



Hot Forming



Diffusion Bonding

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

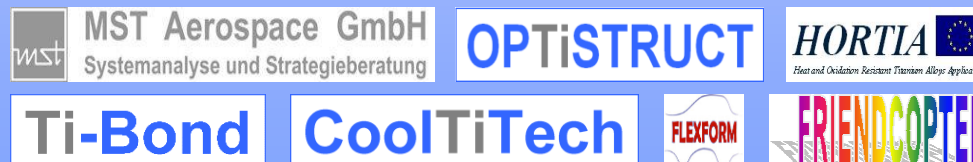
• **Products:**

- 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:**

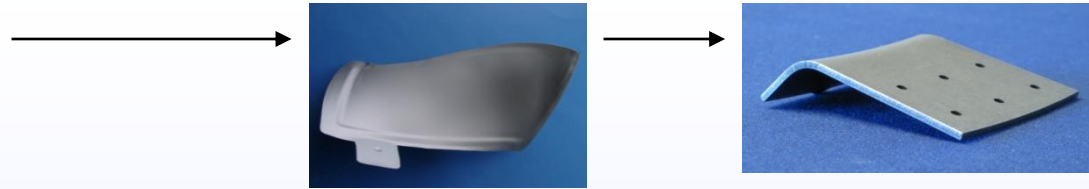


Our quality management system is monitored according to EN 9100 and according to the quality requirements of eaqg EASE rules and regulations approved.

Processes and applications

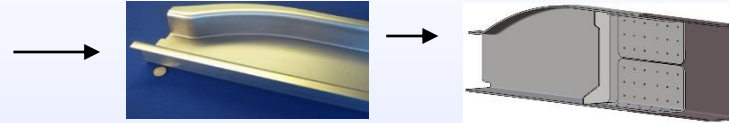
Hot forming/ calibration

→ 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



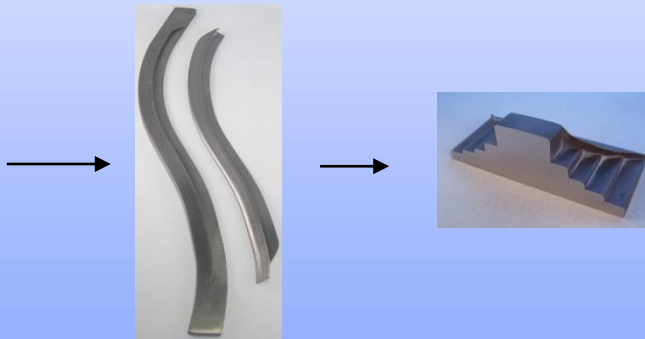
Gas pressure forming/ SPF

→ Struts, hemispheres, thermal shields



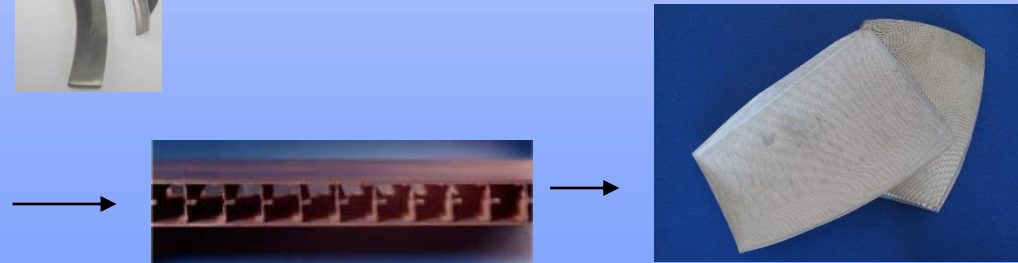
Diffusion Bonding

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



DB / SPF

→ noise reduction, laminar flow, etc



Hot forming, -calibration and - deep drawing

Hot forming offers important cost-reduction by material saving.

