METAL FOAMS

A new powder metallurgy process for production of metal fonms increases the application range of cellular materials. It was first developedfor aluminum foams nnd has recently been extended to other metals and nlloys.

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Metal foams are metallic cellular materials that have a high porosity fraction, typically ranging from 40 to 90 vol%. Because of their high stiffness and low specific weight, cellular iiiaterials are applied in construction, packaging, insulation, noise and vibration damping, and filtering. They are considered by many tobe a new class of engineering materiai.

Typical foaming processes include casting, poivder pressing, metallic deposition, and sputter deposition. Metal foams can be fabricated in a variety of different ways, and many attemyts have been made in the past to develnp good foamstructure. However, the choice frequently seems to be between high cost and poor quality.

Recently, a powder method for fabricating metal foams was invented at the Fraunhofer Institute for Applied Materials Research (IFAM). This niethod allows for direct net-shape fabrication of foamed parts with a relatively homogeneous pore structure. Metallic foams fabricated by this approach exhibit a closed-cell microstructure with higher mechanical strength than open-cell foams. This type of microstructure is particularly appropriate for applications requiring reduced weight and energy-absorption capabilities.

Thr powder metallurgy production method makes it possible to build metallic foam parts that have complex geometry. Sandwich structures composed of a porous metallic foani core and metallic face sheets can also be produced, with options exploiting combined materials and shapes. These foams enlarge the application raiige of cellular materials because of their excellent physical and mechanical properties, as weil as their relative recyclability.

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This article describes the process, microstructure, properties, and applicatioiis of metallic foams produced by the P/M niethod.

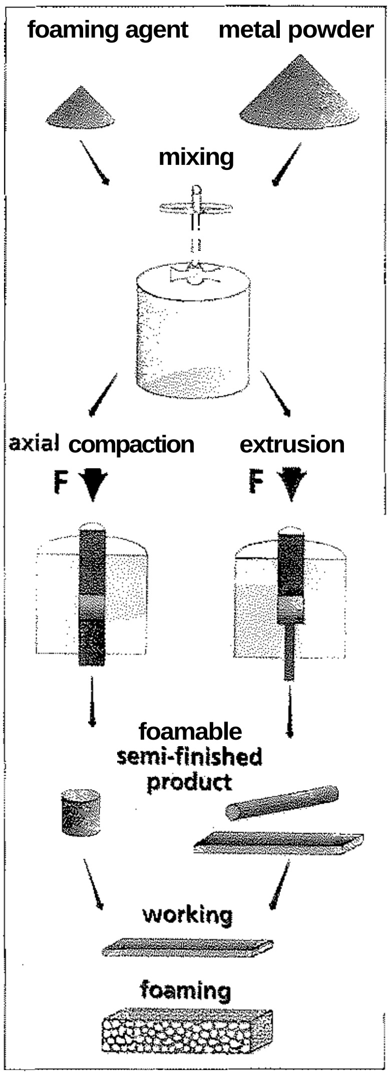

Fig. 1 — Production of metal foam.

Metal powder process

The process is begun by mixing meta1 powders (eitlier pre-alloyed metal powders or powdcr blends) with a small amount of foaming agrnt. When thc agent is a metal hydride, a content of less than 1% is generally sufficient. After the foaming agent is uniformlv distributed within the matrix powders, the mixture is compacted into a dense, semi-finished product with no residual open porosity (Fig. 1 j. Typical compaction methods include uniaxial pressing, extrusion, and powder rolling. The foamahle material may be further shaped through subsequent metalworking processes such as rolling, swaging, or extrusion.

Following the metalworking steps, the foamable material is heated to temperatures near the melting point of the matrix material. During heating, the foaming agent decomposes, and the released gas (hydrogen) forces the densified material to expand into a highly porous structure. The density of the metal foams can be controlled bv adjusting the amount and type of the foaming agent and several other foaming parameters, such as temperature and heating rate.

The most common aluminum alloys for foaming are pure aluriiinum, 2xxx alloys, and 6xxx alloys. Aluminiim-silicon casting alloys are also recommended, because of their low melting points and good foaming properties. However, the Fraunhofer approach is also suitable for other metals such as tin, rinc, lead, bronze, and steel. Different alloys can be foamed by selecting appropriatc foaming agents and process Parameters.

The material may be foamed into complex

integrity of the structure. Roll cladding for direct metallic bonding caii eliininate the need for adhesive bonding in the sandwich panels.

- *Building industry*: Many construction applications require light, stiff, and fire-resistant elements, or supports for such elements.

Foamed sandwich panels could help to reduce the energy consumption for elevators by trimming the deck weight. Combining energy absorption and high specific stiffness, the foamed sandwich panels may be a good candidate for these applications.

Another application of the metal foams is to fasten plugs into concrete walls. To fill the gap between the plugs and the wall, the foamable materials can be inserted into the gap and locally heated. The foamable material will expand and fill the space between the plugs and the concrete wall, provided the resultant foam density is high enough.

- *Further applications*: Additional applications can capitalize on the properties of foams made from other metals. For example, lead and nickel foams may be suitable for batteries, and gold or silver foams may be applicable in art and jewelry.

Furthermore, open-cell foams can be fabncated by modifying the process scheme. This material would be excellent for several applications, such as heat exchangers, filters and catalyst carriers. Foaming of high-temperature alloys such as nickel and titanium will also help expand the application range, especially for aerospace and bio-medical components. ■

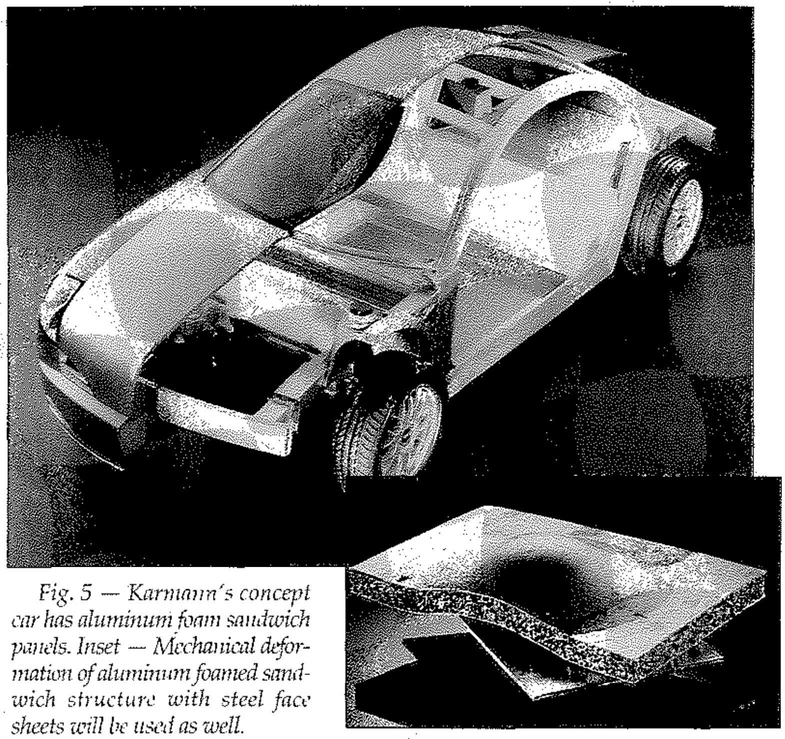

Fig. 5 — Karmann's concept car has aluminum foam sandwich panels. Inset — Mechanical deformation of aluminum foamed sandwich structure with steel face sheets will be used as well.

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