FormTech

Umformtechnologie zur Herstellung komplexer, dünnwandiger Formteile aus Mg-, Al-, Ti-, Ni- und Stahlwerkstoffen

Dipl.-Ing. Werner Beck, FormTech GmbH

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FormTech GmbH, Mittelwendung 35, 28844 Weyhe/Germany
Phone: +49/4203/8045-0, Fax: +49/4203/8045-29, Email: info@formtech.de

Presentation FormTech

- Key technology:
  SPF*, SPF/DB, DB** (hot)
  Sheet metal forming (cold)

- SME cluster ‚Supply Chain‘

- Representation
  •EMFCO, Hi-pressure and hi-temp.ducts
  •ACB, Presses
  •IMSP, Sub-micron materials

→

•R & D

•Feasibility

•Prototyping

•Production

→

•Aircraft

•Aerospace

•Engines

•Automotive

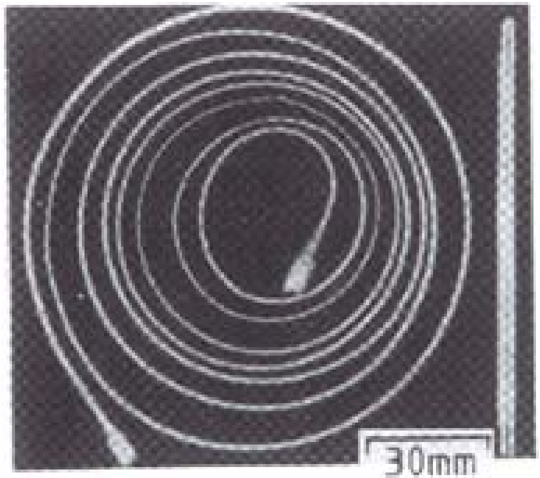
•Medical

•General Ind.

* SPF = Super Plastic Forming, ** DB = Diffusion Bonding

SPF History

Ti 6-4
ε = 834 %



Extruded Bi-Sn eutectic alloy.
Elongation 1950%

Authors	Alloys	Year, source
Bengough	$(\alpha+\beta)$ brass	1912
Rosenhain et al.	Zn-Al-Cu	1920
Hargreaves and Hills	Pb-Sn	1928
Jenkins	Cd-Sn, Pb-Sn	1928
Pearson	Pb-Sn, Bi-Sn	1934
Chaston	Pure Pb	1935
Bochvar and Sviderskaja	Zn-Al	1945
Presniakov and Chervjakova	Al-Cu	1958
Underw ood	Review of Soviet w orks	1962
Backofen et al.	ZN-22% Al Blow ing of hemisphere	1964

