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Cellular Aluminum

Automobile energy-absorbing technology first appeared in the 1960s and 1970s with the introduction of the collapsible steering column, the energy absorbing bumper and the inclusion of side impact door beams. Today's cars still contain these crush zones, which are specifically designed to absorb energy or transfer it away from the passengers as the zone collapses during an accident. This energy absorption can reduce injury to the occupants in the vehicle by changing the dynamics of the accident so the people sustain the effects of the crash as if the car was moving at a much slower speed. Up until now, it was impossible to increase the energy absorption zones without dramatically increasing the car's weight and the higher the weight the poorer the gas mileage.

But a company located in Austria, Metcomb Nanostructures, has made a metallurgic and manufacturing breakthrough that should soon revolutionize the way car crush zones are made.

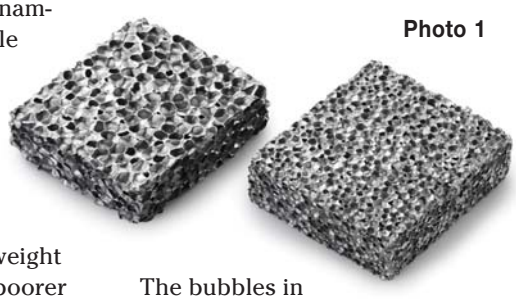
The material that Metcomb developed will also have many defense applications. When the company's cellular aluminum is layered with other materials it not only absorbs the energy of bullets and bombs but can also catch and hold onto their fragments. This could reduce or prevent shrapnel wounds to people in the vicinity of a bomb blast.

To bring you the cellular aluminum story, I have been corresponding with Gerald Högl, the chief executive officer of Metcomb. He answered a series of questions that I sent him and also sent me two articles on the foaming process that was written by the company's chief technical officer, Dietmar Leitlmeier.

The spongy-looking material in Photo 1 is actually foamed aluminum. The process that Metcomb developed produces a uniform cell structure that is superior in many ways to a solid piece of aluminum.

It's cellular structure is similar to that of wood. Wood's cellular structure gives it its excellent strength-to-weight ratio. Without the cells, solid wood would be too heavy to function effectively as a structural element in most construction applications. In the same way, the air cells in cellular aluminum improves the aluminum's characteristics.

Photo 1



The bubbles in Metcomb's foamed aluminum are all uniform in size, and the company can control the size of these bubbles in each manufactured piece to meet the specific needs of a particular customer. Högl listed the following four advantages over other materials that have been used for energy absorption.

• It's lightweight but strong. For example, if a particular volume of steel weighs 100 percent, regular aluminum will weigh 34 percent and cellular aluminum will weigh only 8 percent. For the same weight, cellular aluminum offers a higher bending stiffness than steel and cellular aluminum is so light that it even floats on water.

• Energy absorption. In case of a crash, the material deforms and absorbs the energy of the crash, making it ideal for absorbing the crash energy with a crash box (Photo 2) or replacing heavier steel beams that do not absorb energy but just transfer it to the remainder of the structure of the car.

• Absorption of vibration and sound. For example, in the engine area of a car the ride for the passenger will get more comfortable and more quiet.

• 100 percent recyclability—after all, cellular aluminum is still aluminum.

The process used to manufacture this material involves melting the aluminum, adding ceramic particles and blowing a gas into the mixture. By manipulating the ceramic mix and gas injection, Metcomb controls the size of the bubbles. The process also allows Metcomb to control the thickness of the aluminum oxide outer layer to around 90 nanometers. This thick oxide outer layer is one of the factors that helps stabilize the foam.

Metcomb's manufacturing process next embeds the stabilized foam into a mold for the final die casting of the finished product. The finished parts have a solid skin of aluminum that is tightly connected to the part's cellular core. A finished part's ability to absorb energy, noise and vibration is determined by the size of the individual cells in the cellular core, the thickness of the core's oxide outer layer and the thickness of the outer skin of the part.

Photo 2

For a more in-depth analysis of the foaming process of cellular aluminum, you can read Leitlmeier's articles at www.techtoday.us.

Recalling the Facts

1. How does a car crush zone reduce the force of a collision?
2. Does cellular aluminum float? Why or why not?

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.