Editorial - Photomechanics special issue

The term photomechanics refers to the use of light to determine distributions of quantities such as stress, displacement, strain and temperature in experimental solid and fluid mechanics. This special issue on photomechanics, comprising seven papers, provides a representative cross section of some of the current activity in this field, to illustrate trends in the technique development as well as new areas of application.

For many years, photoelasticity was the main experimental technique within the photomechanics community, as it allowed stress distributions in solid materials with complex geometries to be quantified. However, limitations on the type of material it could be applied to - transparent, isotropic and operating in the linear regime - meant that alternative techniques were needed to help understand and optimise the structural performance of the newer, more complex, materials such as carbon fibre/epoxy or metal matrix composites. The development of many of these alternative techniques over the past 50 years was facilitated by the invention and low-cost production of three key enabling technologies, namely the laser, digital computer, and digital camera.

Modern day photomechanics techniques can be divided into two main categories: those that rely on the wave nature of light to produce interference patterns, and those where the light is simply needed to produce an image of the object. ‘Light’ may nowadays be taken to include non-visible regions of the electromagnetic spectrum, for example infra-red, X-ray, or in recent years the terahertz region. Interferometric techniques, which include holographic interferometry, moiré interferometry and digital speckle pattern interferometry, generally offer better displacement and/or spatial resolution than non-interferometric techniques such as Digital Image/Volume Correlation (DIC/DVC) and their fluid mechanics counterpart Particle Image Velocimetry (PIV). Such sensitivity can however be a drawback in industrial environments and this coupled with the perceived complexity of many of the interferometric techniques has often inhibited their more widespread adoption. There is just one paper based on interferometry in this issue, by Somers and Bhattacharya, which describes the use of speckle pattern interferometry for the measurement of vibration amplitude distributions.

An important trend in recent years has been the extension of the traditional surface-measuring techniques to provide information within the volume of the sample. In many cases this has been through the exploitation of volume imaging techniques originally developed for medical applications, such as X-ray Computed Tomography, Magnetic Resonance Imaging, and Optical Coherence Tomography. The paper by Dahdah *et al*. is an example of the former in which DVC is used to quantify strain fields at the microstructural level within an aluminium alloy. Depth-resolved information on a sample’s thermal properties can also be provided by measuring surface temperature fields resulting from a variable frequency heat source, as described in the paper by Palumbo *et al*.

As the experimental techniques used in photomechanics are predominantly full-field, the resulting data to be processed typically consist of two-, three- or even four-dimensional arrays, and the processing algorithms therefore tend to be computationally demanding. The paper by Le Besnerais *et al*. describes recent developments in the use of GPUs to reduce the processing time in the case of DIC datasets. An extension to DIC based on the correlation of profilometric height images is presented by Kleinendorst *et al*., where the incorporation of shape functions from the Computer Aided Design field is shown to improve the robustness of the algorithm. Other sophisticated numerical post-processing techniques, such as the Finite Element Model Updating and the Virtual Fields Methods, have been developed over recent years to identify material properties from the measured strain fields. The paper by Bertin *et al*. describes the optimisation of a bi-axial test-piece geometry to enhance the measurement accuracy with these new approaches.

The special issue includes three papers which illustrate some of the diverse applications that can be tackled by techniques from the photomechanics 'toolbox'. The papers by Dahdah *et al*. and by Kleinendorst *et al*. already mentioned earlier, are concerned respectively with understanding damage mechanisms in metallic alloys and some mechanical properties of microscopic stretchable interconnects. The third applications paper, by Jagailloux *et al*., is an example of modern-day photoelasticity at near-infrared wavelengths applied to the measurement of residual stresses within silicon wafers.

In conclusion we wish to thank all the authors for their fine contributions, the reviewers for their work behind the scenes, and the Editor-in-Chief, Professor Fabrice Pierron, for the opportunity to create this special issue and his helpful guidance along the way.

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