METAL FOAMS IN RESEARCH AND DEVELOPMENT – NEW APPROACHES IN INDUSTRIAL ALUMINUM FOAM PRODUCTION

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MatCel'2017 & DynMatCel'2017, 25-27 September 2017, Aveiro, Portugal

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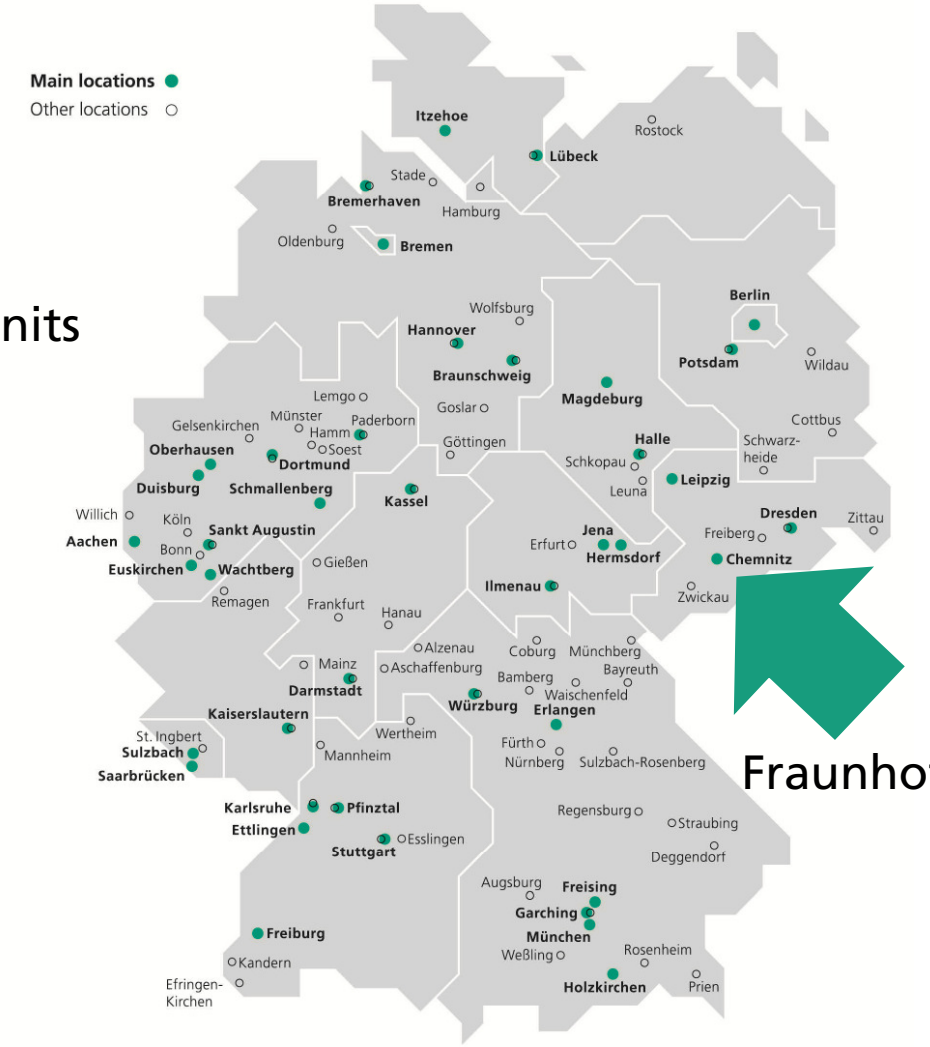
Outline

1. Metal foams at the Fraunhofer IWU
2. Prototypes and Small Serial Parts
3. Sandwich panels - State of the art
4. A new technology -
   Feasibility and implementation
5. Conclusion and outlook

The Fraunhofer-Gesellschaft
Locations in Germany

- 69 institutes and research units
- 24,500 staff



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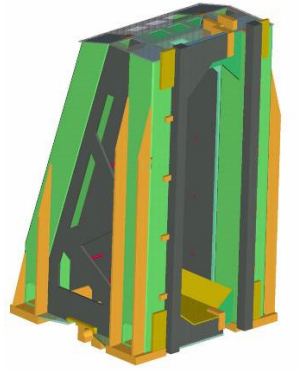
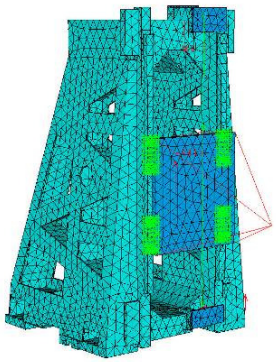
Metal Foam Center of the Fraunhofer IWU

