Hot Forming of Titanium Alloys:
Industrial Solutions for Efficient Manufacturing

Titanium Europe 2018

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Introduction
Aries Alliance – Key Facts

4 Industrial Companies
6 Service Companies

140 M€ Sales
300 employees
95% Aerospace Business
Aries Alliance – Corporate Overview

Machine Manufacturing

- ACB unit
- Cyril Bath unit
- Dufieux unit

Part Production

- Aries Manufacturing
  - ACB unit
  - Cyril Bath unit
  - Dufieux unit

Customer Support

- China
- Canada
- Russia
- United Kingdom
- Singapore
- Japan
Aries Alliance – Process Capabilities

- Hot Forming
- Superplastic Forming
- Cold Stretch Forming
- Panel Milling
- Elastoforming
- Linear Friction Welding
- Hot Stretch Forming
Primary Applications for Titanium

- Sheet and profile forming
  - Increasing demand for structural & engine parts made from titanium (NEO & MAX families, LEAP...)

- APU Exhaust
- Pylon
- C-frame
- Windshield « cap »
- Engine Exhaust
- Air Inlet Structure
- Leading Edge & Fan Blade
How to Form Titanium

Yield stress is very high at room temperature BUT decreases as it is heated to higher temperature

Forming at high temperature
• Reduced flow/yield stress by factor 100
• Better bending ratio (up to 1)
• No springback
• No residual stress
Forming and Joining Processes

Titanium Application
• Developed for the aerospace industry in the 70’s for military aircraft applications

• Technology based on gas pressure at high temperature

Forming temperature: 870 – 920°C
Cycle time = 120 min

Gas inlet

Vacuum/sweeping/air outlet
Superplastic Forming

SUPERPLASTIC FORMING FEATURES & BENEFITS

- High elongation
- High formability
- Forming of large & complex parts in 1 operation
- Assembly reduction & weight reduction

COMPONENTS EXAMPLES

- Fuselage part
Hot Forming

Process developed after SPF

Mechanical action of punch and die
- Homogeneous thickness
- No spring back
- No residual stress

Forming temperature: 650 – 730°C
Cycle time ≈ 30min (heating time included)
Hot Forming

HOT FORMING FEATURES & BENEFITS

- Low elongation
- Short forming cycle time
- Low thickness dispersion
- High productivity

COMPONENTS EXAMPLES

- Pylon part
- Nacelle part
- Wing part

Nacelle part

Pylon part
Linear Friction Welding

LINEAR FRICTION WELDING FEATURES & BENEFITS

- No melting (Solid State)
- Narrow heat affected zone
- Minimal joint preparation
- Easy to automate
- Very repeatable
- Excellent mechanical properties
- High productivity
- Guaranteed process quality

COMPONENTS EXAMPLES

Machined from a block
Machined from linear friction welded part

Savings 51%
Linear Friction Welding Video – Ti64 coupons
Hot Stretch Forming

HOT STRETCH FORMING TECHNOLOGY BENEFITS

- Material saving
- Cost & time saving effective
- Process management
- Buy-to-Fly ratio
- Cost reduction
- Consistent quality

COMPONENTS EXAMPLES
Core Manufacturing Capabilities
How to solve the increased aircraft rate demands for titanium products?
Hot Forming Process Flow-Chart

1. BLANK PREPARATION
2. HOT FORMING
3. 3D TRIMMING
4. INSPECTION
5. FINISHING
6. CHEMICAL ETCHING
Case-Study: Hot Forming Turn-Key Workshop

- Hot Forming workshop dedicated to titanium parts
  - 5 presses with tool preheating furnaces, cooling cocoon and part handler
  - 1 Mantis machine for 2D/3D trimming
Titanium part 3D trimming and drilling - MANTIS
Case Study: Hot Forming Workshop - Layout

- **QUALITY**
  - 3D TRIMMING & DRILLING
  - FINISHING & FINAL INSPECTION
  - CLEANING & INSPECTION
  - FORMING
  - TOOL STORAGE & PREPA
  - BLANK PREPA
  - MATERIAL STORAGE

- **FINISHED PARTS**
  - ETCHING LINE
Case Study: Hot Forming Workshop - Flow Analysis

1. Material storage
2. Blank preparation
3. Stop-off
4. Forming
5. Cleaning
6. Inspection
7. Quenching (for some aluminum)
8. 3D Trimming & Drilling
9. Sand Blasting (for titanium)
10. Chemical Etching (for titanium)
11. Penetrant Inspection
12. Finishing
13. Dispatch
Press Production Capacity - Standalone

- **Hot Forming** production campaign – Based on 20 parts / campaign

- Production capacity for one HF press $\approx 3100$ parts per year.
  
  (Hypotheses: 240 working days per year, 3 shifts, 30 min cycle time)
- Hot Forming production campaign associated to a die pre-heating furnace and a cooling cocoon

- Production capacity for 20 parts≈ **7000 parts per year.**
  (Hypotheses : 240 working days per year, 3 shifts, 30 min cycle time)

125% INCREASE IN PART VOLUME
Automatic storage unit & AGV
Improve safety transfer & reliability, quality for storage

Part/die handling system & robot assisted operation
Improve safety transfer & loading for both operator & part

Machine screen monitoring
No paper solution, bottom-up production data transfer

Overall production monitoring system
Digital solution for better control

Mechanical 2D/3D trimming automatic loading
Greener & faster than chemical process

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Conclusion
Opportunities for the future

- Increasing demand for titanium parts

- Hot Forming technologies to answer technical requirements

- Traditional production management replaced by «smart factory model»
  - Significantly increase production rate and quality

- Need for change regarding surface treatment
  - REACH

Factory of the future
Thank you for your attention!