Hot Forming

Diffusion Bonding

Cost-effective sheet metal forming Titanium alloys for new types of aircraft

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AVIAINVEST, Riga, 2014, April, 10 and 11

- **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, e.g.:**
  - Rolls Royce D and UK
  - AIRBUS Defence, Space, Aircraft, Helicoptres D
  - Turbomeca
  - HEGGEMANN
  - GMT
  - PFW

- **Products:**
  - Production of sheet metal products from very small to very big lots
  - R & D: Bilateral industrial for feasibility & prototyping, national and EC FP´s

- **Materials:**
  - Titanium alloys e.g. Ti 6Al4V, Ti15-3-3-3, β 21 S, Ti-Al, CRES e.g. 1.4462, Nickel based alloys, e.g. IN625, 718(Magnesium, Aluminium)


ASD-EASE

ASTRIUM

Statement of Assessment

Company Name	:	FormTech GmbH
Address	:	Mittelwendung 35
Site	:	D-28844 Weyhe
Assessed activities	:	Metal forming/super plastic forming (SPF)
Assessment Date	:	31.05.2011
Assessment Standard	:	EN 9100:2003 (without design)
Quality System Scoring	:	96,0

The assessment of the Quality Management System was performed by ASTRIUM Space Transportation, Leading Assessing Company of the EAQG EASE Association, in accordance with the EAQG EASE rules.

Ref.: ASSESSMENT REPORT AST 003/11

Member Company Audit Manager — *Lead Auditor*

Issue Date : 30.06.2011

FormTech is fully certified following EN 9100

- **R & D Projects:**

MST Aerospace GmbH Systemanalyse und Strategieberatung

OPTiSTRUCT

HORTIA Heat and Oxidation Resistant Titanium Alloys Applications

Ti-Bond

CoolTiTech

FLEXFORM

FRIENDCOPTER

General market situation

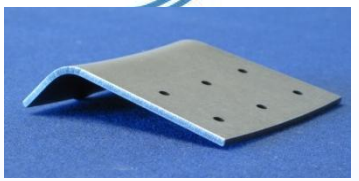
- FT´s mission:
- Provide the market with sheet metal products from „hard“ metals, e.g. Titanium-, Nickel based alloys and corrosion resistant steel (CRES)
- Benefit/ added value for the client
    - Functionality
    - Weight reduction
    - Cost reduction

- SME´s got under pressure from OEM´s global purchase strategy
- Clusters are suitable instruments for networking, fund-raising and creation of international contacts

Processes, applications, current highlights

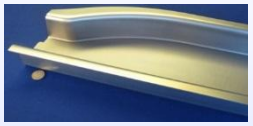
Hot forming/ calibration

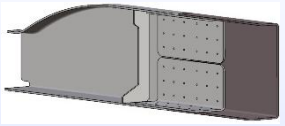
→ brackets, clips etc., Ti6-2-4-2, Ti15-3[3], TiAl

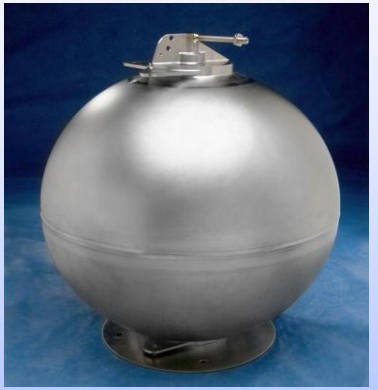


Hot drawing

→ duct halves, hybrid parts/door surrounding etc., CpTi, Ti3-2,5, Ti6-4, Ti6-2-4-2





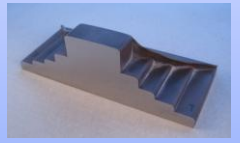


Gas pressure forming/ SPF

→ Struts, hemispheres, thermal shields

Diffusion Bonding

→ Leading edge with erosion-retardant inlay, near-net shape parts, etc.



DB / SPF

→ noise reduction, laminar flow, etc

Hot calibration and hot forming

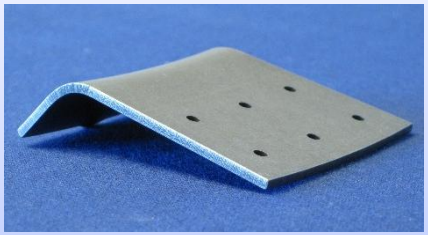
Hot calibration starts from preformed parts →reducting of residual stresses and calibration of final geometry
Hot forming starts from flat blank. Forming and calibration is done in one cycle.

