Energy-Absorbing, Lightweight Wheels

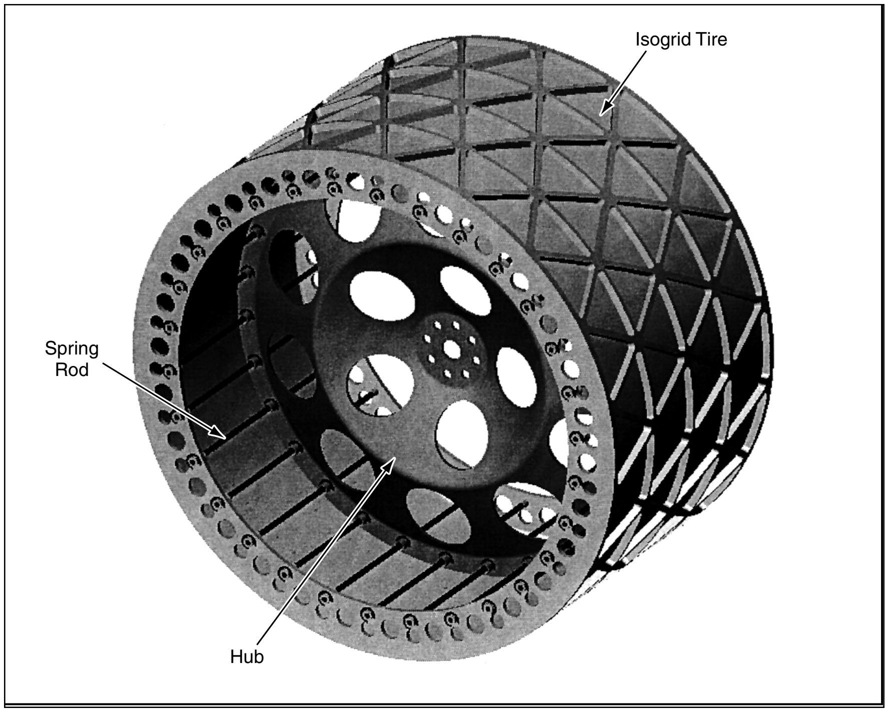
Efficient structures would absorb impact energies and distribute contact loads.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved energy-absorbing wheels are under development for use on special-purpose vehicles that must traverse rough terrain under conditions (e.g., extreme cold) in which rubber pneumatic tires would fail. The designs of these wheels differ from those of prior non-pneumatic energy-absorbing wheels in ways that result in lighter weights and more effective reduction of stresses generated by ground/wheel contact forces. These wheels could be made of metals and/or composite materials to withstand the expected extreme operating conditions.

As shown in the figure, a wheel according to this concept would include an isogrid tire connected to a hub via spring rods. The isogrid tire would be a stiff, lightweight structure typically made of aluminum. The isogrid aspect of the structure would both impart stiffness and act as a traction surface. The hub would be a thin-walled body of revolution having a simple or compound conical or other shape chosen for structural efficiency. The spring rods would absorb energy and partially isolate the hub and the supported vehicle from impact loads. The general spring-rod configuration shown in the figure was chosen because it would distribute contact and impact loads nearly evenly around the periphery of the hub, thereby helping to protect the hub against damage that would otherwise be caused by large loads concentrated onto small portions of the hub.

The spring rods could be made from any of a variety of materials, depending on the nature of the anticipated loading and the scale of the wheel. (Experiments have shown, for example, that graphite/epoxy spring rods behave in a predictable, repeatable way.) The spring rods would be arranged in a pin/roller beam configuration to load them optimally and prevent the application of thrust loads (that is, loads parallel to the axis of rotation) to the tire. By appropriate sizing of the spring rods and selection of the spring-rod material, the mechanical compliance of the wheel can be tailored over a wide range.



The **Spring Rods** would act as shock absorbers and load distributors between the isogrid tire and the hub.

This work was done by Peter Waydo of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.

NPO-30378

Viscoelastic Vibration Dampers for Turbomachine Blades

These dampers can be retrofitted to existing machines.

