AD-A167 792 DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES(U) 1/1
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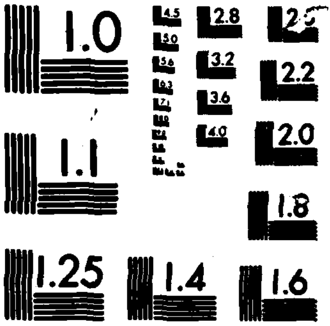

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QUARTERLY LETTER REPORT

Damping Characteristics of Metal Matrix Composites

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Martin Marietta Denver Aerospace
P.O. Box 179
Denver, CO 80201

I. Contract Information

1.a. Title: Damping Characteristics of Metal Matrix Composites .

1.b. ONR Contract Number: N00014-85-C-0857

1.c. Principal Investigator: Mohan S. Misra, Martin Marietta Aerospace, Denver, CO

1.d. ONR Scientific Officer: Dr. Steven G. Fishman

1.e. Period Covered: 12/11/85 - 4/10/86

II. Research Description

II.a. Description of Research

Damping test data of Gr/Al composites, from previous measurements at Martin marietta Denver Aerospace, CO suggests that composites exhibit higher damping than aluminum and titanium base structural alloys. Enhanced material damping of metal matrix composite (MMC), as a structural material will significantly improve the stability control and reliability of space structures. The objectives of the present investigation are: i) to identify the mechanism and the source of damping in MMC (P55 Gr/6061 Al); ii) to determine the role of microstructural parameters, e.g., fiber volume, fiber orientation and interfiber spacing, and iii) to define the role of fiber matrix interfaces.

KeyWords; Analytical Modeling; Strength (Mechanics); Stiffness; Moire Interferometry; Stress analysis; Thermal gradients

II.b. Tests in Progress

II.b.1. Analytical Modeling

The nature of bonding between the precursor wires and metallic face sheets in MMC influences the strength stiffness and damping properties. Preliminary modeling approach is outlined below.

Electron Micr [illegible]

A baseline beam model (Figure 1), assuming perfect bonds at the fiber-matrix interface and also at diffusion bonded interface between precursor wires has been analyzed. Damping in structural metals and non-metals depends on the stress level and thermal histories. In the stress amplitude dependent region damping arises due to yielding of the material and attendant hysteretic effects during stress cycling. Graphite fibers are considered as perfectly elastic and hence do not possess any damping capacity. Material damping, expressed in terms of damping ratio ζ, is related to total damping energy D_o and total strain energy per cycle of vibration U_o:

i.e., $$\zeta = D_o/4 \ U_o \qquad (1)$$

where: $$D_o = \int_v D dv = \int_v J \cdot (\sigma/\sigma^*)^n \cdot dv \qquad (2)$$

σ = stress level

D = specific damping energy

J, n = material parameters

σ^* = endurance limit

Using "J_2 yield criterion" equation (2) can be rewritten as

$$D_o = \int_v (J/\sigma^*).(3J_2)^{n/2} \qquad (3)$$

because under an axial stress, $J_2 = 1/3\sigma^2$

Total strian energy, U_o, of the bean is given by:

$$\begin{aligned} U_o &= \int 1/2E_x \epsilon_x^2 dv + \int 1/2G_{xz} \gamma_{xz}^2 \ dV \\ &= \epsilon^2_{(peak)} E_x \ lbh/30 + \\ &\quad (\epsilon^2 peak \cdot E_x^2 \ /G_{xz} \cdot bh^3/45.1) \end{aligned} \qquad (4)$$

where E_x = Young's modulus of beam along axis

G_{xz} = shear modulus of the beam

$\epsilon peak$ = peak strain level

Damping ratio ζ can be computed by using equations (1), (3) and (4).

Most of the flexural tests are not conducted in a vacuum, and hence air damping effects are also present. In that case, total damping ζ_t may be represented as:

$$\zeta_t = \zeta + \zeta_a$$

where ζ_a is the damping ratio due to air damping and for a uniformly loaded cantilever beam

$$\zeta_a = 1/4 \; \rho_a/\rho \cdot \epsilon_{peak} \cdot l^2/h^2 \cdot C_D^*$$

where ρ_a = density of air
ρ = density of beam material
C_D^* = dimension less air drag coefficient

Figure 2 shows that static deflection under uniformly distributed load matches well with the first mode shape of the cantilever beam. Preliminary calculations using this analysis show pretty good agreement with the measured damping ratio by cantilever beam test method.

II.b.2. In-Situ Damping Tests

Moire Interferometry

Dynamic measurements conducted at Idaho National Engineering Laboratory by using 2400-l/mn grating on the free edge of a single-ply and three-ply Gr/Al [0°] specimens, do detect relative movement between the fiber and matrix. During extensional mode cycling, this test technique detected minor out of plane movement, which may also include dissipation of vibrational energy. Moire interferometry patterns are being analyzed to determine damping after computing the total strain energy and dissipation energy by using equation (1).

Stress Pattern Analysis by Measurement of Thermal Emission

(SPATE-8000 Stress Analyzer)

This technique has been successfully evaluated to measure stress and thermal gradients over a selected area of Gr/Al composites. These gradients can be identified in the matrix region between fibers and quantified by appropriate calibration technique.

In this method, thermal emission emitted from a small area of a dynamically loaded sample is detected by a sensitive infra-red radiometer. Thermal detection sensitivity of the order of .002°F, which is equivalent to 5×10^{-6} strain level in aluminum can be achieved, during axial cycling tests.

