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Role of Fatigue Life in industrial Designs

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ABSTRACT : *Vehicle Life time is highly determined by the fatigue life of its components. Variability in the material parameters may have a strong effect on the fatigue life. In order to achieve better performances together with improved safety, a new design process is needed to build automotive components, This new process requires shift from traditional design approach to a new approach that incorporates all the variability's and uncertainties in the analysis phase and in the design flow and to use computer simulation methods to guarantee design reliability.*

This paper gives an overview of the role of fatigue life in design of mechanical components, and the methods to calculate the fatigue life of the different components and its role in on new designs in optimizing the design based on the life of the components[2][3][4][5].

Keywords – *Fatigue, Design, FEA load cycle, stress life, strain life.*

I. INTRODUCTION

Recent technical demands for improving the performance of engineering components have brought up the need of proper estimation of components/system life to avoid sudden or unexpected failure of equipment. The ability of any system to perform its required function without failure remains a challenging concern for design engineers. As considered as the main cause of failure in industrial components, fatigue remains the main source of unexpected failure in mechanical components as the majority of structures are subjected to cyclic, alternating stress. Consequently, fatigue life can be satisfactorily considered as measure for the reliability of mechanical components. Many research papers have been dealing with fatigue life predictions of different components such as aircraft structural components, riveted lap joints, and welded joints using different methods ranging from finite element analysis to fracture mechanics theories that are mainly based on destructive testing. The aim of this work is to study and review the various techniques of Fatigue life calculations and their applications in design of industrial components.[3].

Prediction of fatigue life by using various methods but are not limited to, some of the methods are:

Prediction of fatigue and calculation of life of the components by using FEA, modal analysis, thermal fatigue.

II. FATIGUE ANALYSIS METHODS

Fatigue life analysis methods broadly classified into following three categories

3.1 FATIGUE ANALYSIS METHODS [1]

There are primarily three fatigue analysis methods available

2.1.1 STRESS-LIFE APPROACH[1]

- Long life applications
- Stresses and strains are elastic
- Deals with total life or life to failure of component

2.1.2 STRAIN-LIFE APPROACH [1]

- Short life applications
- Strain is no longer elastic, but has plastic component
- Deals with crack initiation

2.1.3 FRACTURE MECHANICS[1]

Fracture Mechanics or the da/dN – ΔK, uses the stress intensity factor to quantify the fatigue. Linear Elastic Fracture Mechanics (LEFM) approach deals with propagation life from initial crack to defect.

III. SCHEMATIC REPRESENTATION OF STAGES INVOLVED [1]

IV. FATIGUE LIFE ESTIMATION BASED ON THE STRESS-NUMBER OF CYCLES METHOD

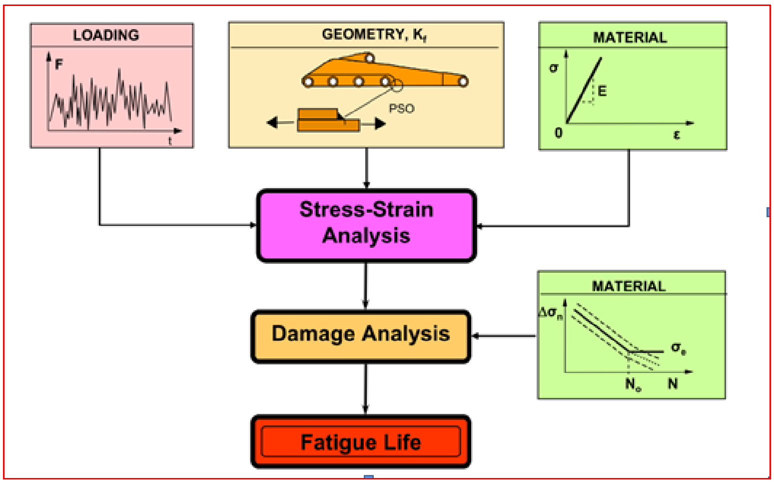

Fig.-1. (Stress method) [1]

