Quantitative lock-in thermography imaging of metal powder components

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Introduction / Overview

Currently, there exists an increased demand for an industrial NDT solution as rising global energy prices, economic upheavals and downturn of the North American automotive industry have accentuated the sunk cost of scrapping sintered parts, the defects of which could have been recognized in the preceding "green" state and recycled back into metal powder. Previously conducted research has identified that cracks can be identified thermographically or by using photothermal radiometry due to changes in thermal-wave fields caused by surface cracks and boundaries, leading to correlated image contrast. These findings have proven infrared imaging to be unique in its ability to evaluate "green" state components. Following the development of thermal-wave detection methods like lock-in thermography (LIT) imaging with NDT applications, it was found that phase images are more true to their thermal origin than amplitude images: They are less affected by non-uniform heating patterns, variations in surface emissivity and optical reflectivity, while also providing higher depth resolution and only relying on thermophysical property contrast, yielding purely thermal wave images. Furthermore, the significantly increased frame rates of today's mid-infrared (MIR) camera technologies allow for accurate quantitative analysis of thermal-diffusivity-driven (photo)thermal decay rates following pulse excitation in solid materials, thereby linking diffusivity to local properties

Methods/Experimental Approaches

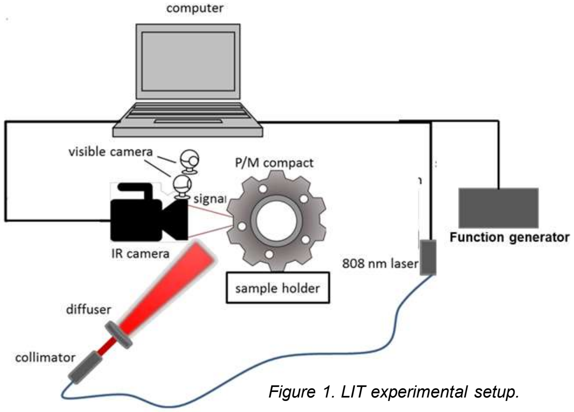

Figure 1. LIT experimental setup.

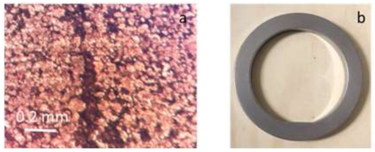

Figure 2. Photograph of the surface crack location at inner edge (a) of .a pre-sintered ("green") compressed metal powder automotive part (b) .

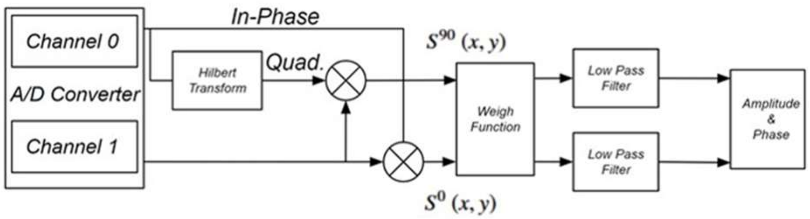

Figure 3. Lock-In signal processing algorithm .

Major Outcomes/Results/Impact

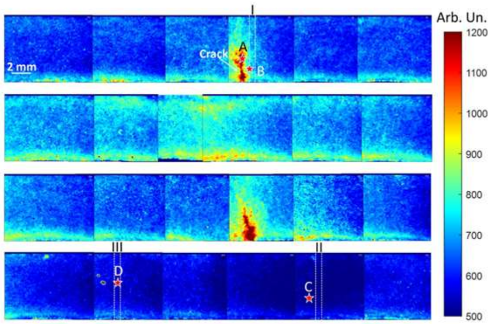

Figure 4. Full 360^{O} panoramic LIT amplitude image of sample with two cracks.

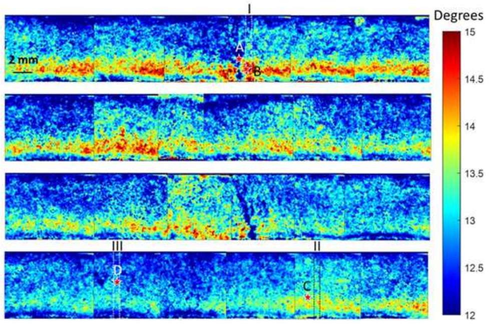

Figure 5. Full 360^{O} panoramic LIT phase image of sample with two cracks .

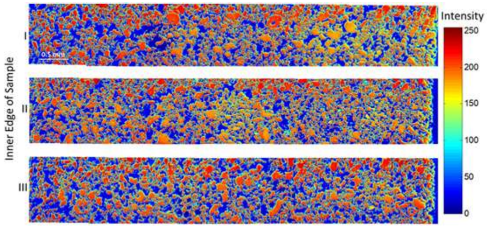

Figure 6. Expanded optical images of sections I, II, and III of the sample.

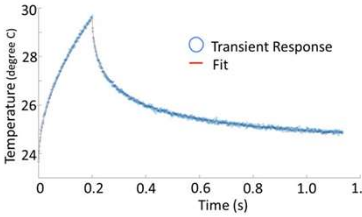

Figure 7. (Photo)thermal transient from location "A" that allows quantitative evaluation of the diffusivity.

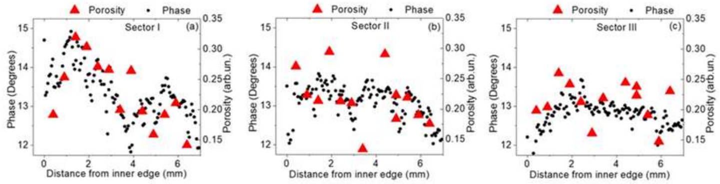

Figure 8. Local porosity and phase distribution at various locations in sectors I (a), II (b), and III (c). The locations of these sectors are shown in Figs.4 and 5.

The Future: Opportunities

Apply the developed experimental technique and associated theoretical model for predictions of crack formation in green powder metallurgy manufacturing components

Acknowledgements

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