Information burst in the field of superplasticity since the end of sixties

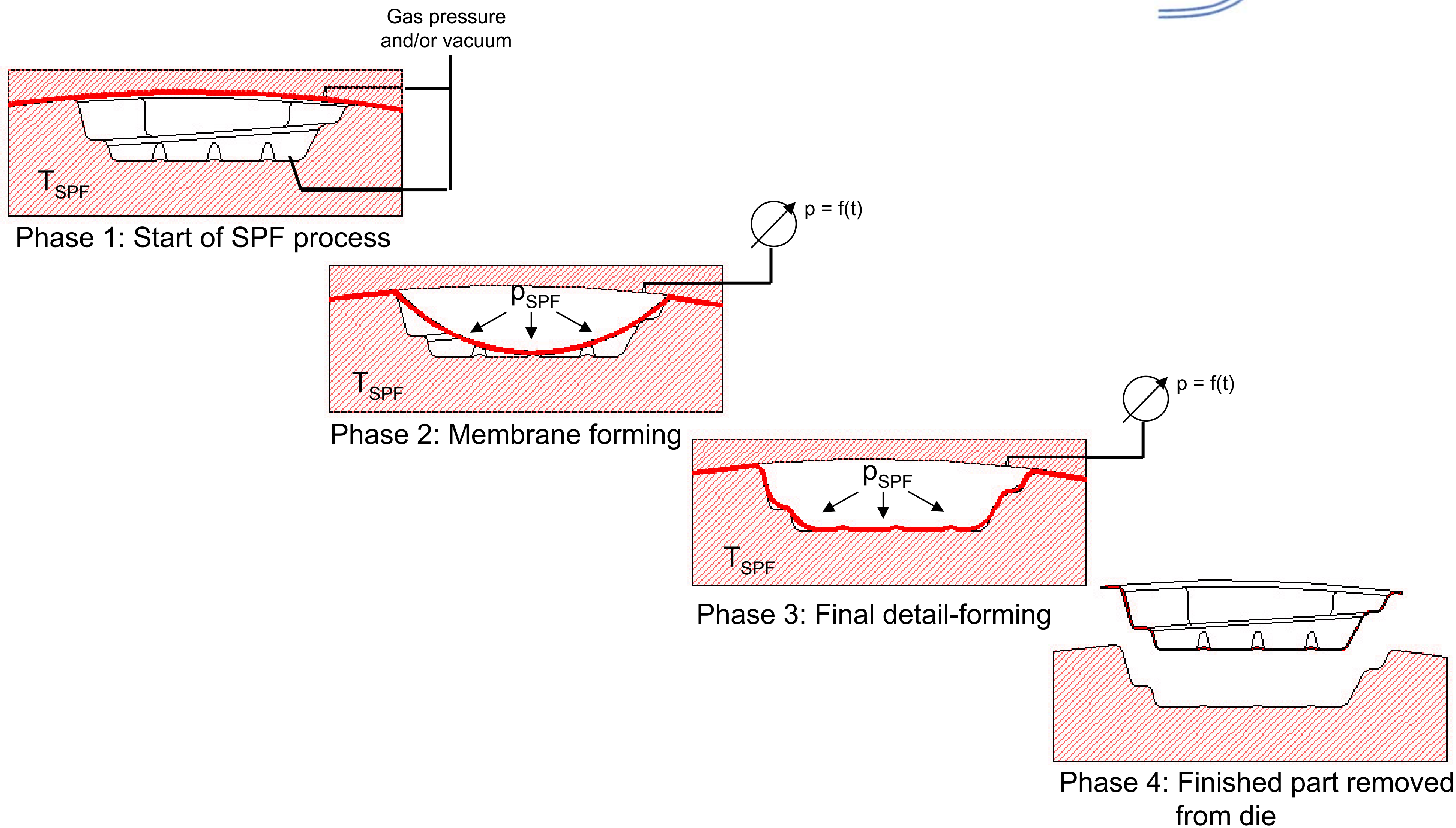
- **SPF Phenomenon under investigation since about 1912**
- **SPF community: ≈ 200 experts world-wide**

General Information SPF

SPF-Mechanism	• Grain boundary sliding • Grain rotation • Diffusional Creep
SPF-Microstructure	• Small Grain size • Globular Shape • Uniform structure • Grain boundary sliding
SPF-Parameters	• From 100% to more than 2000% depending on alloy • Typical strain rate ≈ 3 x 10^{-4} to 3 x 10^{-2} • Typical temperature $T_{SPF} \approx 0.5T_M$
"Standard" SPF-Alloys	• Mg-, Al-, Ti-, CRES- and Ni-alloys • Most published applications with dual/multi-phase alloys like alpha/beta Titanium and Al-alloys • Microduplex steel has splendid SPF performance

