Stress Photonics
Thermoelastic Forum

A Newsletter of Thermoelastic Technology **Vol.1, No.2, Oct. 1992**

First Words

Thank you for the encouraging response to our first newsletter. We hope that we can continue to bring you newsletters that keep you up-to-date with the latest in thermoelastic techniques, equipment and software.

The November SEM conference in Chicago is coming up! In our "Events" column we have provided information on sessions that we think you will find interesting. Please take a minute to read the session and paper titles. There will be no written proceedings from this conference, so if you are not attending and you have a particular interest in one of the topics you'll have to get in direct contact with one of the authors. Stress Photonics can provide you with their phone numbers and addresses.

The "UW-Corner" deals with thermoelastic stress analysis of randomly loaded structures. This is a topic which has received significant study at Stress Photonics as well as at the University of Wisconsin. If you are interested in using your SPATE system for non-sinusoidal loading contact us for a chat and we'll do our best to help you.

Again, we are glad to see that so many of you found the newsletter valuable. If you have any suggestions as to how this newsletter can better serve you please describe your ideas on the comment card provided and return them to us. We would be happy to incorporate your suggestions into upcoming editions of the *Thermoelastic Forum*.

The R&D Side

Image Distortion

By Jon Lesniak

I have for some time been concerned about image distortions caused by the SPATE scan mirrors. Recently, I looked at this problem in more detail.

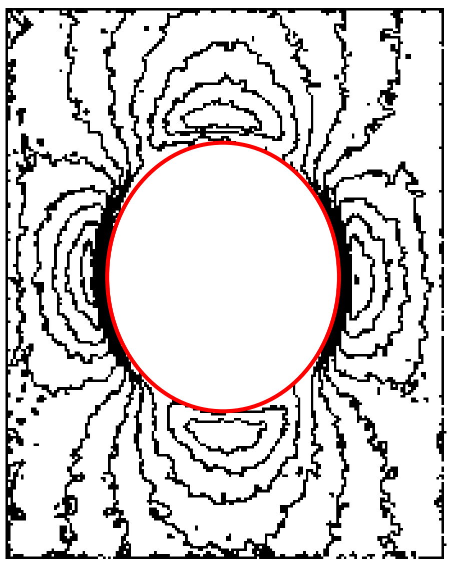

Fig. 1a Distorted Image

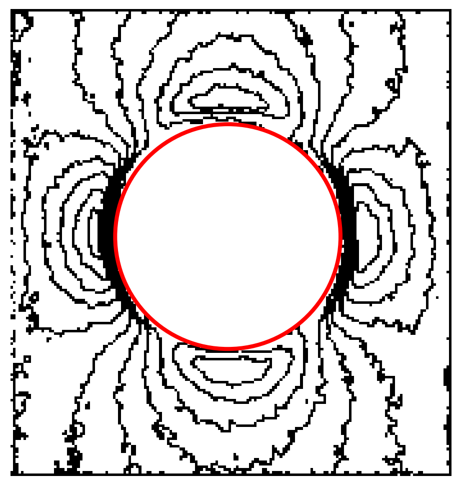

Fig. 1b Corrected Image

There are three common image distortions affecting SPATE data sets:

- X and Y scan mirror separation
- Tan(θ) approximation
- Camera angle

Figure 1a shows a combination of these effects.

Scan Mirrors

As can been seen by looking into the SPATE camera, there are two scan mirrors. The rectangular one on the bottom is the y-scan mirror and the oval one above it is the x-scan mirror. The distance between their axes of rotations is about 2.0 inches.

The mirrors convert the analog steps from the computer DACs to proportional angular steps. The x-y scan position is related to these angular steps by

$$x = (d + 5.0) \tan(\alpha_x N_x)$$
$$y = (d + 3.0) \tan(\alpha_y N_y)$$

where d is camera distance, α_x and α_y are angle/DAC step, and N_x and N_y are the number of DAC steps.