Product development chain

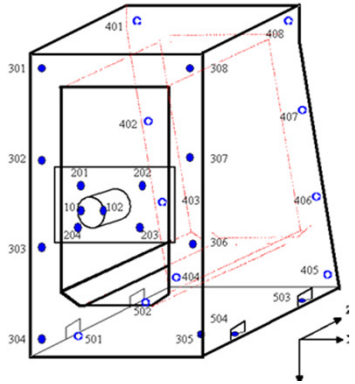


design and construction



simulation

manufacturing



property analysis

Metal foam test site

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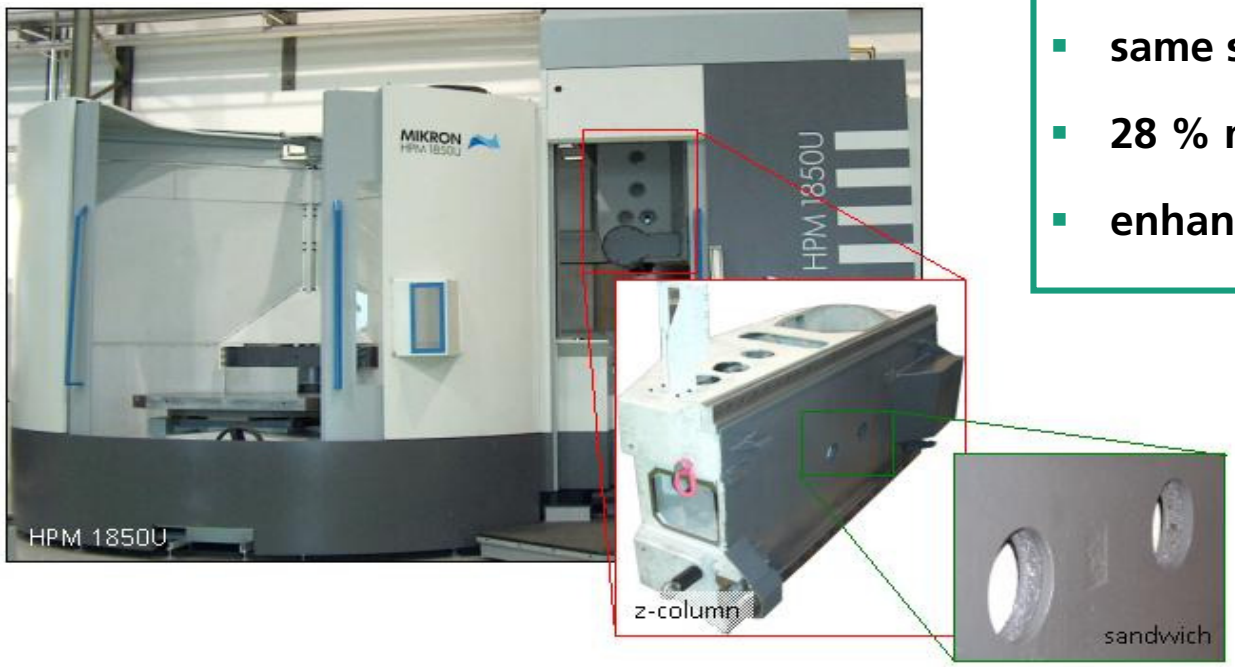
Machine tool structure

first machine tool using Al-foam-sandwich structures made since 2004, 10 pieces per year



Characteristics:

- **same stiffness like the original**
- **28 % mass reduction**
- **enhanced mechanical damping**