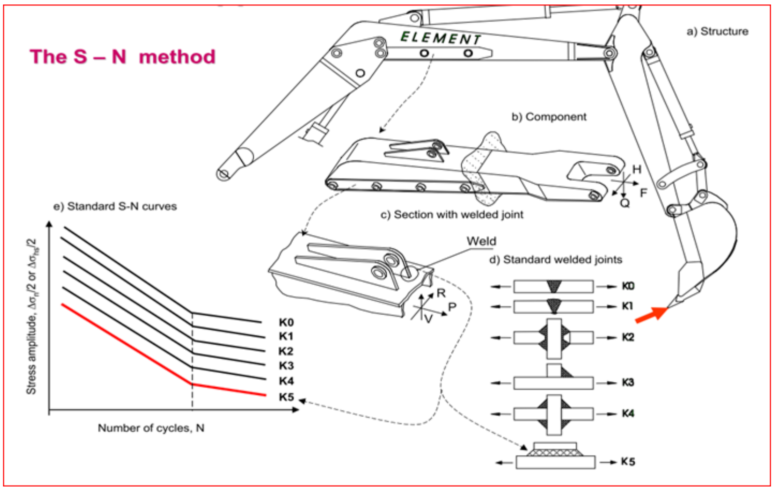

Fig.-2. [1]

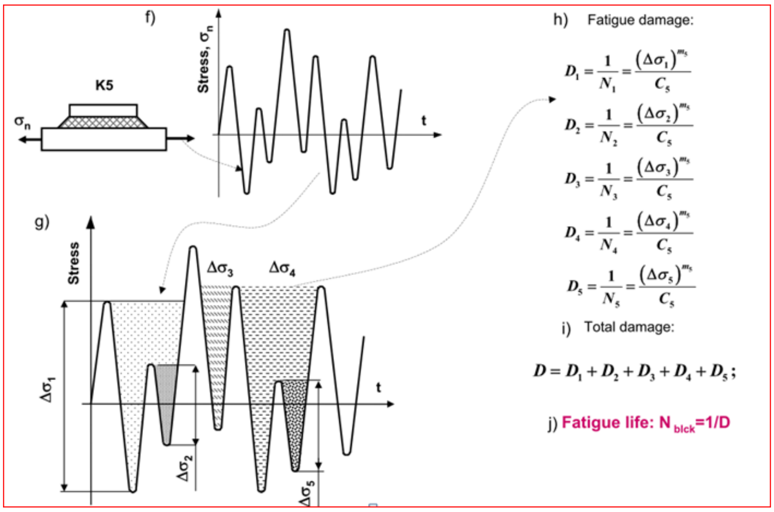

Fig.-3.(Steps in fatigue life prediction by stress approach) [1]

V. FATIGUE LIFE ESTIMATION BASED ON THE STRAIN-NUMBER OF CYCLES METHOD

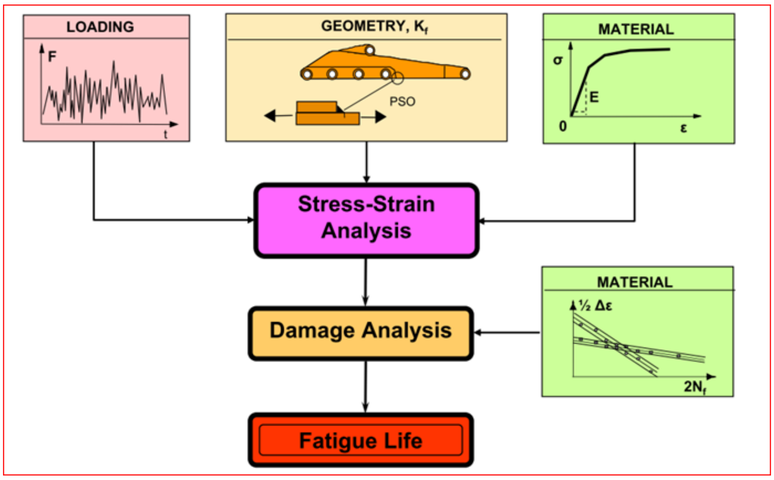

Fig.-4. (Strain method) [1]

