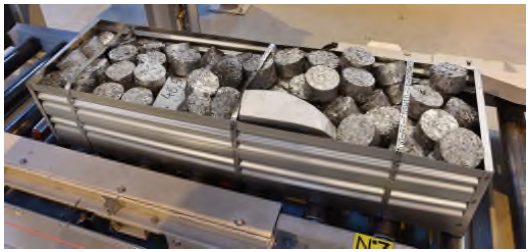
UKAD / Ecotitanium are interesting in PQ/DQ grades, depending on qualification process, associated costs and volumes opportunities.

Capacity which could be dedicated some hundreds to 1 000 metric tons.

# Overview of EcoTitanium process

# Process

- **Scrap preparation to build load**



- **Melting in the plasma furnace: obtaining an electrode**

Ø = 830 mm

- **Remelting in a VAR furnace.**

Ø = 915 mm

- **Finishing, sampling and shipping in UKAD**

# Process: load make up

## Turnings load:

Briquettes:

Ø = 95 mm

Briquettes are transferred in barrels.

Key points :

- Traceability with RFID or bar-code.
- All equipment are with cover to avoid cross contamination.
- Chemical homogeneity ➔ load divided in batches of 200 kg, then divided in mini-batches of 25 kg.

# Process: load make up

- **Solids load:**

Key points:

- Solids are placed in consumable Titanium CP boxes.
- Traceability with RFID or bar-code.
- No crane in this shop to avoid cross contamination.
- Chemical analysis ensure by addition of briquettes.

# Process: plasma furnace

- **The plasma furnace represents 800 t of material and equipment, established on an area of 25 m x 20 m.**

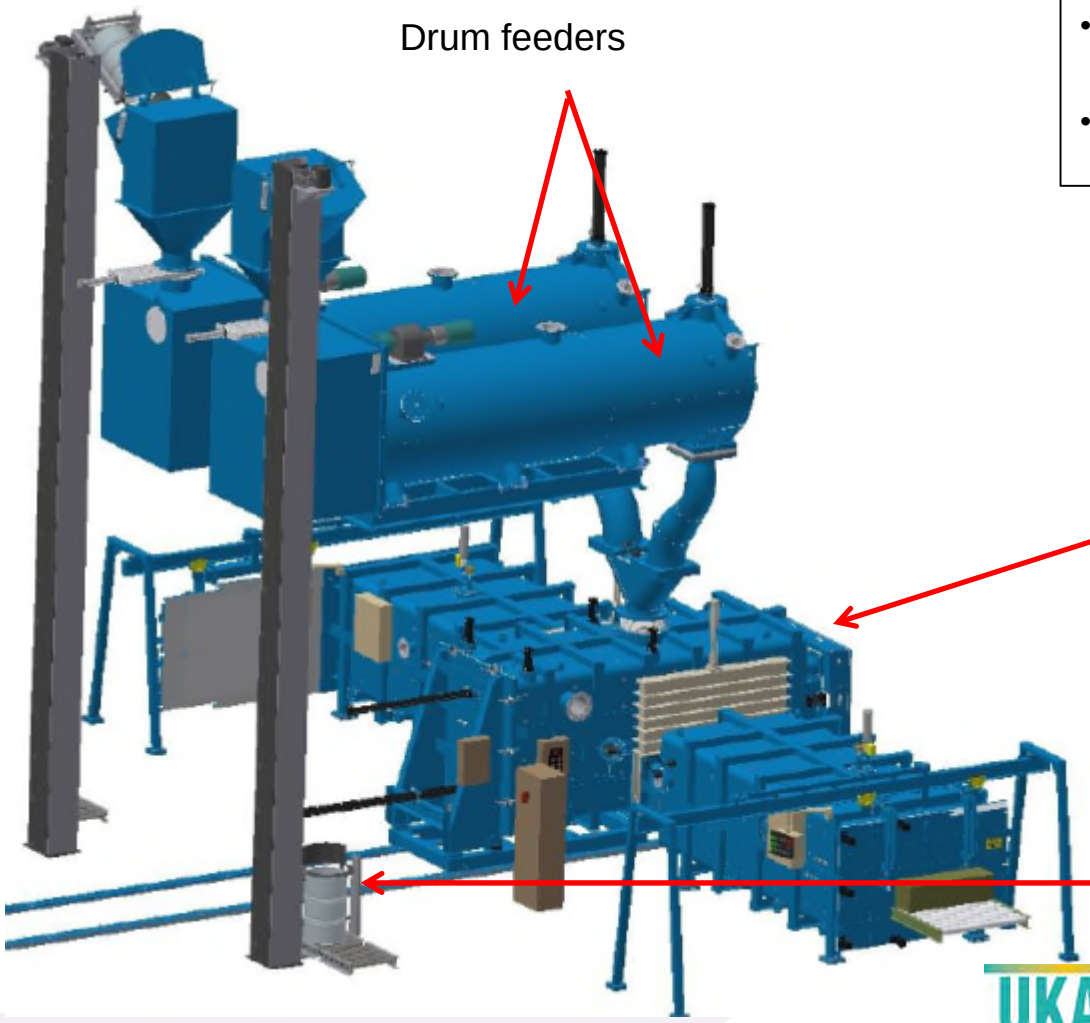
RETECH furnace


Key points:

- Low helium pressure ➔ thermal efficiency.
- Cold hearth on a cart ➔ easy cleaning.
- No water pipes disconnection when opening furnace ➔ no risk of water leak.