*CRES = Corrosion Resistant Steel

SPF – Process Scheme



SPF – Process

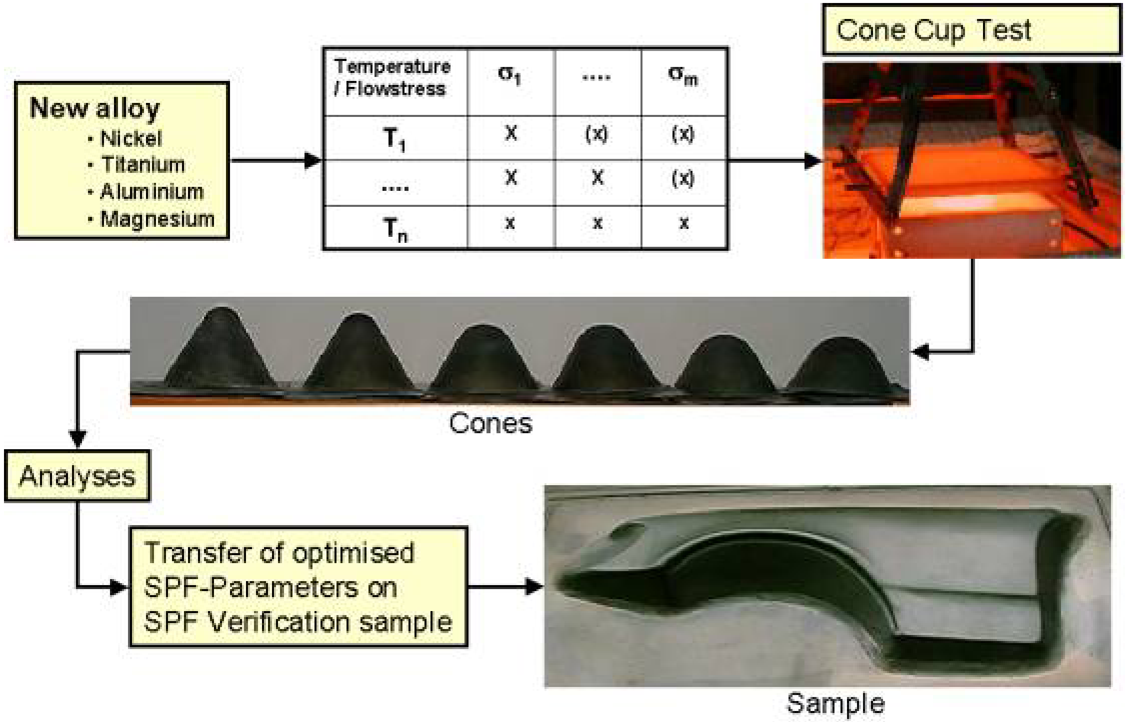
SPF – Characteristics

- SPF sheet metal available from different alloys eg. Mg, Al, Ti, Ti Al, CRES, Ni, Steel-alloys etc.
- Single sheet structures with high complexity due to high strain of SPF materials
- One – step forming process
- Stress relieving heat treatment included in the SPF process
- Forming die inexpensive. Only one cavity and a flat top die necessary
- Short lead time for feasibility studies, prototypes and small volume production
- Ceramic die concept verified

Summary

- Cost savings
- Better material utilisation
- Reduced part number
- Integrated design of many details
- Low assembly cost
- Lower die cost

Verification of SPF – Performance with FormTech Cone Test



Typical applications:

- SPF characterisation of new alloys
- Verification of specified SPF properties
- Comparison of SPF-properties with FT database

FormTech SPF-Database

	Temperature [°C]	Strain rate [s^{-1}]	Resulting cycle time [$t_{SPF/150\%}$]	Characteristics
TiAl	980 x 1050			
CRES	900....980	2×10^{-4}....4×10^{-2}	10 sec.…35 min.	Suitable material available as standard
Ti-alloys	800....940	5×10^{-4}....2×10^{-2}	20 sec.…14 min.	mostly aerospace due to material cost
Aluminium	400....550	1×10^{-4}....1×10^{-2}	40 sec.…70 min.	Backpressure necessary to avoid cavities at higher strains
Magnesium	350....500	5×10^{-4}....1×10^{-2}	40 sec.…14 min.	

Present situation

- Cycle times for „average“ parts depending on material: 2min < t_{SPF} < 30 min
- Cycle times for „average“ parts SPF with optimum SPF material and process t_{SPF} < 2 min
- Mg / Al alloys require backpressure to avoid cavities at higher strains

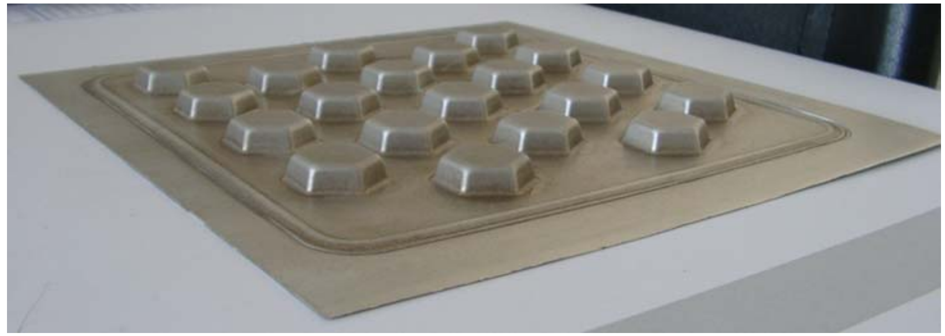
SPF Tooling

- Single mould with a simple cover die
- Heat resistant tooling material - up to 1000 °C (depending on the SPF-material)
- Die materials are standard alloys
- Rapid Prototyping with ceramic tools at FT

SPF- Aluminium AA 5083-SPF, $T_{SPF} \approx$ 480°C

SPF-Titanium TiAl6V4, AMS 4911, $T_{SPF} \approx$ 900°C,

SPF – Activities
Mg Sample parts



- Certain SPF Mg-alloys show extraordinary SPF properties
- Very high weight saving potential
- SPF-properties better Al-alloys AA 5083 etc.