Mirror Separation Distortion

As a result of the difference in the true x and y distance, each y DAC step yields a smaller y distance on the specimen than each x DAC step. If, for example, you were to mark off a 3 in. x 3 in. square on your specimen, you would find that it takes more DAC steps in the y direction than in the x direction. The resulting image would be displayed as a tall rectangle. The amount of y expansion in our camera is plotted in Fig. 2. Note that the angular steps of our mirror motors appear to have been set for distortion free imaging at 60 inches.

See "Image Distortion" on page 2

Events

SEM to program at ASNT'S 1992 Quality Testing Show and Fall Conference: Nov. 16-18

SEM will program jointly with the American Society for Nondestructive Testing (ASNT) at the Quality Testing Show and 1992 Fall Conference to be held at the Sheraton Chicago Cityfront Center.

The Quality Testing Show attracts NDT professionals from all over the globe to share the latest in NDT techniques and applications. The Quality Testing Show typically attracts more than 2,000 people.

The theme of ASNT's Fall Conference is, "Quality Through NDT: A Partner for Success," and will offer approximately 125 presentations. Sessions pertaining to thermal methods are detailed below.

For further information about the program or exhibit, please contact the SEM office, 7 School Street, Bethel, CT 06801; (203) 790-4472.

Technical Session 2. Thermographic Measurement for Structural Assessment Tue., Nov. 17th, 10am-Noon

Sponsored by the Thermal Methods Technical Division

IR Thermography of Fast Transient Phenomena
Steve Shepard, U.S. Army Tank-Automotive Command (USA)

Advanced Thermographic NDE via Dynamic Pattern Projector
J. Lesniak, Stress Photonics, Inc. (USA)

Thermoelastic Stress Characterization in Aircraft Structures
K.E. Cramer, NASA Langley Research Center and C.S. Welch, College of William and Mary (USA)

Thermal Characterization of Structural Material Using Time-resolved Techniques
J.C. Murphy, J.W. Spicer, W.D. Kerns and L.C. Aamodt, The Johns Hopkins University (USA)

Thermoelastic Quantification of Distributed Damage in a Composite Material
B.J. Mahoney, Ford Motor Co. (USA)

Technical Session 4. Nondestructive Testing Applied to Composite Materials Wed., Nov., 18th 9am-Noon

Sponsored by the Composite Materials Technical Division

Low Frequency Ultrasonic Scans of Flaws in Composites
D.K. Hsu, Iowa State University (USA)

Review of Progress in Quantitative NDE for Fiber-reinforced Composites
L.J. House and F.B. Stulen, Battelle Memorial Institute (USA)

Nondestructive Detection of Compressive Fatigue Damage in Thick Composites
R.E. Green and C. Byrne, The Johns Hopkins University (USA)

Damage Accumulation in Thick Composites During Compressive Fatigue
C.Byrne and R.E. Green, The Johns Hopkins University (USA)

Use of Piezoelectric Polymer Sensors for Sensing Stresses and Defects in Adhesives and Composites
G.L. Anderson, Thiokol Corporation; D.A. Dillard, J. Mommaerts, J. Duke and B. Tang, Virginia Polytechnic Institute and State University (USA)

Studies of Impact Damage in Structural Composites by Thermal Wave Imaging
R. Thomas, Wayne State University (USA)

Tutorial: Thermoelastic Stress Analysis Tue., Nov., 17th 1:30pm-5pm

Sponsored by the Thermal Methods Technical Division

Speakers: Bradley R. Boyce and Jon R. Lesniak, Stress Photonics; and Jamal Dajani, Ometron

See "Tutorial" on page 3

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"Image Distortion" from page 1

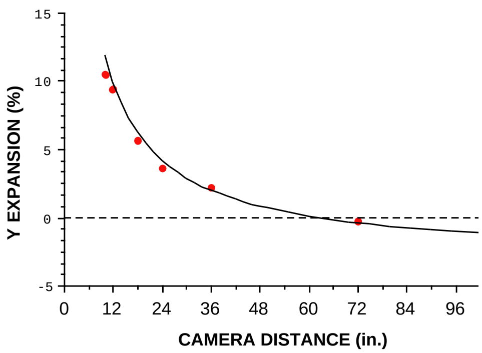


Fig. 2 Mirror Separation Distortion

Unfortunately, the y expansion is largest at a camera distance of 10 in.; the working distance often used to compare SPATE to theory.

