International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June-2018 www.irjet.net p-ISSN: 2395-0072

Fatigue Analysis of Crawler Chassis

Santoshkumar Patil A[1], Asst. Prof. M. Sadiq A. Pachapuri[2]

[1]M. TECH Student, Design Engineering, KLE Dr. MSSCET College, Karnataka, India
[2] Professor, Dept. of Mechanical Engineering, KLE Dr. MSSCET College, Karnataka, India

---

Abstract - *As the countries are converting from small cities to hyper cities, the comfort of the people as well as the need for the better infrastructure has increased and this has forced the construction industries to develop the better and sophisticated heavy earth moving machines, like Excavators, cranes, trucks etc. So the current scope of the project work is to study the structural strength of the crawler chassis of the crane under worst loading conditions and to reduce the mass of the crawler chassis structure without compromising the factor of safety.*

Key Words: **Crawler Chassis, Excavators, Cranes.**

1. INTRODUCTION

Present day building development ventures are exceptionally automated and ending up more so consistently. On construction sites, production equipment is being replaced by transportation equipment, because structural elements are being prefabricated off-site and then installed or collected nearby the site. Material management and lifting equipment currently rule building development sites like more than ever before and they constitute a basic component in accomplishing high profitability. The regular building development site will incorporate a few or more following equipment's: material handlers, cranes, solid pumps, pipes and lifts, and shaping frameworks. However, cranes are the most important machines nearby the sites; regardless of their size, as well as because of the vital part they have in transporting materials and components vertically as well as horizontally.

1.1 Design of Crawler Chassis

The finite element analysis is performed on the crawler chassis using abaqus solver. The dimension parameters of the crawler chassis is given as below:

- Length of chassis: 5600mm.
- Width of chassis: 2900mm.
- Height of the chassis: 2576mm.
- Weight of chassis: 10360kg.

The total vertical weight (dead load + boom load) acting on the chassis at point-A in negative Y-direction, moment due to rotating of the boom on the sleeve ring acting about X-direction at point-B and torsional moment due to the dead weight at the tip of the boom acting about Y-direction at point C as shown in Fig 1. The static structural finite element analysis is carried out to find the deflection and stresses in the crawler chassis. Fig 4.1 shows the vertical load along Y-direction and torsional moment about X-Y directions of crawler chassis.

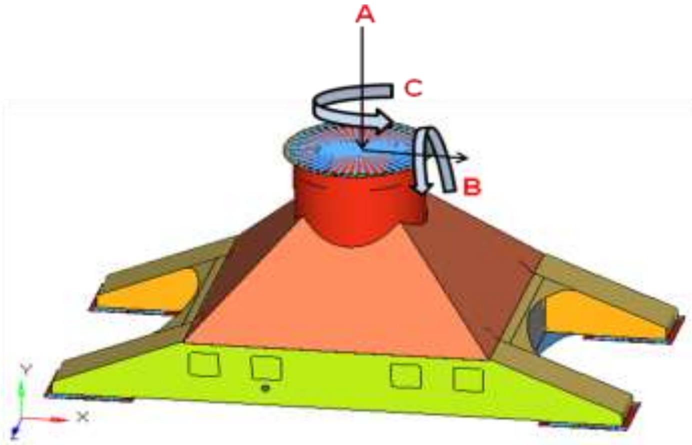

Figure 1 Diagram of Crawler Chassis

1.2 Static Structural Analysis

The general equation of the Static analysis is given by F=KU, where K: Stiffness, U: Displacement and F: Applied external force. Static analysis considers the stiffness to be linear and uses Newton's Raphson's method to solve the algebraic equations. Static structural analysis is carried out for different position of Boom as follows.

- The boom is at 90^0
- The boom is at 0^0
- The boom is at 45^0

1.2 Boundary Condition

The boundary conditions are those which fixes the structure at its position rigidly that no movement is occurred in the fixed condition. There are four boundary condition for the crawler chassis pad under which static strength analysis is carried out using HYPERMESH software.

The boundary conditions are applied after the meshing is done to the crawler chassis. Under these conditions, the crawler chassis having vertical load of 364000N with its weight 10360kg are applied on the four crawler chassis pad.

In real manufacturing, the four crawler chassis pad joints are fixed by welding. But in analysis, the rigid body connections are used which acts like weld joint.