Geometry not possible with ambient temperature forming

Titanium alloys are hot-formable at T > 650°C

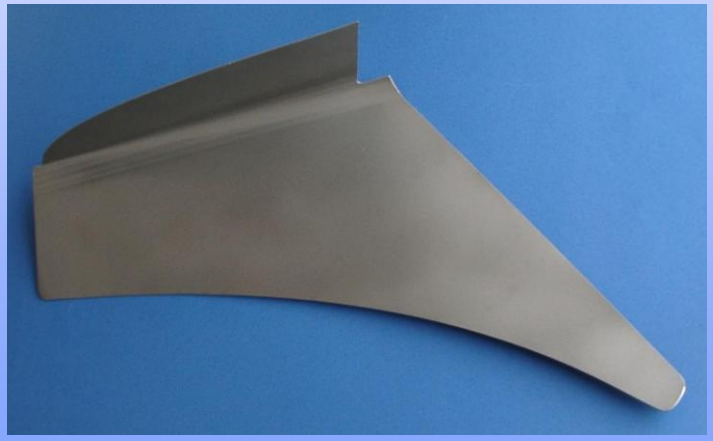
No/ very little surface degradation → Possible to avoid chem-mill/ acid flash pickling

Hot forming of e.g. Mg-, Al- and Steel alloys possible as well



<u>Advantages</u>

- Near-net-shape parts with constant wall thickness
- ~ no residual stress
- ~ no distortion during trimming
- Cycle time much shorter as with SPF
- Cost savings for small to big quantities



Hot deep drawing

Hot deep drawing starts from flat blank

Parts have constant wall thickness

Important cost-reduction by material saving.
→Better buy-to-fly ratio

Process cycle time short

Tool more expansive → blankholder

Titanium alloys are hot-formable at T > 650°C

Surface degradation can be about ~nil

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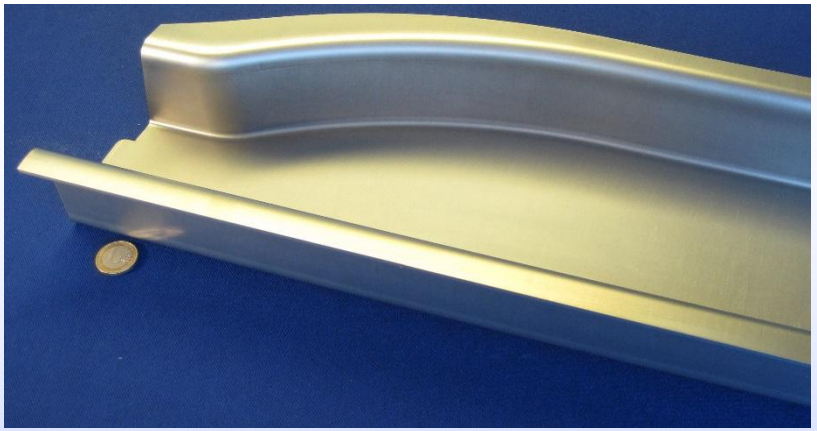

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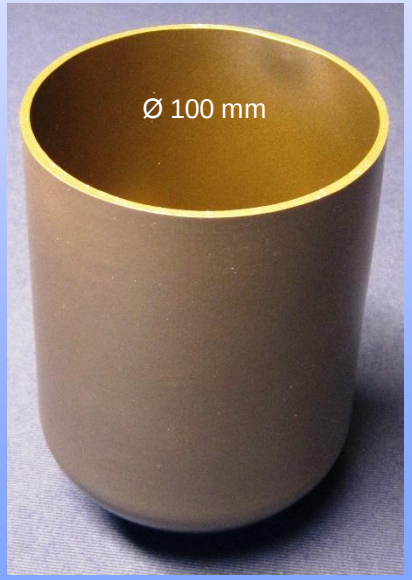


Hot Gas Pressure Forming/ SPF

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

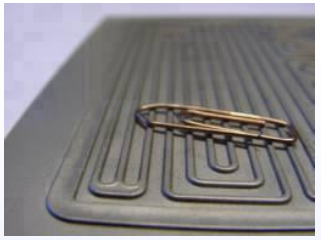
- SPF and HGPF processes are good for complex shape with hi-strength alloys
- Initial wall thickness with very thin gauge, e.g. 0,1mm up to very thick gauge, e.g. >20mm possible
- No residual stress → no spring back
- Relatively low tooling cost
- No final machining in 3D necessary

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

Typical SPF/ HGPF-Sample Geometries

Stützstange, Ti 6-4
t = 7 mm

Aircraft housing, Ti 6-4 and CRES



Fuel cell anode plate: 1.4462, 0,1mm

Bleed Air Duct Ti SP 700

Wave structure for heat exchanger 1.4462, 0,15 mm

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.

