REVIEW OF RESTORATION OF NATURAL FREQUENCIES OF EDGE CRACKED ALUMINIUM CANTILEVER USING COMPOSITE MATERIAL

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ABSTRACT

Cracks are most commonly damage types in the structures due to manufacturing defects and defects. When the stresses near the crack tip will exceed the permissible limit, then crack propagates. Due to fatigue cracks, crack found in structural elements may arise. This take place under service conditions as a result of the limited fatigue strength. They may also be due to mechanical defects. Crack arise may be because of defects due to manufacturing processes. Mechanical accidents, fatigue, environmental attacks are responsible for a crack in a mechanical structure. Due to the mechanical loads and environmental conditions composite materials are damaged. If material damage is not extensive, structural repair is the only feasible solution as replacing the entire component is not cost-effective in many cases. For this reason bonded composite repair are generally preferred. They provide enhanced stress transfer mechanisms and also joint efficiencies and aerodynamic performance. Now a day's usage of advanced composites is increased in primary and secondary aerospace structural components. It is essential to have reliable, robust, and repeatable structural bonded repair procedures to restore damaged composite components. But this method has several scientific challenges with the current existing repair technologies.

Keyword: -*Crack, Defect, Composite, Cost –effective, Repairs*

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1. INTRODUCTION

In structure or machine, cracked parts due to fatigue loading can cause change in a natural frequency. This change can lead to resonant vibrations under normal loading conditions. This may cause failure to the part or whole system. Many researchers have done a lot of work on change in the natural frequency of a cracked beam over a healthy beam. Here model constructed a closed form analytical solution to the change in the natural frequency of a cracked uniform beam. The crack was molded under six different boundary conditions and different parameters. The crack molded using; linear, elastic, massless and rotational spring. Different parameters are crack location and crack depth. Detection of crack locations and its size by relating the fractional changes in the natural frequency. This detection is over natural frequencies of the cracked beam to the healthy beam. The natural frequency of a functionally graded cracked beam resting on a Winkler-Pasternak foundation using the line spring model for formulating and applying the method of differential quadrature to solve it. For the strength of bonded patches, much research had been conducted. Researchers try with different materials, to evaluate its effectiveness under various conditions. The strength of bonded joints using the traditional strength of materials approach. This does not agree with experimental results. In-elastic fracture mechanics, which showed good agreement with the experimental results. For investigation on the repairing effects of fiber composite patches on the fatigue life, much experimental investigation is done so far. Experimental investigation is also done on a cracked aluminum specimen. Piezoelectric patches to repair cracked beams by applying an external voltage to actuate the piezoelectric patches bonded on the beam are done by many of them. Then the patches reduce the singularity produced by the crack tip. This helped in decreasing the maximum deflection of the beam.

1.1. Adhesively bonded repairs

When any machine or structure begins to show signs of wear and damage, there are several options available:

- The entire structure can be replaced
- The damaged part can be replaced
- The damaged part can be repaired

In most cases, replacing the entire structure is not an option due to the high price of structure. For part replacement, it can be difficult to procure parts especially for older structures. This means new parts have to be custom made which is expensive and time consuming. A good feasible option is to repair them. Repairing a damaged part using composite repair patches will be an inexpensive and quick method of returning an structure to flight status. Two approaches for part repair are usually adopted such as mechanically bolted or riveted repairs and adhesively bonded composites. A mechanically fastened repair is often flexibly attached and a crack may to grow under the patch. They introduce further stress concentration at the additional fastener holes which may result in increased in cracks tendency. Adhesively bonded composite repairs provide a method of repair that controls stress concentrations better. The goal of a properly designed bonded repair is to restore the natural frequencies of damaged structures. Damage growth should either be arrested or significantly retarded.

The repair must be carried out without causing further damage or creating a weak link in the structure. In short, the repair allows the structure to fulfill its original intended function. The repair of metal structures with composite materials is a technology that was first introduced in Australia in the early 1970s. The success of a bonding repair depends on the properties of both the adhesive and the patch. The quality of the repair depends upon bonding process and surface treatment. In aeronautics Carbon–epoxy composites have been mostly used. Carbon–epoxy composites have high stiffness and strength to weight ratios. The performance of the adhesive plays a important role in the successful utilization of bonded composite patch repairs. The role of a bonded composite patch is to restore the original strength and natural frequencies of cracked structure. The stress intensity factor is then reduced by the presence of the patch.

1.2. Advantages of adhesively bonded repairs

The advantages of adhesively bonded repairs over other methods are

- High fatigue and corrosion resistance of the composite.
- High strength-to-weight and stiffness-to-weight ratios, reducing weight.
- No new stress concentration is introduced.
- High fatigue and corrosion resistance of the composite.
- Potential time savings in installation.
- Patches are readily formed into complex shapes, permitting the repair of irregular components.