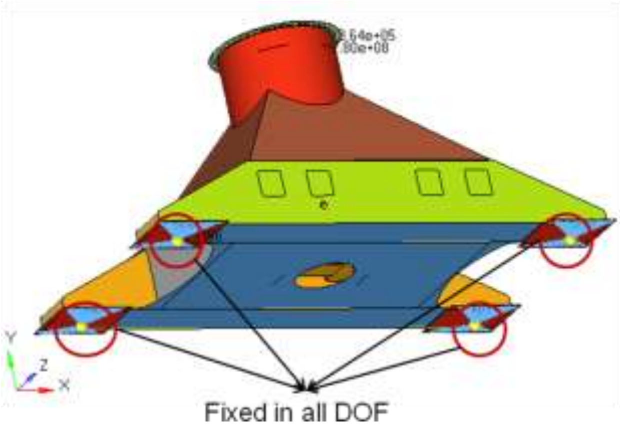

Figure 2 Boundary Condition

2. LOAD CASE

In above load case study of stress behavior is carried out when Boom position is 45 degrees to the length of the chassis. This is the worst loading case among all above three cases. In above loading condition the total vertical and torsional loads are as follows;

A= 364000N in Y-direction,

B= 549245192 N-mm in X-direction, and

B= 549245192 N-mm in Y-direction

C= 67505100 N-mm in Y-direction.

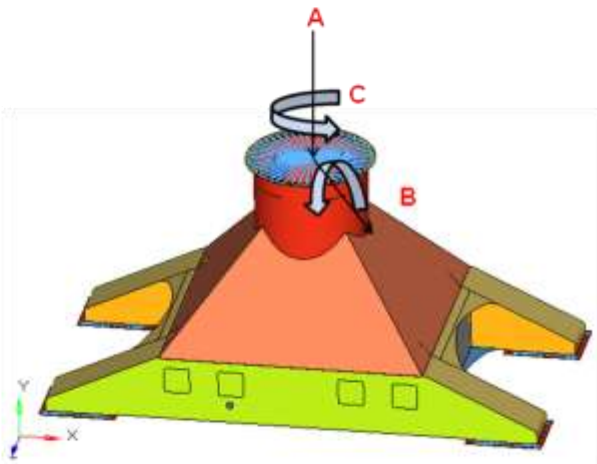

Figure 3 Load Condition at 45^0 of Boom Position

2.1 Strength Analysis Results of the Crawler Chassis in Loaded Condition

After carrying out the static strength analysis under loading condition when boom is at 45^0 to the length of the crawler crane, the maximum Von-Mises stress comes out is 161.2MPa.

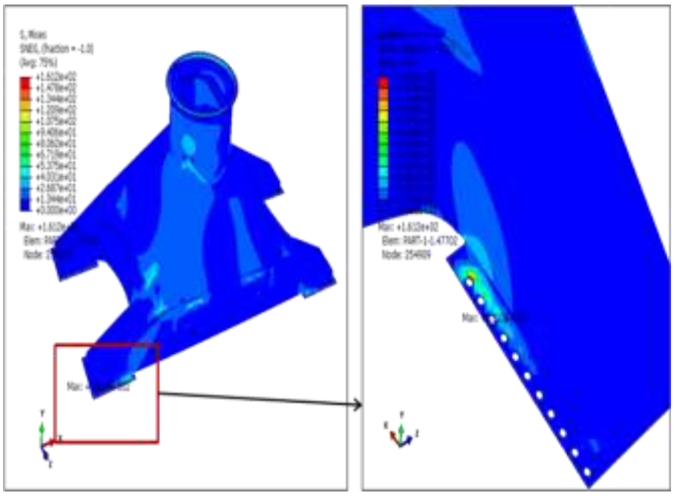

Figure 3 Von-Mises Stress Plot

The maximum principal stress plot for the 45^0 of the Boom position to the length of the crane chassis is 76.2MPa which is shown below.

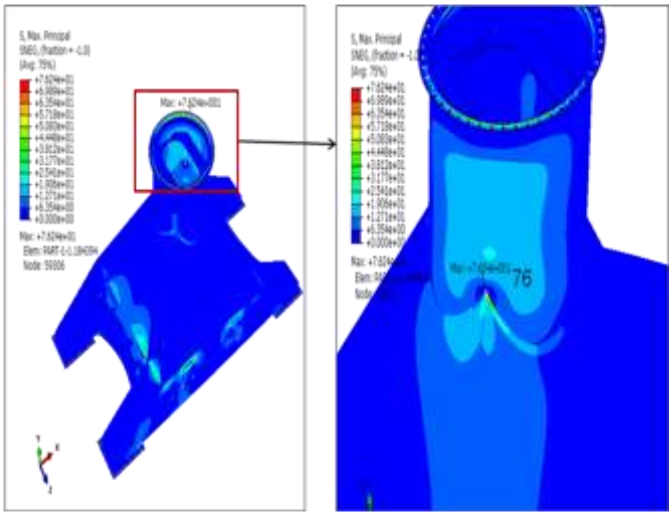

Figure 4 Max Principal Stress Plot

The maximum principal stress is tensile stress which leads to more damage to the crawler chassis than Minimum principal stress (Compressive). Hence minimum principal stress is avoided. The maximum shear stress occurred at the transitional region is 181.4 MPa which is shown below.

