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Editorial

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Non stationary Infrared Imaging for Non destructive Characterization

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Introduction

Infrared non-destructive testing (IRNDT) involves mapping the surface temperature over a test object with the intent of detecting surface and subsurface defects. It is a whole field, non-contact and a nondestructive testing method for defect detection. Since most solids conduct heat, IRNDT has potential for wide use in defect detection in a variety of materials such as metals, composites and semiconductors [1]. IRNDT has numerous applications in aeronautical, space, electrical, electronic and mechanical industries. Of the various possibilities for thermal non destructive testing (TNDT) implementation, IRNDT has gained wide acceptance in non-destructive testing and evaluation (NDT & E). Various methods and techniques have further been developed throughout the world to improve and widen the use of IRT for non-destructive characterization. IRNDT can be carried out either in active mode or in passive mode. Passive thermography involves mapping the temperature profile of a sample surface in the absence of any external heat stimulus. This approach may not provide sufficient temperature contrast over the defect and non-defective regions of the test specimen, especially for defects lying deep inside. In order to reveal these deep defects with a high contrast, active thermography is used. This requires an external thermal stimulus to the inspected specimen in order to obtain significant temperature differences, witnessing the presence of subsurface defects. In active approach, external heat stimulus on to the test sample is provided, whose thermal response is observed. As the characteristics of the external thermal stimulation applied onto the specimen are known (i.e. nature of excitation, its time duration and its band width etc), for a possible qualitative and quantitative characterization of sub-surface defects.

Present Trends

During the last two decades, intensive modeling, simulation and experimentation work is being carried by various researchers throughout the world to introduce new thermal non-destructive testing methods to overcome limitations in existing methods. The most popular modern IRNDT methods are: Pulsed Thermography (PT) [1,2]. Lock-in Thermography (LT) [3] and Pulsed Phase Thermography (PPT) [2]. Choice of any of the above mentioned thermographic methods for NDT & E depends on the intended application, thermal properties of material to be tested, defect location and its thickness. Each method has its own advantages and limitations. In PT, the examined sample is warmed up with a short duration high peak power pulse and the resultant surface thermal response is recorded. The resultant sequence of images recorded contains information about defects in the material at different depths. In practice, this technique requires high peak power heat sources and has the inherent drawback of being sensitive to surface emissivity variations and non-uniform heating on the surface of test sample. In general, for the industry at present, pulsed thermography systems are perhaps the favorite choice. Though image processing techniques do help to improve the capability of the pulsed thermographic techniques for subsurface defect detection with improved resolution and sensitivity, the requirement of high peak power heat sources still remains a major drawback of PT. However wave thermography does have some advantages over PT [3]. In contrast to pulsed thermography, lock-in thermography (LT) is based on thermal waves generated inside the specimen under study. Mono-frequency sinusoidal thermal excitation at an angular frequency of ω, introduces highly attenuated, dispersive thermal waves of the same frequency ($\omega/2\pi$) inside the test specimen. The excitation frequency in LT is chosen by its dependence on the sample thermal characteristics and its geometrical dimensions. Lower is the frequency of the thermal waves, slower is the velocity in the test specimen and deeper is its penetration into the test specimen [4]. From the acquired image sequence, in the stationary regime of heat cycle, information about the phase and magnitude of the reflected thermal wave is derived. Phase images have several advantages including those of being less sensitive to non-uniform illumination of heat sources and variations of surface emissivity over the sample. Even though it requires a longer exposure time, another point in favor of LT is the relatively low increase in temperature of the object, which makes it preferable when the testing specimen sensitive to temperature variations. Further, phase images are capable of probing deeper defects compared to the magnitude images. Due to its mono frequency excitation, the generated thermal wave length inside the test sample gets fixed, leading to a fixed depth resolution. Therefore, in order to get good resolution for various defects located at different depths inside the test specimen, it is necessary to repeat LT with different excitation frequencies [4,5,6]. Research group at University of Laval proposed a technique called pulsed phase thermography (PPT) [2] which has some of the advantages of both conventional PT and modulated LT. The experimental arrangement of PPT is similar to PT, but extraction of various frequency components in the captured infrared image sequence is performed by Fourier transform (FT) on each pixel of the thermogram sequence. The phase images obtained from the Fourier transform in PPT provides all the merits of the phase images as obtained in LT, (i.e. less sensitive to surface in-homogeneous emissivity and illumination variations). Theoretically, the short duration excitation pulse in PPT does launch a large number of frequency components into the test samples, but the higher order frequency components may not have sufficient energy to cause a thermal wave to propagate deep into the sample. In order to detect deeper subsurface defects in test sample, PT and PPT needs high peak power heat sources [4], which may damage the surface of the test sample. In order to overcome these limitations of LT and pulsed based thermo graphic methods, it is necessary to send a desired band of frequencies with significant magnitude into the test

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sample [5]. This is preferably done in a single run without repeating the experiment at different frequencies for improving test resolution. The thermal excitation should be intense enough to generate thermal waves of appreciable magnitude for the desired band of frequencies to be launched into the specimen.

Advanced Methods for Infrared Inspection

In light of the above described limitations of the widely used conventional methods more recently introduced non stationary infrared imaging methods (frequency modulated thermal wave imaging, digitized frequency modulated thermal wave imaging, coded excitation infrared imaging etc.)[5-7], helps to improve detectability of defects lying at different depths, in less time compared to LT and with less peak power heat sources compared to pulsed thermo graphic methods (PT & PPT). In frequency modulated thermal wave imaging (FMTWI) [4], the incident heat flux is varied by driving the heat sources by linear frequency modulated signal, which causes a similar frequency modulated surface heating over the sample. This helps to probe the desired band of frequencies with significant magnitude into the test sample which improves the test resolution. In contrast to FMTWI, modulation of the heat sources is much easier in digitized frequency modulated thermal wave imaging (DFMTWI) [4]. Further in DFMTWI, we can probe more energy into the sample by probing higher frequency harmonics along with the desired band of frequencies, which may improve the depth resolution for near surface defects.

Conclusion

Due to essential requirements of non contact, whole field and quantitative non destructive characterization methods for condition health monitoring of industrial components, it is necessary to develop novel and feasible approaches. One can easily share their potential ideas rapidly on cutting edge technologies for high visibility to open accesses journals. I am sure and glad to let you know that OMICS group of publications are the best choice to share your cutting edge technologies.

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