Helicopter cover Ti 6-4

ARIANE V
Hemispheres Ti 6-4

Functional duct,
Steel or Titanium

Hemisphere Submarine, Ø = 400mm, Ti6-4, s_0 = 20mm

Medical Implant Ti 6-4 ELI
t = 0,2-0,4 mm

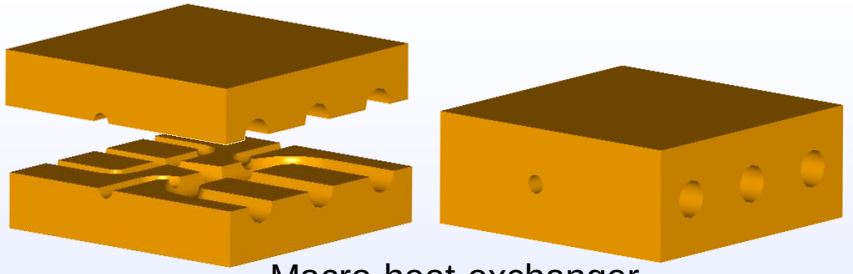
Racing car: Heat shield Ti6-4, S=1,0 mm ; 600 mmx 450 mm

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 and Steel

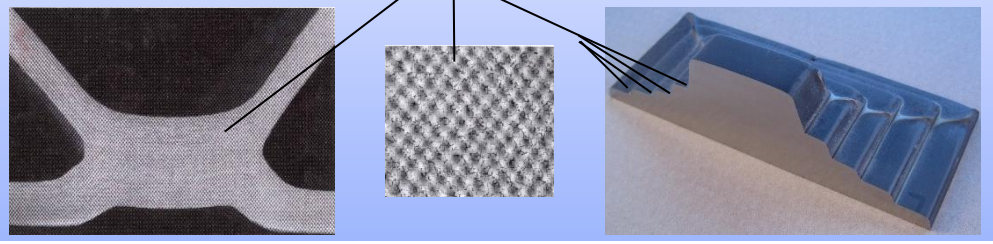


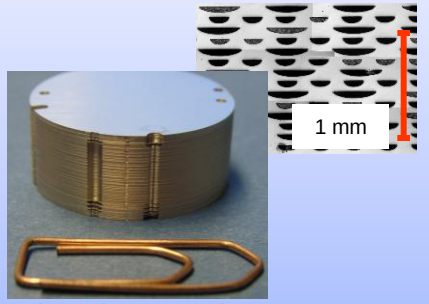
Macro-heat exchanger,
z.B. ITER, t ~14mm

Advantages

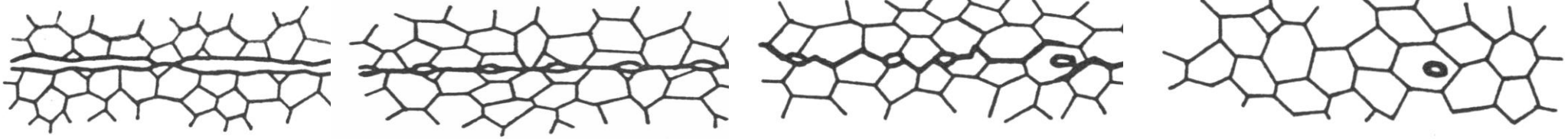
- Creation of complex channel structures, e.g. heat exchangers made from micro-etched foils
- Near-net-shape parts built up from solid details.
- Scrap significantly reduced