Acoustic Emission (AE)
The critical part of test specimen preparation, to minimize extraneous 'noise' interference, has been completed. AE tests are in progress and being analyzed at the time of reporting.

Transmission Electron Microscopy (TEM)
It is extremely difficult to conduct in-situ damping measurements by using a deformation stage. But TEM observation of specimens tested in flexural and extensional mode at different strain levels is in progress, which will provide sub-microstructural details of fiber matrix interfaces and their role in damping behavior.

II.c. Presentation

In IDA/IST evaluation meeting:March 7, 1986 (None - in technical conferences)

II.d. Technical Papers

None

II.e. Publications

None

II.f. Participants

Analytical Modeling: Material Science Corporation, Springhouse, PA
Damping Tests: University of Texas A&M, College Station, TX
Acoustic Emission: University of Denver, CO

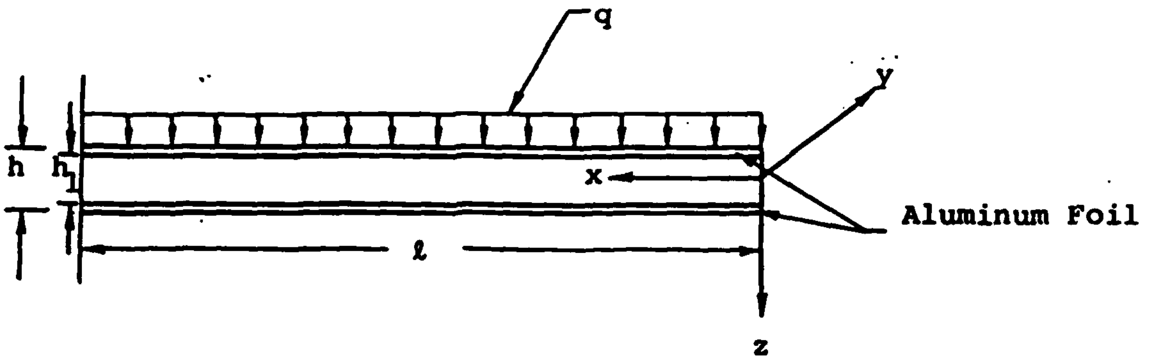

Figure 1. Uniformly loaded cantilever beam

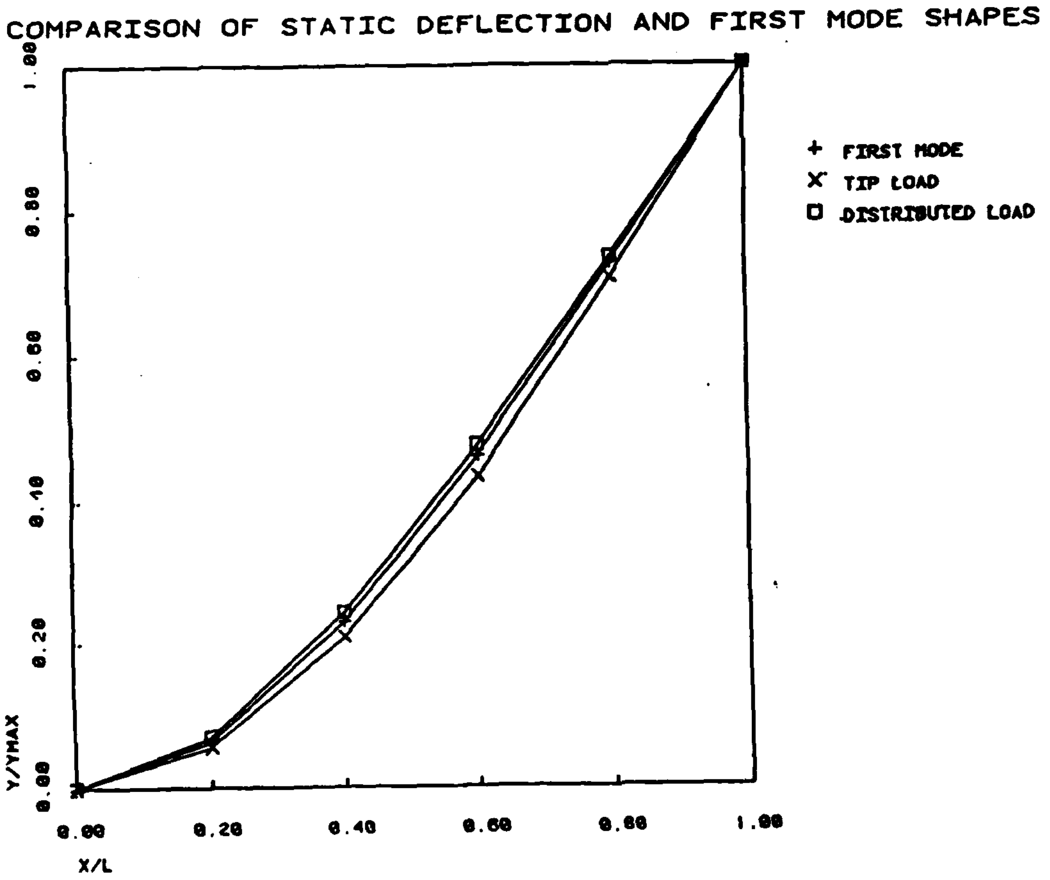

Figure 2. Comparison of Static deflection and first mode shapes for a cantilever beam.

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