Fatigue Analysis of Automotive Steering Link by using Finite Element Analysis

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Abstract: *An automotive steering link is used to transmit the steering forces between pitman arm in the steering shaft and a steering arm in the knuckle. Steering link is subjected to cyclic load during operation. Due to cyclic loading fatigue crack occurs. Because of fatigue failure automobile components are unable to functioning properly which causes problems in vehicle safety. After millions of load cycles steering link will get fatigued due to effect of critical condition of road and rotation of link itself which causes to failure. The present work deals with analysis of automotive steering link. The design parameters such as length, inner diameter, and outer diameter are considered. Fatigue analysis of automotive steering link is carried out using ANSYS software.*

Keywords - ***Steering link, Fatigue failure, cyclic load, Fatigue life, factor of safety.***

I. INTRODUCTION

Steering link connects the pitman arm to the steering arm, or in some applications it connects to the tie rod assembly. Unlike a centre link, the drag link does not connect to an idler arm, and has no inner tie rod ends attached to it. On some applications the drag link swings from the front to the rear of the vehicle. On these applications the drag link connects to the steering arm located at the wheel. In some Jeep applications, the drag link will swing from right to left on the vehicle and will connect to the steering arm at the wheel. Drag links can be a solid one-piece design or an adjustable design. Many drag links have replaceable or rebuild able ends. The steering linkage is a combination of rods, and arms, that transmit the movement of the steering gear to the front wheels. It must transmit this movement to the front wheels, while still allowing for any up-and down movement they may make, while the vehicle is in motion. Very few researchers worked on fatigue analysis of different components of automotive parts but there is no suck work available about automotive steering link. Hence we decide to study the fatigue analysis of automotive steering link by using FEA method.

The steering link used for analysis purpose is as shown in figure 1 below:

Fig. 1 Automotive steering link

II. FATIGUE ANALYSIS USING FEA

Modeling of Steering link

In the present work we find out the mechanical properties of automotive steering link. Also we can find the material of the steering link with parameters such as inner diameter, outer diameter and length of the link. Selected automotive steering link is made up of STKM12C with 0.12 % carbon. The link is circular hollow tube shape component. Inner diameter of link is 9.6 mm, outer diameter of link is 17.6 and the length of link is 315 mm.

Fatigue analysis of automotive steering link is carried out by using FEA method [2]. The typical methodology for the fatigue analysis by using FEA is as shown in figure 2 below:

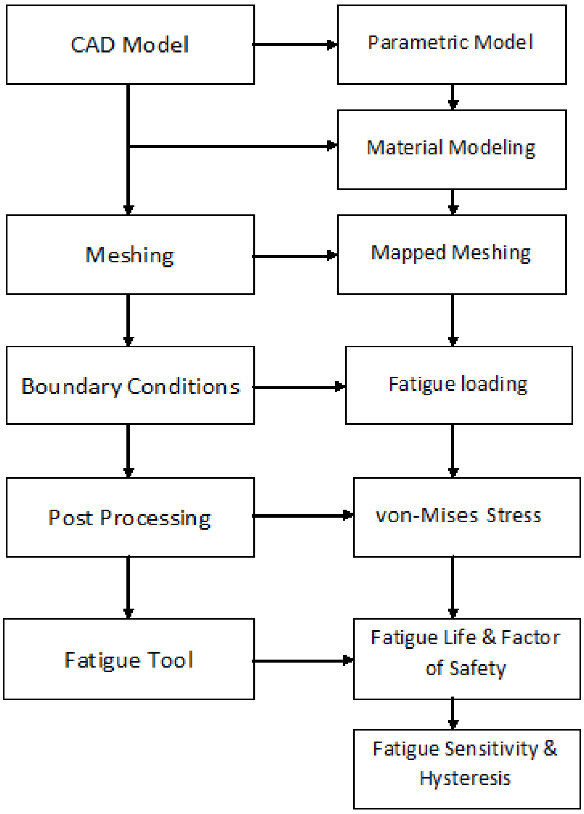

Fig. 2 Methodology for fatigue analysis

An automotive steering link is modeled in ANSYS workbench module. CAD model of steering link is as shown in figure 3.