SPF Sample Parts ´Titanium´

„Tankage Hemispheres“ for Satellites and ARIANE V, Ti 6Al 4V

=> Cost reduction against Forging

„Elbow“ made from SP 700 Ti-alloy

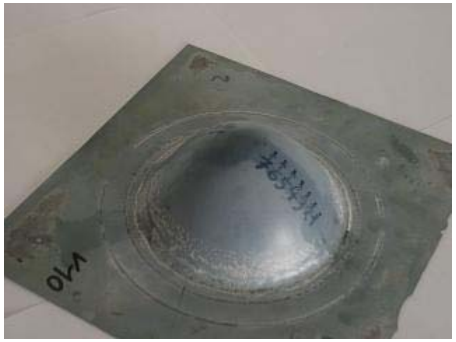
=> Integration, Weight and Cost reduction

„Fedex-Housing“, Ti 6Al 4V,
Ti 6-4, SP 700, Ti 6-2-4-2,
T:6-22-22

=> Rapid Prototyping

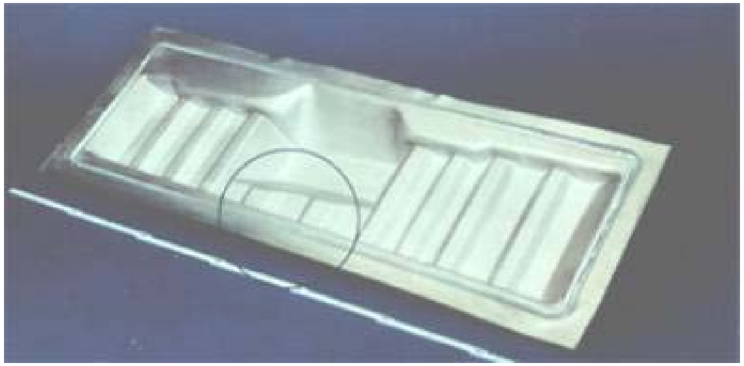
Advantage SPF-Process:
- **Cost Reduction**
- **Weight Reduction**
- **Short Schedule**
- **Complex design possible**

SPF Activities
Ti-Al Sample Parts

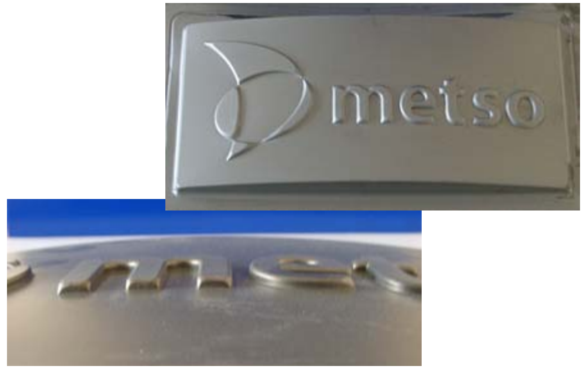



- TiAl offers significant weight reduction potential
- TiAl maintain hi-strenght and oxidation resistance
- TiAl can replace Ni – alloys in hi-temperature applications

SPF Activities
SPF Sample Part ´Steel´



Sample geometry to create new design approaches



Possible with very thin material

Characterisation SPF – Design:

Part geometry not possible with cold forming

Summary SPF

- Alloys with SPF capability show high plasticity at elevated temperatures and closely defined process conditions

- Complex design possible for sheet metal parts even in small production runs

- Forming with gas-pressure. Process-, tooling- and press-technology is industrialised

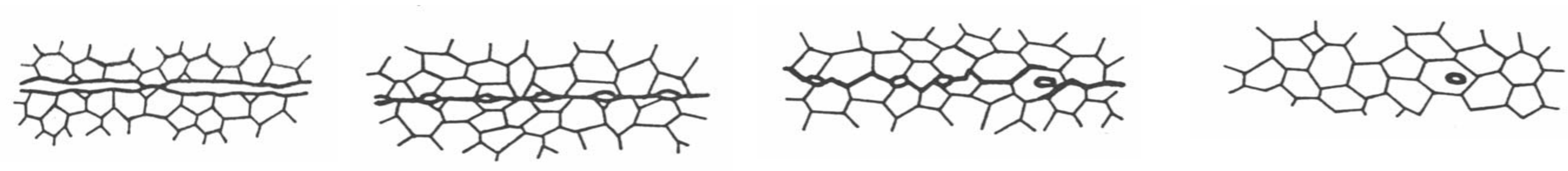
- Economical advantages for small series due to lower tooling cost