# Process: plasma furnace

- **Briquettes load:**




Key points:

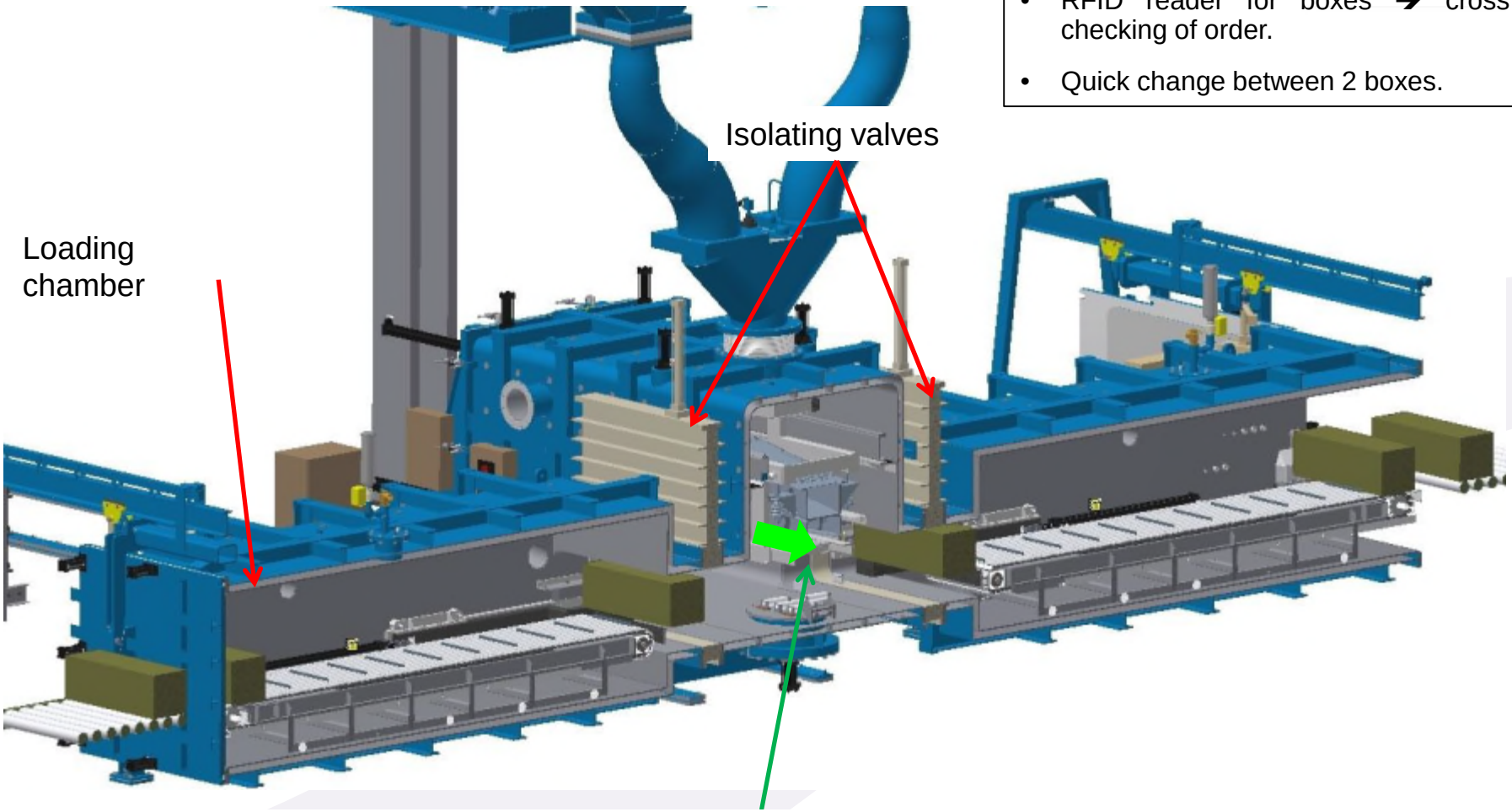
- RFID readers for barrels ➔ cross checking of order during loading.
- Protection against contamination during loading.

# Process: plasma furnace

- **Solids load:**

Key points:

- RFID reader for boxes ➔ cross checking of order.
- Quick change between 2 boxes.