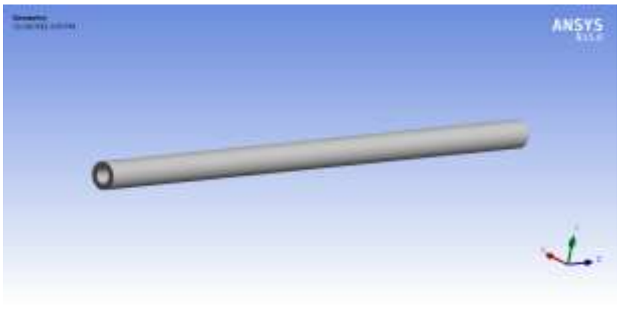

Fig. 3 CAD model of steering link

Shell element is used to mesh geometry of steering link. Mapped type of meshing is implemented. After meshing 660 elements and 427 numbers of nodes are generated. Element edge length of 30 mm is applied for meshing. Meshed model of steering link is as shown in figure 4.

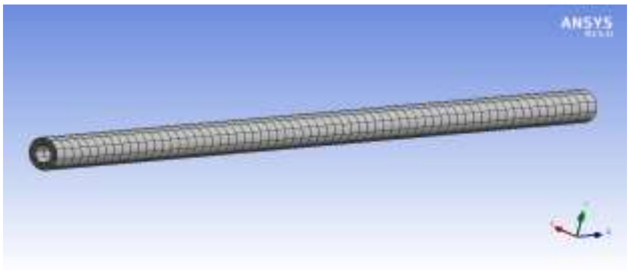

Fig. 4 Meshed model of steering link

Boundary Conditions

In boundary condition one end of steering rod has Zero degree of freedom in all direction, while 20 kN tensile loads were applied in positive X direction. Loading diagram is as shown in figure 5.

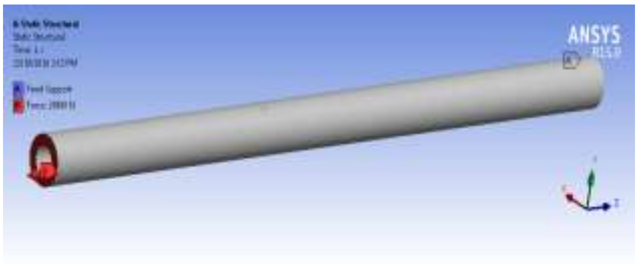

Fig. 5 Boundary conditions for steering link

FEA Results

The total deformation, equivalent von-Mises stress obtained by using static analysis is as follows. Total deformation and von-Mises stress for 20 kN are 0.1827 mm and 125.74 MPa as shown in figure 6 and 7 respectively.

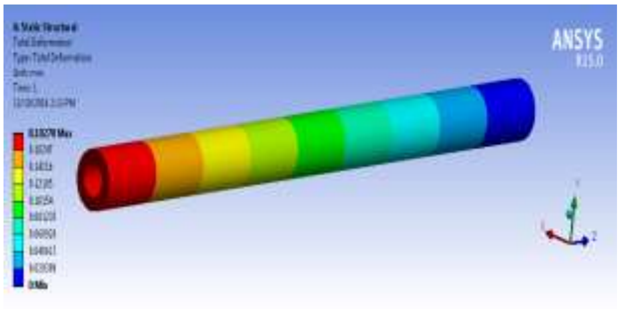

Fig. 6 Contour plot of total deformation at 20 kN

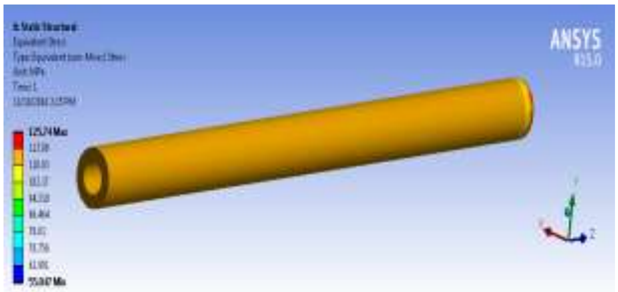

Fig. 7 Contour plot of von-Mises stress at 20 kN

Fatigue tool module from ANSYS workbench is used for fatigue life calculation. Fatigue strength factor is assumed as unity. Fatigue loading was fully reversed with scale factor 1. Stress lives as well as strain life are calculated by considering loading cycles 10^6 while loading one cycle is considered as one minute loading nature during analysis is as shown in figure 8.