Ames Research Center, Moffett Field, California

Simple viscoelastic dampers have been invented for use on the root attachments of turbomachine blades. These dampers suppress bending- and torsion-mode blade vibrations, which are excited by unsteady aerodynamic forces during operation. In suppressing vibrations, these dampers reduce fatigue (thereby prolonging blade lifetimes) while reducing noise. These dampers can be installed in new turbomachines or in previously constructed turbomachines, without need for structural modifications. Moreover, because these dampers are not exposed to flows, they do not affect the aerodynamic performances of turbomachines.

Figure 1 depicts a basic turbomachine rotor, which includes multiple blades affixed to a hub by means of dovetail root attachments. Prior to mounting of the blades, thin layers of a viscoelastic material are applied to selected areas of the blade roots. Once the blades have been installed in the hub and the rotor is set into rotation, centrifugal force compresses these layers between the mating load-bearing surfaces of the hub and the blade root. The layers of viscoelastic material provide load paths through which the vibration energy of the blade can be dissipated. The viscoelasticity of the material converts mechanical vibration energy into shear strain energy and then from shear strain energy to heat.

Of the viscoelastic materials that have been considered thus far for this application, the one of choice is a commercial polyurethane that is available in tape form, coated on one side with an adhesive that facilitates bonding to blade roots. The thickness of the tape can be chosen to suit the specific application. The typical thickness of 0.012 in. (≈0.3 mm) is small enough that the tape can fit in the clearance between the mating blade-root and hub surfaces in a typical turbomachine.

In an experiment, a blade was mounted in a test fixture designed to simulate the blade-end conditions that prevail in a turbocompressor. Vibrations were excited in the blade by use of an impact hammer, and damping of the vibrations was measured by use of a dynamic signal analyzer. Tests were performed without and with viscoelastic dampers installed in the dovetail root attachment. The results of the measurements, some of which are presented in Figure 2, show that the viscoelastic dampers greatly increased the rate of damping of vibrations. Accordingly, dynamic stresses on rotor blades were significantly reduced, as shown in Figure 2.

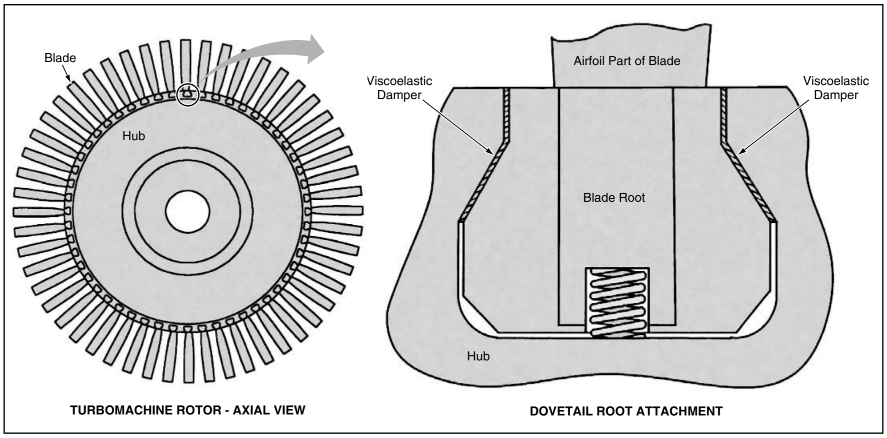


Figure 1. **Thin Layers of Viscoelastic Damping Material** between the blade and hub contact surfaces provide for dissipation of vibrational energy on load paths.

