TOWARD ONLINE NONDESTRUCTIVE TESTING OF COMPLEX SHAPE COMPOSITE MATERIALS

ALAIN SOMMIER

Automation Engineer

INTRODUCTION:

In a previous work we developed methods based on Pulsed Flying Spot (PFS) to measure the in-plane thermal diffusivity of (an)isotropic materials. The measurement zones have to be small (5 5cm) to obtain a good spatial resolution and ensure diffusion estimation accuracy. In this work, we propose to use a robotic arm to analyse a real 3D composite part. Computer Aided Design was used to draw the 3D part and define the different positions of the arm in order to measure in plane thermal diffusivity of a complex shape. Finally, the 2D diffusivity maps are pasted on the 3D shape to visualize heterogeneity and anisotropy.

AIM

In this work, we used Pulsed Flying Spot technique with robot automation for industrial thermal characterization and Non Destructive Testing on large and complex shape composite materials.

MATERIAL AND METHODS

The experimental setup is presented in Fig. 1.a. A CW laser diode (976 nm) of 330 mW power is used to heat the sample surface. A Dual-Axis Scanning Galvo System (Thorlabs GVS112/M) is used to control the spatial displacement of the laser spot at constant velocity over the sample surface. A 160 mm focal length f-theta scan lens is used to focus the laser beam to a spot diameter of 25 µm. A dichroic mirror, treated to reflect 95% of the visible light and to transmit 95% of the infrared radiation is used to direct the laser beam perpendicularly to the sample surface. The temperature field at the sample surface is recorded by an IR video

camera (FLIR SC7000 MCT). The camera is equipped with a 25 mm focal length lens, provides a spatial resolution of 390µm per pixel and allows to analyse samples of typical size 8 × 6cm. The large dimensions of the part (cf. figure 1.b 400 × 300 mm) impose to change scale to analyse 52 small Regions Of Interest (dimension 50 × 50 mm) in order to obtain a good spatial resolution and ensure accurate estimated thermal fields. The main advantage of using the robot coupled with Computer Aided Design of the part allow to scan the complete area of the composite and also to orient the non-plane surface of the sample perpendicular to the IR camera field of view and laser spot. Finally, all the area can be thermally characterized and the retrieved in plane thermal diffusivities maps are pasted on the 3D shape to visualise heterogeneity and anisotropy.

RESULTS

Due to the complex shape and large dimension of the part, it is necessary to complete 52 positions with 49 laser pulsed spots in each ROI (5cm x 5cm) for a total of 2548 laser excitations. Each ROI can be analysed in 12.5 seconds and the robot need 2 seconds to move the part (with low speed). Total scanning time for all the ROI is close to 13 minutes for 0,12m2, calculationand analysis can be done during the scan. The mean values are roughly equal $a_x = 2.9.10^{-7}\ m^2 .s^{-1}$ and $a_y = 2.7.10^{-7}\ m^2 .s^{-1}$, but we can highlight some local differences probably due to fibers orientations or thickness of the epoxy resin demonstrating the anisotropic pattern of the sample.

CONCLUSIONS

In this work, we used Pulsed Flying Spot technique with robot automation for industrial thermal characterization of a 3D complex shape composite material. The large dimensions of this part (400 × 300 mm) impose to change scale to analyse 52 small Regions Of Interest (dimension 50 × 50 mm). A 6 axes robotic arm is used to move the sample and change the position of the different ROI keeping the sample

surface at the focal plane and normal to the laser beam.

Figure 1: a) Experimental setup with a moving laser spot b) part fixed on Kuka c) robot 2D pasted diffusivities map on 3D complex shape of the composite sample: diffusivities mapalong the x direction and d) diffusivities mapalongthey direction.

KEYWORDS:

Pulsed flying spot, thermal diffusivity, robotic arm, and computer aided design