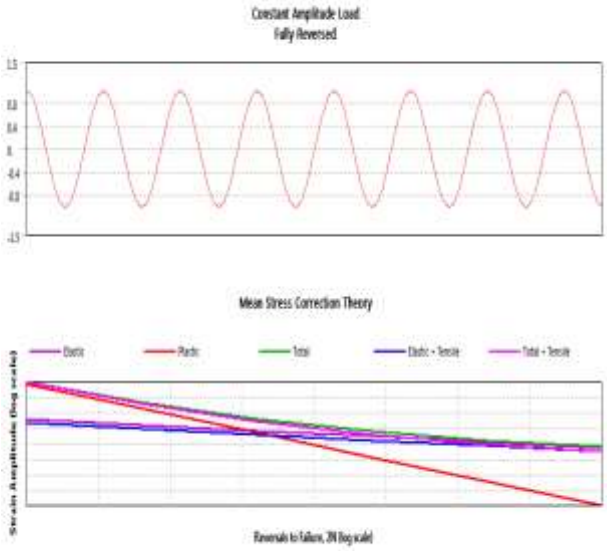

Fig. 8 Constant amplitude load cycle

Load is varied by ± 50% at constant amplitude. During each cycle load is increased by 2 kN up to 30 kN and it is decreased up to 20 kN within interval of 2 kN. It is observed that life of component is improved during negative deviation of load while it is decreased during positive deviation of load. Maximum life of component is 4.5364×10^6 minutes and minimum life is 2.0872×10^5 minutes. The relation between load and available life is as shown in figure 9. The study of the fatigue life obtained at various load condition is carried out for automotive steering link.

