Hot forming of titanium

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• Key technology:
  • **hot:** Super Plastic Forming, Diffusion Bonding, combined SPF/DB, Hot forming, Hot drawing
  • **cold:** Deep drawing, Bending, etc.

• Branches:
  • Aircraft
  • Aerospace
  • Engines
  • Automotive
  • Medical
  • General Ind.

• References:
  • Rolls Royce
  • AIRBUS
  • AIRBUS D&S
  • Turbomeca
  • HEGGEMANN
  • PFW
  • MT Aerospace

• Products:
  • Production with small to big batch sizes
  • R & D, Bilateral, Partner in EC FP´s, Feasibility, Prototyping

• Materials:
  • Magnesium, Aluminium, Titanium alloys e.g. Ti 6Al4V, Ti15-3-3-3, β 21 S, Ti-Al, etc, Steel e.g. 1.4462, Nickel alloys

• R & D Projects:

Our quality management system is monitored according to EN 9100 and according to the quality requirements of eaqg EASE rules and regulations approved.

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Processes and applications

**Hot forming/ calibration**
- brackets, clips etc., Ti6-2-4-2, Ti15-3³, TiAl

**Hot drawing**
- duct halves, hybrid parts/door surrounding etc., CpTi, Exhaust XT, Ti3-2.5, Ti6-4, Ti6-2-4-2

**Gas pressure forming/ SPF**
- Struts, hemispheres, thermal shields

**Diffusion Bonding**
- Leading edge with erosion-retardant inlay, near-net shape parts, etc.

**DB / SPF**
- noise reduction, laminar flow, etc

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Hot forming offers important cost-reduction by material saving.
→Better buy-to-fly ratio
Process cycle time reduction
Titanium alloys are hot-formable at lower $T > 650^\circ C$ with less surface degradation
Hot forming of e.g. Mg-, Al- and Steel alloys possible as well

Advantages

• Near-net-shape parts with constant wall thickness
• ~ no residual stress
• ~ no distortion during trimming
• Cycle time much shorter as with SPF and mid to large strain
• Cost savings for big quantities
Hot Gas Pressure Forming/ SPF

Hot process at ~750 to 900°C and controlled strain rate allow some x00% of strain
Complex geometry. One-step operation
Relatively simple tooling
Forming is done with a shielding gas, e.g Ar for Titanium
Parts are net-shape
Just trimming and usually no further machining required

Advantages

• SPF and HGPF processes are good for complex shape with hi-strength alloys
• Initial wall thickness with very thin gauge, e.g. 0,1mm up to very thick gauge, e.g. >20mm possible
• No residual stress → no spring back
• Relatively low tooling cost
• No final machining in 3D necessary

• SPF/HGPF for complex shape with Hi-strength alloys

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Typical SPF/ HGPF-Sample Geometries

- Stützstange, Ti 6-4
  - t = 7 mm

- Wave structure for heat exchanger 1.4462, 0.15 mm

- Aircraft housing, Ti 6-4 and CRES

- Fuel cell anode plate: 1.4462, 0.1mm

- Bleed Air Duct Ti SP 700

- ARIANE V
  - Hemispheres Ti 6-4

- Functional duct,
  - Steel or Titanium

- Hemisphere Submarine, Ø = 400mm, Ti6-4, s₀ = 20mm

- Medical Implant Ti 6-4 ELI
  - t = 0.2-0.4 mm

- Racing car: Heat shield Ti6-4,
  - S=1,0 mm ; 600 mmx 450 mm

- Helicopter cover Ti 6-4

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Titanium

~Ti 6-4, BT6, BT6-S, Ti6-2-4-2, β 21 S, SP 700
  - Ti 6-22-22, Ti15333, Ti-MMC, CpTi, etc

Ti-Al

~gamma TiAl, TMB

Nickel

~IN 718

Steel

~1.4462, Lean duplex, etc.

Aluminium

~AA 5083, 7475, etc.

Magnesium

~AZ 31, MA 2-1, etc.

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Diffusion Bonding (DB)

DB is an established process to join metallic materials in solid state with resulting base materials’ strength and integrity.

Single parts are pressed together under elevated temperature and the specified cycle time. The matching surfaces join by diffusion of solids.

DB is applicable both for Titanium, steel et al.

Advantage:

- Creation of complex channel structures, e.g. heat exchangers made from micro-etched foils or plate material
- DB joints may be: Point/ line/ large surface, thin/thick, dissimilar matls., Perforated sheets/ meshes
- Near-net-shape parts built-up from solid details for scrap reduction
- Better efficiency and parts’ functionality

Contact Deformation Start of Diffusion Volume diffusion

Micro-heat exchanger made of single foils, t ~0,4mm

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SPF/DB - Lightweight structures

SPF-DB parts are built from single sheets joined by DB and inflated by SPF. SPF-DB parts offer lightweight, sandwich-like construction.

**Advantages**
- Weight reduction and performance optimisation
- Cost reduction

**Applications**
- Hollow fan blades, guide vanes etc.
- Integrally stiffened ducts
- Noise reduction
- Thermal insulation
- Laminar Flow Control
Thank you very much for your attention
Vielen Dank für Ihre Aufmerksamkeit

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