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Ship Steel Plate Condition Monitoring using Continuous Wavelet Technique

Dr. Waheed Sami AbuShanab,
Kingabdulaziz University, Jeddah, Saudi Arabia.
Corresponding author email id: wabushanab@kau.edu.sa

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***Abstract* – This is a very important study used to evaluate different methods of detecting cracks in steel plates. In this case ship steel plates were used as the main specimen for the experiment. To achieve this wavelet analysis was conducted along with the ultrasonic techniques to ensure the appropriate method that can be used to identify fractures in steel plates by closely monitoring their growth. It is important to conduct this research because it is important in ensuring that the ship does not get damaged due to growth of cracks at the base. To achieve this 3-D finite element modeling software alongside with a powerful wavelet based signal processing technique was used to demonstrate the strength of different techniques to identify cracks on steel plates. Data was collected using acoustic transceiver which was considered as the only method that could collect empirical ultrasonic data. The data collected through this means were able to validate the development diagnostic methods. Before conclusion, amplitudes and frequency spectra of the ultrasonic signals were used to measure and predict the result. The result determined were matching those which have been predetermined in order to understand the extent of crack within the steel plate. The result of our study showed that WT is the most appropriate method for detecting damages in steel plates as compared to other methods and it is able to detect different structures and cracks available in the steel plates of a ship.**

***Keywords* – 3-D Finite Element, Condition Monitoring, Risk-Based Inspection, Reliability-Centered Maintenance, Ultrasonic Thickness Measurement, Continues Wavelet Technique, ABAQUS and ANSYS Software.**

I. INTRODUCTION

Monitoring the condition of any structure is a vital action to take at early stages. This is because structures usually get old and the load they are carrying does not change or becoming heavier over time. The second reason for monitoring is economic and life loss problems which usually lead to the sudden collapse of the structure when it is still in use thus causing avoidable accidents. To monitor and detect cracks and fractures in any structure there are various methods that can be used to monitor the condition of the structure such as ship steel plates to ensure any structural damages influenced by corrosion can be reported as early as possible. In this thesis, the condition of ship steel plates is evaluated using modern methods to ensure there are no damages or cracks in steel plates to prevent unnecessary accidents.

Ship steel plates usually develop some cracks within it which may have some negative effect on the functionality of the ship. The detection of such cracks in ship steel plates as early as possible prevent the damage of the whole structure by ensuring there are no fractures beneath the ship. It is not easy to use the ship without observing such fractures and therefore it is important to monitor their occurrence to ensure there is no damage to the ship due to the development of fractures in steel plates used to make the ship. To monitor these conditions, there are traditional methods such as nondestructive evaluation which are essential in detecting fractures and cracks at an early stage in order to take a correct course of action to prevent their occurrence. This method is useful in detecting incipient tiny cracks thereby improving structural safety and integrity especially steel ship. For a long time, dye penetrant inspection has been in use to monitor the growth of cracks in steel plates but for it to work there is a need for it to be in direct in contact with the plate. It is also not capable of detecting very tiny cracks and those found below the surface of water or soil. In addition, there is another important method which can also be used to detect cracks or fractures in different specimens. This method involves the use of conventional ultrasonic evaluation techniques used to identify and evaluate the extent of defects like corrosion in steel plates. Its core function is to monitor the development of fractures and reports their effect on the functionality and safety. This method uses shear waves to monitor the cracks in steel plates but it is only effective when dealing with small scale plates. It cannot be used to monitor cracks in large scale structures because it is time-consuming and it is also done in a point by point manner.

