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Observations of Direct Self-Heating Power in Pre-Stressed Piezoelectric Actuators

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Introduction

Piezoactuators in space instrumentation Spaceborne instrumentation is necessary for observing distant universe objects and monitoring the environment on Earth. The development of larger instruments that are able to achieve higher resolution at the diffraction limit is driven by the demand for imaging of a higher quality. In order to meet this demand, observatories with comparable stowed volumes must be larger and more capable. Using segmented aperture telescopes, which necessitate the precise positioning of their optical elements in relation to one another, is one method for achieving this. Other times, instruments without segmented apertures may also need their focal plane assembly or other intermediate optical path elements to be activated. Deformable mirrors and fast steering mirrors are two examples of these latter components [1].

In order to meet misalignment requirements, advanced future space observatories will incorporate numerous active optical elements whose actuation must be extremely precise. In the past, the stepper motor in conjunction with a reduction gearbox and flexure amplifier was the technology of choice for instruments like the James Webb Space Telescope (JWST). Pre-stressed piezoelectric actuators may power some of these actuation stages in current and future instruments due to their simpler mechanical properties, high stiffness, rapid response, and high repeatability. These materials warm up due to losses that occur when they convert electrical power into motion during repetitive operation—a phenomenon known as self-heating. From a control perspective, piezoelectric actuators have complex behaviour that is characterized by strong field-polarization hysteresis. Additionally, creep and saturation can occur in piezoelectric materials. All things considered, piezoelectric actuators are fit for arriving at goals in the request for one nanometre, gave exact control can be planned. The drive and control of these actuators can be achieved using a variety of methods, as described in the literature [2].

Description

There are two types of piezoelectric ceramics: soft and hard. The piezoelectric constants of hard piezoelectric materials are typically smaller. They are used in applications that require high frequencies and small displacements. Ultrasonic transducers are typical instances. Larger strokes are produced by the larger piezoelectric constants of soft piezoelectric materials. When it comes to actuators that operate at lower frequencies, this is advantageous. Since the application is a precision actuator, the latter kind of material is interesting for this study. Additionally, piezoelectric actuators can be embedded in a wide range of motion amplifiers and can operate in either linear or bending modes. Linear-mode actuators made of piezoceramics are the primary focus of this paper. Compared to stepping bending mode actuators, these actuators have a smaller range of motion but much higher stiffness and blocked force. A frame is used to pre-stress the linear actuators used in applications requiring high precision. This prevents stick-slip behavior at the mechanism-actuator interface and provides a standard interface [3].

Self-warming of piezoactuators might be a test both in optical and thermo-mechanical terms. Thermal infrared (TIR) instrument measurements may be disrupted by additional heat even before the actuator experiences complete thermal failure. Due to thermal expansion of the actuator or its surroundings, heat leakage from the actuator may result in misalignment. Due to the increased current draw at high temperatures, self-heating has also been identified as a potential cause of runaway thermal failure. Additionally, self-heating alters the actuators' electrical properties, which are temperature-sensitive and require compensation. It is possible to design materials with high thermal stability, but removing the temperature dependence is difficult. Weaver and co. reviewed a number of approaches to the characterization of piezoelectric parameters in materials subjected to high temperature. To compensate for actuator capacitance's temperature dependence, it has been suggested to measure temperature as a control parameter. In piezoelectric sensors, adhesive bonding failure has been linked to thermal cycling, which can be caused by self-heating. To qualify the system and construct a reliable thermal model of the mechanism, tests addressing this phenomenon are essential [4].

