Thermally Conductive Metal-Tube/Carbon-Composite Joints

Modified solder joints accommodate differential thermal expansion.

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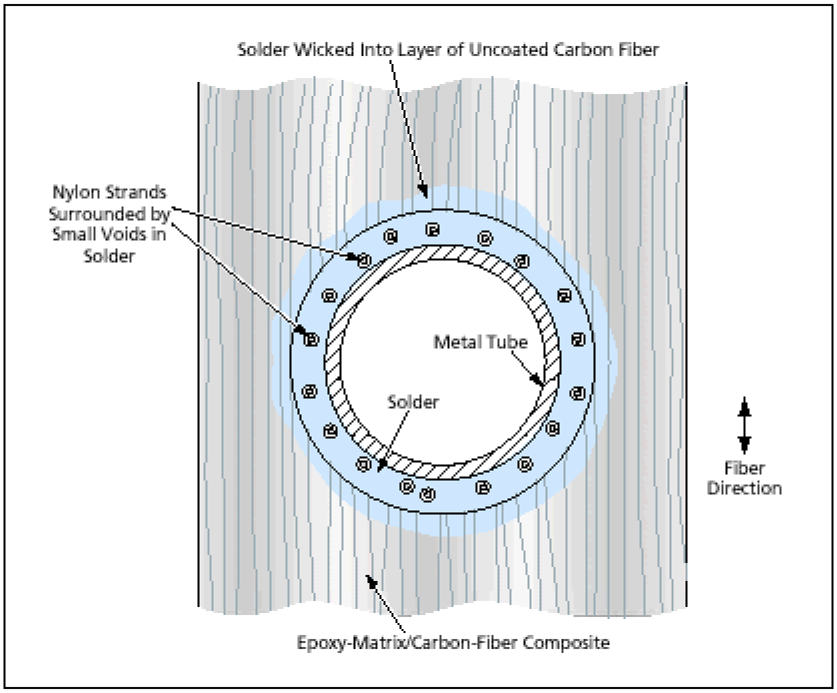
An improved method of fabricating joints between metal and carbon-fiber- based composite materials in lightweight radiators and heat sinks has been devised.Carbon-fiber-based composite materials have been used in such heat- transfer devices because they offer a combination of high thermal conductiv- ity and low mass density.Metal tubes are typically used to carry heat-transfer fluids to and from such heat-transfer devices. The present fabrication method helps to ensure that the joints between the metal tubes and the composite-material parts in such heat-transfer devices have both (1)the relatively high thermal conductances needed for efficient transfer of heat and (2)the flexibility needed to accommodate differences among thermal expansions of dissimilar materials in operation over wide temperature ranges.

Techniques used previously to join metal tubes with carbon-fiber-based composite parts have included press fitting and bonding with epoxy. Both of these prior techniques have been found to yield joints characterized by relatively high thermal resistances.

The present method involves the use of a solder (63 percent Sn,37 percent Pb)to form a highly thermally conduc- tive joint between a metal tube and a carbon-fiber-based composite structure.Ordinarily,the large differences among the coefficients of thermal expansion of the metal tube,solder,and carbon-fiber- based composite would cause the solder to pull away from the composite upon post-fabrication cooldown from the molten state.In the present method,the structure of the solder is modified (see figure)to enable it to deform readily to accommodate the differential thermal expansion.

In fabricating the composite-material structure, the parts of the carbon fibers adjacent to the hole into which the metal pipe is to be inserted are not coated with the epoxy or other matrix material. The hole is made wide enough to accommodate the tube plus a layer of low-density nylon netting between the tube and the inner surface of the hole. The tube and nylon netting are inserted in the hole,then the solder is melted around the tube.The omission of coating on the fibers adjacent to the hole makes it possible for the solder to wick into the spaces between the fibers and form intimate thermal contacts with the fibers.Because the solder does not wet the nylon, a small void forms between each nylon strand and the solder.The thin solder walls that bound the voids are much more flexible than a solid mass of solder would behence, after solidification,the solder can deform to ac- commodate differential thermal expansion of the various materials present.



Small Gaps between the nylon netting and the solder provide flexibility to accommodate differential thermal expansion.

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