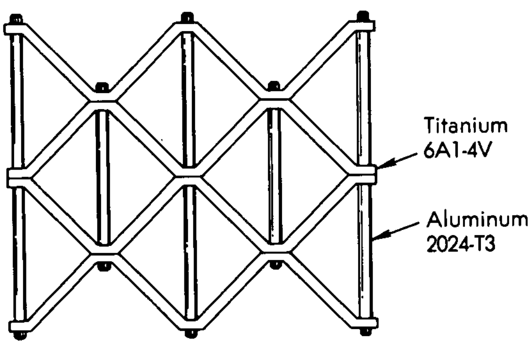
NASA TECH BRIEF
Ames Research Center

Thermally Stable Structural Framework

The problem:

To develop a structural framework with zero or negligible thermal expansion for applications where thermal stresses could result in impairment of structural integrity (such as in advanced flight structures) or where changes in dimensions with temperature could interfere with precision operations (such as in sensing and control components).



The solution:

A macro-composite structure in which two types of metallic materials are combined in a binary trellis arrangement to compensate for thermal expansion in a preferred direction.

How it's done:

Materials of low thermal expansion are generally those of very strong interatomic bonding, i.e., those which exhibit high moduli of elasticity and high melting points. On the other hand, low thermal expansivity is attributable to peculiar molecular arrangements, anisotropic structures, or thermally induced crystallographic effects which tend to compensate for vibrational lattice expansion. In view of the low thermal expansion observed in open molecular networks and highly-oriented crystallographic structures, it became evident that a composite structure could be devised in which axial expansivity is minimized at the cost of a high transverse expansion. Mathematical analysis of such networks formed with conventional materials of construction indicated that a thermally stable gridwork could be constructed in which all trellis elements become nearly parallel and, therefore, also provide highest stiffness and strength in the "stable" direction.

The mathematical analysis also demonstrated that the range of temperatures over which the trellis structure is stable is related to the range over which the ratio of expansion coefficients of the two metals is independent of temperature. Examination of data on the variability of expansion coefficients for 5 common structural materials over a temperature range of $-200°$ to $+200°C$ and computation of thermal expansion ratios for selected combinations indicated that the binary grid should be constructed of titanium and aluminum alloys.

The grid structure consists of "zig-zag" strips, 3.12-mm (⅛-inch) thick, machined from 9.35-mm (⅜-inch) titanium 6Al-4V plate stock. Aluminum 2024-T3 alloy rods of 6.25-mm (¼-inch) diameter are used as transverse spacers; the rods are threaded at the ends, and in the assembled model are held in place by capscrews. The distance between titanium joints is 40.6 mm (1.60 inches), and between aluminum joints, 50.8 mm (2.00 inches); the trellis angle is 50°40′. Thermal expansion coefficients for the construction materials and the binary grid are given below:

(continued overleaf)

Material	α, $10^{-6}/°C$
Titanium 6Al-4V	7.90 ±0.20
Aluminum 2024-T3	23.42 ±0.65
Binary Grid	−0.01 ±0.26

The grid was deliberately designed "over-compensated" because there is no joint rotation; thus, the effect of elastic restraint in the flexure motion was compensated and an essentially zero expansion structure was obtained. The measured expansivity is uniform (within instrumental error) over the measured range from room temperature to 120°C. Good temperature stability is expected over a range from −200° to ±250°C.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference:
   NASA CR-1973 (N72-17929), Thermally Stable Macro-Composite Structures.
2. No additional documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B72-10252

Patent status:

No patent action is contemplated by NASA.

Source: Hans U. Schuerch of
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