Research paper in Failure Analysis Of Without Eye leaf Spring Using FEM

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ABSTRACT

We know that the spring plays very essential part of every automobile for suspension point of view.leaf spring is the main type of suspension system which is used in many light and heavy vehicals. Leaf spring used in many vehicals due to having some main characteristics which are shown bwlow:

1) Uniformaly Load Distribution

2) Lower Cost

3) Rough Used

4) Esiear In Isolation and Tighly attached working frame

Today Every automobile company has been working on increasing the efficiency with reducing the weight without having any load carring capacity. In this paper we would like to review some previous research work performed on the leaf spring by previous researchers for increasing the working condition and capacity with load reduction. In order to analyse the variations in the chemical composition, micro-structural analysis along with material specification has been performed. The failed leaf spring fractured part was analysed by using a visual inspection technique and scanning electron microscope (SEM) analysis. The fatigue life of the proposed leaf spring has increased in comparison with the existing model lifecycles.The paper based on material composition, experimental testing and load (Steady, Dynamic) study etc. Based on the fractography study, it was inferred that the failure of the fractured part was due to the cyclic load. This load lead to fatigue growth on leaf spring of the model truck vehicle. Then finite element analysis of leaf spring was carried out to find out the root cause of the leaf spring suspension system. The failure parameters were also optimised for the truck vehicle during safe operation on the road. The fatigue life of the proposed leaf spring has increased in comparison with the existing model lifecycles.

Keywords :- leaf springs, Material Compositions, fracture mechanics, leaf spring failure, leaf spring stress analysis etc.

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1. INTRODUCTION

A leaf spring is the simple form of spring commonly used for the suspension in wheeled vehicles. Leaf spring is mainly made up of steel, but due to issue of weight today most of the automobile companies used composite materials for the manufacturing of leaf springs. The composite materials used like E-Glass/Epoxy, Graphite/Epoxy, and Carbon/Epoxy etc. The classification of leaf spring included as Elliptical, Semi Elliptical, Three quarter Elliptical, Quarter Elliptical, and Teraservers. The leaf spring mainly consists of different parts like Master leaf, Center bolt, central clamp, Eye, and Rebound clip.

A spring is an elastic body, whose expand in size when load applied and regain its original shape when removed. Leaf spring is the simplest form of spring used in the suspension system of vehicle.It absorbs automobile vibrations, shocks and loads by springing action and to some extend by damping functions.It absorbs energy in the form of potential energy. Springs capacity to absorb and store more strain energy makes the suspension system more comfortable. . The leaf springs always receive a high dynamic load and often experience fatigue failure that occurs after the component is used for a certain period in its operation. Failure due to fatigue is a fracture mechanism that can be identified through 3 stages, the first stage is initiation of crack, then crack propagation and the final stage is fracture. Fatigue failure is the most common failure in automotive components, particularly those involving spring on trucks. This is due to automotive components often experience excessive load and shocks that occur due to the unevenness of the road through the wheel. Based on the fractography study, it was inferred that the failure of the fractured part was due to the cyclic load. This load lead to fatigue growth on leaf spring of the model truck vehicle. Then finite element analysis of leaf spring was carried out to find out the root cause of the leaf spring suspension system. The failure parameters were also optimised for the truck vehicle during safe operation on the road. In this project the main objective is to failure analysis of leaf spring of without eye by using finite Element analysis method. (Fem).

