THE USE OF LINEAR AND NON-LINEAR CHIRP SIGNALS IN PULSE-COMPRESSION THERMOGRAPHY

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Active Thermography (AT) is a Non Destructive Testing (NDT) technique with application in various fields of research and analysis, ranging from diagnostic, material characterization to on-line inspection in industrial production plants [1-2]. AT is commonly carried out by exploiting two main schemes: (i) Pulsed Thermography (PT) [3-4] and (ii) Lock-In technique. By exciting an extended bandwidth, approach(i) provides more information than the latter, which in turn assures higher values of SNR. More in details, PT allows the thermal impulse response of the sample under test (SUT) to be retrieved; the drawback of the technique is that the achievable Signal-to-Noise Ratio (SNR) value is set by the source power.

The said limit can be overcome by modulating the heating stimulus via a coded signal [5], which has a unique feature: the signal bandwidth and time duration are uncorrelated. Thus, the signal bandwidth can be optimally tailored for the investigation of a given SUT, whilst its time duration can be increased almost arbitrarily to achieve the wanted SNR. Moreover, the use of coded excitations allows both time- and frequency- domain processing to be implemented; the former can be retrieved after the application of the Pulse Compression (PuC) step that outputs an estimate of the impulse response; the latter can be directly performed on the raw acquired data. Finally, the use of non-linear chirp excitation helps on spreading the heating energy at deeper depth within the SUT while leaving unaltered the faithful reconstruction of the impulse response [6].

Results

Results shows that the use of an optimized non-linear chirp excitation allows the defect detection capability of deeper defect to be enhanced with respect to its linear chirp counterpart. This is shown in Fig.1 by imaging the retrieved impulse response amplitude after PuC (pixelwise) for both linear and non-linear chirp. The investigated 3D-printed PMMA sample contained flat-bottomed holes having increasing depth from the sample surface.

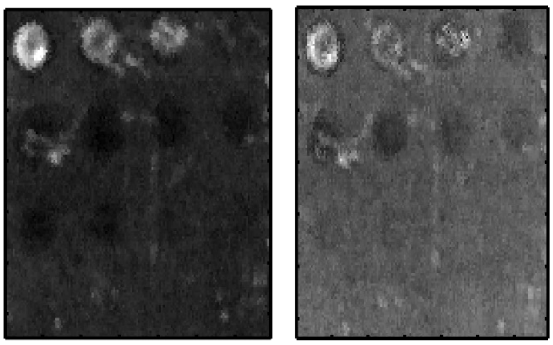
(a)  (b)

Fig. 1: Defects detection after PuC in PMMA sample for (a) non-linear and (b) linear chirp.

Conclusions

Linear and non-linear chirp can be used successfully as a modulation for the heating source in thermography. The use of non-linear chirp signal helps on spreading more energy at deeper depth while leaving unaltered the faithful reconstruction of the impulse response. This can be appreciated from Fig.1(a) where the third row of defects is visible.

References

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