ULTRASONIC PRE-CONSOLIDATION OF COMPOSITES

Manufacturing of composite materials has been on the rise due to the increasing number of applications within aerospace, automotive, and green energy. During the manufacturing of these materials, the individual layers of material undergo a layup process that can trap air in between the layers, causing voids in the final product. These voids can compromise the structural integrity of the composite and cause the material to fail.

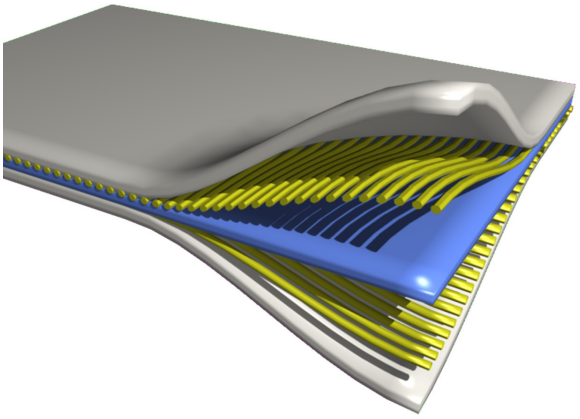
The composite industry spends a significant amount of time and energy developing methods for eliminating air pockets in cured components. Current means of removing the air from the composite layups consist of using vacuum and heat during the layup process and then vacuum and complicated heat cycles during final curing. In spite of these methods, air can remain trapped within the composite and result in voids after curing. In critical applications, the air pockets lead to rejected parts that must be discarded, as they cannot be repaired.

The Ohio State University, jointly with Textron Innovations Inc., has developed a patented device and methodology for pre-consolidating composites during the layup process. This process uses ultrasonic energy to remove residual gases from within the plies of the composite layup. The resulting composite, after final curing, showed lower overall thickness and an improvement in its mechanical properties.

Studies have also shown that residual air within a composite armor solution decreases its ballistic performance. Because of the low resin content and low processing temperatures, it is difficult to remove this air using standard processing techniques. If the air can be removed while the composite laminate is being assembled, the resulting armor would have improved ballistic performance. This would allow for the development of lighter weight solutions for both armored vehicles and personal armor.

INVENTOR

Avraham (Avi) Benatar is an Associate Professor of Welding Engineering and Director of the Plastics and Composites Joining Laboratory. He is also the Coordinator of the Welding Engineering Distance Education Master of Science program and the Faculty Director of the College of Engineering Master of Global Engineering Leadership. He earned his B.S., M.S. and Ph.D. degrees in Mechanical Engineering from the Massachusetts Institute of Technology. Dr. Benatar is internationally known for his work on joining of plastics and composites and has over 30 years of experience in welding, adhesive bonding, and mechanical joining of plastics and composites using ultrasonic energy.



PROJECT LEAD

John Bockbrader received his B.S. in Mechanical Engineering from Ohio State in 1991 and then received an M.S. in Mechanical Engineering from Purdue University in 1997. He spent 7 years at General Motors in the Noise and Vibration Center where he worked to apply engineering principles to solve NVH issues for a variety of vehicles, including two new vehicle platforms. He then started an 11-year career at Battelle where he continued applying his N&V background to solve a wide variety of issues for many commercial and government clients.

While at Battelle, John launched a separate off-site facility to militarize commercial vehicles for the government. After becoming a nationally recognized expert in armor development and integration, he joined OSU as an Engineering Manager.

THE TECHNOLOGY

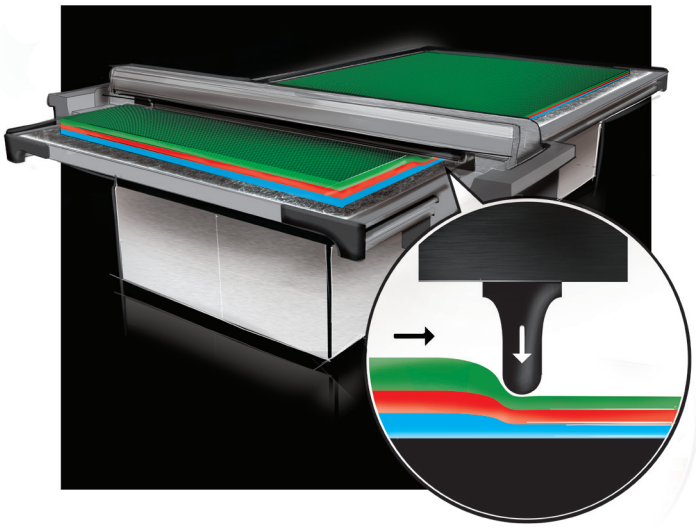
Researchers at The Ohio State University, led by Dr. Avi Benatar, have developed an ultrasonic treatment for composites that can more consistently remove the air from within the layup, improving the performance of the composites. During the layup process, ultrasonic energy is used to remove entrapped gas pockets as each ply is added to the composite. This pre-consolidating process removes the entrapped air prior to final composite curing.

The initial research study concentrated on structural laminates for use in helicopters where weight is critical. The process may also be applied to other structural components, including airplanes and ground vehicles. Another potential application is in the consolidation of composite armor.

CDME is proposing a joint applied industry-specific research project to enable successful commercialization of this device and methodology by our industry partners.

THE MARKET

- The global composites market is projected to reach a value of more than $89 B by 2020 with a growth rate of 6.4% from 2015 to 2020.
- The automotive composite market is expected to reach a value of $7.9 B with a growth rate of 8.5% from 2014 to 2019.
- The aerospace and defense sector is the largest market for advanced structural carbon materials: nearly $1.3 B in 2015 with an expected increase to $1.5 B by 2020.
- The carbon fiber and graphene manufacturing industry currently generates $1.9 B in revenue and is expected to have an annual growth rate of 6.5% from 2015 to 2020.
- Armor and bullet resistant gear accounted for $644 M in 2014 and the market is expected to grow to $868 M by 2019.
- The body armor manufacturing market generated $734 M of revenue in 2014 and is constantly changing due to initiatives to develop lighter, less bulky personal protection gear.



Benefits

1. More consistent parts with fewer flaws means that fewer parts will be rejected.
2. Thinner/stronger laminates allow fewer plies to be required in the laminate, resulting in overall weight savings.
3. The process will eliminate the need for a vacuum bag when curing parts in a press, saving a significant amount of time and money during the layup and breakout process.

Additional Research

Although the initial investigation performed shows promising results, additional work remains before the technology can be transitioned from a laboratory environment to a process that can be used in industry. These investigations include:

- » A method to apply the ultrasonic energy to large composites.
- » A method to apply the ultrasonic energy to cured or complex shaped components.
- » The effect of eliminating vacuum bags for press-cured parts.
- » The method of applying the ultrasonic energy - through a horn or by exciting the layup itself.

Categories

Materials, Composites, Processing, Industrial & Manufacturing, Engineering & Physical Sciences, Aerospace, Transportation & Automotive

College

College of Engineering (COE)

Intellectual Property

US 8,172,969 • Issued • “Apparatus and method for ultrasonic processing of laminates”

US 7, 892,372 • Issued • “Apparatus and method for ultrasonic processing of laminates”

Tech ID

T2016-100

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