Creep Measurement Video Extensometer

This automated system measures test-sample creep rates for materials testing.

John H. Glenn Research Center, Cleveland, Ohio

Understanding material behavior under load is critical to the efficient and accurate design of advanced aircraft and spacecraft. Technologies such as the one disclosed here allow accurate creep measurements to be taken automatically, reducing error.

Before the present innovation, there was no satisfactory method of accurately measuring the mechanical strain characteristics of materials during deformation at high temperatures inside an inert gas or vacuum chamber. The goal was to develop a non-contact, automated system capable of capturing images that could subsequently be processed to obtain the strain characteristics of these materials during deformation, while maintaining adequate resolution to capture the true deformation response of the material.

The measurement system comprises a high-resolution digital camera, computer, and software that work collectively to interpret the image. The camera captures an image of the specimen prior to beginning the test. The image, containing two fiduciary marks at a known distance, is analyzed by the software to determine the relationship between actual distance and the number of pixels separating the fiduciaries in the image. This is the basic calibration prior to the beginning of a test.

Once a test is started, images are captured at a predetermined rate and the calibration relationship is used to determine the distance between the fiduciaries while the specimen is being deformed, by converting the pixel distance between fiduciaries to the actual separation distance via the predetermined relationship. The separation distance is then used to measure the creep rate, and information important to the analysis of the test is automatically written to a file that can be exported to other analytical software. This system can also be used for tensile and compression testing, but data acquisition rates are limited due to the current state-of-the-art in hardware. Finally, the system has been proven out for testing being conducted at low temperature, high temperature, in air, vacuum, and inert gas environments, on systems that give line-of-sight access either directly or via a chamber viewport.

The software for this technology was written in LabVIEW, C, and VBScript. LabVIEW was used for the majority of the code (user interface, program control, data storage, etc.). Standard image processing algorithms were written in C for those areas of the code requiring computationally intensive image processing routines (connected components labeling, circular Hough transform, and circularity measurement). VBScript is used to control the cameras and transfer images from the cameras to the PC. The VBScript uses Windows Imaging Acquisition (WIA) to send commands to the cameras and is based on sample code from Microsoft and a script called "Camera Control."

The system, based on an inexpensive, 12-megapixel, digital SLR camera, provides an accuracy that is within 0.0005 in. (12.8 μm). In contrast, the prior art (optical cathetometry) was only accurate to within 0.001 in. (25.4 μm). Hence, increased accuracy was not only achieved, but can be further increased by using even higher-resolution cameras (when available) or increased magnifications where applications permit.

This work was done by Mark Jaster, Mary Vickerman, Santo Padula II, and John Juhas of Glenn Research Center. Further information is contained in a TSP (see page 1). LEW-18578-1

Radius of Curvature Measurement of Large Optics Using Interferometry and Laser Tracker

This method determines the curvature radius of large mirrors.

Goddard Space Flight Center, Greenbelt, Maryland

The determination of radius of curvature (ROC) of optics typically uses either a phase measuring interferometer on an adjustable stage to determine the position of the ROC and the optics surface under test. Alternatively, a spherometer or a profilometer are used for this measurement.

The difficulty of this approach is that for large optics, translation of the interferometer or optic under test is problematic because of the distance of translation required and the mass of the optic. Profilometry and spherometry are alternative techniques that can work, but require a profilometer or a measurement of subapertures of the optic. The proposed approach allows a measurement of the optic figure simultaneous with the full aperture radius of curvature.

The steps required for this measurement are:

- Alignment of the phase measuring interferometer with the optic under test. For a spherical optic, a transmission sphere that overfills (faster f#) the optic is used.
- The power is nulled by translating the optic under test (OUT) or the interferometer. At this point, the transmission sphere focus is the radius of curvature of the OUT.
- An adjustable mount near the focus of the transmission sphere has a magnetic nest for placing a laser tracker retro-target. This is a spherical target

with a cube corner inset co-aligned with the center of the sphere. These devices are available commercially.

- The laser tracker target is then placed in the calibration nest of the laser tracker, zeroed, and hand-carried to the position of the laser tracker nest near the interferometer. The laser tracker beam must be continuously locked to the tracker to stay in lock. This is a typical mode of the laser tracker used for absolute metrology.
- The spherical laser tracker is positioned so that the shiny (non-retro) surface of the tracker target is aligned to the transmission sphere. It is then translated until a nulled interferogram is observed. At this point, the center of the laser tracker target is at the focus of the transmission sphere (and thereby at the ROC of the OUT.)
- The *x,y,z* position of the tracker target is then acquired by the laser tracker.
- The laser tracker target is then removed from the nest, and without losing lock to the tracker, is hand-carried to the OUT. It is then placed on the OUT at its center (which has a nest on its surface pre-aligned to the center).
- The tracker then acquires the *x,y,z* position of the laser tracker target.
- The data is reduced and the two positions calculated. The position at the ROC is directly at the ROC, while the position on the mirror is displaced by the radius of the laser tracker target. This radius must be added to the distance measurement in the calculation.

This process is repeated to allow redundancy of the measurement.

This work was done by John Hagopian and Joseph Connelly of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15941-1

n-B-pi-p Superlattice Infrared Detector

NASA's Jet Propulsion Laboratory, Pasadena, California

A specially designed barrier (B) is inserted at the n-pi junction [where most G-R (generation-recombination) processes take place] in the standard n-pi-p structure to substantially reduce generation-recombination dark currents. The resulting n-B-pi-p structure also has reduced tunneling dark currents, thereby solving some of the limitations to which current type II strained layer superlattice infrared detectors are prone. This innovation is compatible with common read-out integrated circuits (ROICs).

This work was done by David Z. Ting, Sumith V. Bandara, Cory J. Hill, and Sarath D. Gunapala of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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