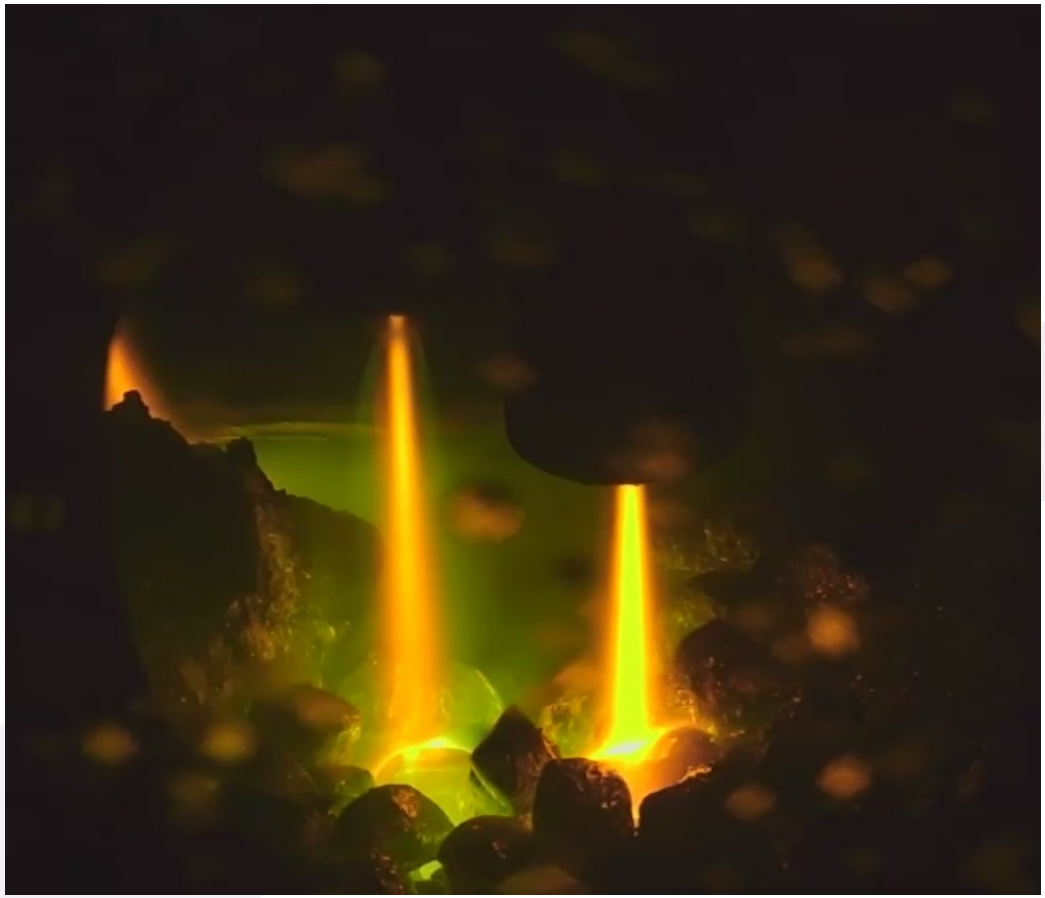


# Process: plasma furnace

- **Scrap melting in a water cooled copper hearth:**

Key points:

- 5 torches with high power ➔ better for inclusions dissolution.
- Furnace steering with a recipe transferred by IT system.

