History and Purpose

by

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Abstract

Starting as a group of researchers interested in photoelasticity, the present Optical Methods Division of the Society for Experimental Mechanics (SEM) is composed of members from university, industrial, and government labs interested in a wide range of optical measurement systems. Areas of special interest are photoelasticity; geometric and interferometric moiré; optical sensors; holographic, speckle, and shearing interferometry; fiber optics; and the marriage of optical data acquisition with computer based analysis. The Division would like to accelerate the technology transfer of research developments into standard industrial practice. Therefore the Division has offered, and continues to offer, short courses in the fundamentals of various optical techniques, and is concerned with the amount of material (or lack thereof) on optical measurement techniques that is incorporated into the current academic training of engineers and scientists.

Background

The Optical Methods Division is one of the original groups of what is now known as the Society for Experimental Mechanics (SEM). The Society was initially a forum for people working in photoelasticity. When the Society expanded and chose its original name as the Society for Experimental Stress Analysis (SESA), the photoelasticity group expanded to a broader range of activities, but continued to be one of the more active groups in the Society. When the internal organization of the Society was formalized and the Technical Divisions were created, the Optical Methods Division was formed. In 1986 the workers in photo-elasticity formed a sub-division of the Optical Methods Division known as the Subdivision on Applied Photoelasticity specifically to act as a forum for presenting and discussing innovative ways in which photoelastic stress analysis could be applied to solve industrial design problems in practical applications such as failure analysis, yield detection, assembly stress measurement, residual stress determination, and proof or acceptance testing. Today the Optical Methods Division draws its membership from a large number of universities, industrial, and national laboratories. Its activities flow from the purposes stated in the bylaws of the Division, "to advance optical technology by providing a forum for the timely exchange of information," and "to promote the development of new applications of Optical Methods in mechanics by organizing symposia-type technical sessions. " The Division has been very active in promoting short courses and special topic sections at the spring and fall meetings. For example, the Division has in the past sponsored sections on Optical Methods in Fracture Mechanics, Speckle Methods for Fluid Velocity Measurement, Three-dimensional Methods in Optics, TV Holography, Optical Methods Applied to Composites, Optical Methods in Non-destructive Testing, and Optical Methods in Sensor Technology. Optical methods are now, and will continue to be, a powerful tool in experimental mechanics.

Future Directions

Although traditional photoelasticity does not receive much attention, it is still a tool of choice when the object under investigation happens to possess artificial birefringence, i.e., compact discs (CDs), both audio and video, and glass and transparent plastic manufacturing. In these environments photoelasticity is an efficient and practical tool for quality inspection. The burgeoning CD industry is thus an example of an area where developments in photoelasticity and its application will be of importance.

Another area of active development is moiré. The traditional geometric moir6 has been extended and enhanced by the development of interferometric moiré. Moiré methods are used to contour complex geometrical shapes and to measure the stress intensity factor in fracture mechanics applications. The number of users, especially of moiré interferometry, is constantly growing. This technique has become quite a mature one, and thus is beginning to find its way into industrial applications. However, it is still a long and complicated process to get desired strain information from a given sample. Much work is still needed to make moiré more useful and more widely applied.

A third and very exciting optical development is the use of fiber optic sensors. A number of researchers in a variety of areas - from stress analysis to smart structures - are using this development to acquire and reduce strain/stress data. Throughout the world an emphasis has been placed on developing an increasingly sophisticated infrastructure while at the same time maintaining our existing one. To assist in this, sensors are required to monitor the effects of aging and to predict the need for component replacement. The implemented techniques of acquiring and assessing data should be capable of monitoring a region over time and the data taken from the sensors should be sufficient to infer when it is appropriate for either a more detailed inspection to occur or for the component to be replaced. The use of optical fiber sensors in these applications has led to a pressing need to obtain experimental data to augment the theoretical development of the relations between strain, temperature, and optical phase changes in these sensors.

Although, in principle, the application of fiber optic sensors appears very promising, a great deal of work still ties ahead for the optics community. Problems of signal quality and stability have to be solved, and new methods for data reduction have to be developed. It is quite possible that a significant part of this work has already been done in the optical research community, but a great deal of technology transfer must be achieved to make this methodology practical. To this end, the Division should be supportive of state-of-the-art applications of

modem optical methods to practical industrial applications such as electronic packaging, manufacturing, composite materials, etc.
The direction that must be followed by the Optical Methods Division cannot be limited only to finding developments in the methods described above. Proper utilization of optical methods will only occur when at least the following two concerns have been addressed/met:

1. Attention must be paid to finding ways to reduce the data obtained by these methods. There is no shortage of optical methods and techniques; what is seriously lacking is the ability to fit these optical methods into the full process of e.g. stress analysis. The full usefulness of an optical method will depend on how well (accuracy, ease of use, etc.) the method can determine the full set of quantities of interest to the experimenter.

   Furthermore, the results must be available in a variety of forms, not just in the original primitive form. In the future, more effort needs to be expended on developing post-processing tools that convert the optical data into useful mechanics quantities.

2. Another area of concern is the incorporation of modem optical technologies into the training of engineers and scientists. Often the difference between a successful method and a dormant one is not how the research community views the methodology, but instead how the developers of the method present their results to workers in industry.

   Practical education is usually the missing element in making a method work in an industrial setting. Thirty minutes at a presentation will satisfy the technical curiosity of a mainstream conference participant, but it will not send such a participant back to the lab with a hands-on approach to using the technology to its maximum advantage. Engineers may initially feel empowered as they adapt new optical methods that promise to make them more productive only to become frustrated when trying to apply these methods to practical problems.

   Therefore, in addition to continuing the practice of offering short courses in specific areas, the Optical Methods Division should try to influence engineering curricula to incorporate these new optical technologies to better prepare the next generation of engineers.

Recommended Research

Although there is always a danger in being too specific about future directions, the contrary danger of limiting recommendations to vague generalities must also be avoided. The Division should at least recognize the areas of greatest potential and usefulness. Specifically, then, the Optical Methods Division recommends that future research focus on the following areas:

- Integration of full-field optical methods with computer based techniques to make data analysis simpler and more direct.
- Development of optical sensors along with the characterization and understanding of their performance characteristics.
- Continue to teach hands-on short courses on the application of optical methods.
- Development of means to accelerate technology transfer to industry.

Bibliography

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