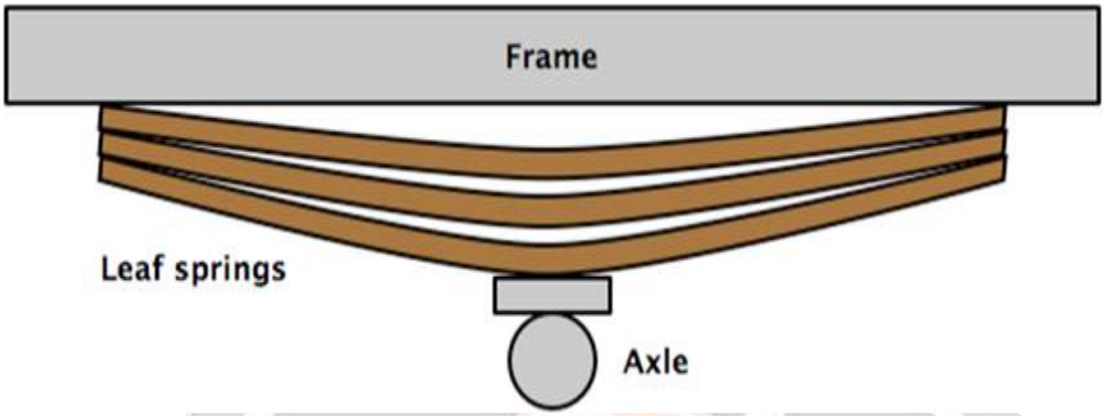

FIG:- Componant Leaf Spring

2. PROPOSED SYSTEM

This project is very informative project, in this i am going to study the Failure Analysis Of Without Eye leaf Spring Using FEM. for that I have studied 20 research paper, I have found that every one analysis on eye leaf spring that using in truck suspension. But I am doing analysis on the single eye leaf spring by using Finite Element System.

3. ANALYSIS OF LEAF SPRING

3.1 Reasons to Perform Failure Analysis Testing

The failure analysis process provides a number of benefits including financial, legal and safety related outcomes:-

1. **Understand Root Cause of Failure**
   Understanding the root cause is often the fundamental part of the failure analysis process. This involves data collection to ascertain whether failure occurred due to manufacturing or material defect or misuse.

2. **Prevent Asset or Product Failues**
   Once the cause of failure has been determined corrective actions can be taken to prevent a recurrence of the problem.

3. **Improve Future Products and Processes**
   Manufacturing processes and product designs can be improved due to an understanding of the failure mode, not only to prevent the problem from happening again but also to prevent costly legal action or replacements as well as protecting a company's reputation.
4. **Meet Standards for Products and Assets**

Failure mode and effects analysis can help to meet standards for manufacturing processes, failed components, products, or assets going forward.

5. Determine Liability for Failure

A failure analysis will not only determine the root cause of the failure, but may also assign liability for the failure. This can be used in legal proceedings to not only apportion blame but also protect yourself from litigation.

3.2 Analytical Analysis

Analytical analysis is performed to obtain the load distribution on each wheel, either the maximum load or minimum load during the operation of the leaf springs. As it is known that the fine crack found in the material that leaded a bending load and resulted the stress intensity factor (K_I) around the crack tip. When the value of $K_I > K_{IC}$ (fracture toughness), the crack propagation will occur, but when $K_I < K_{IC}$, crack does not spread. Based on this understanding, the stress intensity factor was calculated using available data of the failure life spring [11-13]. Further analytical solution is explained in detail in sub sections.

3.3 Numerical Analysis

The simulation of collected data was done on the bolt hole area on leaf springs number eight. The usage of hole area due to the fracture failure is around it. From the result of simulation, the stress distribution known, as well as stress intensity factor and strain also obtained]. The steps and simulation process for numerical analysis were done using FEM software by giving fixed support on the spring eye. The loading type used was centralized load given on th.e bottom of the spring. The truck loading can be calculated by analytical analysis . The meshing steps used the obtained nodes number of 633438 and the number of elements of 5280.

3.4 Load Distribution Analysis.

Loading analysis is one method to determine the cause of damage to leaf springs due to overload, either static or dynamic. In determining the maximum and minimum load received by the spring on each wheel, a calculation was undertaken by applying Eq.1.4mgF×= (1) where F is the force (N) that occurs on the spring, m is the mass (Kg) of the vehicles the weight of, which is divided by the suspension system of the four wheels of the vehicle.

3.5 Stress Analysis

Stress calculations were performed to estimate the reduction in strength in the spring resulting from cracks existing before the accident and the midplane segregation. Exemplar spring test data were also used to provide a basis for estimating the reduction in strength. The reduction-in-strenjgth estimates were then used to determine if normally expected dirt road forces in the absence of a large rock strike were adequate to rupture this spring. Finite-element stress analysis was used to study the existence of transverse tensile stresses at the location of the fracture.

3.6 STATIC ANALYSIS OF LEAF SPRING

The leaf spring modeled in Pro/E was imported to ANSYS in IGES format. Since leaf spring was modeled as a solid, solid element named SOLID187 was used to mesh the model. SOLID187 element is a higher order 3-D, 10-node element. SOLID187 has a quadratic displacement behavior and is well suited to modeling irregular meshes (such as those produced from various CAD/CAM systems). The element is defined by 10 nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities.