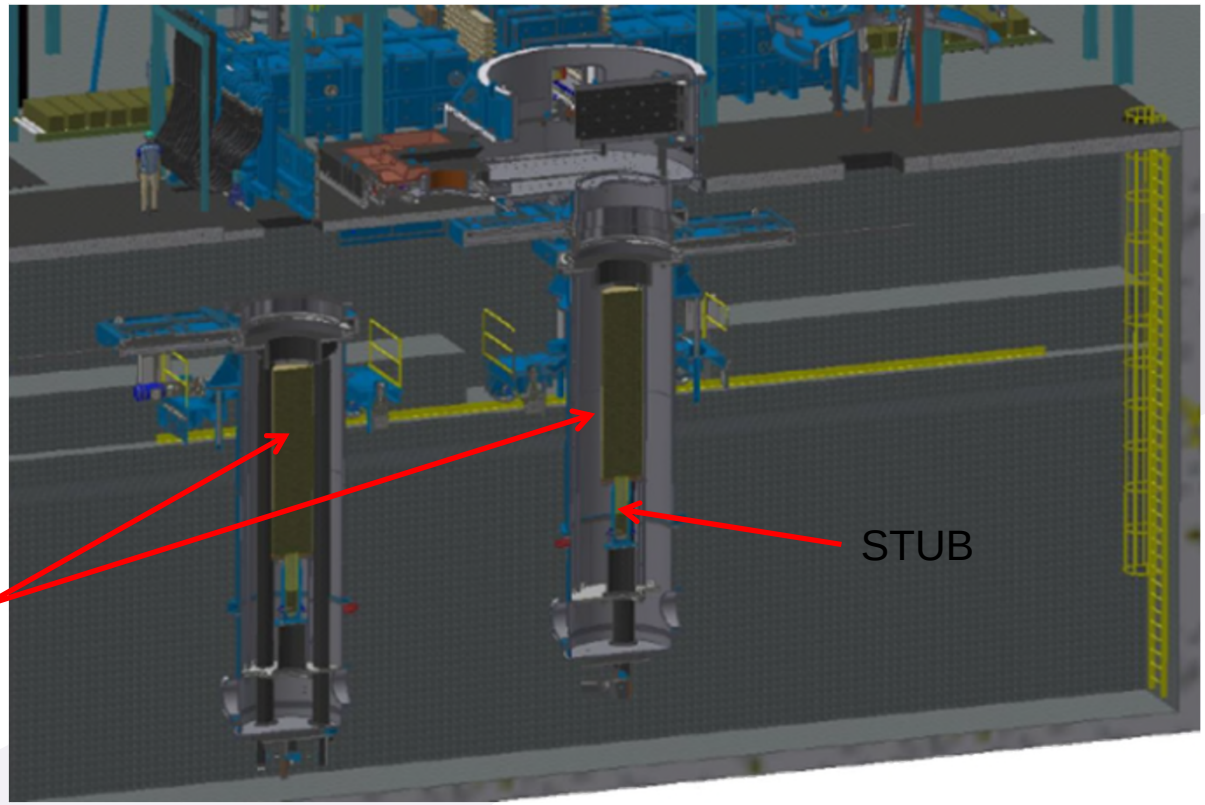


# Process: plasma furnace

- **Withdrawal chambers: VAR stub installed in the withdrawal base plate, before the plasma melting ➔ at the beginning of the casting the first liquid metal is welded with the stub. Stub welding in VAR is thus avoided. A&D applied a patent for this method.**

Key points:

- Good concentricity between stub and electrode ➔ better centring in VAR.
- No stub welding in VAR ➔ no risk of quality.



# Process: plasma furnace

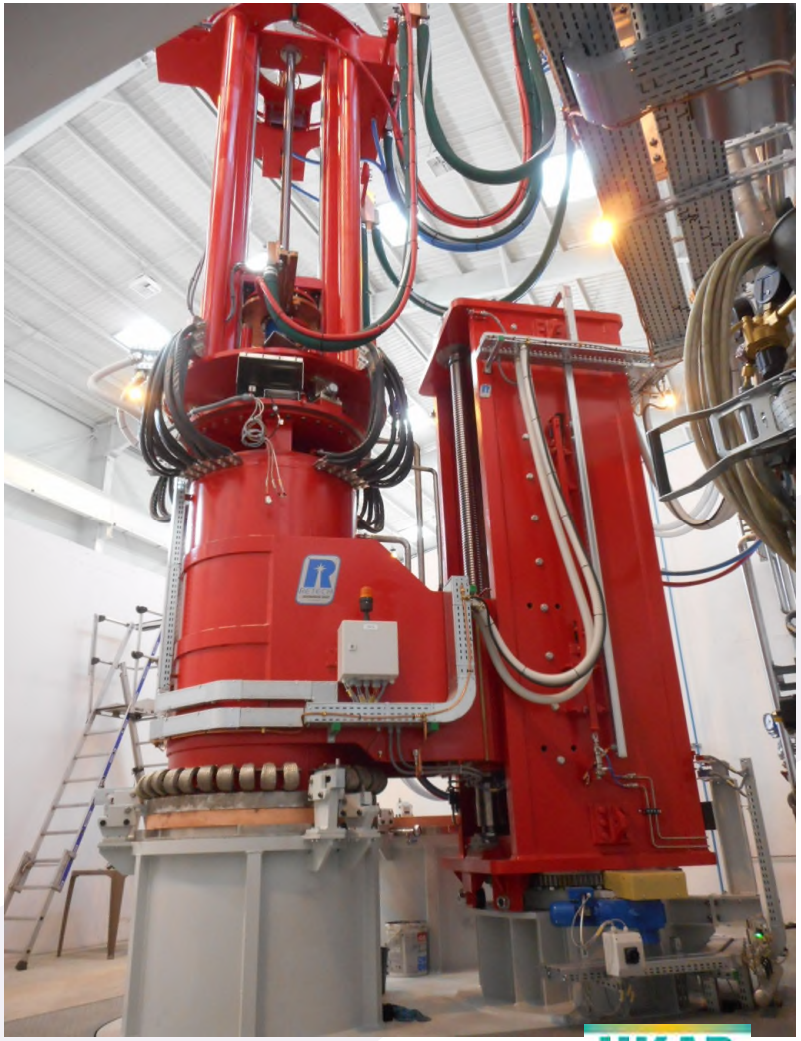
- **Helium recycling unit: coupled with the plasma furnace, a unit to process the helium gas guarantees the gas purification:**
  - > Removal of the undesirable gases (O2, H2, N2) and moisture.
  - > Removal of dusts and chlorine from sponges.

