Stress Photonics Thermoelastic Forum

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First Words

In the May issue of the Thermoelastic Forum, “First Words” opened with "Things have been very busy at Stress Photonics this year." When we consider everything that is going on now, we realize that last May was rather relaxed. In August, Stress Photonics moved to a new, larger location (refer to the "Tid Bits" column for our new address). We have also recently begun a Phase II SBIR contract with the Federal Highway Administration concentrating on detecting flaws in large steel structures (e.g. bridges).

This issue of the *Thermoelastic Forum* will fill you in on what’s new at Stress Photonics as well as what’s new in Thermoelastic Stress Analysis research and the latest in Thermoelastic Stress Analysis techniques. Be sure to read our feature article on SP's new website! Then surf over for a visit. Dan Bazile has some helpful hints for surface preparation when using Thermoelastic Stress Analysis in the “Tech Tips” column. In the “R&D Side,” Jon Lesniak describes a new two-position zoom lens arrangement for the *DELTATHERM™ 1000* system. The "University Corner" highlights TSA work using a *DELTATHERM™* system by Professor Rowlands and Brian Bauman at the University of Wisconsin-Madison. Read the "Events" column to locate technical presentations on TSA and other thermal methods. The “Events” column also gives details regarding the upcoming Technology 2006 Conference and Exhibition in Anaheim, CA on October 29-31 where you can see a live demonstration of the *DELTATHERM™ 1000* system.

www.StressPhotonics.com

Stress Photonics on the Net

By The Webmaster

Stress Photonics is now on the Internet at www.StressPhotonics.com. The Stress Photonics homepage features the ***DELTATHERM™ 1000*** *full-field stress measurement system*. Other Stress Photonics products, accessories, and services are also highlighted. Thermoelastic Stress Analysis is described with example applications, new developments, and pertinent links.

Like the *Thermoelastic Forum*, the Stress Photonics homepage is designed to be an open source of information for TSA users, researchers, developers, test engineers or anyone interested in expanding their knowledge of the field.

Five main sections start you on your journey through the SP homepage: *Products, Newsletters, Technology, Company Info., and Useful Links.*

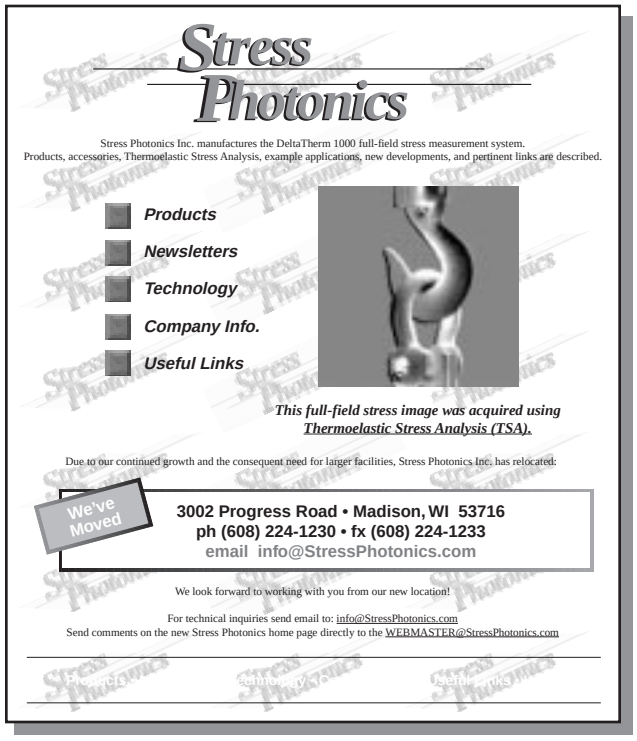
Products offers detailed information on many TSA products that have been discussed in previous editions of the *Thermoelastic Forum.*

The *Technology* section contains a bibliography of nearly 200 TSA papers, articles and journals. In this section you will also find papers on thermoelasticity and examples of TSA being used in the field.

