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Static Analysis of Loader Backhoe chassis 770 Model

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Abstract

Construction industry is undoubtedly the backbone and propelling force behind our progress. In response to booming construction industry, utilization of earth moving equipment has increased considerably leading to high rate of failure. Backhoe Loader chassis is the skeleton of a commercial vehicles. The main function of the truck chassis is to support the different components like engine, cabin, transmission, front axle and rear axle. So it is necessary to analyze chassis to avoid failure while it is in working condition. Computer simulation techniques provides a great leverage in design optimization for weight reduction, better material utilization, shorter design cycles and elimination of major part of prototype testing.

Static analysis of the chassis shows the equivalent stress and deformation contour when Backhoe Loader is in working condition. From static analysis, high stress area can be found out when Backhoe Loader is in different load condition. Also by providing some design changes, stress can be minimized.

Key words: *Static analysis analysis of Backhoe Loader chassis770 model.*

Introduction

Construction industry is undoubtedly the backbone and a propelling force behind our progress. The construction industry includes construction of dams, sky scrapers, bridges, roads & even mining work. This has increased the demand of many construction equipments, especially ‘earth moving machines’. These machines have become an important aspect of our day to day life, replacing the efforts of “thousands of human beings.” In most construction work excavation and earth moving work are of the prime importance. Also there are numerous classes of earth moving equipment available, each aimed at specific purposes.

Backhoe-Loader is most preferred for excavation and earth moving due its versatility. Many construction companies consider the backhoe to be the workhorse of earthmovers.

Why analyze Backhoe and Loader?

Backhoe and Loader are the main working tools. Backhoe is essentially excavation equipment, and hence undergoes various loading conditions. The components must sustain forces as well provide enough strength to carry out the required activity.

When optimizing the design, it is essential to know the nature and magnitude of these forces as well as stresses developed within the components.

This requires three types of analysis:

1. Kinematics Analysis
2. Force Analysis
3. Stress Analysis

Knowledge of the above will provide a guideline for optimizing the design in reference to :

1. Material saving
2. Overall weight reduction
3. Higher productivity of machine with respect to time.
4. Reduced fuel cost for operating the machine.
5. Higher strength and its implications
6. Lower failures
7. Wide variety of application
8. Higher safety

Static and vibration analysis of Backhoe Loader chassis

While in the running and ideal condition backhoe loader chassis subjected to various static and dynamic forces. Static analysis is carried out in order to find out stress and deformation pattern for deferent load cases. Also it is very uncomfortable to operator who is working long our on Backhoe Loader.

Objective of present work

The main objective of present study on "Static analysis of Backhoe Loader chassis" is to find out stress and deformation pattern for different load cases.

Methodology

The procedure described below has been used to obtain the objective of present study.

1) Static analysis is carried out for two different load cases in Ansys workbench

Literature review

Roslan Abd Rahman, Mohd Nasir Tamin, Ojo Kurdi have carried out stress analysis of heavy duty truck chassis. The stress analysis is important in fatigue study and life prediction of components to determine the critical point which has the highest stress. The analysis was done for a truck model by utilizing a commercial finite element packaged ABAQUS. The model has a length of 12.35 m and width of 2.45 m. The material of chassis is ASTM Low Alloy Steel A 710 C (Class 3) with 552 MPa of yield strength and 620 MPa of tensile strength. The result shows that the critical point of stress occurred at the opening of chassis which is in contact with the bolt. The stress magnitude of critical point is 386.9 MPa. This critical point is an initial to probable failure since fatigue failure started from the highest stress point. [1]

Jin yi-min describes the application of MSC product in Beiqi Futian Vehicle Co.,Ltd and then describes how the finite element methods can be

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used for analysis and evaluation of minivan body structure. Including static, dynamic, fatigue, crashworthiness analysis, optimization and sensitivity and so on. In this paper, Author use MSC.Nastran calculate the strength and stiffness in both bending and torsion loadcase. Summarized the strength and stiffness evaluation standards for minivan. And then done the normal model analysis in order to consider the influence of tyre unbalance and engine idle excite. The calculations and analysis were verified by test.[2]

Static force calculation

Introduction

It is very important to find out the forces at different points of the attachment as it plays a crucial role in the analysis, for getting results close to the actual it is required to have accurate values of forces at all pivot points. The methodology adopted is to find maximum breakout force for the given cylinder pressures, and this is done using **Design View.**

There are main two conditions for carried out static calculation. One condition is maximum reach condition. Second is maximum torque condition in which the dipper and boom cylinder are keeping at 90 degree.