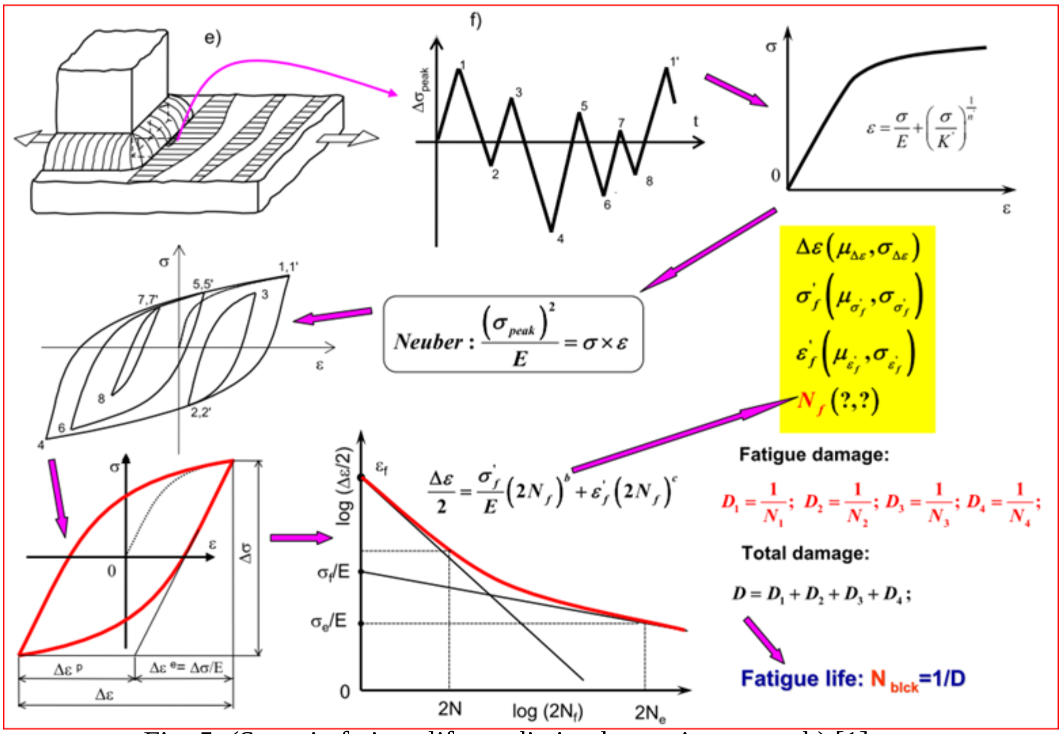

Fig.-5. (Steps in fatigue life prediction by strain approach) [1]

VI. FATIGUE LIFE ESTIMATION BASED ON THE CHANGE IN CRACK GROWTH RATE-STRESS INTENSITY FACTOR

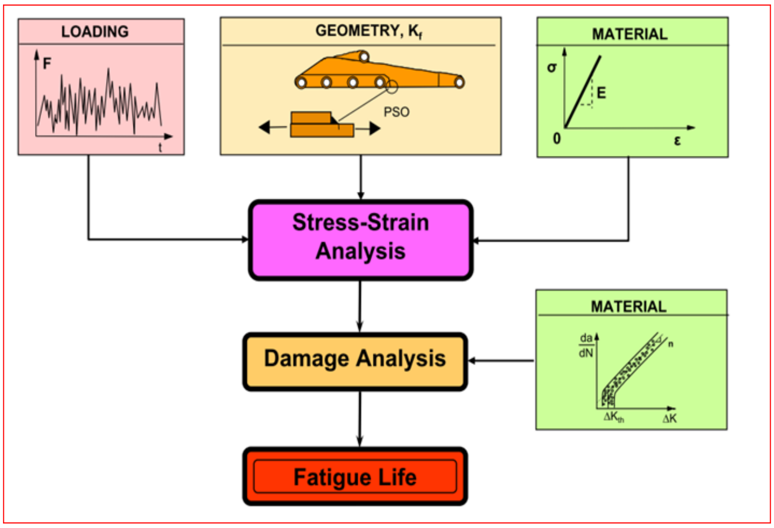

Fig.-6. (crack growth rate method) [1]