A transient analysis of the actuator response has been the basis for previous studies on the self-heating effect of piezoelectric actuators. The actuator is initially inactive in this approach, and self-heating begins upon activation with a certain frequency and amplitude. The method used by Pritchard et al. to calculate the heat dissipation of multi-layer actuators was reversed. The response is comparable to a first-order system's step response when temperature is plotted against time in this configuration. A parameter kT that models the dynamics of the system is used to fit the precise parameters of the decaying exponential solution to the transient. A good fit of the behaviour is made possible by this, which includes the actuator's conductive, radioactive, and convective couplings to its environment. The generated heat flow cannot, however, be directly computed in this study. In addition, if the thermal couplings to the environment are not well characterized, kT is a fitting parameter that is difficult to trace back to basic principles. In addition, it is challenging to incorporate these models into complex boundary-condition system-level thermal models. The thermal path that connects the actuator's environment to the outside world must be sealed off from losses in order to achieve high power production resolution. The actuator's total heat output can thus be measured. Although it is difficult to completely eliminate these heat leaks from the setup, several well-known methods have been utilized to limit them. By wrapping the setup in MLI, radiant losses from the cup to the shroud are reduced. The mass simulator located on top of the actuator is yet another significant potential source of heat loss. A screw in the centre, supported by point contact, connects this to the actuator. Thermal washers with poor thermal conduction are used to further isolate the bolted connections between the actuator and the mass. By matching the temperatures in their thermal paths, losses are further reduced. To further reduce heat loss through the cup, the vacuum chamber's shroud is set to follow the cup's temperature. Guard heaters are installed in the mass and are controlled to match the actuator's top temperature. The mass thermal controller is not set up to closely follow its target, but rather to reach it in steady state, which is why these two temperatures do not always coincide during a transient [5].

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The adapter plate's fluctuation in thermal homogeneity, which serves as the interface between the cold sink and the test setup, is yet another significant source of measurement error. This plate's temperature is controlled by the feedback of one thermocouple and one more. It was anticipated that the second thermocouple would share a constant offset with the first. The spare thermocouple, on the other hand, exhibits slow fluctuations of 0.1 K over several hours, indicating thermal inhomogeneity at this interface, while the controlled thermocouple is stable to within 20 mK. Due to the strong conductive coupling that exists between the actuator and the cold plate, this is significant because these fluctuations also cause significant power fluctuations (of the order of hundreds of miliwatts) to be measured. By placing additional thermocouples in this critical heat path and adjusting the control to ensure that they are all equally stable, an improved version of this test setup could address this issue. Measurement uncertainty arises because the current iteration of the test setup is unable to fully characterize this behavior. The setup's shortcomings were noted during the test campaign. During the calibration process, thermal fluxes could be detected with a resolution of around 60 mW; however, these results cannot be relied upon to be accurate if the cold plate's stability is compromised. Although processes with very low heat fluxes (of the order of 10 mW) may not be characterized without modifications, this is probably sufficient for the majority of applications. With the instrumentation, it is possible to observe temperature rise without noticing an increase in power dissipation [5].

Conclusion

The heat dissipation measurement method described can produce a dissipation profile for piezoelectric actuators and other low-power heat-generating test items. The paper demonstrates and describes the measurement principle, but there are still several obstacles to overcome to improve its repeatability and resolution. This method's measurements have been used to compare dissipation at various temperature set points and can be modified to better reflect real-world boundary conditions. The method's current flaws have been looked at, and for future iterations, mitigation strategies have been suggested.

References

1. Latif Khalid, Joseph George Ray and Olivier Planchon. "Algae on Mars: A summary of the evidence." *J Astrobiol* 7 (2021): 22-28.
2. Joseph Rhawn G, Olivier Planchon, Carl H. Gibson and Rudolph Schild. "Seeding the solar System with life: Mars, venus, earth, moon, protoplanets." *Open Astronomy* 29 (2020): 124-157.
3. Bianciardi, Giorgio, Vincenzo Rizzo and Nicola Cantasano. "Opportunity rover's image analysis: Microbialites on mars?" *Int J Aeronautical Space Sci* 15 (2014): 419-433.
4. Frydenvang Jens, Patrick J. Gasda, Joel A. Hurowitz and Ken S. Edgett, et al. "Diagenetic silica enrichment and late-stage groundwater activity in gale crater, mars." *Geophys Res Lett* 44 (2017): 4716-4724.
5. Hausrath Elisabeth M, D W. Ming, T S. Peretyazhko and E B. Rampe. "Reactive transport and mass balance modeling of the stimson sedimentary formation and altered fracture zones constrain diagenetic conditions at gale crater, mars." *Earth Planet Sci Lett* 491 (2018): 1-10.

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