Stress Photonics Thermoelastic Forum

A Newsletter of Thermoelastic Technology

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First Words

Things have been very busy at Stress Photonics this year. Since our last publication of the *Thermoelastic Forum* we have been particularly active placing new *DELTATHERM 1000*™ systems. This is very exciting for us at SP and in the new "Customer Album" section of this newsletter you can read about how the excitement has transferred to the new *DELTATHERM*™ owners. If you are not yet familiar with the system you can read about it in the "New Products" section.

If you get as excited as our customers do about the *DELTATHERM 1000*™ you will want to pay particular attention to the comment in the "New Products" article about renting a system. The new Rent-a-Therm program will help you solve your hot projects right now and introduce you to ***instantaneous stress imaging*** with the *DELTATHERM 1000*™.

At Stress Photonics we are continuously researching thermoelasticity and IR thermography. The "R&D Side" describes some of the latest advances in thermoelastic techniques.

By now many of you will have received an invitation to join us at the spring SEM meeting in Nashville. One highlight of the conference will be the SPATE™ Application Working Group meeting and Thermal Methods Round Table discussion where you can learn more about thermography techniques from experts and associates. This year SEM has altered it's program and is including oral-only presentations. This has attracted many more industrial presentations and has drastically improved the conference. We have included an advance program with the newsletter. (See the "Events" column for details).

The R&D Side

Stealth Furnace

By Jon Lesniak

Stress Photonics has recently released a furnace designed to address the specific problems of elevated-temperature TSA. Under Air Force funding, the "Stealth Furnace" was used in combination with the *DELTATHERM 1000*™ stress measurement system to monitor crack growth at elevated temperatures. Although previous work performed by Enke and Lesniak demonstrated the ability of TSA to work at elevated temperatures as high as 1100˚C (2000˚F), there was not a complete understanding of thermal radiation or the problems that impede high-temperature testing. Applying TSA to extreme environments was still very much a black art that would often fail to yield results. To improve on this, a deeper understanding of the relationship between thermographic methods and the test environment was necessary.

As seen in the *Thermoelastic Stress Analysis Primer* provided in this issue, the Thermoelastic Equation describes that as the specimen temperature rises so does the differential temperature induced via the thermoelastic effect. Because of this, the signal-to-noise ratio (S/N) can actually improve as the temperature increases. The material properties in this equation should be evaluated at the operating temperature.

Although the thermoelastic effect increases at elevated temperatures, there are practical considerations that must be addressed. At high temperatures, pseudo-signals have a greater effect on data, and need to be minimized. Pseudo-signals are temperature changes that occur in sync with the loading, and therefore are detected by the *DELTATHERM*™ system as thermoelastic signal. The main causes of pseudo-signals are:

- Thermal gradients on the specimen
- Emissivity gradients coupled with furnace wall reflections
- Angular motion coupled with background gradient
- Edge effects

Stealth Furnace with Control Electronics

The Stealth Furnace is designed considering all of the potential pseudo-signals . The furnace is laid out in eight zones six of which control wall temperatures and two of which control the

See "Stealth Furnace" page 4

New Products

DELTATHERM 1000™

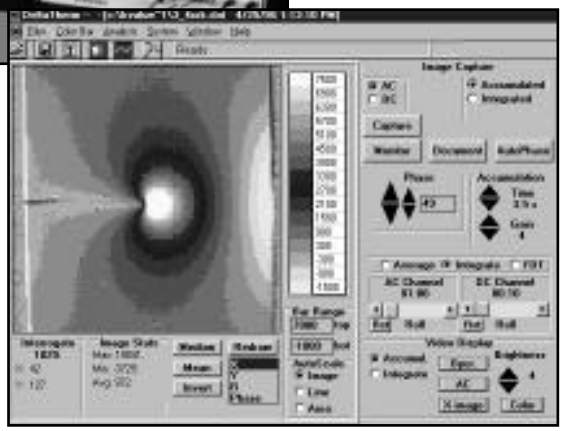
In our last edition of the *Thermoelastic Forum*, Jon Lesniak described the development of the *DELTATHERM 1000*™. Stress Photonics is now pleased to present the *DELTATHERM 1000*™ as a successful new product. A number of systems have been placed in industrial, government, and university laboratories across the country (see the "Customer Album" in this Newsletter).