DB-weld seam





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



Contact | Deformation | Start of Diffusion | Volume diffusion

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

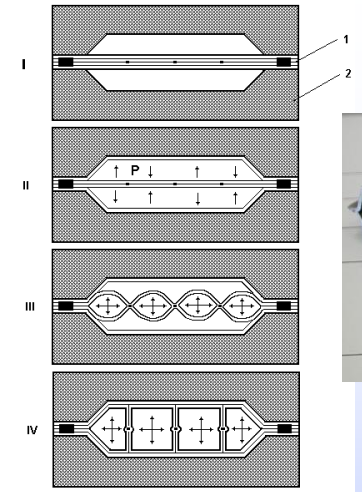
Advantages

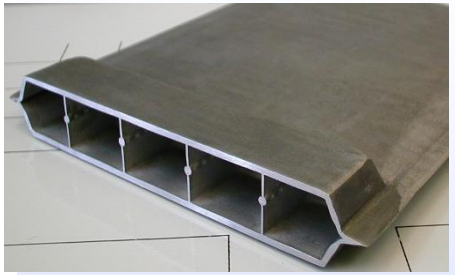
- Weight reduction and performance optimisation
- Cost reduction

Applications

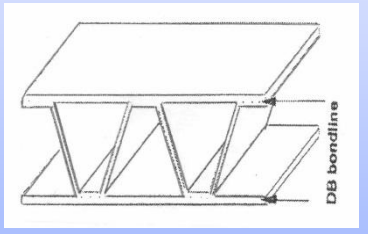
- Hollow fan blades or stators
- Integrally stiffened ducts
- Panels for noise abatement
- Thermal insulation
- Laminar Flow Control