3.7 Hardness of Failure Leaf Spring

The results of hardness test Hardness of Failure Leaf Spring horizontal axis from point A to B and vertical axis from C to D in the sum of 22 points. The distance between point approximately 2 to 5 mm. The hardness in the area close to the bolts whole or in middle of the spring is lower than of the ends of leaf spring. It shows that, the materials toughness on the center of the leaf spring higher than of the spring ends. This result is in agreed well with the result reported by previous researchers.

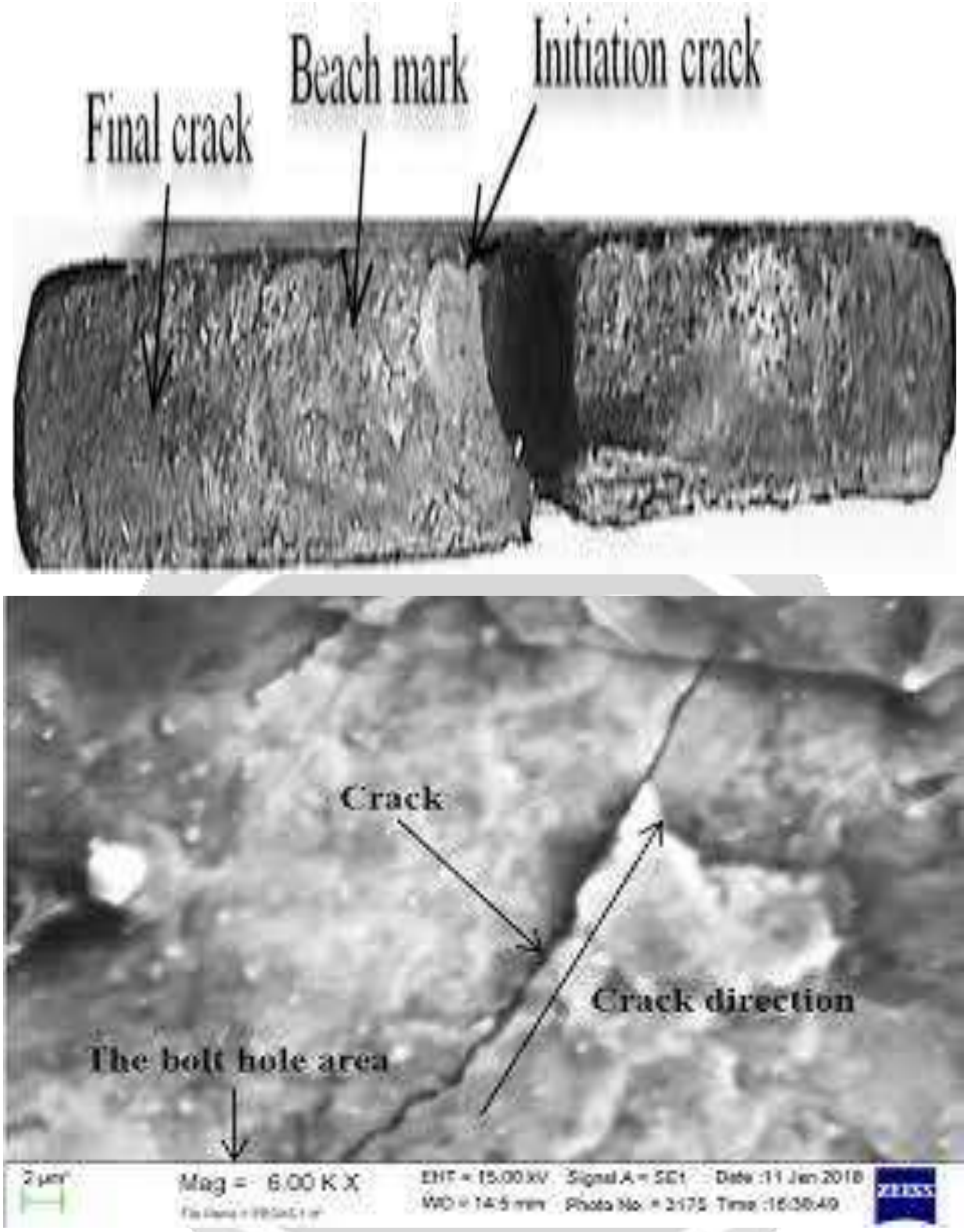

Fig 3.1:- Failure of Leaf Spring

4. RESEARCH METHODOLOGY

4.1 Material and Methodology

4.1.1. Material.

The material used in this study was a 125 PS colt diesel truck leaf spring, which resulted in failure on leaf spring. The failure occurred when a truck used to transport palm oil with excess load capacity operated on an uneven road surface.

