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Metal-Metal Reinforced Laminar Composites

Laminar composites consisting of alternate layers of metal sheet or foil, diffusion bonded together, have demonstrated a potential for high strength at high temperatures. In terms of the strength of the constituents, this potential is comparable to that of fiber reinforced composites. Many combinations of laminated materials can be envisioned that could be advantageously fabricated into parts or components of structures.

The potential of laminar composites can be illustrated by the properties of two recently developed prototype systems:

The first prototype consisted of laminae of the oxidation resistant alloy Nichrome V alternated with tungsten (the reinforcing or stronger phase). These composites contained nominally 50 volume percent of each material as foil or sheets of 0.025, 0.125, or 0.50 mm (0.001, 0.005 or 0.020 inch) thickness. At test temperatures of 1144 K (1600° F) and under all test conditions, these composites had strengths equal to or considerably above the values calculated for them using rule-of-mixtures equations, based on the individual strengths of the tungsten and Nichrome V. At 1366 K (2000° F) for most short-time test conditions (less than 10 hours), the composites had strengths above the calculated "rule-of-mixtures" strengths. For 100 hour life, the strength of the thickest (0.5 mm-0.020 inch) laminae composite equaled the "rule-of-mixtures" strength.

The second prototype consisted of a laminar composite of 77 volume percent W-Re-Hf-C alloy sheet alternated with 23 volume percent Inconel 600 foil. This composite had a 1366 K (2000° F) tensile strength of 6.83×10^8 N/m^2 (99,000 psi) and an extrapolated 100 hour stress-rupture strength of about 3.4×10^8 N/m^2 (50,000 psi). These values compare favorably with some fiber composite materials which have been developed.

These two prototype composites have demonstrated that laminar metal-metal composites have a potential for high strength and high temperature applications similar to that demonstrated for metal-fiber-metal matrix composites. These two composites, intended as demonstration prototypes, were made from available materials rather than materials specifically selected for maximum performance as laminar composites; the results, however, indicate that practical high-performance laminar composites can probably be designed. The results also indicate that the development of stronger reinforcing laminae designed specifically for laminar composite use could result in even higher strength composites.

Because laminar composites have several valuable intrinsic characteristics, they may be more desirable for certain applications than fiber composites. For example, they probably can be made with less in-plane anisotropy than fiber composites without sacrificing maximum strength or modulus. Less in-plane anisotropy should enable laminar composites to withstand high transient stresses arising from impact, fatigue, etc., while providing a higher safety factor. Generally, too it is believed that laminar composites may be less expensive to produce than comparable fiber composites.

Applications for laminar composites are numerous. Laminar composites can be designed or "tailor made" for specific applications, and to have specific properties such as corrosion resistance, strength, modulus, high-temperature strength, impact resistance, and ease of fabrication. One of the most promising potential uses for laminar composites, compared to bulk materials or fiber composites, is in high-speed, high-temperature turbines. For example, disks for the multiple turbine and compressor stages may possibly be made with laminated materials. Other aerospace applications might

(continued overleaf)

include high-temperature turbine blades, vanes, combustion chambers, high-pressure chambers for high-temperature use (e.g., in advanced rocket engines), thrust reversers, re-entry vehicle edges, high-temperature structural panels and stiffeners. Also, furnace supports, furnace or metallurgical hearths, and nuclear furnace components could be made from laminar composites. The laminar approach could also be extended to include composites incorporating ceramics, plastics, and various combinations of these materials and metals.

Note:

Documentation may be obtained from:

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