A Comprehensive Study on Defects Parameters of Ferrous and Composite Materials Using Non Destructive Testing Methods

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***Abstract*: The scope of this review paper is to emphasis on the various defects found during or undergoing the behavior changes like flaws, pinholes, cracks in the welds and other application like automotive and aerospace industries etc. Taking place at microscope level. The conventional methods used under the quality control do not agree or there are large deviations were observed by investigators. To overcome these deviations advanced non destructive techniques like digital image correlation, piezoelectric transducers, neutron imaging mapping, singular value decomposition, terahertz time-domain spectroscopy for hybrid composite materials testing defects and circular arrayed eddy current non-destructive testing sensor, spatial-carrier technique, ultrasonic transducers and thermo grapy analysis were used and presented in their research papers .**

***Keywords*: ultrasonic testing, die penetration test, laser beam and neutron imaging etc.**

Introduction:

Junyu Zhoua et al [1] presented in their technical paper a selective detecting and focusing approach for fatigue cracks through use of decomposition of the time reversal operator in combination with nonlinear Lamb waves. In the proposed approach, the time reversal operator was only decomposed at the second-harmonic frequency, which has been widely utilized in recent years to evaluate micro-damage, rather than the fundamental frequency in the traditional decomposition of the time reversal operator method. Further, an imaging algorithm based on the total focus method is introduced to locate nonlinear scattered. The proposed approach was experimentally investigated to locate two fatigue cracks with different fatigue cycles in an aluminum plate with a set of surface bounded piezoelectric transducers. The results show that the significant Eigen values are related to the fatigue cycles of fatigue cracks when the time reversal operator was decomposed at the second-harmonic frequency, and the number of significant Eigen values was exactly equal to the number of fatigue cracks. The two fatigue cracks are selectively located accurately and are also distinguished from linear scattered by use of the proposed method.
Abderraouf Bouloudeninea et al [2] presented in their technical paper a circular arrayed eddy current non-destructive testing sensor for detecting fibers orientation and in-plane fiber waviness defects in unidirectional carbon fibers reinforced polymer . The design procedure involves two steps, the application of the rotating rectangular sensor principle on a pair of coils. In this case, to test the used simulation method, the results are experimentally verified. In the second step, the resulted form is exploited to simulate a circular arrayed sensor. This sensor allows the cancellation of the mechanical rotation of the conventional sensors and it permits to reduce the inspection procedure duration. The electromagnetic phenomena are calculated by using three dimension finite element method based on the electromagnetic formulation. Then, the sensor responses are analyzed through polar diagrams of the impedance variation. The circular arrayed sensor is used to characterize a unidirectional carbon fibers reinforced polymer and to detect the in-plane fiber waviness in a layer of carbon fibers reinforced polymer .
A. Darntona and M. Ruzzenea [3] presented in their technical paper the phase congruency for damage mapping method utilizes full guided wave field measurements to visualize the extent of subsurface damage in plate-like structures. The method exploits the phase of wave field components calculated from a filter bank decomposition of the wave field in space. Testing for alignment of phase between components over the measurement domain generates a plot of discontinuities in the wave field. Discontinuities in the wave field indicate the existence and extent of damage in the specimen considered. Damage maps for a host of cases ranging from simple changes in thickness to complex impact damage are presented.
L. Missoum et al [4] presented in their technical paper a new method of repairing a reduced (intact and damaged) beam degraded by mechanical loading using composite materials, allowing to study and understand the main action of reinforcement by carbon fibers reinforced polymer and green fibers reinforced polymer similar cases considering the specifications of the degradations and to extract the possible constraints of application and finally, to evaluate the performance of the repaired structures elements by applying the static load tests on this type of reinforced.
K. Ashok Reddy et al [5] presented in their technical paper a review of various investigators of composite materials used in automotive, aerospace engineering, building construction and apart those used for low temperatures applications like cryogenic systems were highlighted . The polymer materials need to possess good mechanical and physical properties at cryogenic temperatures such as liquid helium (4.2 K), liquid hydrogen (20 K), liquid nitrogen (77 K), and liquid oxygen (90 K) temperatures, etc., to meet the high requirements by the cryogenic engineering applications.

Mr. M. Nayeem Ahmed et al [6] presented in their technical paper to evaluate the flexural strength by using different types of matrix material and also to optimize the thickness of lamina was done, and comparisons are made by using different categories of matrix material on different thickness of laminates.

M. Nayeem Ahmed and Mr. Mohammed Salman Mustafa[7] presented in their technical paper a review of the mechanical properties of a hybrid composite : carbon fiber (37%) – E glass fiber (30%) – Graphite particulate (3%) – Epoxy resin LY 5052(30%).

Mark Bowkett and Kary Thanapalan [1] presented in their technical paper a review and analysis of current non-destructive failure detection methods of composite materials and a brief outline of the build of a bamboo bicycle which has been used as a development platform and test bed for the initial development of a novel and practical non-destructive failure detection solution, which has future compatibility for carbon-fibre based bicycles. The paper begins by presenting the current market condition of composite materials and in particular, carbon fiber and carbon fiber -reinforced plastic, and then follows onto failure modes and proceeds to investigate a comprehensive range of failure detection methods.