Key points:

- Chlorine removal ➔ no corrosion.
- High level of supervision.

# VAR melting

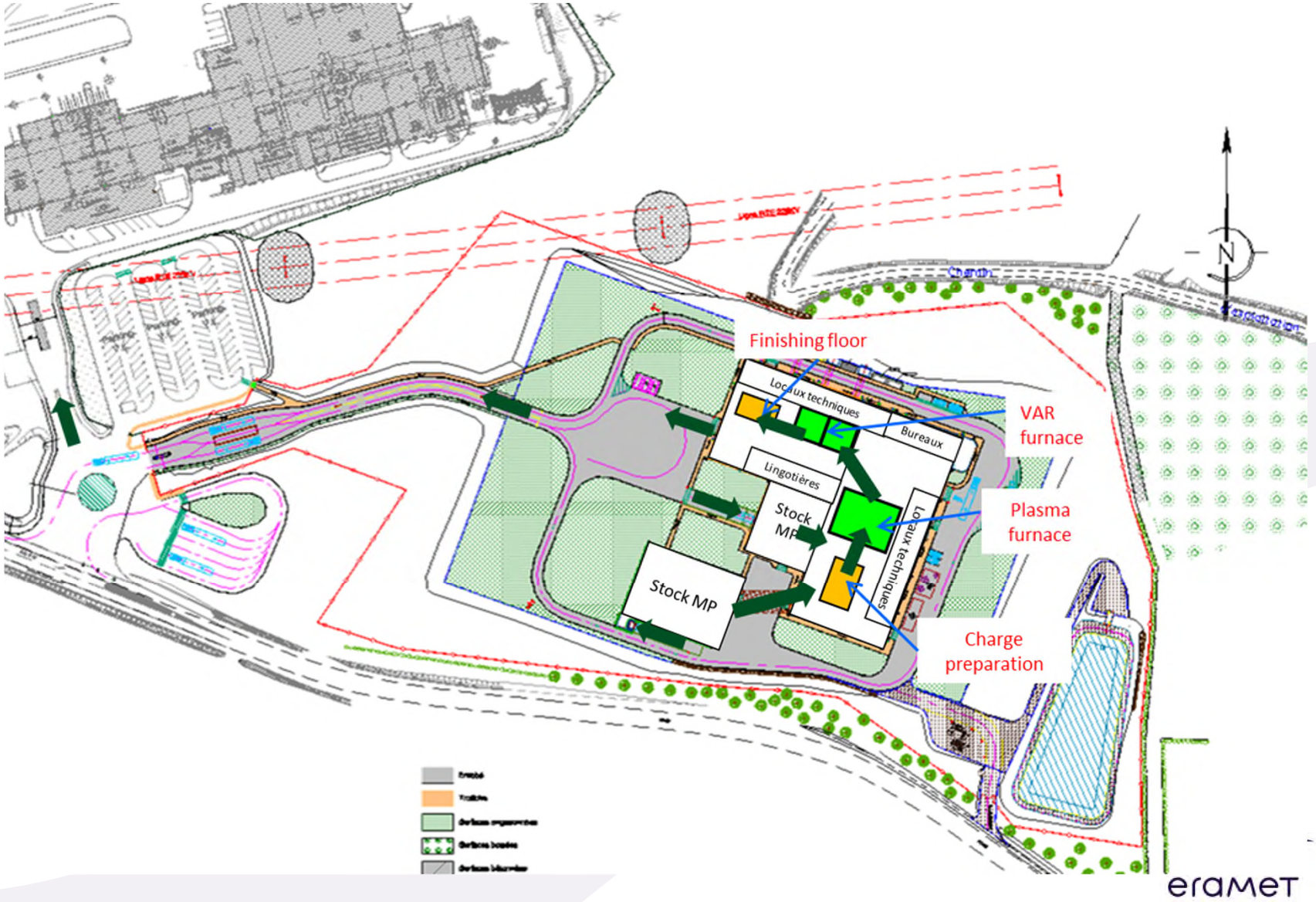
- **2 VAR furnaces:**



Key points:

- Robust conception.
- A&D requirements (easy cleaning…).

