

Press Release

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Sandwich Construction with Aluminum Foam for Ship Walls and Decks

Lightweight Construction for Cargo Vessels: Never More Valuable Than Today

Low water levels on the Rhine, Danube, and Elbe are placing substantial pressure on inland shipping. The longer these conditions persist, the more significant their impact on economic activity becomes. Further deepening of navigational channels remains controversial due to environmental concerns, while shifting heavy freight transport back onto roads is not feasible for many goods and would place additional strain on already heavily burdened bridges and road sections in need of repair. A more sustainable approach is to optimize ship design itself: reducing vessel weight decreases draft, enabling ships to continue transporting cargo even when others risk running aground.

For example, ship sidewalls and decks built using sandwich construction could achieve substantial weight savings. During low-water periods, this could increase payload capacity relative to the vessel's net weight by up to 30 percent, or allow ships carrying the same payload to operate at lower water levels.

Sandwich Construction with a Lightweight Aluminum Foam Core

In this type of sandwich construction, aluminum foam is placed between two thin steel or aluminum face sheets. Aluminum foam is an ultra-light metallic structural material with a density well below 1 g/cm³. The basic manufacturing principle resembles the process of making a sponge cake: a blowing-agent powder (such as titanium hydride) is added to aluminum powder. When heated, the blowing agent releases gas, typically hydrogen. The resulting gas bubbles disperse throughout the molten aluminum, expanding it into a foam-like structure. During the foaming process, the aluminum foam metallurgically bonds to the metallic face sheets, creating an integral material connection. No adhesives are required for the composite manufacturing process, which offers a significant advantage for end-of-life recycling. The foam is subsequently cooled and solidified, permanently preserving its porous structure.

The result is a material containing numerous enclosed pores that combines extremely low weight with excellent performance characteristics. At Fraunhofer IWU, aluminum foam-based structures are already being developed for applications such as machine tools and traction battery housings for electric vehicles.

Dr. Jörg Hohlfeld, Head of the Metal Foam Group at Fraunhofer IWU, emphasizes that such sandwich structures are also ideally suited for ship hulls and superstructures: “With approximately 30 percent less weight compared to conventional shipbuilding steel, these sandwich panels are by no means inferior to traditional steel plates in terms of stiffness.”

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The lightweight, shear-rigid aluminum foam core keeps the face sheets at a constant distance from one another, thereby maintaining the sandwich panel's bending stiffness. The outer sheets absorb and transfer external loads. From a manufacturing perspective, researchers see no insurmountable obstacles. Uniform pore distribution within the foam core can now be reliably achieved even in large-volume components, ensuring reproducible material properties. The sandwich panels can be prefabricated in large dimensions (e.g., 2.0 m × 1.5 m) and assembled into larger structures using conventional welding processes such as MAG welding.

Although material and processing costs for sandwich panels are somewhat higher than those of conventional steel plates, the economic and environmental benefits are expected to more than compensate these additional costs in shipbuilding. This is particularly relevant given that periods of low precipitation and low water levels have increased significantly in recent years.



Fig. 1 Low water levels on the Rhine. Further declines in river levels could impose additional restrictions on inland navigation. © iStock I A-Tom

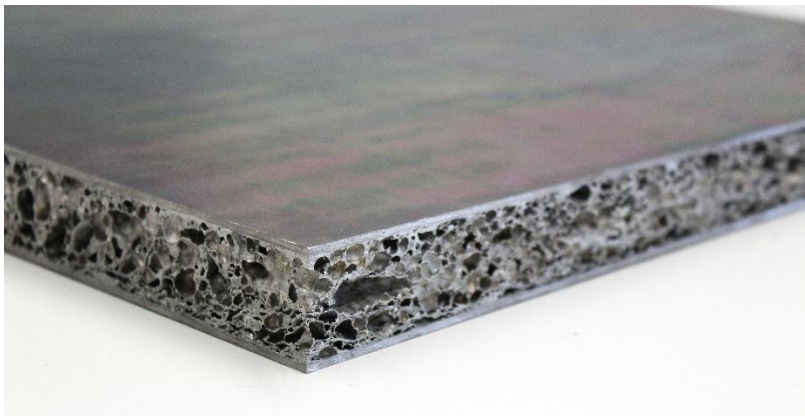


Fig. 2: Thin face sheets and a lightweight foam core. Typical sandwich construction using aluminum or steel sheet as the face material. © Fraunhofer IWU



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Fig. 3: Prototype cargo hold section (one half) for an inland container vessel. The sandwich panels used measure 2 m × 1 m and have thicknesses ranging from 14 mm to 28 mm.

The lightweight design concept for inland container vessels using aluminum foam sandwich structures was developed as part of a collaborative project involving: SMK Ingenieure GmbH & Co. KG (Chemnitz) | SET Schiffbau- und Entwicklungsgesellschaft Tangermünde mbH (Genthin) | KRAFOTEC GmbH (Wittenberg) | IFF Engineering & Consulting GmbH (Leipzig) | Fraunhofer IFF (Magdeburg). The project received funding from the German Federal Ministry for Economic Affairs and Energy (BMWE), administered by Projektträger Jülich.

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Contact

Andreas Hemmerle

Fraunhofer Institute for Machine Tools
and Forming Technology IWU

Spokesperson

Phone +49 371 5397 1372

andreas.hemmerle@iwu.fraunhofer.de

www.iwu.fraunhofer.de