RESEARCH NEWS

Melting polymers in the mold using infrared radiation

Rapid and energy-efficient production of lightweight components

When consolidating carbon fiber reinforced plastics (CFRP), individual layers of fibers and plastic connect to each other under pressure and high temperatures to form a homogeneous plate. Fraunhofer researchers have developed a method which is fast and energy efficient, and which is also suitable for smaller quantities as well as high-temperature plastics: CFRP is directly irradiated in a vacuum by infrared radiation.

Current CFRP production often involves large, expensive equipment. The molten polymer is pressed between the reinforcing carbon or glass fibers. Using this method, the plastic is only heated indirectly by the massive mold. The molds have to be moved, cyclically heated with variotherm process control, and cooled again. Depending on the process, this can require a significant amount of energy and time. The often high investment costs for presses and other large systems mean that smaller and medium-range batches are not profitable. However, there is an alternative for this: Researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal can heat the CFRP directly in a vacuum with infrared radiation. The energy acts where it is needed. Immediately. For the mold wall, the researchers have found a material that transmits infrared radiation in the desired wavelength range, but which undergoes almost no internal heat expansion. Usually, vacuum based variotherm manufacturing processes take between 30 minutes and several hours, depending on the thickness of the component. Using the ICT's approach, this is done in less than 60 seconds.

"Our method is faster, more economical and more energy efficient than the current state of the art," says Sebastian Baumgärtner, mechanical engineer at the institute in Baden-Wuerttemberg. Processing in a vacuum protects the material. The plastic does not oxidize, as it does in open procedures. Trapped air and possible exhaust gases are sucked out. The process is very stable and easy to use. "All forms of electromagnetic radiation are suitable for heating CFRP in our approach, including microwave radiation," Baumgärtner explains. The industry saves energy, costs and materials and can manufacture more quickly. The method is suitable for both large and small series. "It will particularly benefit smaller and medium-sized companies that do not want to pay for expensive system technology," Baumgärtner clarifies.

Editorial Notes
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Exhibit at the JEC

In a test plant, the researchers use the process to produce 40 x 40 centimeter wide CFRP sheets. Similarly large parts are already found in sporting goods and automotive applications. "Our system fits on a normal shop floor," Baumgärtner explains. Unlike with large presses, no superstructures, substructures or special foundations are needed. The scientists will present the project at the JEC (the trade fair for composite materials) from March 8th to 10th in Paris (Pavilion 5A, Booth E70).

The system produces distortion-free plates. "This is a major challenge when manufacturing with CFRP. We heat and cool symmetrically, use a mold wall with minimal thermal expansion and operate at relatively low process pressures, in order to avoid squeeze flow," says Baumgärtner. The smooth surface of the mold wall also creates an almost reflective CFRP plate surface. This is very advantageous in the final component, particularly for applications in visible areas.

The plastic heats up immediately once the infrared radiator is switched on. Scientists cannot yet say exactly how much energy is saved. "We don't have the precise comparative figures. The effect is evident, though, since there are no large thermal masses that have to be heated up and cooled down again, as is the case with the pressing process," the researcher adds.

In cars, airplanes and sporting goods

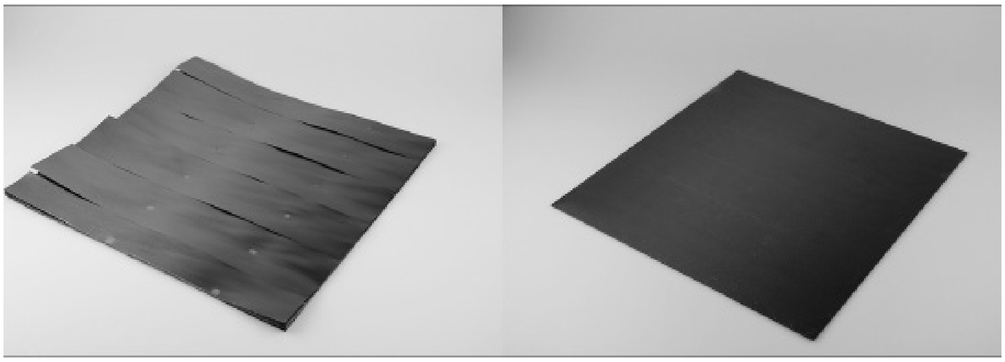
Carbon fibers are thinner than a human hair. In new developments, thermoplastics often serve as suitable matrices for CFRP. They can be melted repeatedly and recycled completely. Fibers and plastics are stacked layer by layer until the desired component thickness is reached. Heat and pressure bring fibers and melted plastic together. A particular challenge is to manufacture the panels without any gaps or air pockets without any shifting of the fibers. Unidirectional CFRP is stiff in the direction of the fiber and flexible perpendicularly. As a result, components with customizable properties can be manufactured through a specific arrangement of the layers. CFRP is not only interesting for aerospace and Formula 1. It is currently used in cars, airplanes and sporting goods.

The next steps

In addition to automated process monitoring, production without the use of a separating agent is a major issue in the industry. Separating agents are required to demold the CFRP plates. Residues can remain on the plates, which make further processing difficult. "Together with our colleagues from the Fraunhofer Institute for Manufacturing Technology and Advanced Materials Research IFAM in Bremen, we are developing a special, durable separation layer. Our goal is to apply this to our mold wall," says Baumgärtner.

Weblink:

Fraunhofer ICT – Research group for thermoplastic processing:
http://www.ict.fraunhofer.de/en/comp/pe/tp.html



Carbon fibers and heated plastic combine under pressure to form a homogeneous CFRP plate. With infrared radiation in a vacuum, this occurs quickly and with a high degree of energy efficiency. © Fraunhofer ICT | Picture in color and printing quality: www.fraunhofer.de/en/press