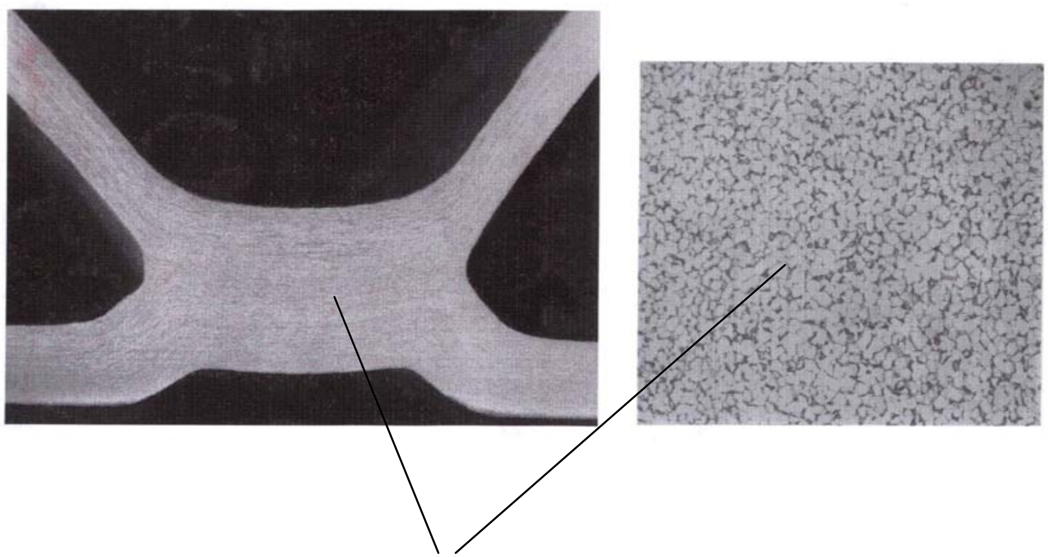
- Cycle times down to < 2 min possible. Today t_{SPF} ~ 6-7min

➢ Depending on design requirements SPF related materials can provide a benefit for design and performance of cars.
➢ SPF/ Hot pneumoforming technology provides an advantage for „small“ quantities of about 10.000 parts/year

DB Principle

Contact | Deformation | Start of Diffusion | Volume diffusion



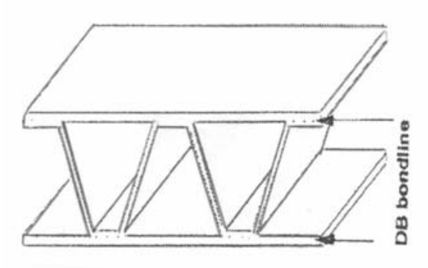


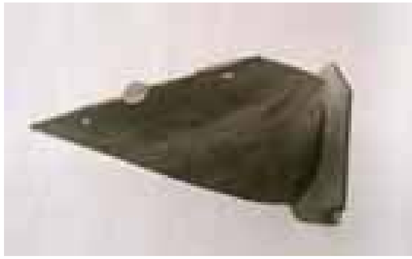
DB-bonding zone

- DB applicable for materials like Ti, Steel, Cu, ceramics etc.
- Mostly applied for Titanium alloys
- Oxide layer diffuses most easily into the Ti-material
- Typical process parameters for Ti: t_{DB}~ 2h, $p_{DB} \cong 30$ bar, $T_{DB} \cong 920^{o}C$
- Stop-off prevents DB where necessary
- Stop-off application with silk screen printing