The conventional ultrasonic method cannot also produce a very good result because it is unable to detect fractures which are at right angles to the upper and lower surfaces of very thin steel plates. To ensure there is the high-quality result, it is important to use wavelet technique to solve all the problems encountered when using traditional methods. The use of wavelet allows the thin plate to interrelate with the wave which influences consecutive manifestation, refraction and mode conversions that form wavelet through a complex mixture of productive and harsh interference. When it is compared with the conventional ultrasonic shear wave technology, it is able to penetrate deeply through the structure therefore able to monitor cracks in steel plates found far away from the surface of the water. It is therefore important for structural integrity monitoring and also to identify cracks in steel plates of a ship to ensure there is safety in the ship by reducing the risk of submergence. In my consideration, the use of wavelet is more suitable for inspecting and monitoring cracks and other fractures. The availability of fractures and cracks in ship steel plates damages the ship and may lead to submerging of ship thereby killing people. It is therefore important to monitor the formation of cracks and fractures throughout the lifetime of the ship to prevent the development of such fractures. To monitor such conditions, always try to use modern methods instead of the traditional method which has numerous limitations such as the inability to detect cracks below the water surface. The wavelet transform is the best and precise way of examining the signals and ensure that all the problems observed when using other signal processing has. The function of the wavelet is comprised of a group of related functions with the ability to depict signal in a localized time and frequency. This research employs different methods such as continuous wavelet transforms which is believed to be the sum over all time of the signal multiplied scaled shifted version of the wavelet function. This method is used for both mode shapes and acceleration signals of cracked beam that have the different level of damages. The funding of this method is used to compute energy indices and designating the coefficient for various spoil points on the steel plate.

II. Literature Review

There are many researchers who concluded that wavelet transform is the appropriate method that can be used to monitor cracks in thin plates. According to Wang and Mc Fadden, it is also possible to examine actual vibration signals of the gearbox to detect cracks and other fractures caused by vibration. They indicated that the damages in the gearbox have a stronger relationship with signals reflected by wavelet scale plots. In the research conducted by Sung et al, the application of wavelet transform is shown where it was used to identify the impact the damage caused on the composite laminates. In this analysis, acoustic emission wave produced by the effect of the load was examined using wavelet transform and their variation was determined in the process. In the research conducted by Zhan et al, mathematical simulated dynamic response data were used to identify damages but in order to improve the process, it was suggested to use various impact positions. In the same research the influence of sensor position, damage intensity and harshness of damage were also examined. Other researchers such as Liew and Wang suggested the use of spatial wavelet theory to detect the cracks in different structures. The determined the wavelet between different points of the beam through the use of arithmetic solutions redirect the beam. To identify the crack location on the wavelet data, an excitation oscillated quickly on the surface of the beam was employed to stimulate the beam. The crack which has been identified as shown by a peak reflected by the deflection of some kinds of wavelets that appears on the surface of the beam.

In addition, other researchers such as also produced other unique techniques which can be used to detect fractures in plates. In their research wavelet, transform was also used to examine spatial circulation of signals on the surface of the beam. To achieve these flexural vibrations function that has transverse cracks were collected and the outcome examined through the use of wavelet transform. The process allows for the proper detection of the crack even though they looked very tiny when observed using naked eyes. The research of Vibration damage identification of cracks was also conducted by Chang and Chen and they concluded that it is the best approach that can be used to determine and monitor the presence of cracks in the metal plates. In their research cracks were shown through a rotational spring. The spatial signals were then examined and the result reported once the whole the wavelet transform method had been completed. After a long research, Naldi and Venini further used wavelets to identify cracks in different structures. They arithmetically simulated damages along the surface of a beam but all of the cracks were along the axial axis.

Maintenance also involves engineering decisions and their related actions that are required for specified equipment capability's optimization. This implies the ability to carry out some specified functions within a performance level range that may be associated with rate, responsiveness, safety, capacity, and quality. Apparently, the costs of maintenance hugely form part of operational expenses. Therefore, downtime or breakdown affects product quality, production cost, plant capacity, environment as well as health and safety. Consequently, maintenance is increasingly being viewed today from a strategic perspective, thanks to the utilization of such advanced technologies as wavelet. Besides, the technique guarantees increased safety, adherence to environmental regulations as well as optimized operations with the reduction of emissions and increased fuel efficiency. Indeed, maintenance activities impacts of the standards of availability and reliability of the shipping industry. Additionally, the activities are significant factors in a ship's lifecycle and have the potential of reducing the costs of operations and lessening downtime.

