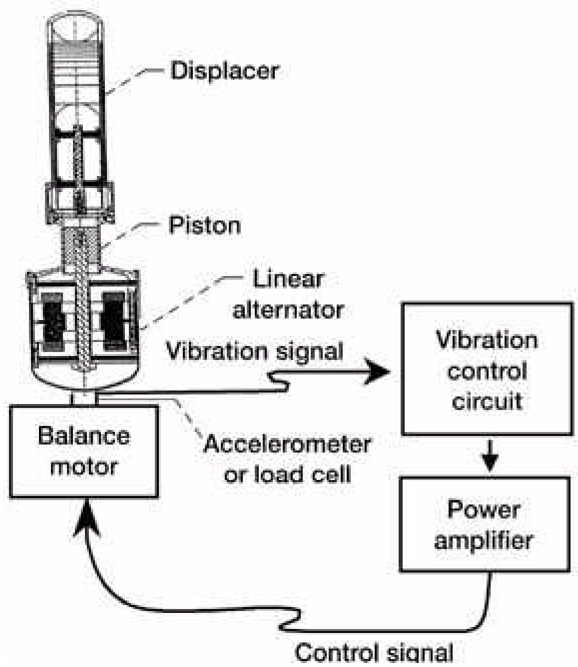
Adaptive Vibration Reduction System Shown to Effectively Eliminate Vibrations for the Stirling Radioisotope Power System

Stirling Technology Company (STC), as part of a Small Business Innovation Research contract Phase II with the NASA Glenn Research Center at Lewis Field, is developing an Adaptive Vibration Reduction System (AVRS) that will effectively eliminate vibrations for the Stirling radioisotope power system. The AVRS will reduce vibration levels for two synchronized, opposed Stirling converters by a factor of 10 or more under normal operating conditions. Even more importantly, the AVRS will be adaptive and will be able to adjust to any changing converter conditions over the course of a mission.

The Stirling converter is being developed by NASA and the Department of Energy (DOE) as a high-efficiency option for a radioisotope power system to provide onboard electric power for NASA deep space missions. The high Stirling efficiency of over 25 percent for this application will reduce the required amount of isotope by more than a factor of 3 in comparison to the current radioisotope thermoelectric generators (RTG’s). Stirling is the most developed converter option of the advanced power technologies under consideration.



Adaptive vibration reduction system.

The AVRS (see the preceding illustration) uses an active balance system with feedback from a vibration signal and will cancel the fundamental vibration and up to 10 harmonics. A balance mass is driven by a separate linear motor; only one balance motor is needed for two opposed Stirling converters. A balance motor being used in the first AVRS testing is shown in the following photo. A fast Fourier transform of the vibration signal is used to construct a compensation signal that is sent to the balance motor through a power amplifier. Both the amplitude and phase of each harmonic can be adjusted. Converter frequency must also be measured on a continual basis and factored into the control algorithm. The AVRS will adjust to any change in converter operating conditions, any converter degradation that may occur over a mission, and even to a converter failure, in the unlikely event that one occurs. The AVRS will first be demonstrated on two 350-We RG–350 converters and then on the DOE/STC 55-We converters being developed for the radioisotope power system.

Balance motor for 350-We converters.

Initial tests of the AVRS on the RG–350 converters have shown a 500-fold reduction in unbalanced vibrations under normal operating conditions with two synchronized converters in an opposed configuration. This compares to a fortyfold to fiftyfold reduction achieved when the converters are just synchronized, and these further reductions were accomplished with only 2 W of power dissipation. Testing was also done with a simulated failed converter, and a fiftyfold vibration reduction was obtained with only 7 W of power dissipation. This power dissipation scales to less than 2 to 3 W for a 55-We converter. For these initial tests, the AVRS balanced only the fundamental of the vibration signal (no harmonics). The full control algorithm is now being developed, and vibration levels should be even further decreased as the balancing is extended to include the harmonics of the vibration signal.

Find out more about research at Stirling Technology Company http://www.infiniacorp.com/main.htm and NASA Glenn http://www.grc.nasa.gov/WWW/tmsb/stirling.html.

Bibliography

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