Small Angle Approximation Distortion

The SPATE system approximates TAN (θ) as θ. This can have a significant effect on larger scans. For example, for a scan extending ± 25˚ a 7% dimensional error occurs at the edges of the scan.

Camera Angle Distortion

The details of camera angle distortion can be slightly more complex than one would first expect. But simply, if the camera is viewing the surface at an angle β, then there is a compression of the image of 1-cos(β) in the direction of the angle.

Image Correction Software

It is not difficult to correct any of the aforementioned image distortions. The scan shown in Fig. 1a was taken at 18 in. from the specimen with a 30˚ camera angle. A camera angle of 30˚ results in a 13% compression of the x dimension. At 18 in. the scan mirror separation causes a 6% expansion of the y dimension.

Figure 1b is the result of a new analysis routine that I have created to correct these image distortions. The routine is a simple spatial transformation which interpolates data for the new coordinates from the original data set. Notice that the image is not affected in any way other than the spatial correction. The data can still be considered “raw data”.

If you are interested in the software, check the appropriate box on the response card.

Tech Tips

Replacing Battery and Setting TIMEDATE for SPATE 9000

In 1992, the clock battery inside many HP310 and 320 computers started to run out. As a result, the data file creation date in the upper left corner of SPATE 9000 outputs may be incorrect. This is a particularly frustrating problem with two-computer systems because the Data Acquisition and Control (DAC) computer does not have a keyboard or a video monitor; therefore, setting the time is tricky. This tip applies to two-computer systems but can easily be applied to one-computer systems.

Replacing the Battery

Replacing the battery is as easy as changing the battery in a calculator. You will need a BR2325 Lithium battery. A Radio Shack catalog # 23-168 ($1.98) will work fine. To replace the battery follow these steps:

- Identify the DAC computer. Two-computer 9000 systems have three similar looking boxes: the main computer, the DAC computer, and the disk drive. The DAC computer has an empty jack for a keyboard and is not connected to the video monitor.
- Loosen the screws on the CPU board of the DAC computer and gently pull it out an inch or two. (The CPU board has the keyboard jack)
- Locate and remove the battery. In order to get the old battery out, place your fingernail between the battery and its holder near the battery clip. Gently push down and out; the battery should slide right out from under the clip.
- Put the new battery in and button up the computer.

Setting the Time and Date

Now that you have the new battery in, you need to set the time and date to current values. Once this is done the computer will keep fairly good time for the next few years. To set the time and date you need to get the DAC computer to execute a SET TIMEDATE command. You do this by making a change to the AUTOST program that both computers run when they first boot after power up. Here are the steps;

- Change AUTOST to include current time and date by adding line 355 as highlighted below
- RE-STORE AUTOST
- Reboot the computers
- Delete line 355
- RE-STORE AUTOST

```
330   CONTROL Hpib,3; Dac_cpu_adrs                 !  address to 22
340   DISP "LOADing DAC"
350   MASS STORAGE IS ":,700,0,0"
355   SET TIMEDATE   DATE ("30 Sep 1992")+TIME ("08:15:00")
360   LOAD "DAC"            !   THE routine loaded here has
```

If you are an experienced programmer this should be a sufficient set of instructions. However, if you are a novice, call us and we'll FAX you the step-by-step instructions (or return the response card with the appropriate box checked and we'll send the step-by-step instructions).