Initially, maintenance was treated as an actionable course that could be undertaken arbitrarily whenever a need arises. It was mainly intended at saving operational time loss and lessening chances of unforeseen failures. Being a predetermined part of the production, maintenance was largely regarded as a 'necessary evil.' It was only when necessary that replacement and repair were tackled and even then, there was no concern for optimization. However, over the last few years, this attitude has continued to shift, and most shipping organizations are increasingly embracing maintenance as a strategic issue.

There are three broad categories of maintenance. These include preventive, corrective and predictive. Traditionally, corrective maintenance is what many ships were accustomed to. However, due to the codes and regulations by the International Safety Management, preventive maintenance began to be adopted. Predictive maintenance followed suit. Predictive maintenance evolved from preventive maintenance. Predictive maintenance has three further subdivisions. These include Condition Monitoring (CM) Risk-Based Inspection (RBI) and Reliability-Centered Maintenance (RCM). Today, maintenance is approached as an operational method that is capable of generating profits and reducing operational expenses through an enhanced strategy of Operation & Maintenance (O & M).

III. Condition Based Maintenance

This concept was first introduced during the late 1940s by the Rio Grande Railway Company. The British Standards defines condition based maintenance as a policy for preservation that is undertaken in reaction to significant machine deterioration as shown by an alteration in a particular machine status parameter under monitoring. It can also be defined as a set of actions for maintenance that are based on real time assessment of the conditions of equipment. This evaluation is done through external tests, embedded sensor as well as the wavelet technique. Therefore, contrary to preventive and breakdown maintenance, CBM emphasizes on component diagnostics and fault detection as well as failure prediction and degradation monitoring.

CBM is a method applied in uncertainty reduction of maintenance activities and performed in accordance with the requirements of the equipment condition. Unfortunately, there is still a glaring literature gap regarding CBM hence difficulty in achieving the effectiveness of the maintenance. Nonetheless, various technologies such as Radio Frequency Identification, (RFID), wireless telecommunication, Product Embedded Information Device (PEID), Micro-Electro-Mechanical System (MEMS), Supervisory Control and Data Acquisition (SCADA), wireless communication as well as wavelet technique have emerged. They are expected to rapidly enhance the gathering and monitoring of component status, systems and sub-systems during the period of usage.

IV. Methodology

Data sources for mechanical systems and ship structures were thoroughly examined to gather useful and adequate information. This is the information intended to assist in the identification of the most critical and important systems and parameters to be monitored. The identified systems and parameters are also essential in determining and analyzing the performance and reliability of ship steel plate as compared to obtaining huge volumes of data, which may not be of much help in accomplishing analyses of that nature. More than seventy different documents including drawings and reports were gathered and studies to visualize all data and the available information. Regarding the ship steel plate condition monitoring, the types of data and information include reports issued during dry docks, structural drawings for ships, reports by Classification Societies as well as data from real time monitoring. Measurements of real time are achieved through positioning sensors on the hull structure of the ship. This will then be conveyed in the SRA tools.

Conversely, machinery data include such information as planned maintenance system (PMS), drawings of the ship machinery, statutory surveys by Classification Societies and monitoring data in real time. These sources are used for choosing machinery equipment and systems for the evaluation and monitoring in three case studies. Data is gathered in all the three types of the ship for both machinery and structural aspects of the ship steel plates. Nonetheless, all the three types of the ship have the same categories.

Data and information types of the basic measurements of the vessel steel plate include reports from dry-dock, reports from Classification Societies, structural drawings of the ship steel plate as well as real time monitoring. Architectural drawings include drawings of the midship section, shell expansion drawings, and general arrangement drawings. The general arrangement drawings contain sectional drawings of the emergency room floor, plan for ship profile, mid ship section, upper deck plan and emergency room floor deck.