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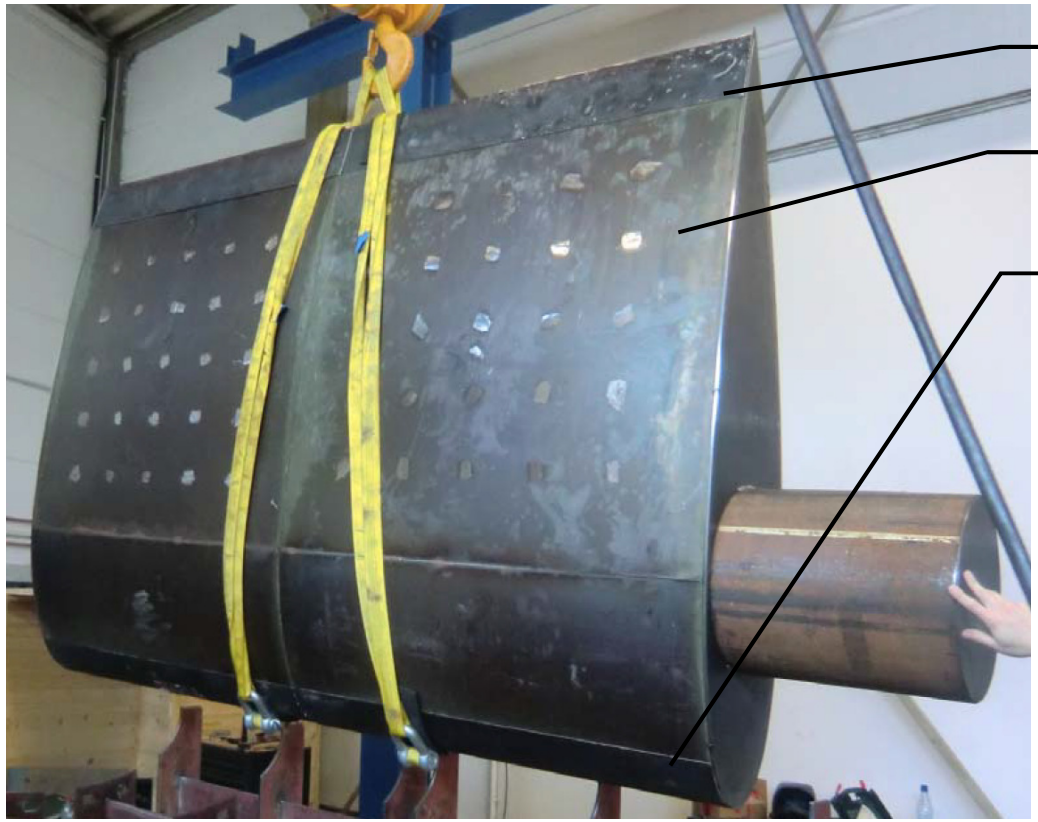
Ship rudder

scale 1:1, 2.6 m x 1.4 m x 0.5 m

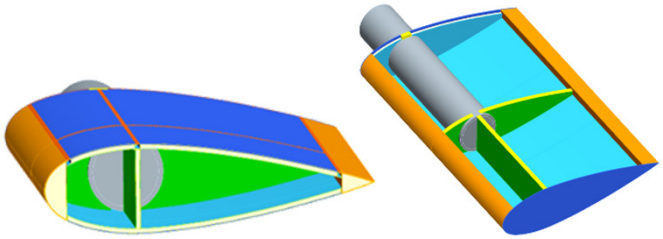


foam filed profile

curved steel aluminum foam sandwiches

foam filled profile

- 22 % mass reduction (912 kg)
- easier manufacturing



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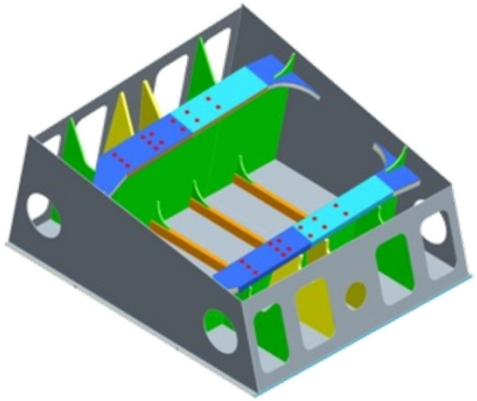
Gear base of a ship

scale 1:1, 2.6 m x 1.4 m x 0.5 m



Results:

- 20 % weight reduction

  (≈ 1,000 kg)

- Good vibration damping

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Front end of a train

scale 1:1, demonstrator build out of aluminum foam sandwiches

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Light weight scraper for chain conveyors