2 sheet design

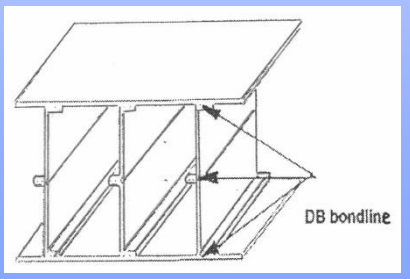


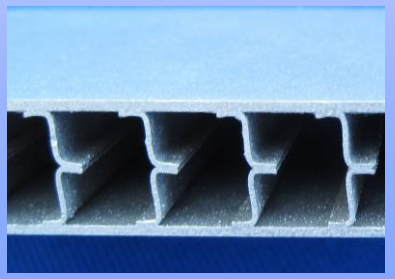


3 sheet design



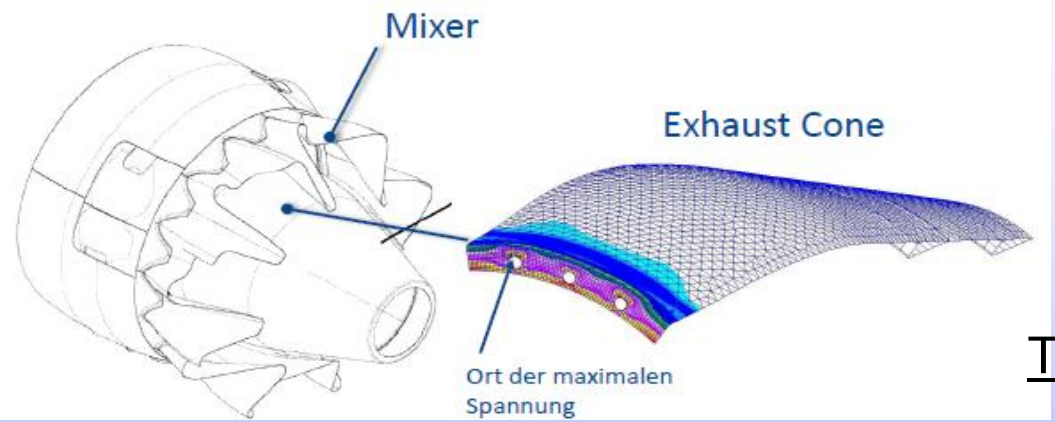
4 sheet design



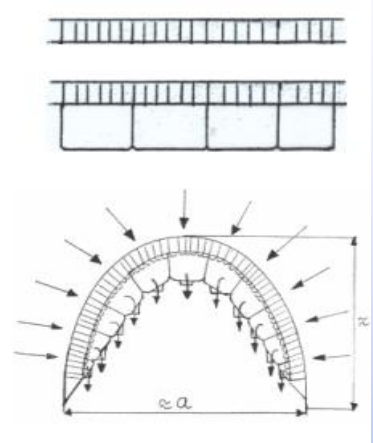


Current hi-potential applications

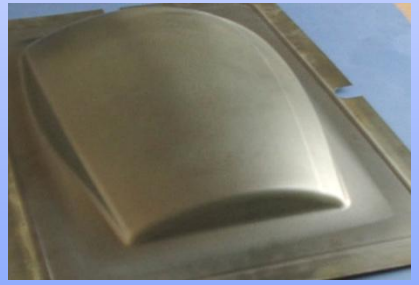
Noise reduction for new engines



Laminar flow control



TiAl in hot sections



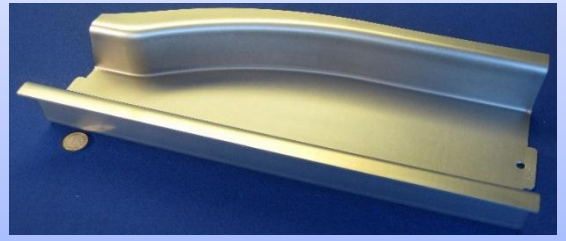
Tie-rods

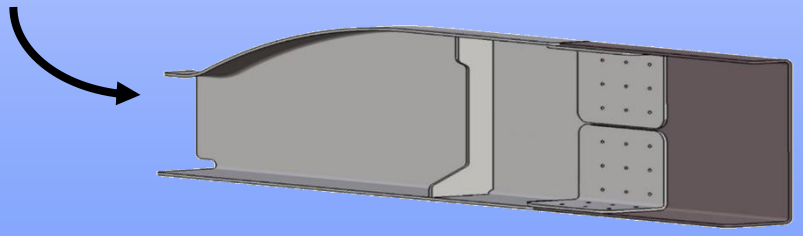
Noise reduction and NOx pollution → Clean Sky and Horizon 2020

Hybrid structures

„Door surrounding“

- Hot formed, near-net-shape Ti6-4 part
- Rib and doublers assemblyby LBW
- CFRP spar
- Novel hybrid joint CFK-Titan
- Better load transfer
- Increased fatigue live
- Ti-saving ~ 80%
- Cost saving ~40%





„Hybrid fan blade“

- Composite body by new approach
- Ti leading edge
  - DB-ed multi layer LE body
  - Increased erosion resistance from „hard“ Ti-alloy
  - Hot forming of final near-net-shape
- Ti erosion shields suction and pressure sides
  - Hot forming/ hot calibration

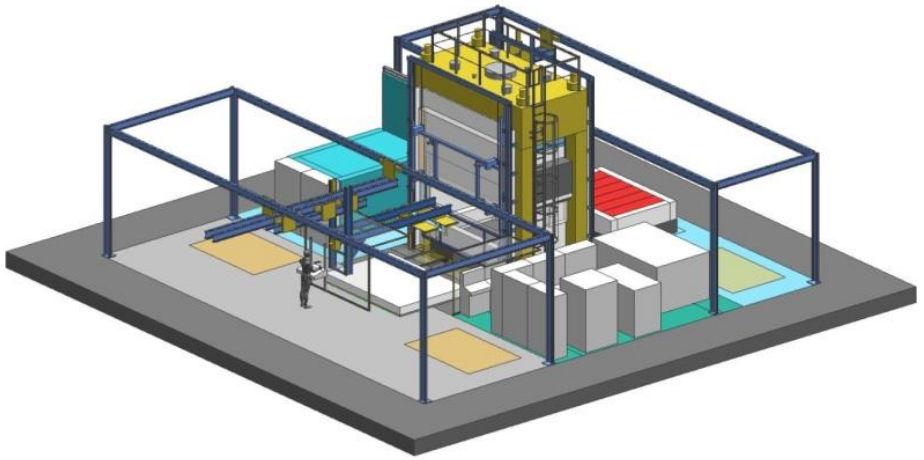
Forming production process evolution

Cost / process optimisation:

- Reduction of material cost
  - →Waste
  - → Alternative Ti alloys
- Reduction of preparation cost
- Reduction of SPF cycle time

Industrialisation with production cell

Joint approach SCHULER/ FT:
Delivery of machine, tool, technology



SCHULER

Summary

- Titanium alloys offer considerable advantages for new engines and aircraft
- Hot forming and diffusion bonding guarantee for cost saving and technical benefit
- FormTech is deeply involved and offers co-operation

Thank you very much for your attention

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