Reports of dry-docks contain such information as schematics and surface condition reports, repairs and maintenance action images, consumable specification tables, Ultrasonic Thickness Measurement (UTM) reports, schematics and status reports, daily inspection reports, and consumable specification reports. On its part, the structural information from the Classification Societies contains corrugated strength reports, basic checklists, and first close up survey. The Classification Societies are engaged in certifying the worthiness of the ship by carrying out ship surveys and inspections to ensure safety. The real-time data monitoring shows the information on the significance of data sensors and the types in use as well as analyses types and sensor locations. Structural platforms such as INCASS require that its model is calibrated to predict ship structures' extreme response and fatigue damage.

V. The oretical and Experimental Outcomes

The structural data measurements will be used together with respective fundamental DSS and SRA tool for the improvement of response modeling, provision of fatigue damage's better estimates, which can assist in calibrating the structural strength and loading models before enabling inspection processes that are efficiently more targeted. The accelerometers and Inertial Measurement Units (IMU) are expected to feed the INCASS software with real time data for further examination of reliability and evaluation. The cost of Hull condition monitoring includes such expenses as installation costs like cabling, piping, and housing, strain gauges purchase as well as accelerometers (Gopalakrishnan, Ruzzene, & Hanagud, 2011).

VI. Findings and Novelty Conclusions

The collected data will be applied in the near future. Furthermore, the data will offer the means for validating and testing the MRA and SRA tools as well as the entire INCASS platform. It also opens doors for future research, which will include the likelihood of providing the vessel's crew with portable equipment that they can use to send data periodically to an office located in offshores. Moreover, there is also a future possibility of combining MRA and SRA tools for an onboard and real-time data analyses and report. Apparently, this can be used in other vast applications fuel or energy utilization onboard.

The system of hull condition monitoring has apparently been installed in some onboard container ships with expectations of further utilization. Besides, it can allow the control of such systems as generators and boilers, but this depends on the investment level. Under the actual conditions of operations, monitoring of additional systems would not only ensure safety but also guarantee increased and safer operational efficiency of the ship steel plates together with optimized processes like emission reduction and fuel efficiency. Moreover, based on the budgets and costs of implementation, there can be an installation of more sensors on a particular interest system to enhance the conduction of periodic measurement. This will allow improved data collection and measurements for assessment and analysis to improve maintenance, efficiency, safety and ship performance (Martinez-Luengo, Kolios, & Wang, 2016).

3D Finite Element Modelling (FEM) to Describe the Dynamic Behavior (ABAQUS, ANSYS, Est.) of Ultrasonic Wave Propagations into Ship Steel Plate. With the continuous emergence of more sophisticated algorithms for handling data coupled with powerful computational resources, the analysis of finite elements is increasingly becoming a significant part of orthopedic and biomechanics research. For a long time, there was rarely any tool that could be used to appropriately model systems of complicated, 3D, and nonlinear biomechanical. Until recently, the analysis of finite element in biomechanics was only confined to 2D approach, single or simulation tissue types or linear analyses. This has however changed today. Presently, there exist resources that can successfully model 3D, nonlinear, multi-joint systems or multi-tissue (Cao, Sha, Gao, & Ostachowicz, 2017).

The rapid development and fast aging infrastructure have prompted the necessity to monitor infrastructural health and ensure the integrity of the systems. This has been achieved through detection of onset damages such as corrosion and fatigue cracks in such critical structures as ship hulls, marine structures, off shore facilities for oil and gas production, power plants as well as airframe and rail structures. The development of relevant techniques for the evaluation of these damages requires the use of sensitive and reliable diagnostic methods. For, a shipping plate, the technology will be based on ultrasonic procedure and wavelet analysis, which will be achieved through the use of a three-dimensional finite element finite modeling, specifically the ABAQUS CAE or ANSYS. Combined with a powerful wavelet based signal, the processing technique will be used in collecting empirical ultrasonic data to be used in validating the diagnostic method developed.

