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A new system for measuring residual stress by using 3D digital image correlation techniques

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Summary

Residual stress plays an important role in structural and material manufacturing. Measurement techniques of residual stress can be neatly divided into destructive and non-destructive ones. The destructive techniques are dependent on inferring the original stress from the displacement incurred by completely or partially relieving the stress by removing material. The hole drilling method for residual stress measurement is a destructive method and was first introduced in the 1930s by Mathar. In recent years, the hole drilling method for evaluating residual deformation has been implemented with optical method such as holographic interferometry, electronic speckle pattern interferometry, digital image correlation (DIC), and moirAC interferometry to overcome certain limitations of the strain rosette version of hole drilling.

In particular, the 3D DIC originally developed by Luo et al. in the field of experimental solid mechanics can not only reconstruct the shape of surface, but more importantly it is able to determine the full-field 3D deformation of test object surface that is deformed by applied loads such as forces, thermal loads, etc. Nelson et al. first employed 3D DIC techniques to measure residual stress in 2006. However, using optical measurement techniques, it is important to eliminate the rigid motion caused by removing the material of specimen by using machinery. In order to measure the residual stress in-situ and eliminate rigid motion between hole-drilling. Thus an in-situ high precision hole-drilling machine is developed.

In this study, a system that can measure residual stress in-situ is introduced, which including an in-situ high precision hole-drilling machine and 3D DIC detecting system. 3D DIC technique is employed for evaluating the residual displacement on the surface during hole-drilling. And software for Residual Stress Measuring by Using Hole-drilling Method with 3D DIC developed by Tsinghua Photomechanics Lab is also presented. A much more reliable displacement field can be determined with this system thus the residual stress of specimen could be easily calculated. The system is verified by using a known residual stress specimen. The procedure of measuring residual stress by using 3D DIC is specified. The system is readily applied to measure residual stress in engineering fields.

In summary, an in-situ high precision hole-drilling machine is designed and manufactured. Some typical test are conduced to verify the feasibility the utilizing the combined system with 3D-DIC techniques and hole-drilling machine. The success-

ful results demonstrate the system has a satisfied accuracy for the residual stress measurement.