The *Thermoelastic Forum* is also available on-line in both HTML and PDF format. The PDF format preserves both graphics and color of the original typeset document.

If you are not familiar with the history of Stress Photonics, the *Company Info.* section gives a brief overview of the company’s development.

Useful Links pinpoints links and resources pertaining to thermoelasticity such as societies, manufacturers, and government agencies. If you would like to suggest a link, including your own, please send e-mail to WEBMASTER@StressPhotonics.com.



University Corner

Stress Measurement in Metal Plate Connectors

By Professor Bob Rowlands and Brian Bauman of the University of WI

Mechanical Engineering researchers (Brian Bauman and Bob Rowlands) at the University of Wisconsin-Madison, in conjunction with the USDA Forest Products Laboratory (Ron Wolfe), are using Thermoelastic Stress Analysis to measure the stresses in metal plate connectors such as those commonly found in wood frame trusses. The following figures show a 3x5 in. commercial connector plate butt-joining two standard 2x4's. The joint was incrementally loaded longitudinally at 2 Hz to failure and the stresses were recorded with a Stress Photonics' ***DeltaTherm™ 1000***. Total scan time per image was approximately 5 minutes. Figure 1 shows the plate connector cycled between 500 and 2500 lb, whereas Fig. 2 shows the same metal connector near failure when loaded from 1000 to 4000 lb tension. Most truss failures occur at a joint. Objectives of this study are to develop improved design methods and to optimize such connections, thereby saving both metal and wood.

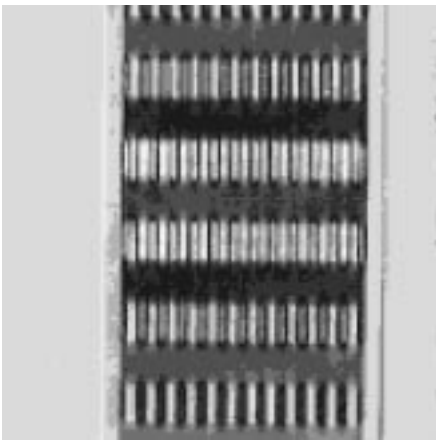


Figure 1

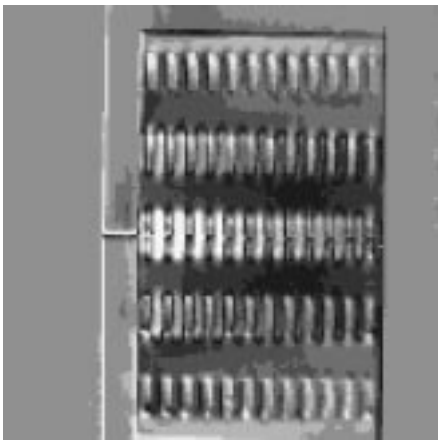


Figure 2

Tech Tips

Thermographic Coatings

By Dan Bazile

All thermographic techniques are dependent on the optical and thermal properties of the target surface. When TSA is considered, quality surface preparation is the key to ensuring quality data. Usually a coating is employed to improve the data collection. The coating should be

- uniform
- thin
- highly emissive
- well bonded
- non-reflective
- diffuse

Although flat black paint is the most commonly used preparation, it is not the only paint used for TSA. It is not the color so much as the emissivity which affects the image quality. A flat paint, no matter what the color, is superior to other finishes or bare metal. Most SPATE™ and *DeltaTherm*™ users are quite familiar with Krylon Ultra Flat Black, which we recommend as a coating for TSA imaging. There are several other coatings in use including other manufacturers' flat black paints, ceramic sprays, and oxides. Water soluble tempera paints have also been used successfully with only small losses in image quality. Water soluble, environmentally friendly coatings are becoming more important as regulations on the use of spray paints become stricter.

Coating should be uniform and as thin as possible. Whatever coating is used, don't apply the paint any thicker than required to get a complete and uniform coating. Thick coatings can attenuate the TSA signal, thereby reducing the quality of your results.

