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Fatigue Analysis and Design Optimization of a Digger ARM

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ABSTRACT

Excavator's machines are also called as heavy duty earthmoving equipment which is very important and normally used for excavation task. During the excavation operation unknown resistive forces offered by the terrain to the bucket. Excessive amount of these forces adversely affected on the machine parts and may be failed during excavation operation. Design engineers have great challenge to provide the better robust design of excavator bucket parts which can work against unpredicted forces and under worst working condition.

In this paper, We will suggested the use Finite Element Analysis (FEA) as a tool for static analysis of backhoe excavator bucket for existing as well as optimized excavator bucket. And to find out the maximum stress point and deformation and the method to minimize it with increasing the life of backhoe excavator bucket by changing the profiles of the bucket.

INTRODUCTION

In the era of globalization and tough competition the use of machines is increasing for the earth moving works, considerable attention has been focused on designing of the earth moving equipment's. Today hydraulic excavators are widely used in construction, mining, excavation, and forestry applications. The excavator mechanism must work reliably under unpredictable working conditions. Poor strength properties of the excavator parts like boom, arm and bucket limit the life expectancy of the excavator. Therefore, excavator parts must be strong enough to cope with caustic working conditions of the excavator. The backhoe hydraulic excavator or backhoe loader is by far the most popular construction machine in India. According to 'Equipment analysis: India backhoe loader report backhoe loader accounting for around 45 per cent of the mobile construction machinery market. This market still expected rise as Indian government focuses on developing the country's infrastructure in future. Bucket is an important attachment used in backhoe excavator machines. There are various types of backhoe excavator buckets used for the different applications as per the requirement, such as digging bucket, rock bucket and the V- bucket.

Force Calculation for Bucket:

Bucket penetration into a material is achieved by the bucket curling force (FB) and arm crowd force (FS). The rating of these digging forces is set by SAE J1179 standard "Surface Vehicle Standards - Hydraulic Excavator and Backhoe Digging Forces" (SAE International, 1990). These rated digging forces are the forces that can be exerted at the outermost cutting point (that is the tip of the bucket teeth). These forces can be calculated by applying hydraulic pressure to the cylinders providing the digging force.

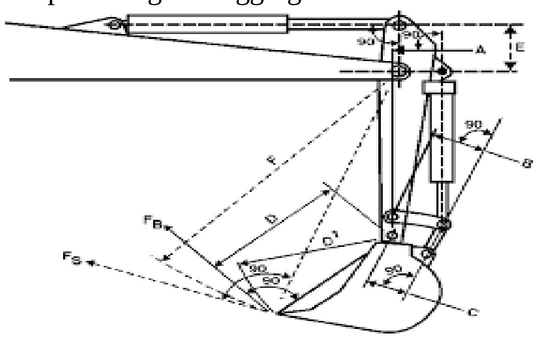

Fig - Determination of digging forces by following the standard SAE J1179

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Fig.1 shows the measurement of bucket curling force FB, arm crowd force FS, the other terms in the figure lA, lB, lC, lD, lE, and lF shows the distances of different part.

According to SAE J1179: Maximum radial tooth force due to bucket cylinder (bucket curling force) FB is the digging force generated by the bucket cylinder and tangent to the arc of radius lD1 . The bucket shall be positioned to obtain maximum output moment from the bucket cylinder and connecting linkages. FB becomes maximum when distance lA reaches maximum, because rest of the distances in (1) are constant.