→ Better buy-to-fly ratio

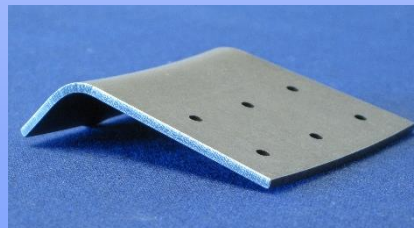
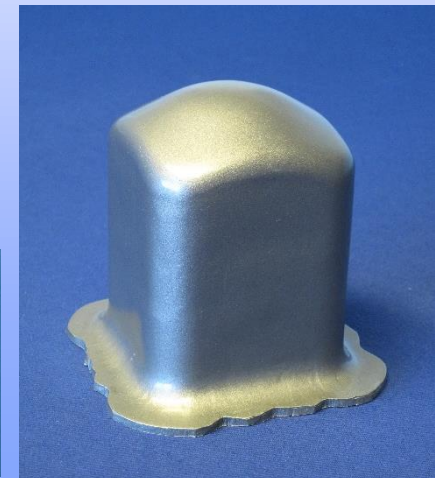
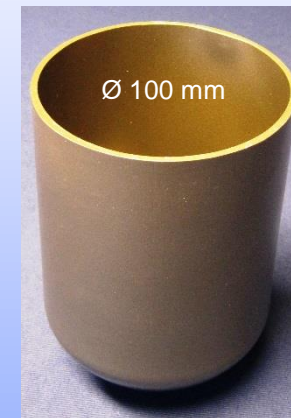
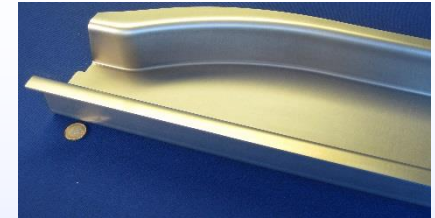
Process cycle time reduction

Titanium alloys are hot-formable at lower $T > 650^{\circ}\text{C}$ 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 x100% 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

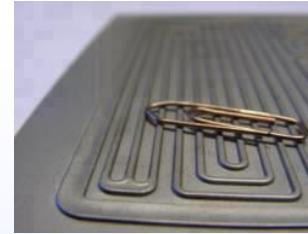
Typical SPF/ HGPF-Sample Geometries



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, $\varnothing =$
400mm, Ti6-4, $s_0 = 20$ mm



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)

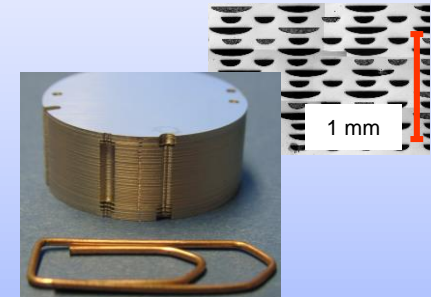
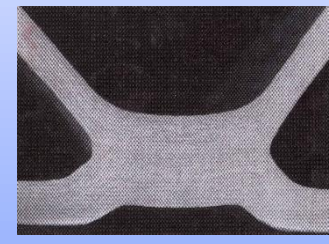
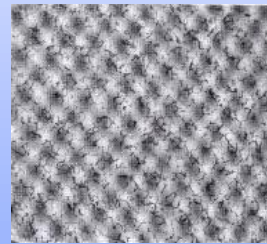
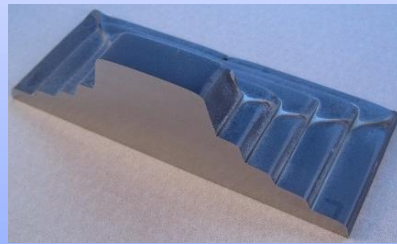
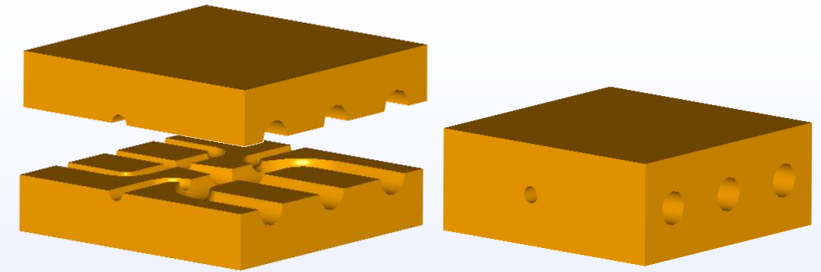
DB is an established process to join metallic materials in solid state with resulting base materials' strength and integrity

