THE ROLE OF PIXEL QUALITY IN RS MEASUREMENTS BY HDM-ESPI

Claudia Barile, Caterina Casavola, Giovanni Pappalettera, Carmine Pappalettere(*)
Dipartimento di Meccanica, Matematica e Management (DMMM), Politecnico di Bari, Bari, Italy
(*)Email: carmine.pappalettere@poliba.it

ABSTRACT
Industrial processes, which lead to the creation of the final components, are potential sources of residual stresses. These can be evaluated, among other techniques, also by HDM-ESPI. This is a powerful approach consisting in detecting, by an optical interferometric technique, the displacements field around a hole drilled in order to get local stress relaxation. However, quality of the recorded images can affect the reliability of the measurement. In this paper some considerations on pixel quality are presented along with some indications about a proper choice of the internal radius of analysis.

Keywords: Residual stresses, hole-drilling, ESPI.

INTRODUCTION
Residual stresses (RS) are present in a material even in absence of an external load as a consequence of manufacturing processes. Nowadays, the most commonly adopted method for measuring RS is the Hole Drilling Method (HDM), being an approach based upon the operation of drilling a hole in the material under test and measuring the on-surface deformation connected with the drilling operation.

A promising improvement, which is under investigation in these years, is connected with the possibility of replacing strain gage rosette with optical systems for measuring the strain on the surface [1]. With this approach, it is possible to get high sensitivity and high-resolution measurement of the strain field around the hole, greatly increasing the statistics involved in the measurement in view of the fact that each single pixel can be considered to act like an extensimeter [2].

When performing this kind of measurements the operator is free to set the position of the circular crown including the analysis area. This is the area including the pixel whose information will be used to extract the displacement information and the consequent stress calculation. However the quality of the information connected with each pixel cannot be considered uniform. For example, different points on the surface can present different reflectivity and this can require the adoption of preliminary spray painting of the surface. Furthermore, some dust resulting from the drilling process can be deposited around the hole during the drilling process.

In this paper we will show how this effect depends on the drilling speed and how this affects a proper choice of the internal radius of analysis.
MATERIALS AND METHODS

Test were performed on a Titanium grade 5 (Ti-6Al-4V) specimen (248.5 mm x 42.5 mm x 3.0 mm) which was loaded in a four-point-bending frame in order to induce a known stress state on the sample. The sample was loaded so that an unidirectional longitudinal stress field is obtained with $\sigma_x=144$ MPa. A solid-state laser source was used in order to shine the sample and generate the speckle pattern, which is then recorded by a CCD camera. Light diffused by the sample is made to interfere on the CCD matrix with a reference beam (Fig.1). Four-step temporal phase shifting algorithm is adopted in order to obtain the phase. The hole is drilled by means of a high-speed turbine, which is mounted on a precision travel stage. Two different levels of the turbine speed namely 5000 and 50000 rpm and were tested. The cutter is made by tungsten coated by TiN and it has a nominal diameter $d=1.59$ mm.

The HDM+ESPI method was utilized to evaluate the external four-point bending applied stress. A hole was drilled up to 0.40 mm depth, each step was 0.05 mm.

![Experimental set-up adopted for HDM-ESPI evaluation of RS](image)

RESULTS AND CONCLUSIONS

In Fig. 2 results of the stress measurements are presented for the two rotation speeds. In particular, it is possible to observe that a strong variation in the calculated stress is observed for the case of 50000 rpm if the internal radius of analysis is reduced. This means that including more pixels near the edges of the drilled holes introduces a disturbance in the measurement.
This behaviour can be explained if the quality of the pixel is evaluated. Fig. 3 shows, in fact, that in both cases the ratio of bad pixel increases approaching the edges of the hole; however things are worse in the case of high-speed drilling, due to the fact that a bigger amount of fine dust is produced in the process, which stick to the surface in particular near the edges of the hole, altering the measure.
Fig. 3 - Bad pixel ratio as a function of the internal radius of analysis.

REFERENCES