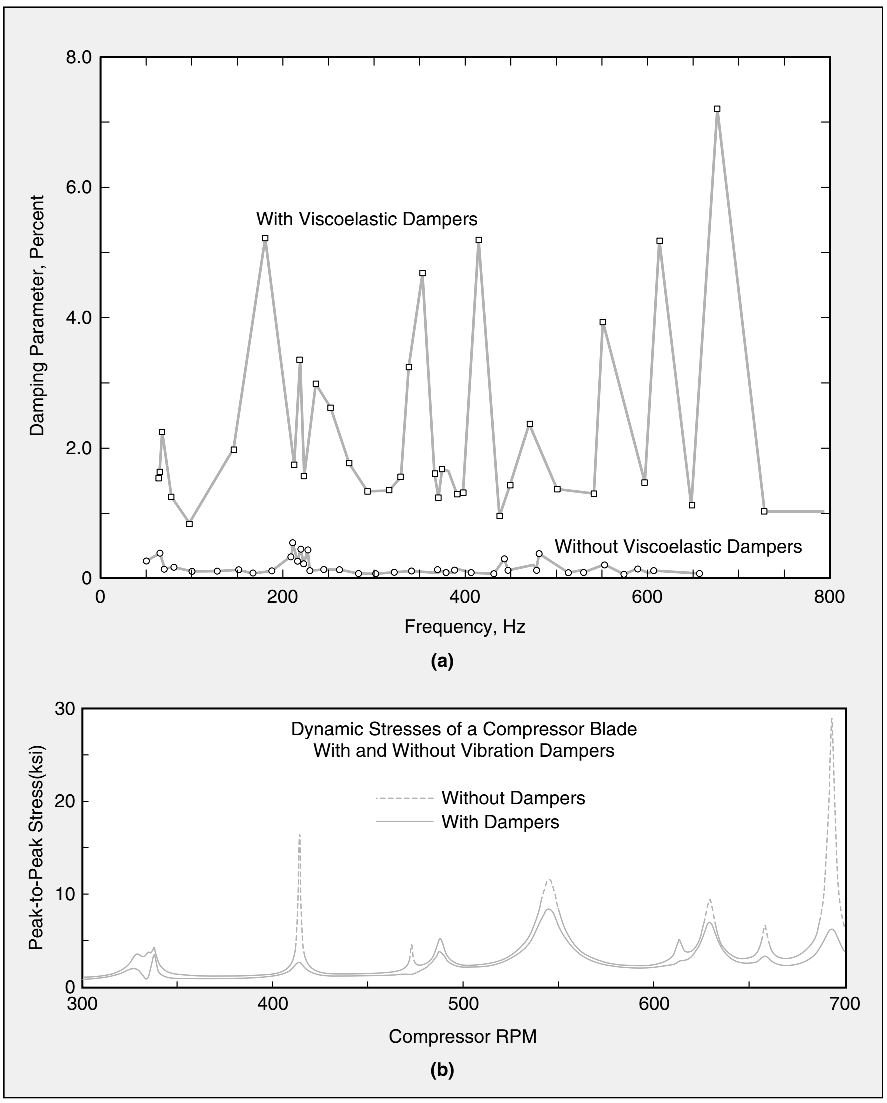


Figure 2. The **Results of the Measurements** have shown that the rate of damping at all frequencies was found to be increased significantly when viscoelastic dampers were installed, as observed in (a). This damping increase results in a significant reduction in operational vibratory stresses of rotor blades in a compressor, as seen in (b).

This work was done by Nhan Nguyen of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.

This invention has been patented by NASA (U.S. Patent No. 6,102,664). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14061.

Books and Reports

Soft Landing of Spacecraft on Energy-Absorbing Self-Deployable Cushions

A report proposes the use of cold hibernated elastic memory (CHEM) foam structures to cushion impacts of small (1 to 50 kg) exploratory spacecraft on remote planets. Airbags, which are used on larger (800 to 1,000 kg) spacecraft have been found to (1) be too complex for smaller spacecraft; (2) provide insufficient thermal insulation between spacecraft and ground; (3) bounce on impact, thereby making it difficult to land spacecraft in precisely designated positions; and (4) be too unstable to serve as platforms for scientific observations. A CHEM foam pad according to the proposal would have a glass-transition temperature (T_g) well above ambient temperature. It would be compacted, at a temperature above T_g, to about a tenth or less of its original volume, then cooled below T_g, then installed on a spacecraft without compacting restraints. Upon entry of the spacecraft into a planetary atmosphere, the temperature would rise above T_g, causing the pad to expand to its original volume and shape. As the spacecraft decelerated and cooled, the temperature would fall below T_g, rigidifying the foam structure. The structure would absorb kinetic energy during ground impact by inelastic crushing, thus protecting the payload from dam-