Mass reduction of 30% per scraper

- Lower weight (up to 25 tons fewer moved material per conveyor)
- Less friction
- Less drive power

→ Higher Resource efficiency!

saving electrical energy of a village with 2,000 inhabitants per year

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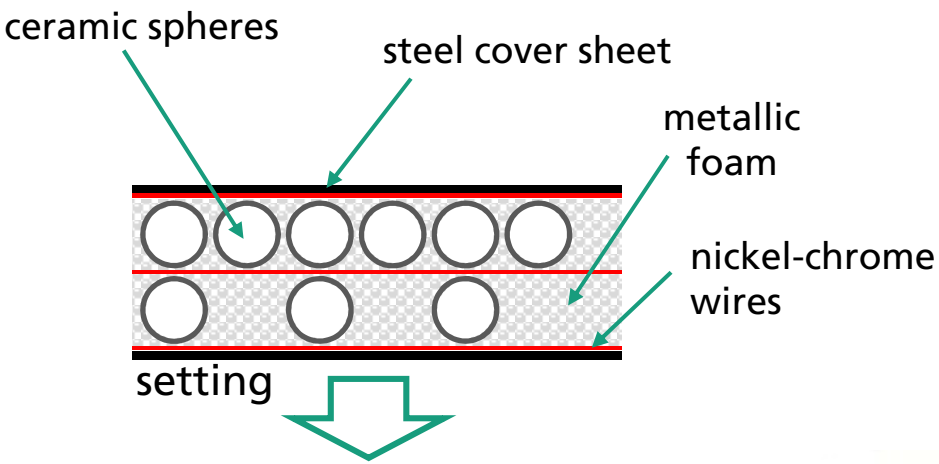
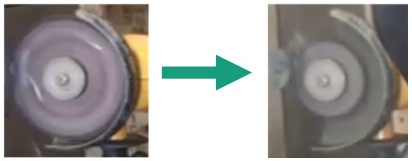
Light weight security panels

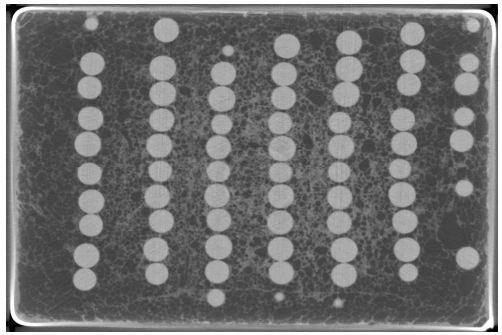
Panels are made up of a pattern of ceramic and metallic inclusions, sealed in a metallic foam core, and protected with external steel face sheets.





UNIVERSITY OF SURREY

manufacturing



foamed sample, core density 1,5 g/cm³

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Design Chair
build up of aluminum foam side panels

- aluminum foam side panels (1 m x 1 m) made of cross shaped bulk material as precursor

→ Load cappacity and weathering tests passed

→ Small series is planned

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State of the Art
Typical semi-finished aluminum foam products

sandwiches
e. g. 3.0 x 1.5 m (Hmf)
e. g. 1.8 m x 1.4 m (IWU)

foam-filled tubes
e. g. 6 m (IWU)

foam parts and plates
(IWU)

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State of the Art
Manufacturing of sandwiches with aluminum cover sheets

Producer: Pohltec Metalfoam GmbH
Product name: **A**luminum **F**oam **S**andwich (**AFS**©)

Foamable material → Rolling of the foamable aluminum with aluminum cover plates to foamable composite → Foamed sandwiches

- **AFS-process is stable and tested**
- **quality of sandwiches is reproducible**
- **high production effort by rolling**

