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Noncontacting Devices to Indicate Deflection and Vibration of Turbopump Internal Rotating Parts

In the past, prototype turbopumps developed for liquid rocket engines had to undergo expensive, complicated tests to determine deflections and vibrations of internal parts. Most of these tests required the insertion of strain gauges and slip rings into a cryogenic environment, major disassembly of pump sections to permit the placement of various sensors, and the mechanical connection of measuring devices to the high-speed rotating parts.

In an attempt to simplify this testing, a feasibility study was performed to evaluate the noncontacting devices which would monitor internal turbopump components remotely. The study, published in a report, discusses the feasibility of the following:

1. Ultrasonic techniques
2. Neutron techniques
3. X-radiography
4. Optical devices
5. Radioisotope and gamma ray devices
6. Conventional displacement sensors

The ultrasonic approach uses an ultrasonic Doppler transducer. This transducer applied to the outer case of a turbopump can measure vibration of internal parts with a high degree of accuracy so long as there is a liquid or a solid path connecting it with the rotated part.

The neutron technique calls for a directional fast-neutron detector which was evaluated analytically and found feasible. The problem of its expensive development, however, remains to be resolved.

Flash X-rays, pulsed over a 20-nanosecond interval, were found feasible for real-time measurements. Commercial units are available which produce X-ray energies of 300 kV, 600 kV, and 2 MV, Lower power units do not have sufficient energy to penetrate large turbopumps. At the present stage, this technique is limited to detection of ±0.125 mm (5 mils) in vibration amplitude.

Among the optical techniques evaluated, light-pipe-reflectance was selected as the most appropriate one because it is easy to apply, it can measure a large range of amplitudes, it is not affected by large temperature variations, and it does not require accurate reflecting surfaces. The method uses a fiber optic probe which is inserted through a hole drilled in the turbopump housing. The probe is very flexible and can be easily inserted into difficult-to-reach locations.

Radioisotope and gamma ray devices, based on a simple Mössbauer analysis, were found to be too sensitive for turbopump measurements.

Conventional displacement sensors, using magnetic devices to measure vibration, did not offer any improvements over those in existence. The use of signal transmitters in place of slip rings indicated a possible improvement and will be the subject of further study.

Note:

Requests for further information may be directed to:

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