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

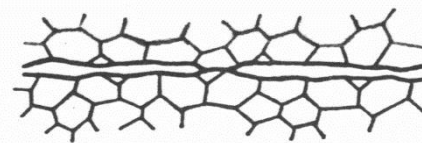
DB is applicable both for Titanium, steel et al

Advantage

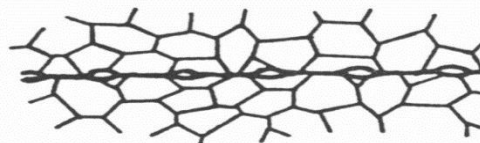
- Creation of complex channel structures, e.g. heat exchangers made from micro-etched foils or plate material
- DB joints may be: Point/ line/ large surface, thin/thick, dissimilar matls., Perforated sheets/ meshes
- Near-net-shape parts built-up from solid details for scrap reduction
- Better efficiency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



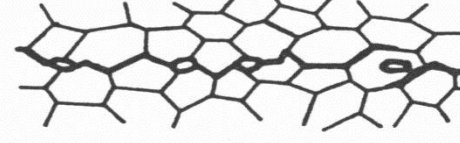
Micro-heat exchanger made of single foils, $t \sim 0,4\text{mm}$



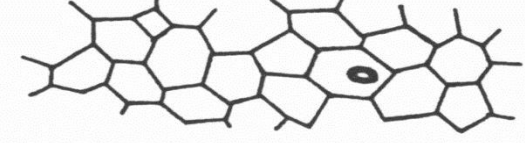
Contact



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

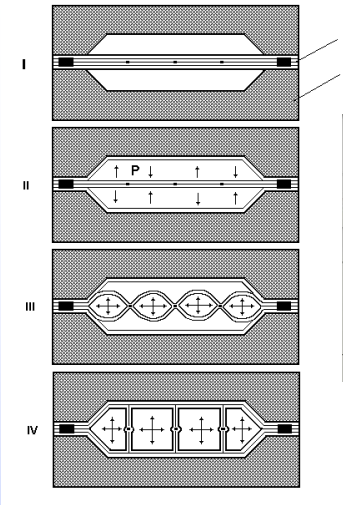
- Weight reduction and performance optimisation
- Cost reduction

Applications

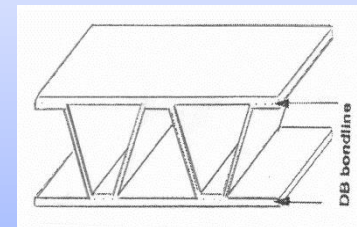
- Hollow fan blades, guide vanes etc.
- Integrally stiffened ducts
- Noise reduction
- Thermal insulation
- Laminar Flow Control



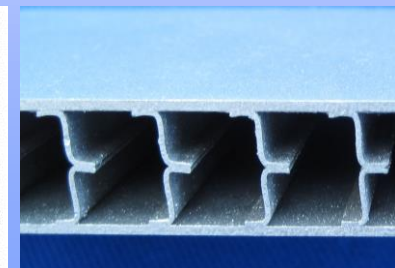
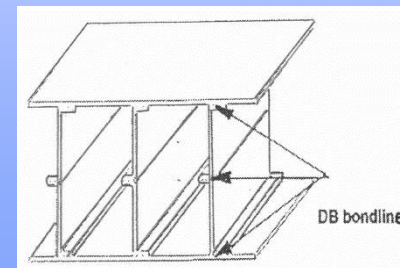
2 sheet design



3 sheet design



4 sheet design



Thank you very much for your attention
Vielen Dank für Ihre Aufmerksamkeit

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