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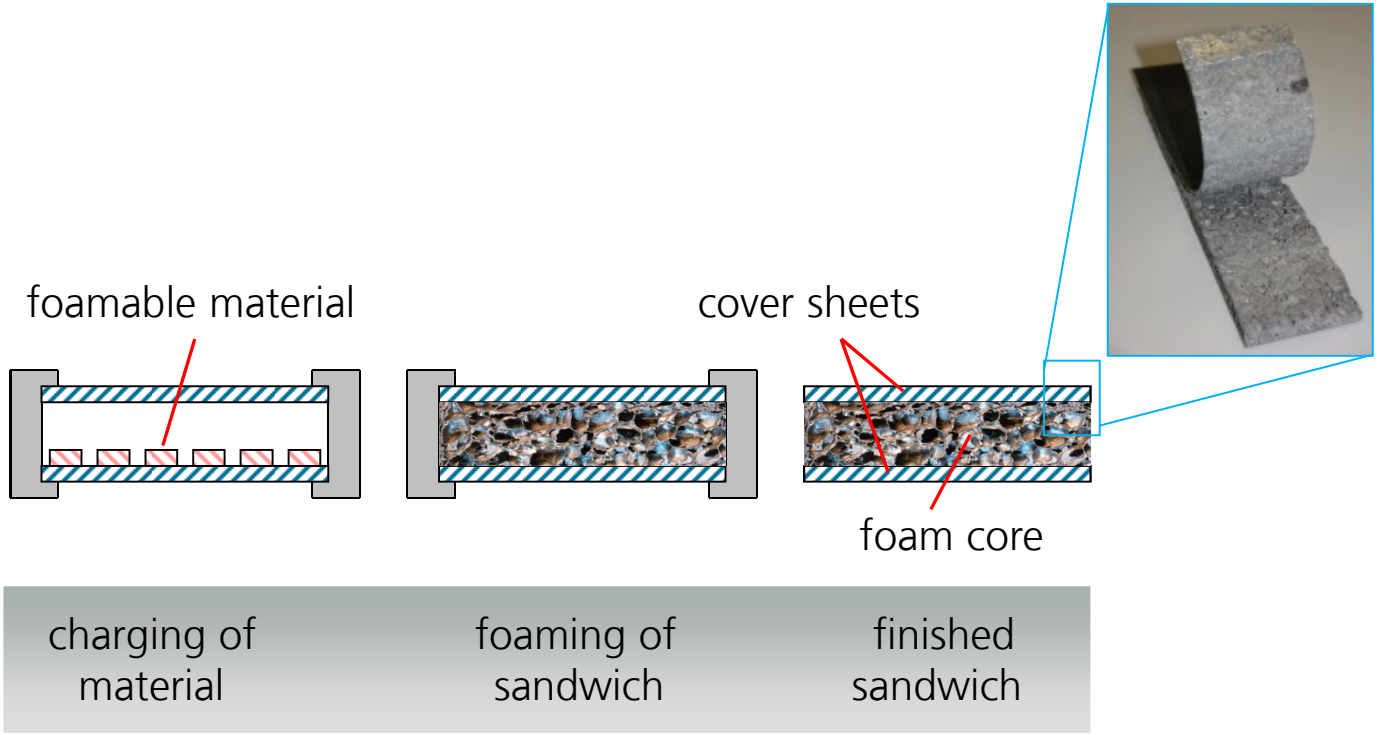
State of the Art

Manufacturing of sandwiches with steel cover sheets

Producer: Havel metal foam GmbH, Fraunhofer IWU

Product name: **S**teel – **A**luminum foam – **S**andwiches (**SAS**)



A new Technology Attempt

Manufacturing of sandwiches with aluminum cover sheets

Materials

Cover sheets

Alloy	**EN AW**	**Melting range**	**Strength R_m**
Al99,5	1050A	646 – 657 °C	65 – 135 N/mm²
AlMg1	5005	630 – 650 °C	100 – 210 N/mm²
AlMgSi1	6082	585 – 650 °C	150 – 310 N/mm²

Foamable aluminum

Alloy	**Melting range**
AlSi10	575 – 585 °C (1)
AlSi12	570 – 585 °C (1), 574 – 583 °C (2)
AlMg3Si6	556 – 561 °C (2)

(1) … Aluminium-Taschenbuch, (2) … own measurements

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Feasibility and Implementation