The development of these techniques used for damage evaluation offers direct and indirect quantitative and real-time results that much nondestructive evaluation (NDE) field experts are accustomed to. Acoustic transceiver developed for collecting empirical ultrasonic data is used for validating the diagnostic method. Apparently, data pertaining the ship steel plate is collected in the form of x-rays, eddy currents, optical and thermal imaging, microwave, gamma rays and acoustic methods. The wavelet analysis and ultrasonic procedure can rely on conventional electromagnetic imaging, which can apparently function in three various resolution regimes. These include diffusive, far field or coherent and near field.

The spatial resolution and imaging depth always have a tradeoff because of the system's set up and physical limits. The far-field is the only place where the wavelength determined the resolution. This occurs in the transducer size order and does not depend on the near-field regime's wavelength. With the recent developments in single imaging methods, there is prone to be better detectability and improved quality of images. For instance, a sonic image is used for the detection hidden objects or defects inside the sheet steel plates. On its part, the methods of thermal imaging demonstrated the capability of mapping the shape and length of cracks in addition to providing qualitative crack depth data.

To improve the capability of imaging of the technique of single imaging and also reach beyond the limit of physical distraction, engineers have proposed the use of wavelet technique. This method apparently combines the concepts of two different waves that are sequentially generated and leveraging on each wave's merit. For instance, in thermal acoustic imaging, acoustic waves offer image contrast while thermal absorption provides a spatial resolution that is superior.

From the nature of wave combination, wavelet technique may produce a single image, but enhanced with the best resolution and contrast. Wavelet analysis and ultrasonic technique provide a hybrid system, which is characterized by improved image quality. However, it combines two single methods and then fuses data and registers typically essential images. In the hybrid methods of imaging, a single wave does not serve as the source for generating for other types of waves. Indeed, the wavelet and ultrasonic techniques have provided a fertile field where new technologies and ideas are emerging. It does not offer only a new direction, but also a brighter future in the structural health monitoring (SHM) and nondestructive evaluation (NDE).

The wavelet analysis and ultrasonic technique approaches are rapidly gaining prominence because of the crucial role they play in maintaining the integrity and safety of complex systems and infrastructure. They are primarily used in complex systems and infrastructures that are configured data systems that are sophisticated for propulsions, controls, electronics and other essential subsystems. Over the past few years, there has been increased emphasis on the potentiality of applying data capabilities in combination with technologies for data management and emerging sensor for monitoring of situ health of the conditions of materials. Nonetheless, SHM and NDE are not all that perfect. Concerning characterization and identification of structural degradation, they present challenges that are unique (Zhang & Harvey, 2011).

Based on this observation, it is significant to do a comprehensive analysis of the criteria of structural design, structural maintenance, potential mechanisms for damage and fail-safe features of ship steel plates. This is the only way; a wavelet sensor based system that can effectively monitor the structural conditions of steel plates can be developed. The SHM and NDE also face a challenge of real-time provision. Besides, information on the quantitative and qualitative image about the damage is not accurate. Wavelet technique is a multi-wave imaging concept, which was independently proposed by some groups in the physics community. This is where an energy form serves as the source for excitation of the other. For instance, in thermos-inductive imaging, the electromagnetic radiation, which has been absorbed through radiation occasions an alteration in temperatures, which transient infrared thermography can inspect.

By the nature of wave combination, wavelet imaging has the potential of producing one single image that has higher spectral and spatial resolutions and better contrast. When it was initially introduced, wavelet was intended to improve the capabilities of biomedical diagnostic. Today, it has managed to open up new avenues in the SHM and NDE fields as well as provide new guidelines for quantitative imaging. This is attributed to its superior results as compared to the outcomes from conventional imaging. It is a phenomenon is based on the interaction effects that portends that one nature of waves, which has components undergoing a test can generate another wave kind. On the other hand, a hybrid imaging has more detailed definition and can strategically multiple methods of imaging to accurately obtain better data or appropriately detect the problems associated with SHM and NDE.