4.1.2. Methodology.

This study employed several methods of testing, namely, experimental testing and analysis. The testing step began with preparing the test specimen, observing the fractured surface of the leaf springs, performing hardness tests, observing the microstructure using a scanning electron microscope (SEM).

After completing the experimental testing, this was followed by modelling the leaf springs using the Autodesk Inventor 2017 software application and finite element method using FEMAP software [14] to obtain the maximum value of stress received by the leaf springs, to determine the cause of failure of the leaf spring specimen

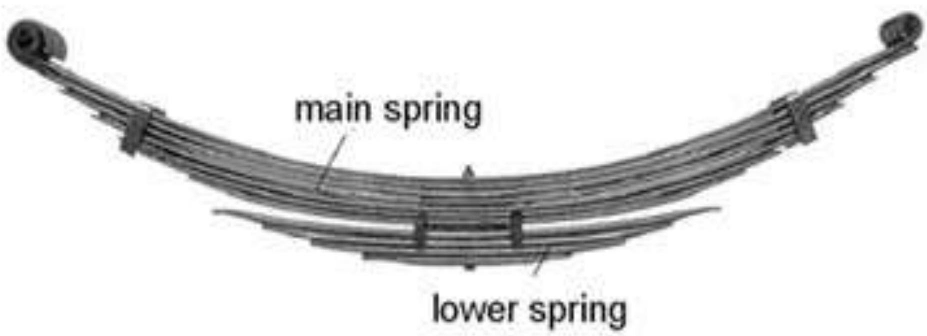

FIG 4.1.2:- Multi Belt Leaf Spring

4.2 Visual Observation

Visual inspection was undertaken in this study to observe the fracture surface of the damaged spring to determine the likely indicators that may have caused the failure or fracture in the leaf spring material based on the fracture surface conditions. Visual observation is 90 Advanced Technologies in Material Processing II

Normally conducted to identify any unique patterns, such as the mechanism of fracture until final failure. This would typically consist of three stages, initial crack, crack propagation, and the final fracture caused by a certain type of loading received by the leaf spring. Moreover, it could also help to predict the type of failure experienced by the leaf spring so that further testing could be undertaken that would help to understand what factors led to causing the initial crack. Two methods, as mentioned, were employed in this study to observe the fracture surface, namely visual observation to observe the characteristics of the fracture surface at a macro level and observation on the fracture surface using SEM to observe the fracture surface topography microstructure.

4.2.1 Maximum Stress.

To avoid structural failure due to maximum stress, the maximum stress on the spring must be less than the value of the material structure strength or yield strength. By considering the safety factor with a value of 1.65 [7], the maximum allowable stress can be examined applying Eq. 2.

MaxyfSSσ = Sy/Sf

here Sy is the yield strength of the material, and Sf is the safety factor.

4.3. Modelling and Finite Element Analysis.

Modelling and Finite Element Analysis CAD 3-D modelling was undertaken using Autodesk Inventor 2017 software, which is a Computer Aided Drawing (CAD) application supported by solid modelling. Autodesk facilitates a concurrent engineering approach to design and stress analysis [16]. Knowledge-Based Engineering (KBE) is a set of algorithms and methods that provide a parametric modelling approach, which then implements the design into a CAD model. As such, the dimensional formulas, design rules, and build constraints are used to transform a design problem into a configuration problem [17]. Finite element analysis (FEA) on the leaf spring was performed using Siemens™ FEMAP v.12.0.1 software, which is engineering simulation software able to solve engineering problems from products and engineering systems to even the most complex problems more easily, quickly, and accurately. FEMAP can virtualize model components, assemblies and then describing response behavior for a given operating environment by entering loads and constraints.

CONCLUSION

The study done by us here gives a review on previous paper and journals based on different ideas and modifications with the help of mathematics, experiments, and computational methods. Now in this portion we concluded here the main parameters analyze by us from the study of these previous papers. The failure analysis yielded the following conclusions:

- The presence of sulfur segregation at the midplane weakened the spring.
- The spring was cracked for some time in advance of the accident
- The prior cracking in the spring was extensive enough to reduce the strength of the spring to the point where normal dirt road forces were adequate to produce rupture.
- Marks in the wheelwells and on the road surfaces were consistent with and support rupture of the spring at the start of the accident sequence.
- The rock strike possibility was ruled out because forces adequate to rupture the spring were present well in advance of the rock strike, and wheelwell marks were not consistent with short-duration forces expected from a rock strike.

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