The *DELTATHERM's* small size, fast imaging speed, and ease of operation combine to make it a highly productive structural analysis tool. The *DELTATHERM*™ system is simple to setup and operate. It can be unpacked, setup, cooled down, and collecting data in less than 30 minutes. Thermoelastic stress maps are formed so fast that a structure can be surveyed for high stress "trouble spots" in a matter of a few minutes. High quality full-field stress images are formed in just a minute or two.

The *DELTATHERM*™ system consists of an ultra-sensitive IR camera head, special image processing electronics, and a laptop computer. Windows™ 95 compatible software on the laptop provides an easy-to-use control panel interface that allows the user to easily manage the collection, storage, and presentation of data. The software automatically documents system settings, data processing history, and user's notes for every image.

The array detector technology used in the *DELTATHERM*™ is also capable of high quality thermal mapping. In the "DC" mode, *DELTATHERM*™ collects thermal maps, or IR digital photographs of the target, for documentation purposes.

DELTATHERM 1000™ *Stress Imaging System*



DELTATHERM™ *control panel interface*

System Performance

Frame Rate:
434 frames/s
Specimen Temperature:
0°C to 50°C
(unlimited range with accessories)
Sync Bandwidth:
1-125 Hz
Dewar Hold Time:
5 hours
Thermal Resolution:
2mK full-field (30s acquisition time)

Optics

Array:
128 x 128 InSb, 3-5µm sensitivity
Lens:
25mm, 50mm, 100mm, f/2.3
Other lenses available upon request
Focus Range:
5.0 inches to infinity
Dewar:
Liquid N_2
Overall Size:
12 in. long, 7 in. wide, 9 in. high
Weight (dry):
8.4 lb.
Spatial Resolution:
as little as 0.002 in

Electronics

Power:
100 - 250V, 100W
Size:
19 in. wide, 8 in. high, 10 in. deep
Weight:
14 lb.
Video Outputs:
NTSC composite
Computer Interface:
Bidirectional parallel

RENT-A-THERM™

Stress Photonics is now offering a rental program for customers who would like to try the *DELTATHERM*™ on a project of their own. The system can be rented on a weekly basis. Rental fees apply toward the purchase of a *DELTATHERM*™ system*. One day of on-site training is required for first time renters.

**75% of rental fees are credited toward a purchase, provided the purchase is made within two years of the rental.*

DELTAVISION™ for Windows

After receiving a number of requests, Stress Photonics has decided to offer *DELTAVISION*™ for the Windows platform. *DELTAVISION*™ is a thermoelastic image processing software package capable of opening both SPATE™ 9000 and *DELTATHERM*™ data files. It provides the user simultaneous high performance processing of multiple data sets. With multiple images on the screen, it is easy to compare various scans and optimally prepare them for presentation. *DELTAVISION*™, used in combination with Windows applications (i.e. Word, WordPerfect, Power Point), makes generating and printing reports an easy final step. Windows DV is written in Microsoft's Visual Basic so users can easily make modifications to meet their own needs or have Stress Photonics do the fine tuning. *DELTAVISION*™ for Windows will be available in July '96.

Stress Photonics

NEW!

DELTATHERM 1000™ Customer Album

By Mike Zickel

The *DELTATHERM 1000*™ is in use and performing well in laboratories across the country.

Elliott Cramer of NASA Langley Research Center's Nondestructive Evaluation Science Branch (NESB) has been using the *DELTATHERM*™ for Non Destructive Evaluation (NDE) of aircraft structures. He reports being very pleased with the results, and talks briefly about the inspection of a particular part. "[We] used the *DELTATHERM 1000*™ to successfully image the stresses in a door latch assembly experiencing dynamic loading" (shown below) "This work was done to confirm finite element modeling of the stress distribution in that part. A series of additional tests and demonstrations of the capabilities of the *DELTATHERM 1000*™ are being planned for the near future."

DELTATHERM 1000™ *Stress Image acquired by NASA Langley Research Center's NESB*

Two *DELTATHERM 1000*™ systems are measuring stresses on existing automobile parts at two separate General Motors facilities, GM NAO Body Test Lab and Warren Test Lab. Finite Element Analysis (FEA) and *DELTATHERM*™ image results are combined providing a valuable two-pronged assessment of the stresses in a test part.

Ford Motor Company has used their *DELTATHERM*™ for locating hot spots and for FEA model correlation. Jim Franko of Ford describes a recent experience using their system. "Thermal Stress Analysis has become a more valuable technique since the introduction of the *DELTATHERM 1000*™. The speed and simplicity of the system allows us to help many more programs and everyone on our team has been excited to use it. In fact the excitement goes beyond our laboratory. We regularly receive visitors from the design and CAE development teams who are anxious to learn from the scans. I feel we have created a learning environment with much more interaction between testing and CAE because the system allows us to say 'what if' and obtain immediate answers.