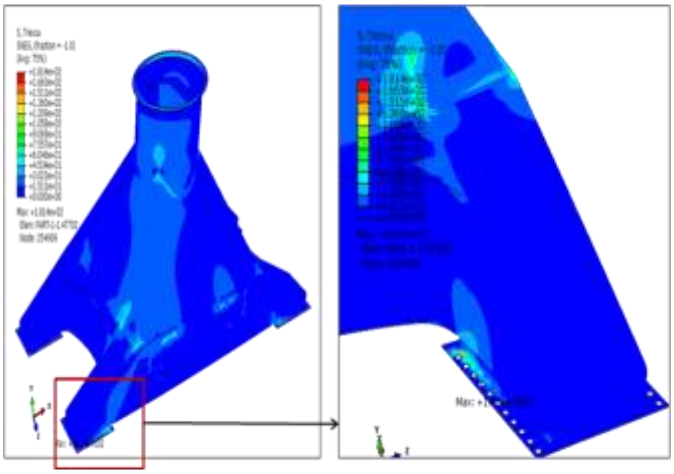

Figure 5 Max Shear Stress Plot

In all above cases the shear stress is maximum i.e, Shear stress=181.4 MPa and hence this stress is taken into account for further prediction of FOS and Fatigue life.

After carrying out the static strength analysis under loading condition when boom is at 45^0 to the length of the crawler crane, the maximum deflection is 0.69mm.

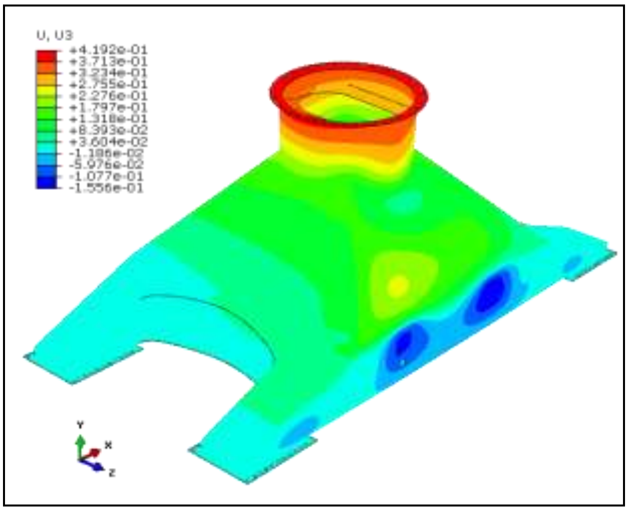

Figure 6 Max Deflection Plot

Since maximum deflection is observed in this condition only (When boom is 45^0). The observed deflection is very small as compared to crawler chassis dimensions. And hence this much deflection is adopted generally.

3. RESULT

The result summary for Factor of Safety (FOS) based on the maximum stress and yield stress of the material is shown below.

Table 1 Result Summary for FOS.

YS (MPa)	Max Stress(MPa)			FOS
	Von-Mises	Max Principal	Shear stress	
350	161	76	181	1.93

The result summary for Displacement in all the three direction when boom is at 45^0 to the length of crawler chassis.

Table 2 Result Summary for Displacement.

Displacement(mm)			
Mag	X	Y	Z
0.69	0.26	0.50	0.42

4. FATIGUE ANALYSIS:

The life of the crawler chassis is predicted by using S-N curve. The S-N curve is usually obtained by conducting experimental test data. But the cost of collecting the fatigue data by experiment is high; hence most of the industries prefer to use the data which is already available from previous test or from design hand books. If the information is not available by any of the above means. Engineers prefer to generate the fatigue data by the application of the Basquin's equation. The Basquin equation is given by $\mathbf{S_f=A(N_f)^B}$ where S_f : Strength of material at N_f cycles(usually 1 million cycles) and A : ultimate strength, N : number of cycles and B: slope of the curve. Using the above relation the fatigue S-N curve is generated and as shown below.