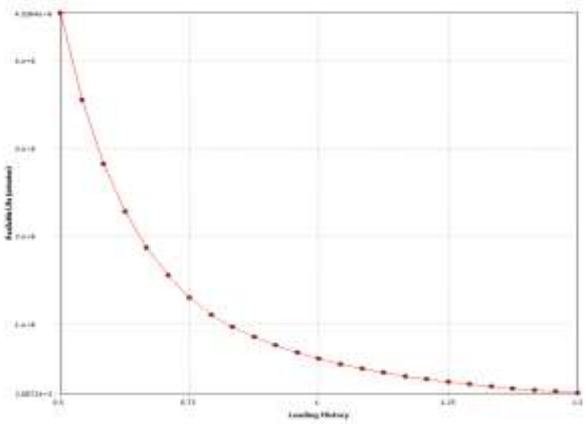

Fig. 9 Load vs. available life

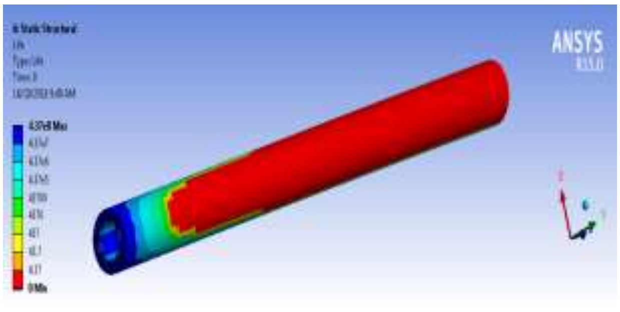

Fig. 10 Fatigue life at 20 kN cyclic load

Fig. 11 Fatigue life at 22 kN cyclic load

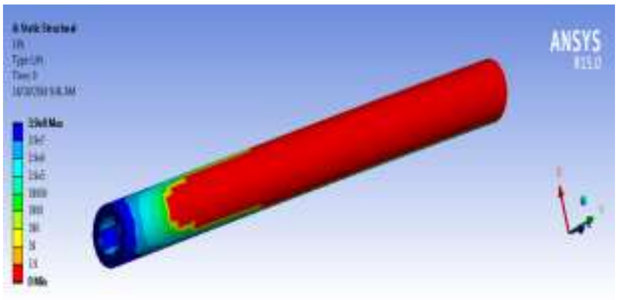

Fig. 12 Fatigue life at 24 kN cyclic load

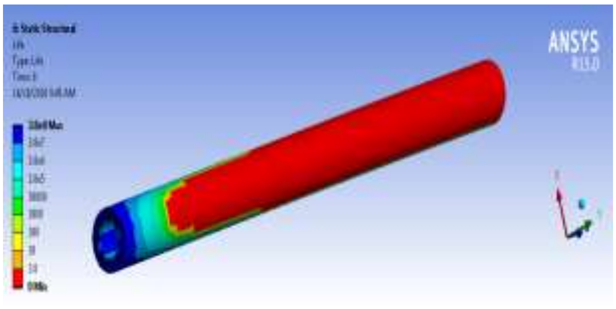

Fig. 13 Fatigue life at 26 kN cyclic load

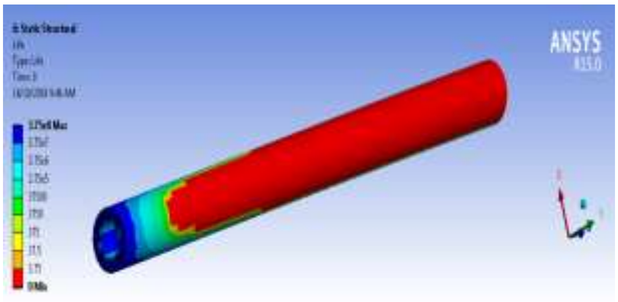

Fig. 14 Fatigue life at 28 kN cyclic load

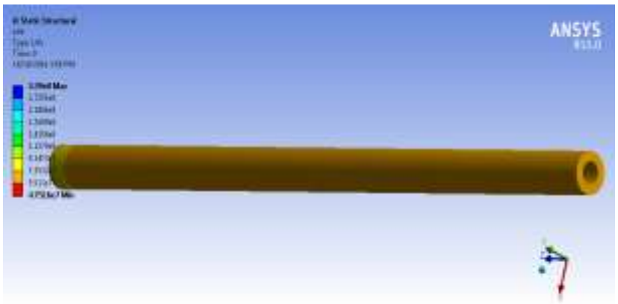

Fig. 15 Fatigue life at 30 kN cyclic load

It is observed that fatigue life is reduced when load is increased from 20 kN to 30 kN. Fatigue life is increased when load amplitude is reduced from 30 kN to 20 kN. Factor of safety is obtained region wise.

III.PERFORMACE ANALYSIS

Analysis carried out for fatigue life calculation by FEA method following results are obtained

Table 1 FEA results of Fatigue test

Sr. No.	Load (kN)	Life (Cycles)
1	20	4.37×10^8
2	22	4.03×10^8
3	24	3.90×10^8
4	26	3.80×10^8
5	28	3.75×10^8
6	30	3.39×10^8

FEA results of fatigue test are tabulated in above Table 1. Fatigue life was calculated for different load condition. It is observed that, as load increases life (Cycles) decreases as depicted in figure 15.

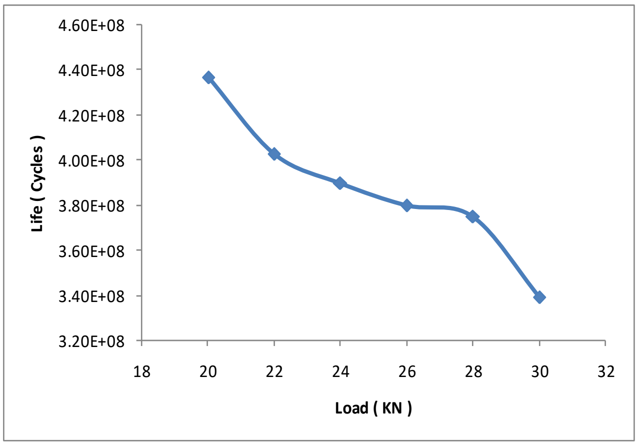

Fig. 15 Load vs. Life (Cycles)

IV. CONCLUSION

This paper demonstrates the Finite Element Analysis of steering link for static and fatigue analysis by using ANSYS. Life of steering link is predicted by varying amplitude in cyclic load from 20 kN to 30 kN. For the studied steering link, it is observed that, the life (cycles) 4.37×10^8 at 20 kN while 3.39×10^8 life (cycles) at 30 kN. It is also observed that in most of regions factor of safety is in between 1.22 to 2.7.

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