1.3. Disadvantages of adhesively bonded repairs

The disadvantages of adhesively bonded repairs over other methods are

- In case the structure to be repaired is subjected to very high loads, mechanical joints may be more efficient.
- Stringent cleaning and processing steps may not be adhered to, within a controlled environment.
- The structure to be repaired may withstand the high cure temperatures required for bonded repairs.
- High humidity environment may prevent achievement and maintenance of good quality bond.

2. REVIEW OF LITERATURE

K.B.Katnam (2013) proposed a method of detection of crack locations and its size by relating the fractional changes in the natural frequency of the cracked beam to the healthy beam due to the presence of cracks. The natural frequency of a functionally graded cracked beam resting on a Winkler-Pasternak foundation. For that use the line spring model for formulating and applying the method of differential quadrature to solve it. For the strength of bonded patches, much research had been conducted, with different materials, to evaluate its effectiveness under various conditions. The strength of bonded joints using the traditional strength of materials approach. This does not agree with experimental results. In-elastic fracture mechanics, which showed good agreement with the experimental results. Much experimental done investigation on the repairing effects of fiber composite patches on the fatigue life of a cracked aluminum specimen. Many researchers used piezoelectric patches to repair cracked beams by applying an external voltage to actuate the piezoelectric patches bonded on the beam. Then the patches reduce the singularity produced by the crack tip.

Okafor (2005): studied and analyzed the durability of adhesively bonded composite patch repairs of cracked aircraft aluminum panels repaired with octagonal single sided boron/epoxy composite patch. Pre-cracked 2024-T3 clad aluminum panels of 381 x 89 x 1.6 mm, repaired with octagonal single sided boron/epoxy composite patch were used as test specimen. Two different composite ply configurations, 5- and 6-ply were investigated. Linear and non-linear finite element analyses were performed on the test specimen using 8-noded 24 degree of freedom (DOF) hexagonal elements for the aluminum panel, boron/ epoxy patch and adhesive material subjected to uni-axial tensile loading. The stress distributions obtained were used to predict the increase in strength and durability of the repaired structure. They found that the maximum stress decreases significantly after the application of the patch and the region of maximum stress shifts from the crack front for an unpatched panel to the patch edges for a patched one.

Wei-Chung Wang and Chien-hua chean (2000): was invented the vibration behavior of a clamped edge-cracked composite plate repaired by composite patching. Modal testing was first used to measure the natural frequencies and mode shapes of the composite plate before and after repair. The amplitude fluctuation electronic speckle pattern interferometry (AF ESPI) was also employed to find the real-time absolute whole-field displacement. Based on the results from those two methods, effects of different stacking sequences and numbers of layers of the patching on the vibration behavior of the composite plate were studied. It was found that the change of fiber orientation and the number of layers of the patching have more significant influence on the variation of mode shapes of higher modes.

Vaziri.H. Nayeb-Hashemi (2005) suggested that the dynamic response of repaired composite beams under a harmonic peeling load was studied theoretically and experimentally. The repair method was based on removal of the damaged region and bonding a composite patch into the gap with adhesive. In the theoretical part, the equations of motion in the axial and transverse directions were derived assuming that the viscoelastic adhesive layer resists both peeling and shear stresses and both the patch and parent materials behave as Euler–Bernoulli beams. The validity of the theoretical model for evaluating the dynamic response of repaired composite beams was examined with the results of the finite element model.

The finite element results indicated that the deformation mechanism of the repaired composite beam depends on the Adhesive elastic modulus. For low values of the adhesive elastic modulus, shear deformation in the adhesive layer is the dominant deformation mechanism and the proposed theoretical model replicated the results of the computational analysis. In the experimental part, the response of unidirectional fiberglass-reinforced epoxy composite specimens with various repaired patch lengths, thickness, and material properties were measured by hammer test technique using a non-contact laser vibrometer. The patch section was either the fiberglass-reinforced epoxy composite or E-glass fiber reinforced composites with various stacking sequences. The repairing patches were bonded to the composite beam with an epoxy. The experimental results were compared to those of the theoretical model and finite element analyses. The experimental results were related to the adhesive material properties, its loss factor and to the patch material properties.

A. A. Baker and R. Jones (1998) analyzed that due to high specific strength and stiffness, composite material has been widely used in various flying vehicles. Occasionally, defects are found in the structural components. When defects are not critical enough to make the replacement of the components, patching is one of the best ways to extend the structural life and reduce maintenance expenses. Baker and Jones first introduced the concept of bonded repair.

L. R. F. Rose (1982) formulated the theoretical derivations and discussed experimental aspects of various bonded repair methods. Rose carried out the repair by adhesive bonding of the isotropic and orthotropic materials with crack first employed the speckle technique to determine the stress intensity factor of a side-cracked aluminum alloy sheet patched by the fiber-reinforced composite material.