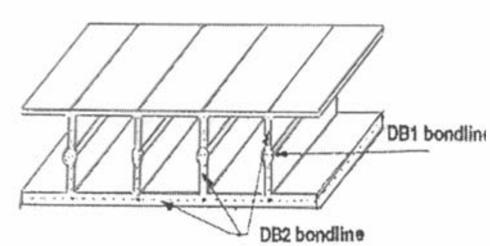
SPF/DB*

Representative Sandwich Design Solutions



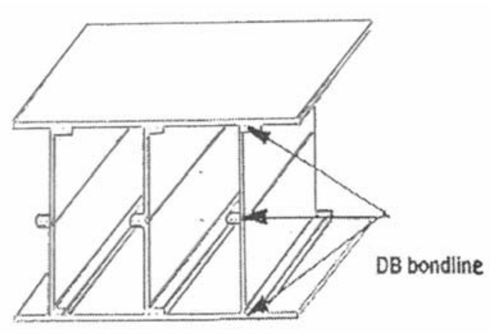


Engine blade
⇒**Weight reduction**

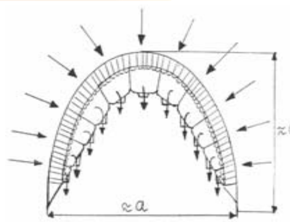


Draufsicht

Integrally stiffened fuselage panel for SST***
⇒ **Weight reduction**
⇒ **Strength optimisation**



Cooler Outlet Duct
⇒ **Cost reduction**
⇒ **Weight reduction**



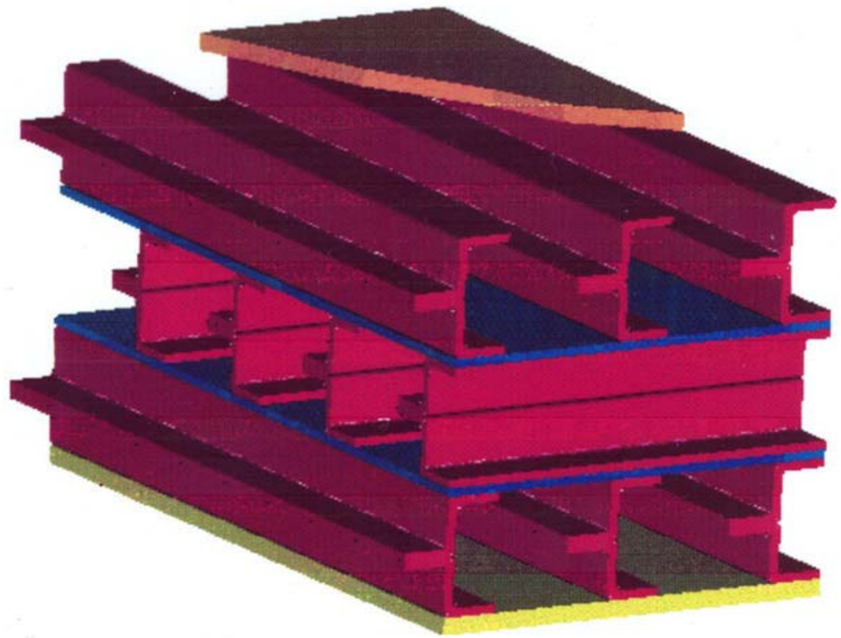
Laminar Flow Panel for RaWid**
⇒ **Integration of different functions**
⇒ **Cost reduction for future productions**

* SPF/DB = Super Plastic Forming / Diffusion Bonding

* *RaWid = Reduction of Aerodynamic Resistance

*** SST – Supersonic Transport „Sänger“

SPF / DB
Integrally stiffened, light-weight sandwich design



- SPF / DB opens wide range of design solutions, e.g.:
  - Double skin walls for safety containers or safety petrol tank
  - Flat, bent or cylindrical parts

Summary DB

- DB process applicable for many metal alloys
- Same alloy for matching parts preferred, but some combinations work also
- Continuous material structure, no ´metallurgical notch´ from fusion weld seam
- Welding factor can be 1 (No degradation of integrity)
- Aerial bonding or line-bonding possible
- Material thickness from very thin to very thick. Every combination possible.
- Combination SPF and DB for advanced, lightweight sandwich structures
- Solid bodies with inside channel structure possible for e.g. heat exchangers

FormTech offers partnership in aerospace, aircraft or engine programs:

- Weight reduction and/or performance optimisation from application of new materials, new design, new processes
- Sheet metal forming, Complex geometry from Mg, Ti 6-22-22 or TiAl
- Sandwich components

FormTech contribution possible for design, feasibility studies and test component manufacturing

- Advanced forming technology
- Material´s data base
- SPF and SPF/DB workshop

Technical points of cooperation

Magnesium alloys:	eg panels, housings, pans for weight reduction (oil pan UL-aircraft engine)
Ti-alloys:	eg complex shapes, thin gauges
TiAl:	eg hot sections exhaust systems, weight reduction from replacement of Ni-based materials
Sandwich parts:	eg integrally stiffened wing panels for laminar flow, firewalls, integraliy stiffened ducts