No runs, no drips, good data. Do not allow paint drips to form. Remember you are trying to apply a thin uniform coat; if drips form you are applying too much paint.

Spray from a distance. When done correctly, it is almost as if you are dusting your specimen, allowing the paint to partially dry in the air on the way to the specimen.

Take care in preparing the surface. Quality results don't just depend on the coating itself. Dirt, corrosion and other contaminants left on the part can seriously change the results of TSA images. Care should be taken in cleaning, ensuring that previous coatings are not prohibitively thick and are securely bonded.

Use caution in spraying one coating over another. Often times, the coating you are applying acts as a solvent to the coating already on the object. This can result in a poor coating which must be reapplied. If possible, check compatibility on an extra part or an area you will not be imaging.

One last tip. There is some variance from batch to batch of any coating. Small changes can effect the emissivity and reflectivity of the coating. Look for changes in coating appearance by using a comparison bar or running a quick test.

One simple test is to wave your hand in front of the specimen so that it will reflect into the camera. If using a *DeltaTherm*™, there should be no change in the AC mode if the coating is acceptable. A flashlight or other incandescent source can also be used to look for changes in the "Live " mode. For SPATE™ users, the same test can be run by watching the detector output on an oscilloscope and looking for changes in the output of the lock-in amplifier.

The R&D Side

TSA Microscopy

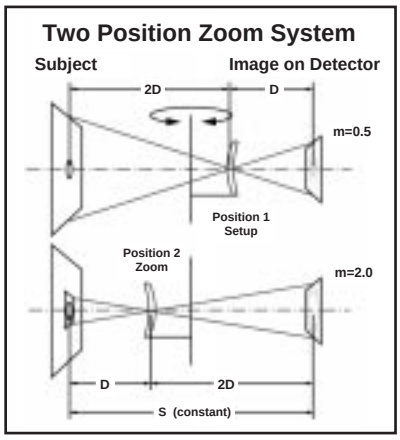
By Jon R. Lesniak

No matter what experimental stress analysis technique is discussed- moiré, photoelasticity, strain gages or Thermoelastic Stress Analysis- all stress engineers run into an application that pushes the limits of spatial resolution. A materials researcher may be examining local stress distributions at small damage sights. Designers might need to know the stress concentration at a small fillet in a critical component.

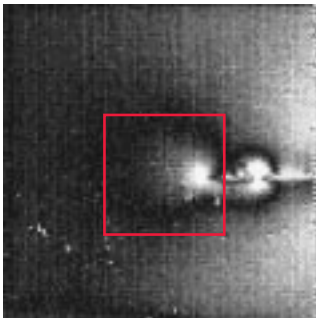
All techniques have some limiting aspect whether it is gage size, coating thickness or simply the practicality of applying necessary procedures at a small scale. TSA has an advantage in that the only necessary preparation is the application of a thin coat of spray paint. Because TSA is a simple optical imaging technique it is able to image tight places like the edges of small holes and inside corner fillets and notches. TSA's key limiting factor is the effect of heat conduction; however, this can be controlled by increasing the load frequency.

The big problem with most magnification techniques is that they are difficult to use. "What am I looking at?" and "Is it in focus?" are two questions often asked. To answer the demand for high resolution optics yet maintain ease-of-use, Stress Photonics has designed a two position zoom. A two position zoom is the simplest and the least costly zoom lens design. In a two position zoom system, the optical system is effectively flipped by moving a single element, hence, the reciprocal magnification is achieved. What does this mean? Lets start with the fundamental concept of an optical system. For each object to detector distance there is a position that focuses an image of the specimen on the detector. By looking at the undeviated ray that passes through the center of the lens, it is easy to see from similar triangles that the magnification is equal to the ratio of the distance to the detector from the lens divided by the distance from the object to the lens. In this example, the magnification is 0.5.