# Detailed process flow



# Contamination prevention practices

- **PQ oriented workshop :**
  - Protection on our critical equipment to avoid cross contamination
  - No crane in the raw materials storage areas
  - Implementation of areas with restricted access (WBU, PAM, VAR).
- **Regular awareness for the EcoTitanium employees to the risks of cross contamination.**
- **Awareness to the areas with restricted access for the EcoTitanium employees and subcontractors working in the workshop**
- **Dense metals are prohibited on site or used under authorization :**
  - No ballpoint pen containing tungsten in workshop
  - Procedure to change the tungsten bulbs in the workshop
  - No WC tools used for production (HSS tools for sampling)
  - WC tools used under authorization if necessary with recording and control
  - TIG welding performed by only one person (electrodes in a closed suitcase) : control and records before and after use.
  - Torch cut only under authorization if necessary with recording and control

# Overview of UKAD process

# UKAD PROCESS

**Ingots**


2 sources :
- UKTMP
- ECOTITANIUM

Operations subcontracted to Aubert & Duval

➔ **UKAD :**

- Ingots from 7 (titanium) to 18 t
- Blooms and billets (round) from 80 to 430 mm in Ø and 4 to 6m long and rectangular bars.

# UKAD LAYOUT

Stationary hearth furnaces

Peeling

Sawing

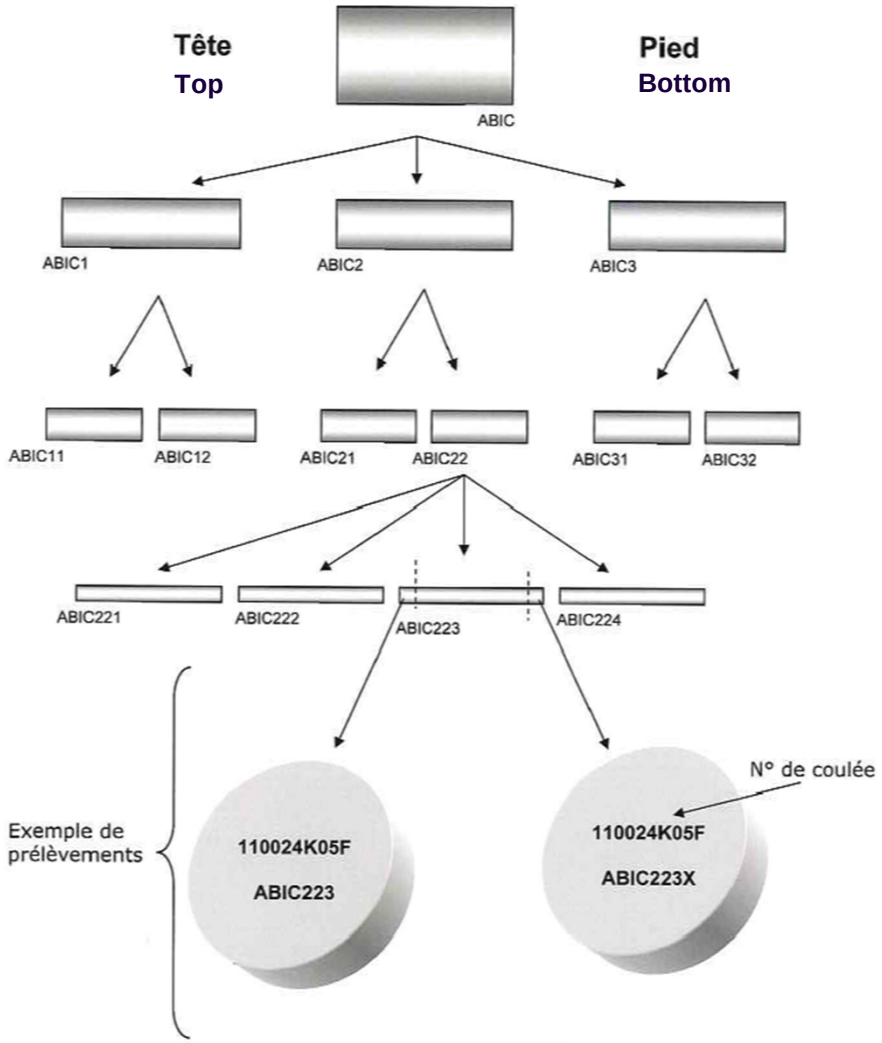
Forging press

Grinding

Ultrasonic

Mobile hearth furnaces

# UKAD MATERIAL IDENTIFICATION



02

# Raw materials

# Raw materials

## Raw materials suppliers :

> Ti Sponges : UKTMP,
> Master alloys : GFE, AMETEK.

## Materials inspection :

> Inspection realized by suppliers,
> EcoTitanium :
  - Procedure to inspect material before use (PQ03) : damages on the containers, seal on the drums, foreign particles on the top of the drum
  - Qualification of suppliers : audit, cross contamination risk assessment, counter-analyses.