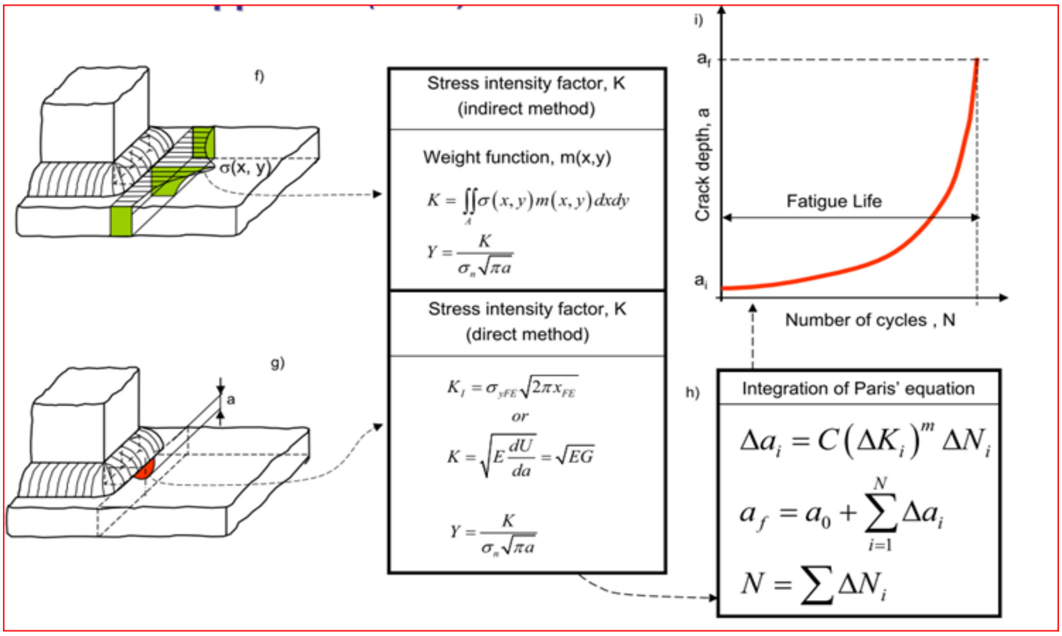

Fig.-7. (Steps in fatigue life prediction by fracture mechanics approach) [1]

VII. FATIGUE LIFE PREDICTION OF A REAR AXLE HOUSING PROTOTYPE

A full scaled CAD model of the housing was prepared for the analyses as shown in Figure-9[2], the solid model of the housing was composed via CATIAV5R15. CAD model of the complete housing was imported into ANSYS Workbench V11.0 preprocessing environment to constitute the FE model required in the analyses. According to the acceptance criteria, a housing prototype has to resist N = 5 X10^5 load cycles without a fatigue failure. During the vertical fatigue tests of asymmetric type axle housing, fatigue crack initiation occurred on some of the prototypes before this load cycle limit.

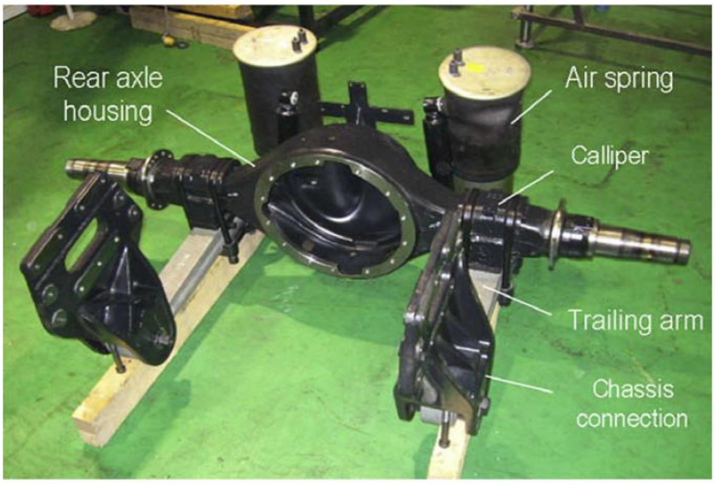

Fig.-8. Rear axle assembly of a commercial vehicle [2]

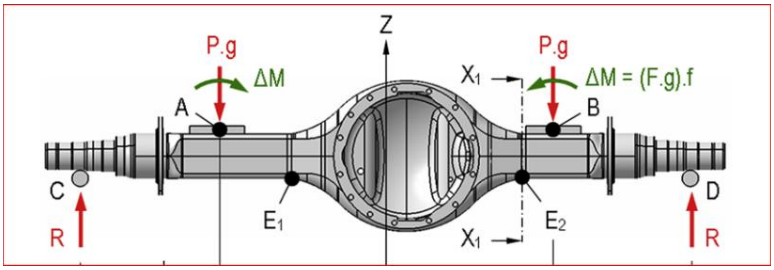

Fig.-9. Applied loads on a housing [2]

Load applied to the FE model was chosen according to the loading range used during the vertical fatigue tests where pre-mature failure was seen.