The medical imaging society is one success story of the wide PET/CT imaging use and the impending PET/MR cross system. Through these systems, both the anatomical details and abundant functioning of an object are provided. Overall, combining different techniques of imaging into one hybrid platform has beneficial advantages to the speed and quality of imagery. Besides, it makes it possible to acquire data simultaneously. The minimal effort on registration of the image ensures that the subsequent analysis of data and post processing can be eased significantly as compared to the individual acquisition of the picture. A good example of NDE imaging is the magneto-optic imaging (MOI). This is based on the effect of Faraday rotation as well as the optical waves and electromagnetic waves' integration. Apparently, the resultant integration between optics and electromagnetic images leads to the generation of high sensitive real-time images. This is attributed to the fact that the angle of optical rotation and the local field of small EM are proportional. Therefore, the wavelet and ultrasonic cross imaging are indeed emerging as solutions to the challenges associated with SHM and NDE.

VII. THE PHENOMENON OF WAVELET AND IMAGING

The SHM and NDE applications have witnessed a proposal of various techniques that are based on the aspects of multiple waves. Additionally, there have been successful studies and developments regarding their detection methods. However, there has been limited access in such quantitative imaging as electromagnetic-ultrasonic methods, photo-acoustic methods, electromagnetic-thermal methods, photo-thermal methods as well as ultrasonic infrared thermal wave methods (Chang, 2003).

VIII. FINITE ELEMENT ANALYSIS (FEA)

Finite element analysis is the modeling of systems and products in an environment that is virtual for purposes solving and finding an existing or potential performance or structural issues. It finite element method's (FEM) practical application that scientists and engineers use to solve numerically and mathematically model very complex, fluid, Multiphysics and structural problems. The FEA software can find use in various industries. However, the field where it is used most commonly is the biochemical, automotive and aeronautical industries (Lu, Wang, & Zhang, 2016).

A model of a finite element consists of system points referred to as nodes, which apparently form the design's shape. The finite elements themselves are connected to these nodes in such a way that they form a mesh of finite element that contains the structural and material properties of the model. This helps to define the manner in which it will react to particular conditions. A finite element's density may differ throughout the material, and this depends on the expected change in the levels of stress within a certain area. Apparently, regions experiencing high-stress changes require more density as compared to those with no or little pressure variations. Points of interest could include fillets, materials that have been previously tested, high-stress areas as well as complex details.

FE models can either be created using 1D the beam, 2D shell or 3D solid elements. The use of shells and beams rather that solid element helps in the creation of a representative model with the use of fewer nodes even as accuracy is maintained. Each scheme of modeling must have different property ranges defined appropriately. These properties ranges include section areas, inertia moments, torsional constant, blending stiffness and transverse shear. To simulate the real world working environment's effects in FEA, the FE model can receive various types of loads. Some of these loads include nodal, elemental and body fluid acceleration. Nodal include forces, displacements, heat flux, moments, temperature, velocities, and accelerations while elemental include pressure, heat flux, distributing load and temperature.

The types of analysis involving FEA include linear statistics, nonlinear dynamics and statics, normal modes, dynamic response and heat transfer. Apparently, normal modes are vibration's natural frequencies while dynamic responses are the motions or loads that vary with frequency and time. The buckling is the critical loads from where a structure can be rendered unstable. On its part, heat transfer is the radiation, conduction or change phase. FEA can find its application in the new design of products or even in refining an existing product. This ensures that the design's performance will be in accordance with specifications before manufacturing. Moreover, with FEA, one can predict and improve the reliability and performance of a product, reduce physical testing and prototyping, evaluate various materials and designs as well as reduce usage of materials and optimize the design.

IX. Experimental Verification for Verifying the FEM Outcomes

Simulation integration into multiple processes of product development stages can produce huge yields regarding process efficiency and cost reduction. However, this can only be achieved if engineering firms undertake this integration process in an organized manner and with strong adherence to accountability. Apparently, verification and validation form one of the most critical pieces of the integration. V & V, as it is always known within quality cycles, constitute the cornerstone of any credible plan for quality assurance that is associated with simulation. For a simulation plan to succeed, a proper focus must be given to the V & V items. Otherwise, if one ignores V & V, there is prone to be more instances of harm in simulation, and this will occasion the design processes to head to the wrong direction (Seera, Lim, Nahavandi, & Loo, 2014).