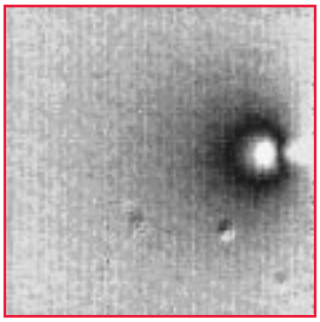
For each object to detector distance, a given lens has only one other position at which it can focus an image on the detector. If the lens is moved to be a distance D from the specimen, it will be focused on the detector at a distance 2D. The total distance S does not change but the similar triangles have been flipped. Now by comparing similar triangles it is clear that the magnification is 2.0. It is clear that by flipping the lens around the center axes of the optical system, we can flip from a magnification of m to 1/m. The detector size in a *DELTATHERM™ 1000* is 6.4 mm, which means that the image will be 12.8 mm x 12.8 mm in the wide position and 3.2 mm x 3.2 mm in the zoom position. Considering the array has 128 x 128 detectors, the pixel resolution in the zoom position is about 25 μm.



Stress Photonics has the opportunity to develop such a system with Air Force SBIR funding out of Wright Patterson AFB. The optical system has been tested on the bench and is now being packaged as a commercial product. The wide angle view can be used to target the area of interest and to focus. With the flip of a switch, an in-focus high-resolution image is available for capture.



12.8 mm x 12.8 mm Setup Image



3.2 mm x 3.2 mm Zoom Image

Thermoelastic Forum is produced by
Stress Photonics Inc. • 3002 Progress Rd. • Madison, WI 53716
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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.

Events

Technology 2006

The Seventh National Technology Transfer Conference and Exposition sponsored by NASA , NASA Tech Briefs and the Technology Utilization Foundation will be held in Anaheim, CA October 29-31. Mike Zickel and Dan Bazile will represent Stress Photonics with a live table-top demonstration of the *DELTATHERM™ 1000* in the SBIR Pavilion. The exhibit will feature all of the latest enhancements to the *DELTATHERM™* system and *DELTAVISION™* software.

SPIE Meeting

A technical conference entitled Nondestructive Evaluation Techniques for Aging Infrastructure & Manufacturing will be held in Scottsdale, AZ, December 2-5 at the Double Tree Paradise Valley Resort. Stress Photonics will participate in the technical session, "Nondestructive Evaluation of Bridges and Highways," which will be in the Flagstaff Room on Wednesday and in the Chaparral Room on Thursday. Jon Lesniak will present a paper at the session entitled, "Structural Integrity Assessment via Coating Tolerant Thermography" on Thursday at 4:50 pm. Phil Fish of the Wisconsin DOT will present a paper in the "NDE of Steel Bridges" session, and Conference Chairman Steve Chase of the Federal Highway Administration will be giving the opening and closing remarks.

IMAC-XV

The 15th International Modal Analysis Conference will be held at the Sheraton World Resort in Orlando, FL February 3-6, 1997. The conference will feature a new theme entitled, "New Horizons for Damage Detection." IMAC-XV has broadened its scope to include many interesting topics in Applied Modal Analysis, Civil Engineering Structures and Damage Detection. The traditional focus on automotive testing and analysis will be expanded to include the aircraft/aerospace and marine industries as well as bridges, buildings and other large civil structures. The conference, which is sponsored by SEM, will mark Stress Photonics' first appearance in the Exhibition Hall at IMAC. Brad Boyce and Brian Bartel plan on attending. Visit the SP booth and see a live *DELTATHERM™ 1000* demonstration.

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Tid Bits

We've Moved!

After doubling in size over the past two years, the Stress Photonics office started to get pretty crowded! Our new expanded location is complete with an optics lab, a shop, and an expanded production area. Be sure to record our new information:

Stress Photonics Inc.
3002 Progress Rd. • Madison, WI 53716

PH 608-224-1230 • FX 608-224-1233
info@StressPhotonics.com
http://www.StressPhotonics.com

We look forward to serving you from our new facility.