Embedded Heaters for Joining or Separating Plastic Parts

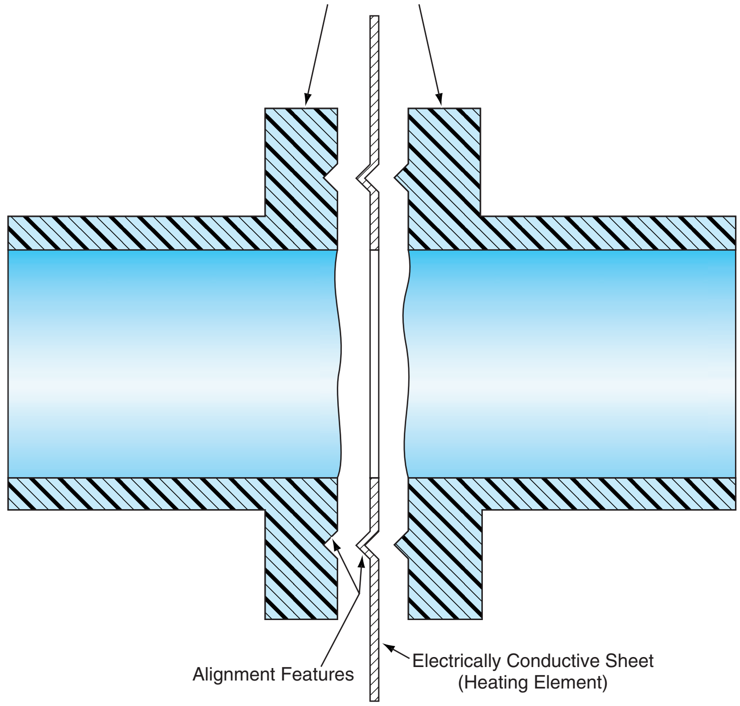
Bonding heat would be generated and applied locally.

Marshall Space Flight Center, Alabama

A proposed thermal-bonding technique would make it possible to join or separate thermoplastic parts quickly and efficiently. The technique would eliminate the need for conventional welding or for such conventional fastening components as bolted flanges or interlocking hooks. The technique could be particularly useful in the sign industry (in which large quantities of thermoplastics are used) or could be used to join plastic pipes.

A thin sheet of a suitable electrically conductive material would be formed to fit between two thermoplastic parts to be joined (see figure). The electrically conductive sheet and the two parts would be put together tightly, then an electrical current would be sent through the conductor to heat the thermoplastic locally. The magnitude of the current and the heating time would be chosen to generate just enough heat to cause the thermoplastic to adhere to both sides of the electrically conductive sheet. Optionally, the electrically conductive sheet could contain many small holes to provide purchase or to increase electrical resistance to facilitate the generation of heat.

After thermal bonding, the electrically conductive sheet remains as an integral part of the structure. If necessary, the electrically conductive sheet can be reheated later to separate the joined thermoplastic parts.



An **Electrically Conductive Sheet** would serve as a heating element to join two thermoplastic parts.

This work was done by Melvin A. Bryant III of **Marshall Space Flight Center.**

This invention has been patented by NASA (U.S. Patent No. 6,394,501). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Benita Hayes, MSFC Commercialization Assistance Lead, at benita.c.hayes@nasa.gov. Refer to MFS-31403.

Curing Composite Materials Using Lower-Energy Electron Beams

Less shielding is needed at lower beam energies.

Marshall Space Flight Center, Alabama

In an improved method of fabricating composite-material structures by laying up prepreg tapes (tapes of fiber reinforcement impregnated by uncured matrix materials) and then curing them, one cures the layups by use of beams of electrons having kinetic energies in the range of 200 to 300 keV. In contrast, in a prior method, one used electron beams characterized by kinetic energies up to 20 MeV. The improved method was first suggested by an Italian group in 1993, but had not been demonstrated until recently.

With respect to both the prior method and the present improved method, the impetus for the use of electron-beam curing is a desire to avoid the high costs of autoclaves large enough to effect thermal curing of large composite-material structures. Unfortunately, in the prior method, the advantages of electron-beam curing are offset by the need for special walls and ceilings on curing chambers to shield personnel from x rays generated by impacts of energetic electrons. These shields must be thick [typically 2 to 3 ft (about 0.6 to 0.9 m) if made of concrete] and are therefore expensive. They also make it difficult to bring large structures into and out of the curing chambers.