Manufacturing of sandwiches with aluminum cover sheets

Experimental plan and results of foaming tests

No.	Experimental Plan				Evaluation of the results			
	Cover sheet		Foam Core		Foam core	Cover sheets		Compound
	Alloy	Thickness	Alloy	Density		Flatness	Surface	
1	Al99,5	1 mm	AlMg3Si6	0,9 g/cm³	++	-	+	++
2	Al99,5	2 mm	AlSi10	0,7 g/cm³	-	++	++	+
3	Al99,5	1 mm	AlSi10	0,7 g/cm³	-	-	-	-
4	Al99,5	2 mm	AlMg3Si6	0,9 g/cm³	+	++	++	++
5	AlMgSi1	2 mm	AlSi10	0,9 g/cm³	++	++	+	++
6	AlMgSi1	2 mm	AlMg3Si6	0,7 g/cm³	-	-	+	-
7	AlMgSi1	1 mm	AlMg3Si6	0,7 g/cm³	-	-	-	-
8	AlMg1	1 mm	AlSi10	0,9 g/cm³	-	-	+	+
9	AlMg1	2 mm	AlSi10	0,9 g/cm³	+	+	+	++
10	AlMg1	1 mm	AlMg3Si6	0,7 g/cm³	-	-	+	-
11	AlMg1	2 mm	AlMg3Si6	0,7 g/cm³	-	-	+	-
12	AlMgSi1	1 mm	AlSi10	0,9 g/cm³	++	++	+	+

Results:
- **sheets thickness of 2 mm** is ideal for even sandwiches
- with **AlSi10** a completely foamed sandwich core is achieved
- a **foam density of 0.9 g/cm³** is good for the bonding

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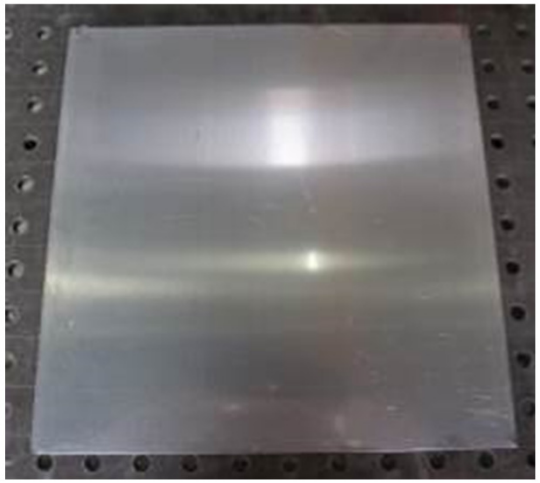
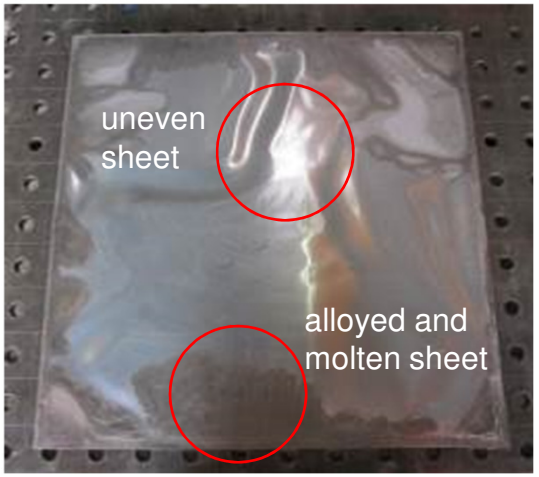
Feasibility and Implementation

Manufacturing of sandwiches with aluminum cover sheets

Results of foaming tests



+	Foam core	++
++	Flatness	-
++	Surface	+
++	Compound	++



Sandwich 4

Sheets: Al99.5, **2 mm**

Core: AlMg3Si6, 0.9 g/cm^3

Sandwich 1

Sheets: Al99.5, **1 mm**

Core: AlMg3Si6, 0.9 g/cm^3

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Feasibility and Implementation

Manufacturing of sandwiches with aluminum cover sheets

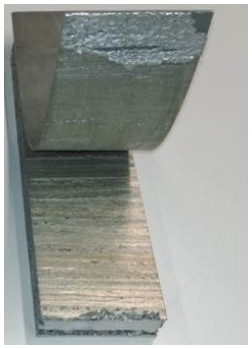
Peeling tests and results

(Standard for peeling test: DIN 53 295)

No.	Experimental plan		Results of peeling		Maximum difference in sandwich thickness	Maximum deviation from flatness, upper sheet
	Alloy of sheets	Alloy of foam core	Average peeling moment	Failure		
	[-]	[-]	[Nmm/mm]	[-]	[mm]	[mm]
A	AlMgSi1	AlSi10	20	boundary layer	0,4	0,4
B	AlMg1	AlSi10	39	boundary layer	0,5	0,5
C	Al99,5	AlSi10	54	boundary layer / core	0,6	0,6
D	Al99,5	AlMg3Si6	185	boundary layer / core	0,6	0,6
E	AlMg1	AlMg3Si6	116	core	0,3	0,4
F	AlMgSi1	AlMg3Si6	71	core	0,2	0,4

