Newly-developed Material Could Lead to Lighter, Safer Car Designs

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A new form of 3D-printed material made by combining commonly-used plastics with carbon nanotubes is tougher and lighter than similar forms of aluminium, scientists say. The material could lead to the development of safer, lighter and more durable structures for use in the aerospace, automotive, renewables and marine industries.

In a new paper published in the journal Materials & Design, a team led by University of Glasgow engineers describe how they have developed a new plate-lattice cellular metamaterial capable of impressive resistance to impacts.

Metamaterials are a class of artificially-created cellular solids, designed and engineered to manifest properties which do not occur in the natural world.

One form of metamaterials, known as plate-lattices, are cubic structures made from intersecting layers of plates that exhibit unusually high stiffness and strength, despite featuring a significant amount of space between the plates. Those spaces, which are a property engineers call porosity, also makes plate-lattices unusually lightweight.

The researchers set out to investigate whether new forms of plate-lattice design, manufactured from a plastic-nanotube composite they developed, could make a metamaterial with even more advanced properties of stiffness, strength, and toughness.

Their composite uses mixtures of polypropylene and polyethylene – low-cost, reuseable plastics widely used in everyday items like plastic bags and bottles – and multi-wall carbon nanotubes, tiny filaments constructed from carbon atoms.

They used their nanoengineered filament composite as the feedstock in a 3D printer which fused the filaments together to build a series of plate-lattice designs. Those designs were then subjected to a series of impact tests by dropping a 16.7kg mass from a range of heights to determine their ability to withstand physical shocks.

First, the team tested three types of typical plate-lattices they designed and built – a simple cube formed from the intersection of three plates, a more complex cube with additional intersecting plates, and a more multifaceted design. Those typical plate-lattices were made in two batches – one from polypropylene and one from polyethylene.

Then, they tested three more ‘hybrid’ plate-lattices which incorporated features from the simpler designs in the first experiments – a simple cube/complex cube hybrid, a simple cube/multifacet hybrid and one which amalgamated all three. Again, batches made from polypropylene and polyethylene were made.

The hybrid design which amalgamated elements of all three typical plate-lattice designs proved to be the most effective in absorbing impacts, with the polypropylene version showing the greatest impact resistance. Using a measure known as specific energy absorption, which scientists use to determine a material’s ability to absorb energy relative to its mass, the team found that the polypropylene hybrid plate-lattice could withstand 19.9 joules per gram – a superior performance over similarly- designed microarchitected aluminium metamaterials.

Dr Shanmugam Kumar, Reader in Composites and Additive Manufacturing in the James Watt School of Engineering, led the research project. The research team also involved mechanical and chemical engineers from Khalifa University in Abu Dhabi and Texas A&M University at College Station in the USA.

Dr Kumar said: “This work sits right at the intersection of mechanics and materials. The balance between the carbon nanostructure-engineered filaments we’ve developed as a feedstock for 3D printing, and the hybrid composite plate-lattice designs we’ve created, has produced a really exciting result. In the pursuit of lightweight engineering, there is a constant hunt for ultra-lightweight materials featuring high performance. Our nanoengineered hybrid plate-lattices achieve extraordinary stiffness and strength properties and exhibit superior energy absorption characteristics over similar lattices built with alumiunium.

“Advances in 3D printing are making it easier and cheaper than ever to fabricate the kinds of complicated geometries with tailored porosity that underpin our plate-lattice design. Manufacture of this kind of design at industrial scales is becoming a real possibility.

“One application for this new kind of plate-lattice might be in automobile manufacture, where designers perpetually strive to build more lightweight bodies without sacrificing safety during crashes. Aluminium is used in many modern car designs, but our plate-lattice offers greater impact resistance, which could make it useful in those kinds of applications in the future.

“The recyclability of the plastics we’re using in these plate-lattices also makes them attractive as we move towards a net-zero world, where circular economic models will be central to making the planet more sustainable.”

Read the original article on University of Glasgow.