Ronald Julian et al [2] presented in their technical paper a pattern recognition system that implements an Artificial Neural Network classifier to detect and classify damage on composite beams. Classifiers were trained and tested using acoustic signals emitted by healthy and damaged beams after an impulsive load was applied to them. Singular value decomposition was used to filter the acoustic signals whereas Principal Component Analysis was implemented to extract relevant information from the filtered signal. The extracted information was used as inputs to the classifier that was able to predict four different levels of damage on glass fiber and carbon fiber beams with more than 97% accuracy.

Egor V. Yakovlev et al [3] presented in their technical paper the ability to use the terahertz time-domain spectroscopy for non-destructive evaluation of composite matrix . By combining the time-domain spectroscopy technique with appropriate methods of solving the inverse ill-posed problems, we have shown that time-domain spectroscopy could be applied for composite matrix testing. At first, we have demonstrated that time-domain spectroscopy could be used to control the polymerization process and, as a consequence, the composite matrix binder curing. Secondary, we have shown the ability to detect the internal defects (non-impregnated voids) inside the composite matrix via the time-domain spectroscopy based terahertz time-of-flight tomography. Thereby, the results of our study allow highlighting the prospective of non-destructive evaluation of composite matrix using the time-domain spectroscopy.

Christian Gruenzweig et al [4] presented in their technical paper neutron imaging was an alternative non-destructive inspection technique compared to the well-known x-ray method. Although neutron imaging data look at a first glance similar to x-ray images it must be underlined that the interaction mechanism of the sample material with neutrons differs fundamentally. x-ray interaction with matter occurs with the electrons in the atomic shells whereas neutrons interact only with the atomic nuclei. Hence, both methods have a different and to great extent complementary contrast origin. Neutron imaging allows for a higher penetration through heavier metals whereas a high contrast is given for light hydrogen. By the use of neutrons instead of x-rays exhaust after-treatment systems can be successfully examined non-destructively for their soot, ash, urea and coating distributions.

Sijin Wu et al [5] presented in their technical paper dynamic measurement of deformations in modern industry, spatial-carrier technique is developed to extract the phase information from a single speckle interferogram, yielding less time cost during a test. In this paper, both temporal phase-shifting and spatial-carrier techniques are investigated in theory as well as experiment. The experiment results from measuring a same deformation behavior using both techniques are used to compare the performances of the two phase extraction techniques.

Wan Xu et al [6] presented in their technical paper new methods for determining the edge stretching limit of the sheet coupons, with and without pre-stretching, based on the digital image correlation technique. A numbers of sets of notch-shaped smaller coupons with three different pre-stretching conditions (near 5%, 10% and fractured) are cut from the pre stretched large specimens. Then the notch-shaped smaller coupons are stretched by uni axial tension up to through edge cracking observed. A dual-camera three dimension digital image correlation system is utilized to measure both coupon face strain and thickness strain in the notch area at the same time.

Xin Xie et al [7] presented in their technical paper unique experimental procedure for large elongation measurement. By utilization of quad-camera digital image correlation system and data stitch technique, the strain history for plastic material under hundreds percent of elongation can be measured. With a quad-camera digital image correlation system, the correlation was conducted between two adjacent cameras.

Whitney Poling et al [8] presented in their technical paper the retained austenite volume fraction variation with strain with improved precision. Digital images of the gauge section of tensile specimens were first recorded up to selected plastic strains with a stereo digital image correlation system. The austenite volume fraction was measured by synchrotron x-ray diffraction from small squares cut from the gage section. Strain fields in the squares were then computed by localizing the strain measurement to the corresponding region of a given square during digital image correlation post-processing of the images recorded during tensile testing.

Bita Ghaffari et al [9] presented in their technical paper modified version of this technique to inspect Al-adhesive joints in both laboratory and production environments. A matrix array of ultrasonic transducers was used to obtain ultrasonic pulse echoes from joint interfaces, analysis of which produced c-scan images of the adhesive bead.

Jozef Pilc et al [10] presented in their technical paper the application of non-destructive potentiometric detection technology when considering the size of die forging cracks that arise in the process of forming.

Alexander Maier et al [11] presented in their technical paper prototype for a car's base plate was produced by using vacuum infusion. For research work, testing specimens were produced with the same multi-layer build up as the prototypes. These specimens were charged with defined loads in impact tests to simulate the effect of stone chips. Afterwards, the impacted specimens were investigated with thermography analysis. The research results in that work will help to understand the possible

fields of application and the usage of thermography analysis as the first quick and economic failure detection method for automotive parts.

Conclusions:

1.Using ultrasonic testing inspection on specimen plate, the weld defects parameters conclusion made by Anita Biradar and Bharat S. Kodli [19] as : at (120A),(13V) and gas flow rate (10 L\min), the maximum defects were observed.

2. Phased array ultrasonic technique gives advantage over other method due to its beam focusing and steering ability.

3. Pulsed-eddy-current -stimulated thermography was used to observe the fiber orientation for surface and subsurface layers, giving the potential for minor defect detection of fiber breakage.

4. Although Pulsed-eddy-current -stimulated thermography and flash thermography did not detect the delamination deeper than 930 µm for carbon reinforced matrix composite layers orientation , they offer rapid inspection and better visualization of delamination from transient thermal images.

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