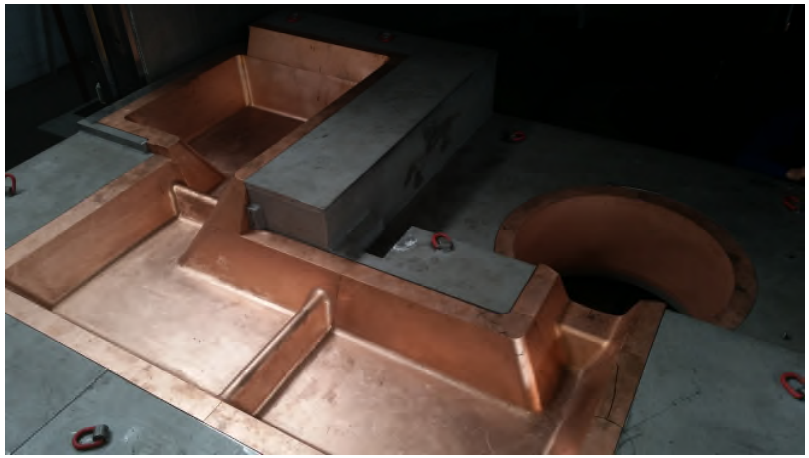
## Blending and compaction :

> Realized on EcoTitanium's WBU
> Equipment with cover to avoid cross contamination
> Weighing of raw materials according to a chemical recipe
> Blending
> Compaction in compacts around 1kg with record of compaction pressure for each compact.

# 03

## Hearth melt

# Hearth melt



## Hearth capacity

> Nominal capacity = 4200 t of electrodes per year

## Furnace:

> Type : PAMCHR furnace,
> Manufacturer : RETECH
> Hearth design : RETECH design with 2 refining areas
> Torch movement : assistance of PAM experts to determine pattern movements
> Parameter controls :
- Melting rate,
- He pressure in each chamber
- Torches parameters (movement, current, voltage, power, pattern #)
- Gases content in the Helium before and after recycling unit : %H2, %N2, %O2.

## Seeded heat trials:

> Realization of simplified seeded trial for Airbus with only HDI : ongoing
> R&D experience on pilot PAM furnace
> Residence time : not measured but frozen process for standard application (max melting rate, torches pattern) to avoid process variations ➔ no detected inclusions with frozen process (108 tons inspected).

# 04

## VAR

# VAR

## VAR capacity

> 2000 t with one furnace

## Electrode / Ingot:

> Max electrode length : 4000 mm for a 830 mm diameter
> Max ingot length : 2600 mm for a 910 mm diameter
> Max ingot weight : 7500 kg

## Furnace:

> Manufacturer : RETECH
> Age : 3 years
> Parameter controls:
  - Leak test before remelting
  - Pressure in the furnace during remelting
  - Remelting rate, current, voltage
  - Hot topping
  - Weight of the biscuit.
> Stub welding : stub welded in the PAM furnace at the beginning of the melting – stub is a part of the baseplate in the PAM furnace.

05

# Conversion

# SOURCES OF RAW MATERIAL

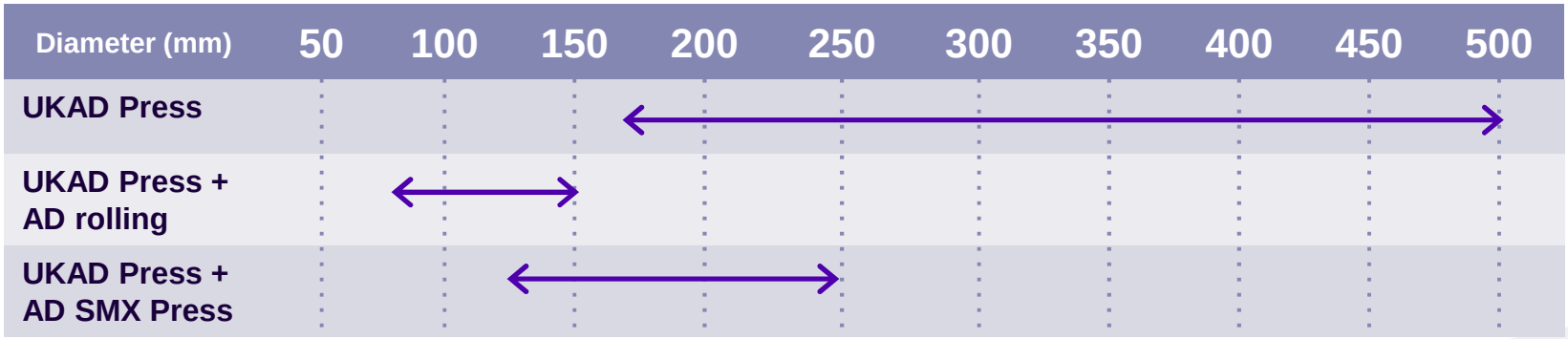
2 sources :

- UKTMP

- ECOTITANIUM

Compliant with internal specifications called STMU

# Size range and experience by alloy



# A history of production

Since UKAD's startup date of 2013 UKAD has produced 12 000 tons (metric tons) Ti 6-4 billets.
Production according to AMS 4928 and other customers specifications.
Additionally UKAD produced 2 650 tons (metric tons) blooms for fastening applications towards US companies.
Ingots are produced by UKTMP.