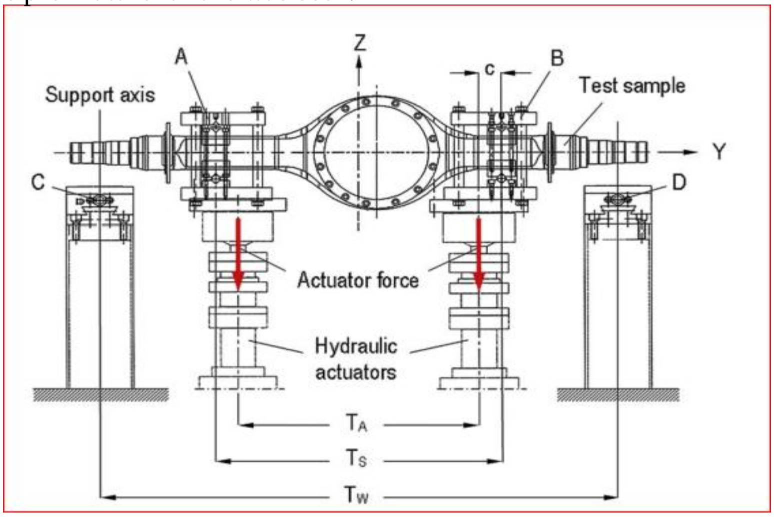

Fig.-10. Schematic for fatigue test [2]

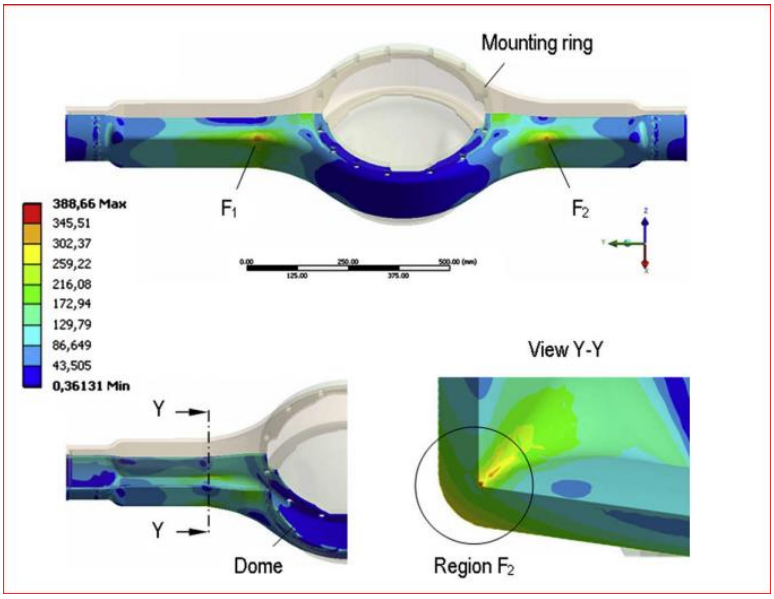

Fig.-12. over all stress distribution [2]

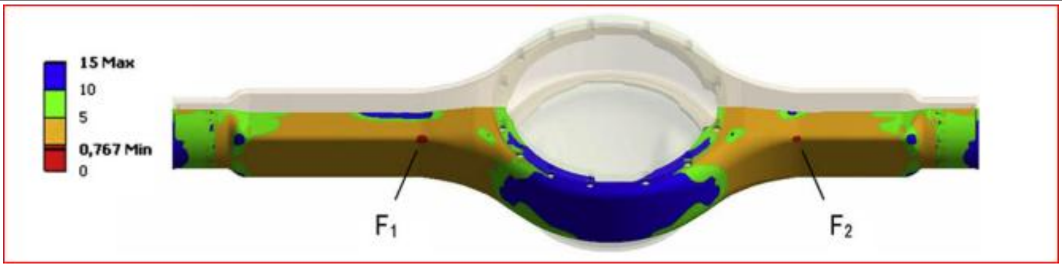

Fig.-13. Factor of safety distribution on lower shell [2]

VIII. CONCLUSION

FE analyses showed that the regions, where fatigue failure was initiated during vertical fatigue tests, are subjected to stress concentration, which can cause a premature failure before the predicted $5X10^5$ minimum cycles limit. The results are in agreement with the results of vertical fatigue tests. Enhancement of the fatigue life of the housing is dependent on the decrease of the stress concentration. The simplest way to reduce the stress concentration and improve the fatigue life is to increase the thickness of the sheet metal. However, except regions F1 and F2, the housing satisfies the infinite life criteria. An increase of sheet metal thickness causes an unnecessary weight increase [2].

Identifying the right fatigue life evaluation method of a component plays a critical role in the early product design stage of component before actual verification in the test setup results.

Various other methods of fatigue life evaluation are also in scope such as using modal analysis, thermal analysis are further extension of these methods.

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