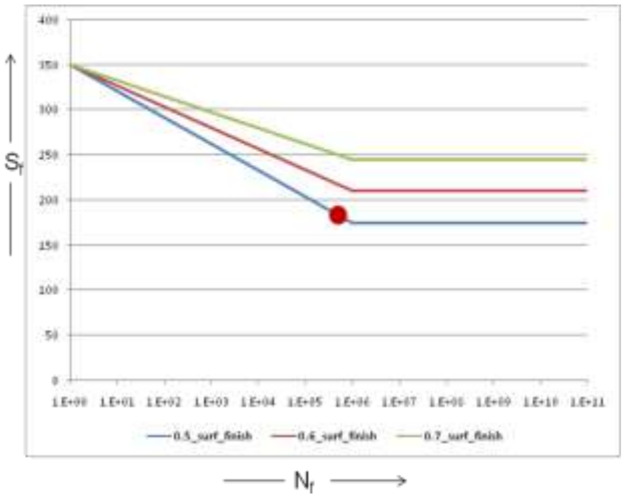

Figure 7 S-N Curve

The three fatigue curves shown above are different and depends upon the surface finish (surface finish parameters considered are 0.5, 0.6 and 0.7)

Table 3 Result Summary for Strength at 10^6 cycles.

Surf_finish	Ultimate	Y.S	strength at 1 cycle	Strength at N_f 1M cycle
0.5	700	350	700	175
0.6	700	350	700	210
0.7	700	350	700	245

5. CONCLUSION

From the above result summary table the stresses in the crawler chassis structure are well below the yield strength and hence the structure is safe from strength and deflection point of view. Out of 3 load cases the stresses in the load case when boom position is 45^0 to the length of crawler chassis is maximum and is considered as worst case condition and based on the results of the worst case the factor of safety is predicted which is around 1.9. The fatigue life of the structure is around 1 million cycles. Hence the structure is safe and can be recommended for manufacturing.

6. FUTURE SCOPE OF THE PROJECT

The current weight of the structure is 10360 Kg and the stresses in the structure are well below the yield strength with minimum of 1.9 as factor of safety. Still there is lot of scope to reduce factor of safety up to 1.5.

Hence the topology optimization can be performed on the structure by reducing the thicknesses of the plates in the chassis without compromising the factor of safety up to 1.5

ACKNOWLEDGEMENT

I would like to thank Honorable Principal Dr. Basavaraj Katageri, Head of Department, Dr. S. F. Patil and my guide Prof. S. A. Pachapuri who have encouraged me and guided me and given valuable technical information.

REFERENCES

1. Korayem, M., Azimirad, V., and Nikoobin, A., “Maximum load-carrying capacity of autonomous mobile manipulator in an environment with obstacle considering tip-over stability”. International Journal of Advanced Manufacturing Technology, vol. 46, pp. 811-829, Jan. 1, 2010.
2. Lawrence, J., W., Crane Oscillation Control: Non-linear Elements and Educational Improvements. PhD thesis, Georgia Institute of Technology, Atlanta,GA, 2006.
3. Maleki, E., Pridgen, B., Singhose, W., and Seering, W., “Educational use of a small-scale cherrypicker”. International Journal of Mechanical Engineering Education, vol. 40, pp. 104-120, Apr. 1, 2012.
4. Yihai Fang, Yong K. Cho, Jingdao Chen “A framework for real-time pro-active safety assistance for mobile crane lifting operations”. Automation in Construction 2016.
5. Wenjun Li , Jiong Zhao, Zhen Jiang , Wei Chen, Qicai Zhou “A numerical study of the overall stability of flexible giant crane booms”. Journal of Constructional Steel Research 105 (2015) 12–27.
6. Le Peng, David K. H. Chua “Decision Support for Mobile Crane Lifting Plan with Building Information Modelling (BIM)”. Procedia Engineering 182 (2017) 563 – 570.
7. Florentin Rauscher, Oliver Sawodny, “An Elastic Jib Model for the Slewing Control of Tower Cranes”. IFAC PapersOnLine 50-1 (2017) 9796–9801.
8. Arkadiusz Trąbka “Dynamics of telescopic cranes with flexible structural components”. International Journal of Mechanical Sciences 26 July 2014.
9. Gang Wang, Zhaohui Qi, Xianchao Kong “Geometrical nonlinear and stability analysis for slender frame structures of crawler cranes”. Engineering Structures 83 (2015) 209–222.
10. Jia Yao, Fei Xing, Yuqin Fu, Xiaoming Qiu, Zhenping Zhou, Jianhong Hou “Failure analysis of torsional buckling of all-terrain crane telescopic boom section”. Engineering Failure Analysis 73 (2017) 72–84.