Eco Titanium is in the final phases of qualification with Safran and Airbus.
Eco Titanium is presently producing and selling ingots according to AMS 4928: 500 metric tons since our first delivery in 2018 towards or through UKAD.

# Furnaces

Today, to supply its press, Ukad has :

- **5 gas furnaces**
  - 4 with 40t max load
  - 1 with 90t max load

- **3 electric furnaces**
  - 3 with 40t max load

They are heating furnaces for forging, **Class 4 from AMS 2750**.

Temperature are monitored and recorded for all products and at each heating step.

Heat treatment is done by subcontractors (A&D Les Ancizes or Bodycote) in furnaces with Nadcap certification and according to MIL-H-81200.

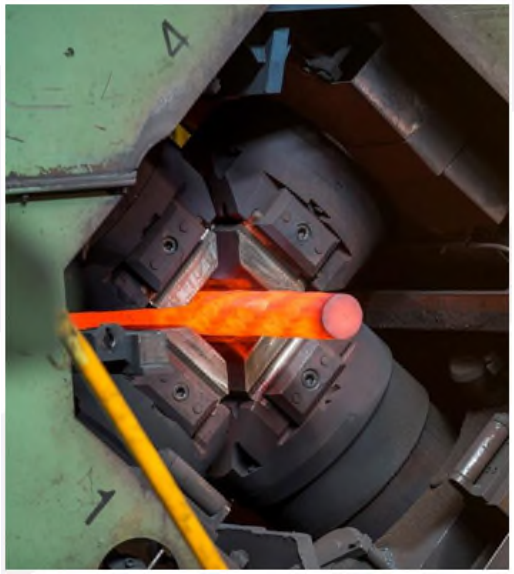
# Press and rotary GFM equipment

**UKAD press**

4500 T Hydraulic press
With 2 manipulators

**Aubert&Duval SMX rotary equipment**

Hydraulic press with 4 hammers



UKAD EcoTitanium eramet

06

# Inspections

# Inspection capacity

UKAD uses the A&D Les Ancizes laboratory for all destructive testings.

- **Macro etching** is done with MAC21 (chlorhydric fluorhydric) according to AMS2380. Blue etch anodize could be done by subcontracting.

- **Chemistry analysis** done on samples from ingot and for example according to AMS4928.

**- Mechanical testing**
Tensile test on slice done according to ASTM E8/E8M

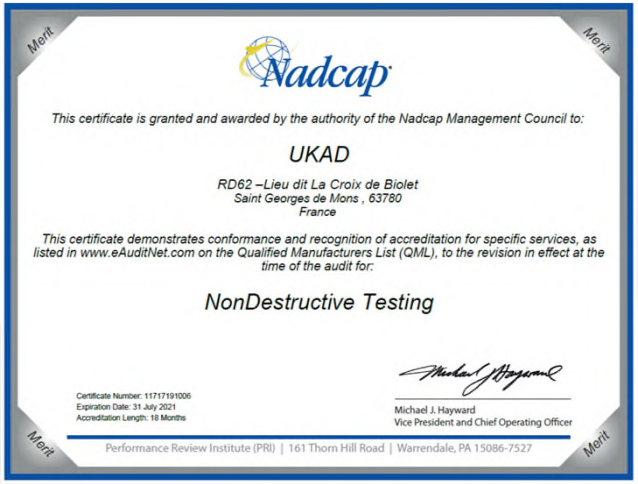
- **Beta transus** determination on billets done today according to EN3684

# Inspection : ultrasonic inspection

UKAD : Phased Array ultrasonic inspection.
Supplier : OLYMPUS
UT electronic : QUICKSCAN

For inspection of billets diameter 80 to 430mm and length of 7m

Nadcap agreement with Merit.


Nadcap

This certificate is granted and awarded by the authority of the Nadcap Management Council to:

UKAD

RD62 –Lieu dit La Croix de Biolet
Saint Georges de Mons , 63780
France

This certificate demonstrates conformance and recognition of accreditation for specific services, as listed in www.eAuditNet.com on the Qualified Manufacturers List (QML), to the revision in effect at the time of the audit for:

NonDestructive Testing

Certificate Number: 11717191006
Expiration Date: 31 July 2021
Accreditation Length: 18 Months

Michael J. Hayward
Vice President and Chief Operating Officer

Performance Review Institute (PRI) | 161 Thorn Hill Road | Warrendale, PA 15086-7527

A&D Les Ancizes :
Immersion method, multi zone equipement for Ø 80 mm to 450 mm, and length max 7m.

**Special Processes:**

| Process Code | Name of Process | Category | Specification Approvals |
|---|---|---|---|
| AF | Inspection, Ultrasonic | 2 | AF01; AF04; P3TF52 CL-A, CL-B; P29TF82 CL-A, CL-B |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