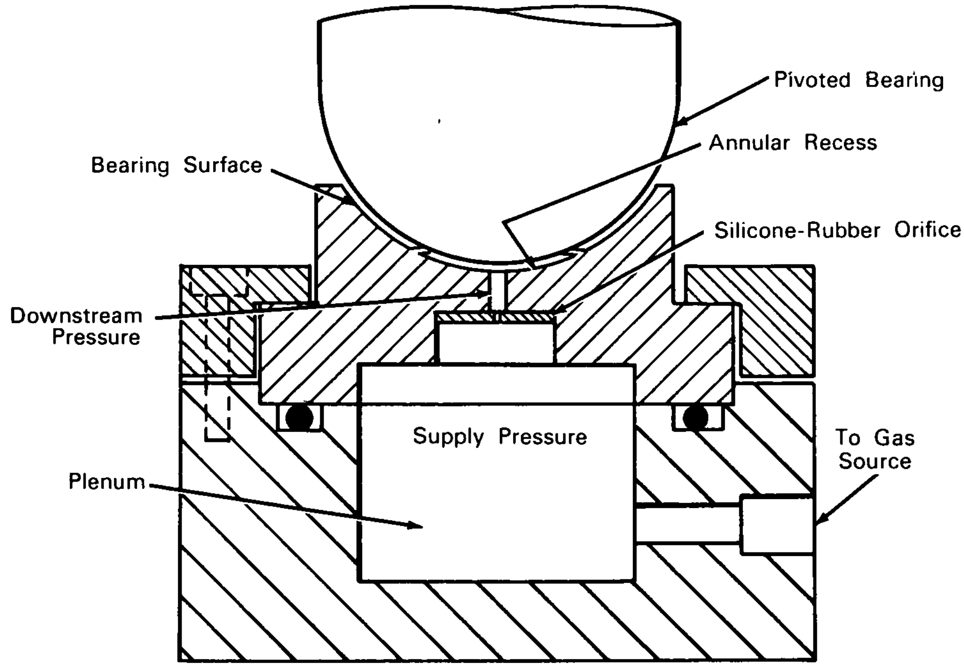
NASA TECH BRIEF

Elastic Orifice Automatically Regulates Gas Bearings



The problem: Recent trends in machine-tool and instrumentation technology have placed increasing emphasis on the development of externally pressurized liquid bearings to obtain performance characteristics that are difficult to achieve with rolling-contact bearings. Liquid bearings are inherently capable of providing smoother operation than rolling-contact bearings, and eliminate the need for special lubricants that must remain effective in extreme environments (e.g., under high temperatures or vacuum). They have many limitations, however, among which is a high frictional resistance at high speeds.

Gas-lubricated bearings, on the other hand, have low frictional resistance at high operating speeds, but their use has been limited because of their relatively high power consumption (gas pressure × orifice area × gas velocity) and low stiffness, especially at higher bearing loads. A further limitation is that these bearings have high efficiencies and optimum characteristics only at the loadings for which they were designed, since at high loads not enough gas flows for lubrication and at low loadings flows are excessive. Thus, a method for automatic control of gas flow was sought in order to permit bearings to be operated over wide ranges of loadings and speed.

(continued overleaf)

The solution: Use of an elastic, pressure-sensitive orifice to regulate the rate of gas flow into the bearing under varying loads. Orifices of this kind, in comparative tests with fixed orifices, appear to be more stable and provide greater bearing stiffnesses (especially at higher loads), lower power consumption, and greater load-carrying capacity per unit of power consumption.

How it's done: An orifice is formed in a circular disc of an elastomer (e.g., silicone rubber), by molding uncured elastomer around a metal pin and withdrawing the pin after the elastomer has set. A cross-sectional view of a typical spherical gas-lubricated bearing is shown above. In operation, the supply pressure is usually held constant. The pressure just downstream of any orifice is lower; it is at a minimum when the bearing is not loaded and at a maximum when it is loaded. Thus, the pressure differential across a fixed orifice and the gas flow through it are very great under light loads and altogether too small under heavy loads. However, when the fixed orifice is replaced with an elastic one, an increased bearing load decreases the pressure differential across the orifice, allows the elastomer to relax, and thus leads to an increase in the effective diameter of the orifice. As a result, the gas flow tends to remain constant even though the load on the bearing varies widely; the overall result is a significant saving in gas and power consumption, especially at lighter bearing loads.

The elastic orifice has been found to provide a definite improvement in stiffness. Although the maximum load-carrying capacity for a given bearing may be lower with an elastic orifice than with a fixed orifice, it can be shown that elastic-orifice bearings designed specifically for high loadings present definite advantages. Elastic orifices, furthermore, are particularly efficient when gas can be supplied at high pressures.

The results of preliminary tests indicate that an elastic orifice increases the stability characteristics of a given gas bearing, especially at low gas-flow rates.

Elastic orifices tend to be free of clogging by dust particles, particularly when load variations are sufficiently large, and are simpler to construct and maintain than other types of automatic fluid-control devices.

Notes:

1. Use of a bearing with an elastic orifice is recommended in situations where improved load bearing stability is required, where major load variations occur or the exact load cannot be anticipated, and where gas and power consumption must be held at a minimum value.
2. Alternative designs of the elastic orifice may be advantageous in some applications; for example, the elastic orifice may be placed between metal discs, or provisions may be made for interchangeable units.
3. Instead of using the elastic properties of plastic materials, a flexible orifice may be constructed of metal by incorporating springs or diaphragms in a valve-type design. This would be preferable in high-temperature applications or in a radiation environment.
4. For further information about this innovation, inquiries may be directed to:

    Technology Utilization Officer
    Jet Propulsion Laboratory
    4800 Oak Grove Drive
    Pasadena, California 91103
    Reference: B63-10123

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: John L. Laub and Frank Batsch
(JPL-135)