For example, we were verifying stress distributions in a floorpan for the sole purpose of FEA validation. We reported finding concentrators in areas that were not reported by the FEA analysis so the modeler visited our lab to find out why. In less than an hour we convinced the modeler that our output was real and together determined why his model wasn't demonstrating the same results. He was so excited that we could help him improve his work that he asked us to demonstrate our capabilities to his entire work group."

Our newest additions to the *DELTATHERM*™ Customer Album are Cleveland State University's Civil Engineering Laboratory and Sandia National Laboratories in Albuquerque, New Mexico.

Caterpillar, Inc. rented a *DELTATHERM*™ system for experimental stress analysis of engine components. Darrin Johnston of CAT emphasized that, "The system is useful for locating high stress areas and correlating FEA models."

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T S A

Thermoelastic Stress Analysis (TSA) produces a full-field stress map by imaging temperature changes with a sensitive infrared camera. All materials, whether solid, liquid or gas, change temperature when compressed or expanded. In solids, stresses cause small temperature changes described by the thermoelastic equation

$$\Delta T = \frac{-\alpha T}{\rho C_p}(\Delta\sigma)$$

To provide accurate measurements, the temperature changes induced by the thermoelastic effect are repeated and time-averaged during a continuous dynamic loading, usually provided by a closed-loop hydraulic load frame.

A special infrared camera, known as a differential thermographic system, correlates the load-induced IR signals with the reference signal from the load system. This allows a thermal resolution of 1.0mK, which translates to the following stress resolutions:

Material	Stress Resolution	
Steel	150psi	1.0MPa
Aluminum	60psi	0.4MPa
Epoxy	8.0psi	55kPa

Stress sensitivity is similar to that of a common strain gage.

Tid Bits

Stress Photonics *DELTATHERM*™ Seminar

By Brian Bartel

In February 1996, Stress Photonics co-sponsored a course at Defiance Testing and Engineering Services in Westland, MI. Representatives from eight companies in the Detroit area attended, including

Atoma Interior Systems, The Budd Company, Chrysler Corporation, Dana Corporation, Defiance Testing and Engineering Services, Ford Motor Company, General Motors, US Manufacturing Company

The four-hour course consisted of a classroom lecture, a group discussion, and hands-on laboratory time. Sample data was collected from a simple hole-in-plate specimen and a rod-end manufactured by Defiance. Attendees left the course with a good working knowledge of the *DELTATHERM*™ system's capabilities, existing applications, and future directions.

Attending a seminar is an excellent way to become acquainted with the *DELTATHERM 1000*™ system and with Thermoelastic Stress Analysis. If you would like to see a *DELTATHERM*™ seminar organized in your area send in a reader response card or just give us a call.

Events

Thermosense XVIII

Thermosense XVIII, a conference at SPIE's 10th Annual International AeroSense Symposium, was held April 10-12 in Orlando, FL. On the exhibition floor, Stress Photonics was a part of NASA-Langley's Technology Transfer display, which highlighted a mutually beneficial relationship between NASA and SP. Interest in both TSA and NDE drew many visitors to the booth where Stress Photonics had a "live" *DELTATHERM*™ demonstration.

Jon Lesniak and Dan Bazile presented a paper entitled, "Forced-Diffusion Thermography Technique and Projector Design," which generated much interest and added to the number of visitors who stopped by SP's TSA demonstration.

SEM Spring Conference

The Thermal Methods Technical Division of SEM is sponsoring a technical paper session as well as a Thermal Methods Round Table Discussion. The discussion will be held in conjunction with the SPATE Application Working Group (SAWG) meeting. See page 8 in the enclosed program for details.

While you're at SEM, make sure to visit the Stress Photonics booth on the trade show floor where we will be demonstrating the *DELTATHERM 1000*™.

The conference will be held in Nashville, Tennessee, June 10-14 at the Sheraton Music City Hotel.

from "Stealth Furnace" page 1

temperature of the specimen, compensating for the conduction of heat through the specimen and into the grips. Temperatures can be controlled to within ±2° C, which is adequate for minimizing the pseudo-signals described above. Keeping the zonal temperatures similar solves the problems of thermal gradients, angular motion, and edge effects. Wall reflections are minimized by the construction and shape of the furnace, hence the name "Stealth Furnace."

(Contact Stress Photonics for detailed references).

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