Currently, all major companies that fabricate composite-material spacecraft and aircraft structures form their layups by use of automated tape placement (ATP) machines. In the present improved method, an electron-beam gun is attached to an ATP head and used to irradiate the tape as it is pressed onto the workpiece. The electron kinetic energy between 200 and 300 keV is sufficient for penetration of the ply being laid plus one or two of the plies underneath it. Provided that the electron-beam gun is properly positioned, it is possible to administer the required electron dose and, at the same time, to protect personnel with less shielding than is needed in the prior method. Adequate shielding can be provided by concrete walls 6 ft (≈1.8 m) high and 16 in. (≈41 cm) thick, without a ceiling.

The success of the present method depends on the use of a cationic epoxy as the matrix material in the prepreg tape, heating the prepreg tape to a temperature of 50 °C immediately prior to layup, and exposing the workpiece to an electron-beam dose of ≈2 Mrad. Experiments have shown that structures fabricated by the present method have the same mechanical properties as those of nominally identical structures fabricated by the prior method with electron beams of 3 to 4 MeV.

This work was done by Catherine A. Byrne and Alexander Bykanov of Science Research Laboratory, Inc. for **Marshall Space Flight Center**. *Further information is contained in a TSP (see page 1).*

MFS-31837

Aluminum-Alloy-Matrix/Alumina-Reinforcement Composites

Relatively inexpensive, lightweight composite parts could be substitutes for some superalloy parts.

Marshall Space Flight Center, Alabama

Isotropic composites of aluminum-alloy matrices reinforced with particulate alumina have been developed as lightweight, high-specific-strength, less-expensive alternatives to nickel-base and ferrous superalloys. These composites feature a specific gravity of about 3.45 g/cm^3 and specific strengths of about 200 MPa/(g/cm^3). The room-temperature tensile strength is 100 ksi (689 MPa) and stiffness is 30 Msi (206 GPa). At 500 °F (260 °C), these composites have shown 80 percent retention in strength and 95 percent retention in stiffness. These materials also have excellent fatigue tolerance and tribological properties. They can be fabricated in net (or nearly net) sizes and shapes to make housings, pistons, valves, and ducts in turbomachinery, and to make structural components of such diverse systems as diesel engines, automotive brake systems, and power-generation, mining, and oil-drilling equipment. Separately, incorporation of these metal matrix composites within aluminum gravity castings for localized reinforcement has been demonstrated.

A composite part of this type can be fabricated in a pressure infiltration casting process. The process begins with the placement of a mold with alumina particulate preform of net or nearly net size and shape in a crucible in a vacuum furnace. A charge of the alloy is placed in the crucible with the preform. The interior of the furnace is evacuated, then the furnace heaters are turned on to heat the alloy above its liquidus temperature. Next, the interior of the furnace is filled with argon gas at a pressure about 900 psi (≈6.2 MPa) to force the molten alloy to infiltrate the preform. Once infiltrated, the entire contents of the crucible can be allowed to cool in place, and the composite part recovered from the mold.

This work was done by Uday Kashalikar and Boris Rozenoyer of Foster-Miller, Inc., for **Marshall Space Flight Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MFS-31784, volume and number of this NASA Tech Briefs *issue, and the page number.*

Fibrous-Ceramic/Aerogel Composite Insulating Tiles

The best features of aerogels and fibrous ceramics are exploited.

Ames Research Center, Moffett Field, California

Fibrous-ceramic/aerogel composite tiles have been invented to afford combinations of thermal-insulation and mechanical properties superior to those attainable by making tiles of fibrous ceramics alone or aerogels alone. These lightweight tiles can be tailored to a variety of applications that range from insulating cryogenic tanks to protecting spacecraft against re-entry heating.

The advantages and disadvantages of fibrous ceramics and aerogels can be summarized as follows:

- Tiles made of ceramic fibers are known for mechanical strength, toughness, and machinability. Fibrous ceramic tiles are highly effective as thermal insulators in a vacuum. However, undesirably, the porosity of these materials makes them permeable by gases, so that in the presence of air or other gases, convection and gas-phase conduction contribute to the effective thermal conductivity of the tiles.
- Other disadvantages of the porosity and permeability of fibrous ceramic tiles arise because gases (e.g., water vapor or cryogenic gases) can condense in pores. This condensation contributes to weight, and in the case