Breakout force

The breakout force is the available force at the tip of the teeth created by the bucket cylinder. Breakout force can be calculate by given equation

$$F_{brk} = \frac{Fbub * A1 * C1}{B1 * D * 9.81}$$

F_{bub}- Bucket cylinder force

A1- Perpendicular distance bucket cylinder axis - lever pivot

B1- Perpendicular distance connecting link axis - lever pivot

C1- Perpendicular distance connecting link axis - bucket pivot

D- Radius bucket pivot-tooth lip

For simplicity of static analysis, a co-ordinate system is defined at global pivot point. All the forces are in a single plane and hence analysis can be carried out considering coplanar forces. Thereafter, following steps are carried out.

1. All the forces are resolved along the global co-ordinate system. That is X- and Y-component of forces.

2. Thereafter considering the component in static equilibrium the following laws of static equilibrium are applied.

    i) Algebraic sum of moment on the component is zero.

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$$\sum M = 0$$

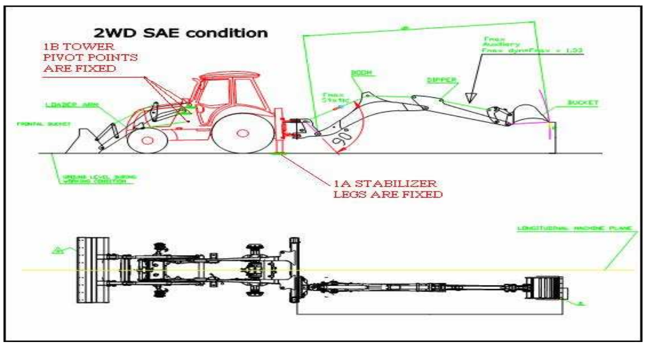
ii) Algebraic sum of resolved components of forces along X-axis is zero

$$\sum Fx = 0$$

iii) Algebraic sum of resolved components of forces along Y-axis is zero

$$\sum Fy = 0$$

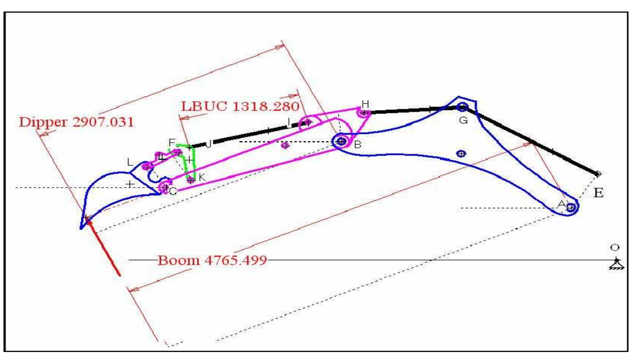
Load case1



Maximum reach condition diagram

The designed mechanism is producing 4020.783 **Kg** of **breakout force**. It can be calculated using the equation 5.1 mentioned above.

Global coordinate (case1)



Global Coordinates with respect to 'O'

a) Rotating Boom about Point A

As we know the coordinates of boom w.r.t. pivot A keeping Boom horizontal as shown in Fig. 6.3 Angle of rotation of Lower Boom w.r.t horizontal taken from DV file Angle of rotation of dipper w.r.t. horizontal:

$$\alpha = \ (-19.793 \text{ deg})$$

Boom Rotation Matrix:

$$R_t = \begin{pmatrix} \text{Cos}\alpha & -\text{Sin}\alpha & 0 \\ \text{Sin}\alpha & \text{Cos}\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

New Positions of Boom Points:

$$B_1 := Rt_b B_o + A_b$$

$$G_1 := Rt_b G_o + A_b$$

b) Rotating Arm by an angle about point B

As we know the coordinates of dipper w.r.t. pivot B keeping Dipper horizontal as shown in Fig

Angle of rotation of Dipper w.r.t. horizontal taken from DV file Angle of rotation of dipper w.r.t. horizontal

$$\beta = (18.072 \text{ deg})$$

Dipper Rotation Matrix:

$$R_t = \begin{pmatrix} \cos\beta & -\sin\beta & 0 \\ \sin\beta & \cos\beta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

New Positions of Dipper Points:

$C_1 := Rt_d C_o + B_1$

$H_1 := Rt_d H_o + B_1$

$I_1 := Rt_d I_o + B_1$

$K_1 := Rt_d K_o + B_1$

c) Rotation of Bucket by an angle about point C

Angle of rotation of bucket w.r.t. horizontal: $\gamma = (24.915)$ deg

Bucket Rotation Matrix:

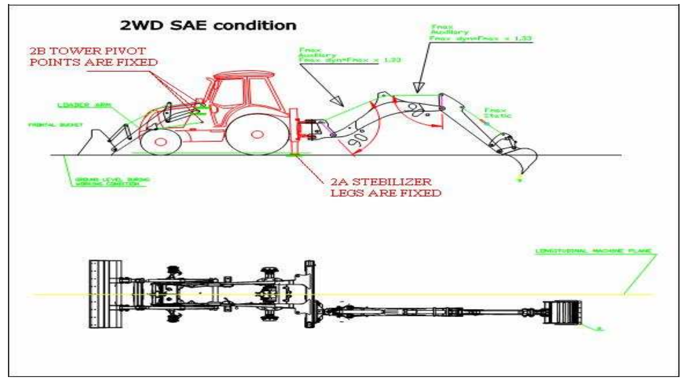
$$R_t = \begin{pmatrix} \cos\gamma & -\sin\gamma & 0 \\ \sin\gamma & \cos\gamma & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

New Positions of Bucket Points:

$D_1 := Rt_{bu} D_o + C_1$

$L_1 = Rt_{bu} L_o + C_1$

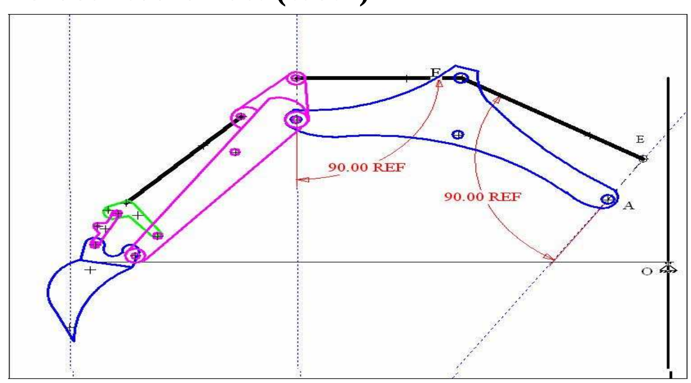
Load case2



Maximum breakout condition diagram

The designed mechanism is producing 4254.273 **Kg** of **breakout force**. It can be calculated using the equation 5.1 mentioned above.

Global coordinate (case2)



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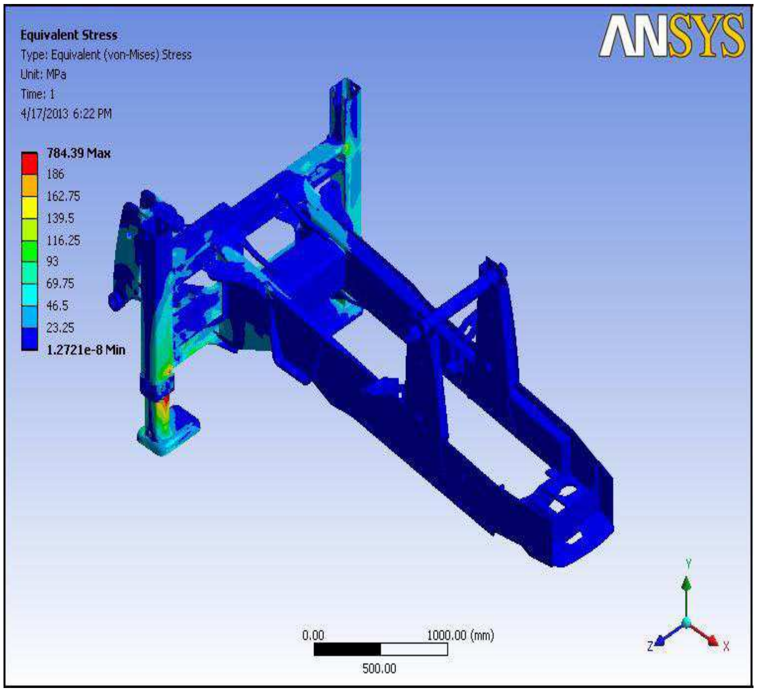
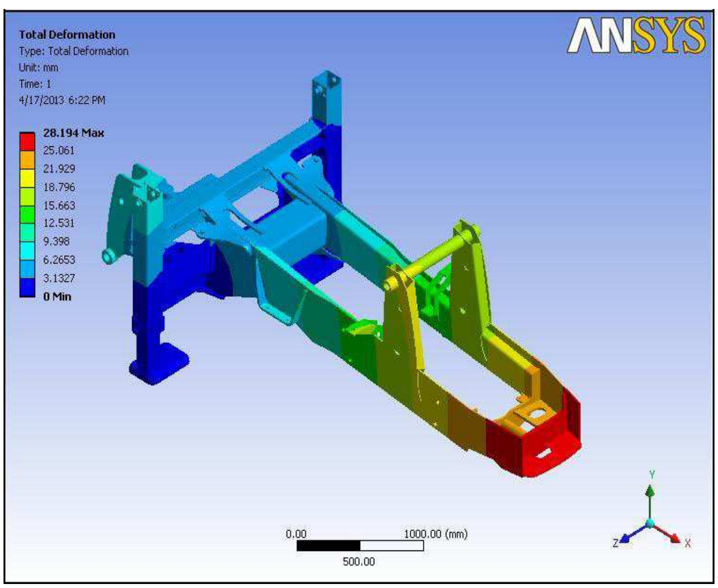
Results of static analysis for load case1 and load case2



von-Mises stress for load case1A



Deformation for load case1A

For load case1A we can observed that stress generated are higher at stabilizer legs as compare to other part of the chassis. Also we can observe that deformation is higher at front side of the chassis which has max value of 28.194 mm.