Without the right checks and balances in the most appropriate places, simulation can go astray. Verification is the process through which FEA is checked if it was undertaken properly while validation is the process of checking if the results of the simulation reflect that of the real world. In other words, verification is the manner of establishing if the problem was correctly solved while validation the act of finding out if the problem that was solved was the correct one.

X. the Importance of Verification

Finite element analysis is not robust but approximate. Therefore, such small errors in data input, boundary conditions, and modeling can cause large faults in the final results. Worse still, sometimes these errors are relatively small and hence cannot be easily identified, but still, have much service life or performance impacts. For instance, using a reference temperature that is not correct in a structural model for thermal strain may have effects on the stresses by some percentage. When comparing the results of FEA to hand calculations, this error might not be huge enough to raise eyebrows. Nonetheless, the same mistake may be so huge to significantly alter the fatigue life. Apparently, these are not mistakes that can easily be detected without thorough analysis reviewing. This implies that in finite element models, errors are inevitable. They are more likely to occur in more complex models. The most significant thing is to identify them and put processes in place for catching them before they could be able to cause further damage and this is the verification process.

XI. Steps in the Process of Verification

There are many different forms that can be taken by verification process. However, the process depends on the type of analysis being undertaken, the analyzed parts, the required accuracy and the involved risk level. It is important to start the analysis with goals that are clearly defined, key assumptions and accuracy. Additionally, it is essential to create a template for verification for repeatability, ease of use and eventual success. Verification ought to be a gated process for use by anyone involved in the FEA performance.

XII. CWT Verification for Verifying the FEM Outcomes

FEM is a method used for solving PDE's by use of numbers. It is through PDE's that such physical phenomenon such as fluid flows or structural behavior is described. Apparently, this is the same way FEM is applied towards the solution to these problems. Therefore, FEM can simply be described as a tool used for understanding the physical phenomenon. However, any tool is always just as good as the person using it. This implies that FEM results are trustworthy only if the user is aware of the actual thing that is under simulation. There are three steps involved. These include pre-processing, simulation and post-processing.

XIII. Pre-Processing

This involves creating a model (CAD model), which provides an object under simulation's geometry. As a matter of fact, the geometry must be very permissively realistic. However, a user must be aware of the several limitations involved. After creating geometry, it must undergo discretization or meshing. This is where the geometry is separated into smaller elements or pieces. It is thus essential to consider suitable meshing (Chang, 2003).

XIV. Simulation

This is where the actual simulation takes place. It is this process that the right solution is chosen. The choice must ensure that what is chosen is indeed accurate. It is significant to note the energy and residential norms where simulation converges. Several commercial software has fewer thresholds for convergence of simulations. The solution lies therefore in the choice of the most appropriate material choices and solvers. Examples include plasticity, hyperplastic material, and contact.

XV. Conclusion

In this research, the effectiveness of continuous wavelet transform was assessed through the use of different examples and in this case damages in steel plates were used as the main specimen for study. I conducted two different experiments namely wave propagation and thermal problems and we only implemented 3-D wavelet transform. The result of our study showed that WT is the most appropriate method for detecting damages in steel plates as compared to other methods. The result also indicated that its effectiveness in detecting fractures in thin plates fully depends on the nature of wavelet and structural response signals. Another final thing that makes WT very important in damage detection is that it is also able to determine the intensity of damage.

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AUTHOR'S PROFILE

Waheed Sami AbuShanab
Email: wsabushanab@gmail.com, D.O.B: May, 11,1968; P.O.B: Makkah, Saudi Arabia, Education: Master Mariner Ticket (AASAT, 2008) Ph.D. Mechanical Engineering (Manchester Metropolitan University 2013) Field of Study: Marine Engineering.