UW-Corner

Thermoelastic Stress Analysis of Structures under Random Loading

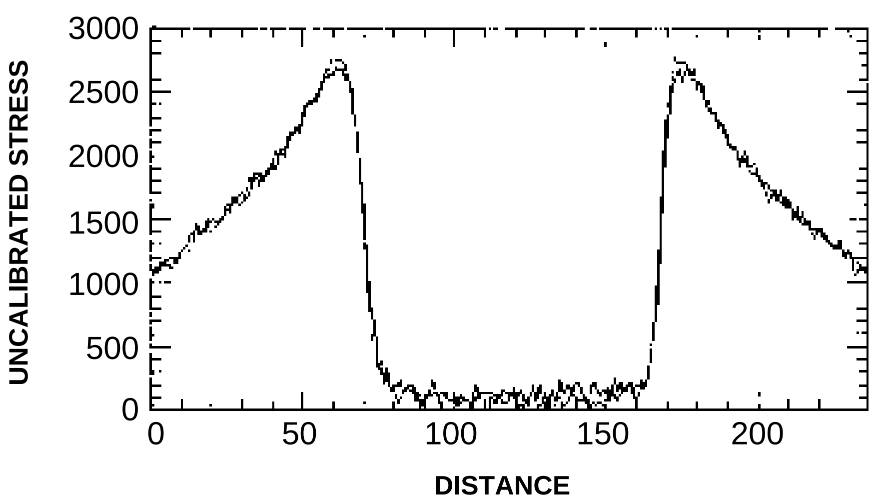
By J.P. Miles, B.J. Mahoney, B.I. Sandor
Department of Engineering Mechanics, UW-Madison

Traditional Thermoelastic Stress Analysis (TSA) uses a sine-wave reference signal as an input to the SPATE lock-in amplifier. Harwood and Cummings[1] have demonstrated the use of the Fourier technique under random excitation whereby a frequency response function between a reference input and the TSA output is determined. This approach is useful when the system exhibits frequency-dependent response. However, the method suffers from a lack of user knowledge of the frequency domain technique, and an increased total data acquisition time. A different signal processing technique has been developed for the TSA system which accommodates a component subjected to variable amplitude, random loading.

Using a strain gage placed locally in the area of interest as a reference, the technique exploits the linearity between the known strain and the resulting TSA signal. A ratio between the total power of the TSA signal and the total power of the reference signal is calculated. Under non-modal behavior, this ratio is equivalent to the square of the frequency response function and is constant at all frequencies.

An aluminum flat plate with a hole in the center was used to test the random signal analysis method. The specimen was loaded in a closed-loop servohydraulic testing machine and subjected to a 10-40 Hz tension-compression random load. The reference signal was obtained from a strain gage placed at the far-field stress location. Figure 1 shows the results of a line scan passing through the center of the hole. For comparison, the results of a traditional sinusoidal line scan are also shown and are in excellent agreement with the line scan produced by the random signal analysis method.

[1]Harwood, N. and Cummings, W. M., “The Theoretical Basis of the Use of Random Excitation Signals for Thermoelastic Stress Analysis”, SPIE, 713, 32-43,1987



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[ ] Send more information on TSA Show
[ ] Send instructions for Replacing Battery & setting TIMEDATE for SPATE 9000
[ ] Send more information on Image Correction
[ ] Add to the *Thermoelastic Forum* mailing list
[ ] Change of address
omments

"Tutorial" from page 3

The tutorial is planned to run two and one-half to three hours and will cover the fundamentals of thermoelastic theory, instrumentation, and application. Application examples with detailed explanation of instrumentation, and data analysis will be used to illustrate the capabilities and shortcomings of the technology. Some advanced applications of Thermographic Stress Analysis (TSA) will also be discussed briefly.

Publications:

"A Method of Thermographic Stress Separation," Boyle, J.T., Hamilton, R., Applied Solid Mechanics IV Conf.