

Near-Net-Shape Processing of Sintered Fibrous Ceramics Achieved

A variety of sintered fibrous ceramic (SFC) materials have been developed over the last 50 years as thermal barrier materials for reentry applications. SFC materials typically exhibit very low thermal conductivities combined with low densities and good thermal stability up to 2500 °F. These materials have flown successfully on the space shuttle orbiters since the 1960's. More recently, the McDonnell Douglas Corporation successfully used SFC tiles as a heat shield on the underside of its DC-X test vehicle. For both of these applications, tiles are machined from blocks of a specific type of SFC called an alumina-enhanced thermal barrier (AETB). The sizes of these blocks have been limited by the manufacturing process. In addition, as much as 80 to 90 percent of the material can be lost during the machining of tiles with significant amounts of curvature. To address these problems, the NASA Glenn Research Center at Lewis Field entered a cooperative contract with the Boeing Company to develop a vacuum-assisted forming process that can produce large (approximately 4 ft²), severely contoured panels of AETB while saving costs in comparison to the conventional cast-and-machine billet process.

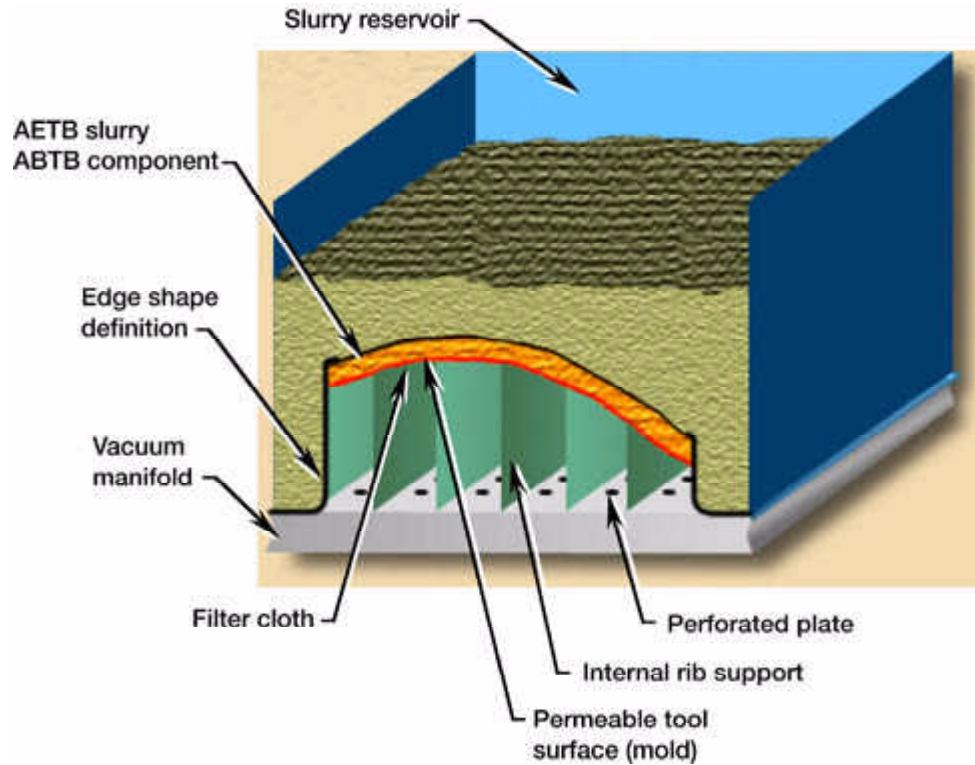
For shuttle use, AETB is slurry cast, drained, and fired to form square billets conforming to the shape of the filtration box. The billets are then cut into tiles of the appropriate size for thermally protecting the space shuttle. Processing techniques have limited the maximum size of AETB billets to 21.5 in.² by 6.5-in. thick, but the space shuttles use discrete heat shield tiles no more than 8 to 12 in.² However, in other applications, large, complex shapes are needed, and the tiling approach is undesirable.

For such applications, vacuum-assisted forming can produce large parts with complex shapes while reducing machining waste and eliminating cemented joints between bonded billets. Because it allows contoured shapes to be formed, material utilization is inherently high. Initial estimates show that the amount of material lost during machining can be reduced by 50 percent or more. In addition, a fiber alignment favorable for minimum heat transfer is maintained for all panel shapes since the fibers are aligned parallel to the contoured surface of the forming tool or mold. The vacuum-assisted forming process can complete the entire forming operation in a matter of minutes and can produce multiple parts whose size is limited only by the size of the forming tool. To date, panels as large as 2 ft² have been demonstrated (see the following photo).



2- by 2-ft AETB panel with complex curvature manufactured by the vacuum-assisted forming process.

The vacuum-assisted forming process starts with the fabrication of a permeable forming tool, or mold, with the proper part contour. This reusable tool is mounted over an internal rib support structure, as depicted in the diagram, such that a vacuum can be pulled on the bottom portion of the tool. AETB slurry is then poured over and around the tool, liquid is drawn from the slurry, and the part forms over the tool surface. The part is then dried, fired, and finished machined. Future plans include an evaluation of the need for additional coatings and surface-toughness treatments to extend the durability and performance of this material.



Depiction of vacuum cooling and equipment.

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