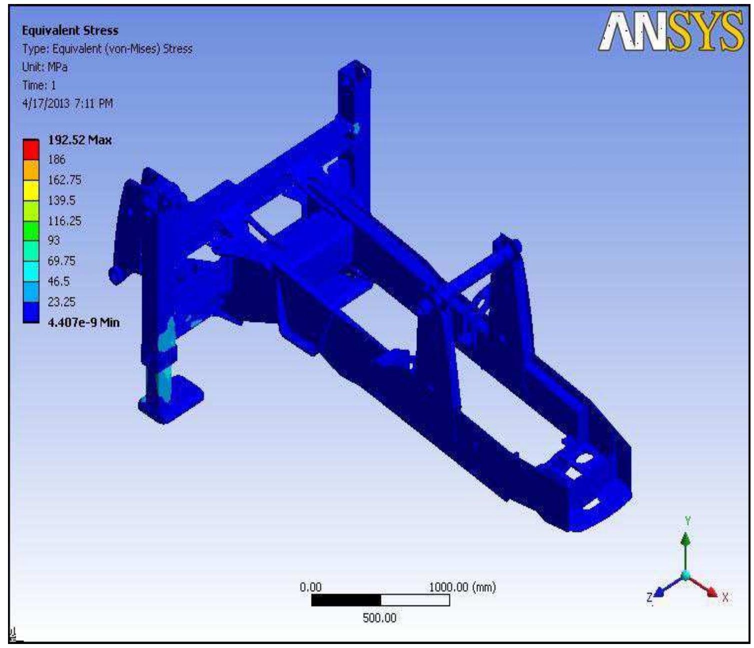


Figure 6.16 von-Mises stress for load case2A

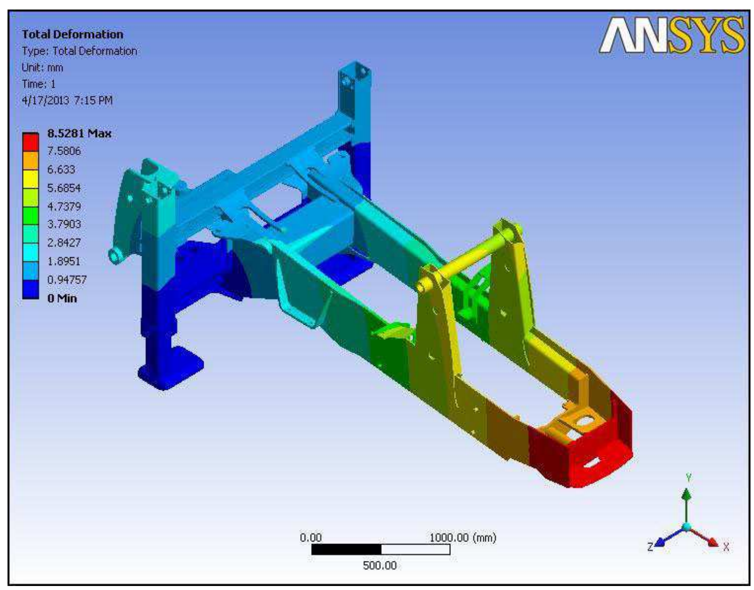


Figure 6.17 Deformation for load case2A

For load case2A we can observed that stress generated are higher at stabilizer legs as compare to

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other part of the chassis as same in the load case1A. Maximum deformation is at front end of the chassis which is 8.5281mm.

Conclusion and future scope

- From linear static analysis, maximum deformation of the component and maximum stress can be known and from that the material can be changed if required to meet the loading condition.
- If the component is failing, either the plate thickness can be changed or the curvature can be increased and again check for the loading conditions. After redesign of components, the stress is under the allowable limit.

- Earth moving equipments have been known well for more then fifty years. Backhoe works well in the digging below ground level. The life of components of backhoe depends on the density of the earth, whether it is a soil digging, rock digging or it is used for mines.
- Higher stress region can be minimized by removing sharp corners, by providing smooth fillet.

Future scope

The work done can be extended in following directions

- In the present study, the static force analysis of the backhoe loader has been carried out. It can be modified by including the inertia effect of all the components. Effect of friction can also be taken into consideration for future work.
- Static analysis will be carried out for other different load cases like maximum digging, loader breakout, side digging etc.

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