Peeling sample

Sandwich I, Probe 1



Failure in the boundary layer

Sandwich I, Probe 3

Failure in the core

Sandwich VII, Probe 3

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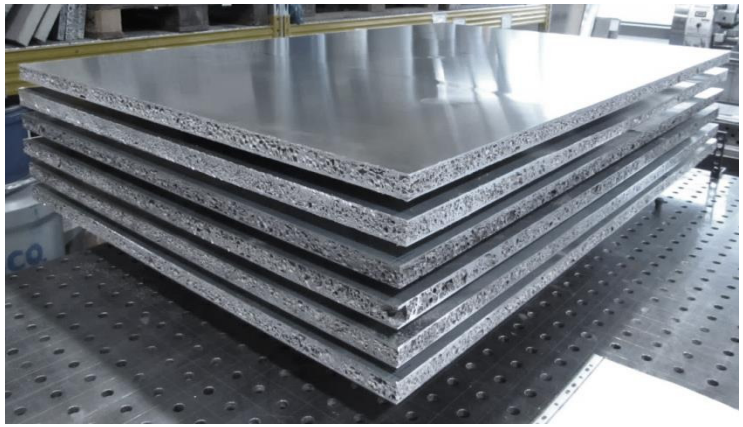
Feasibility and Implementation

Manufacturing of sandwiches with aluminum cover sheets

Scale-up attempts – sandwiches with 1500 mm x 1000 mm

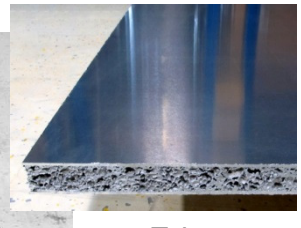


Manufactured Sandwiches

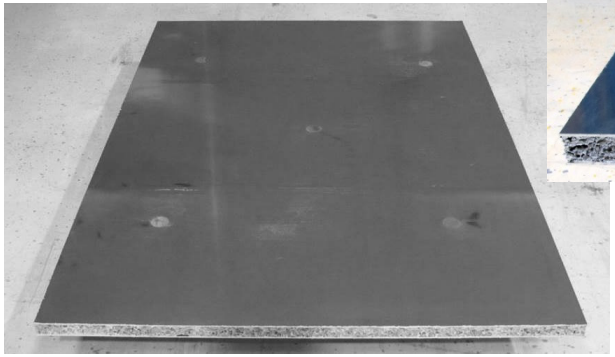
Results

- sandwiches were even after foaming
- complete formation of core material with 0.7 g/cm^3
- top sheets showed only small surface defects
- bottom sheets were locally alloyed on the edges

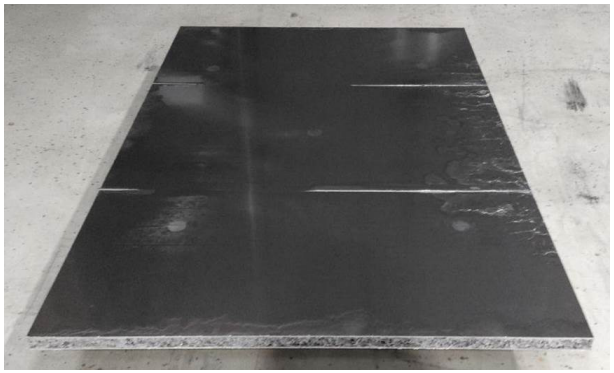
Example: Sandwich with sheets made of AlMg1 and foam core made of AlSi12



Edge area



Top



Bottom

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Conclusion and outlook

Conclusion of results

- successful demonstration: Sandwiches can be manufactured **without rolling**

  → **The new AAS-process works!** **AAS** = **A**luminum – **A**luminum foam – **S**andwiches
- sandwiches dimensions of **1500 mm x 1000 mm** were achieved
- **alloy of cover plates** and also **sandwich thickness** can be **selected free**

Aims and Outlook

- **elimination of alloying marks** on the cover plates.
- **uniform sandwich quality**

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Thank You for your interrest!

Any Questions?

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