Mahmoud Nadim Nahas (1982) developed a method of cyclic loadings cause fatigue to the elements of machines leading to crack initiation and propagation. This phenomenon decreases the age of the elements. In particular, cracks decrease the stiffness of the parts and lower the parts natural frequency, leading to failure under normal working conditions. This paper introduces a new application to carbon nanotube (CNT) composites in the repairing process of a cracked specimen to restore the natural frequency of the specimen. Commonly, patches are made of high strength and high stiffness materials. This paper shows that even low stiffness materials, such as epoxy reinforced with CNT, can contribute to the repair of a cracked specimen. A 2D finite element (FE) simulation is used to study the effects of bonding CNT composite patches over the crack location to repair cracked metal specimens. The effects of the patch thickness, length, and CNTs weight concentration ratio are investigated. Results showed an increase in the natural frequency of 31% compared to the cracked specimen at a crack depth of 70% of the beam depth and at a distance of 20% of the total beam length from the support.

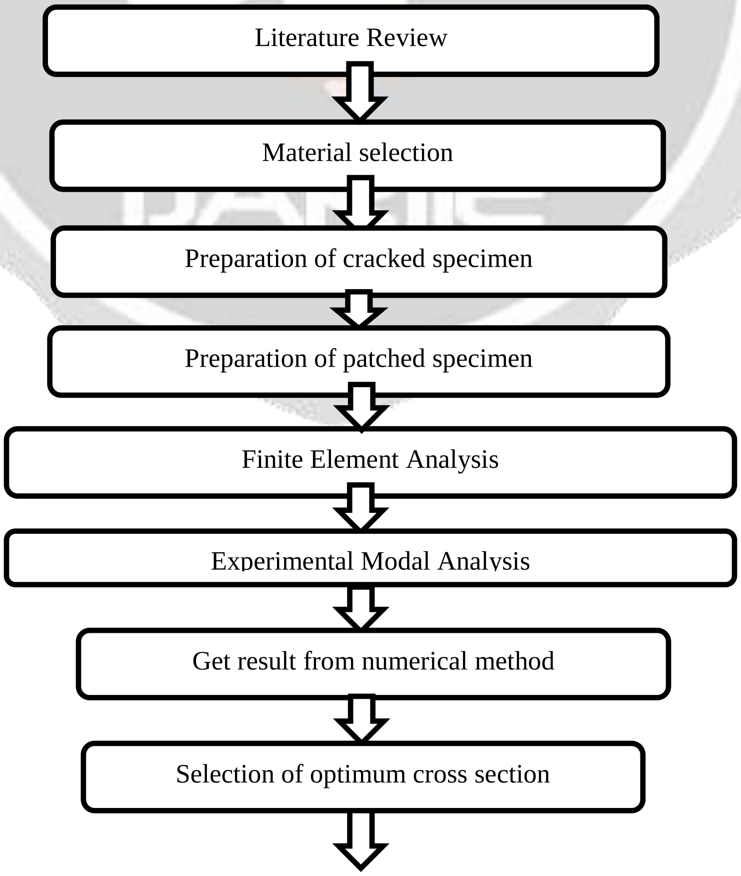
W. C. Wang and G. H. Lin (1997) done limited research work has been done on the vibration characteristics of the patched components. Wang experimentally investigated the vibration of a composite plate containing a circular hole repaired by composite patching. The fiber orientation of both the composite plate and patching is the same.

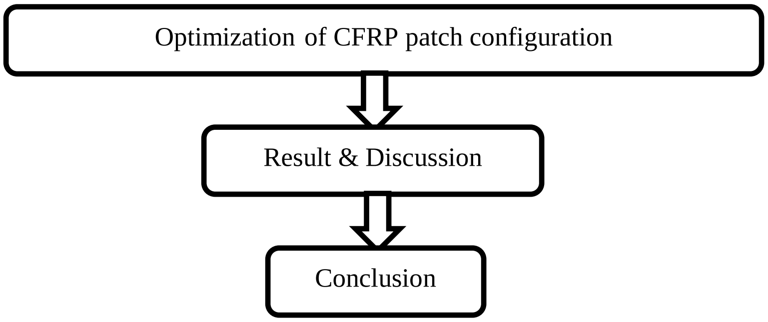
3. OBJECTIVE

- To repair a crack in a thin 6061-T6 aluminium alloy sheet to be repaired by bonding carbon-fibre-reinforced-polymer (CFRP) patches.
- To study specimen properties carefully so that the natural frequencies of the original specimen are restored.
- To develop an appropriate CFRP patch configuration in such a way that it enhanced the natural frequencies of the repaired plate up to the natural frequencies of original 6061-T6 aluminium plate which are decreased due to presence of edge crack on it.

4. METHODOLOGY

Following methodology is to be adopted during project





5. PROBABLE OUTCOME

- The ability of the patch to repair the cracked specimen and also restore the natural frequencies of cracked specimen to be study.
- From the numerical results, the outcome will be ,"no significant effect of patching in y-direction for first five modes of the edge cracked plate".
- Experimentally also this patch configuration will give correct results for different crack length and crack positions

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