ORIGINAL DIGGER ARM

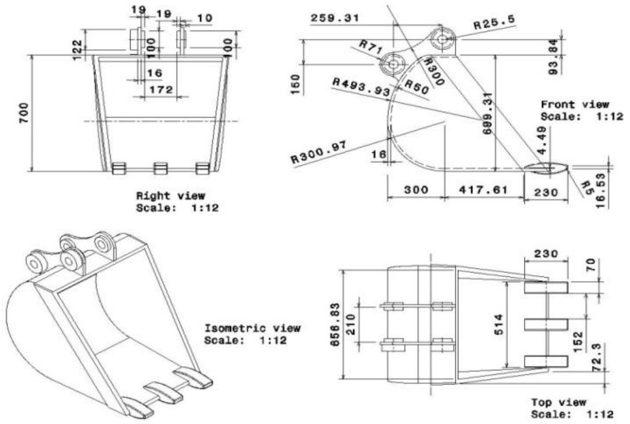

Fig - Original Digger Arm Drafting Views

FATIGUE ANALYSIS OF A ORIGINAL DIGGER ARM USING STEEL A 36 GRADE

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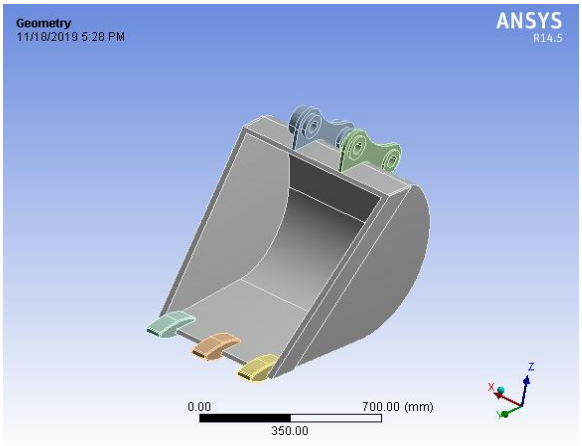
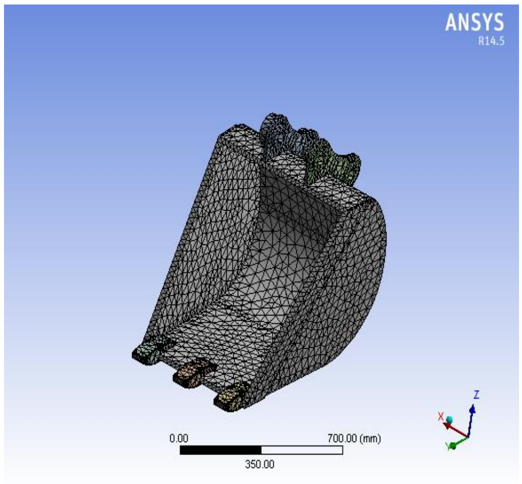
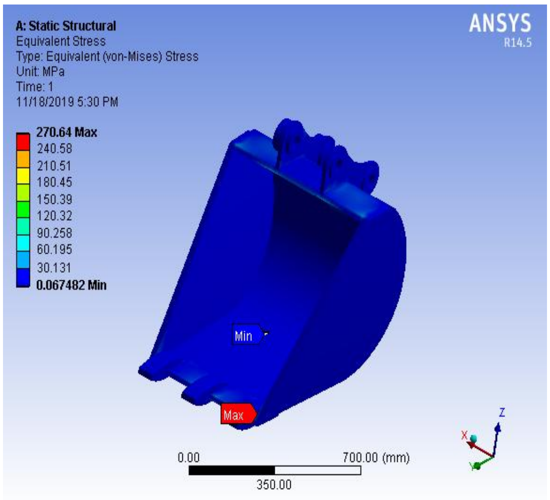


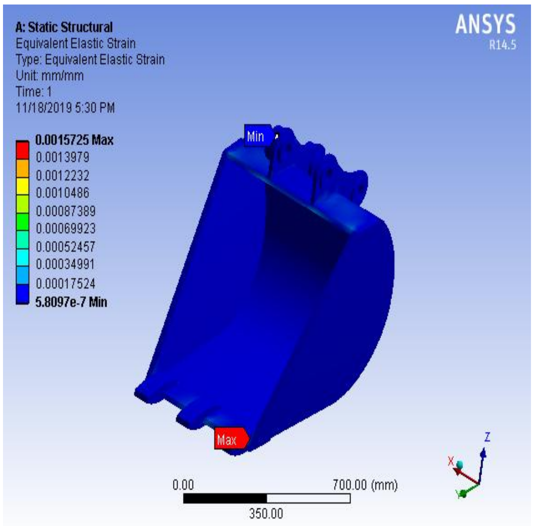
Meshing



Stress



Strain



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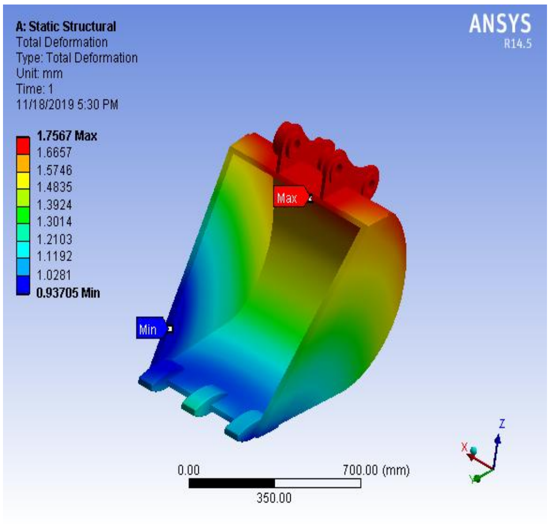
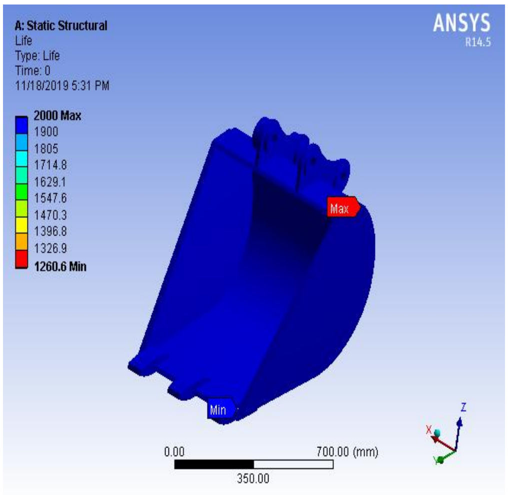
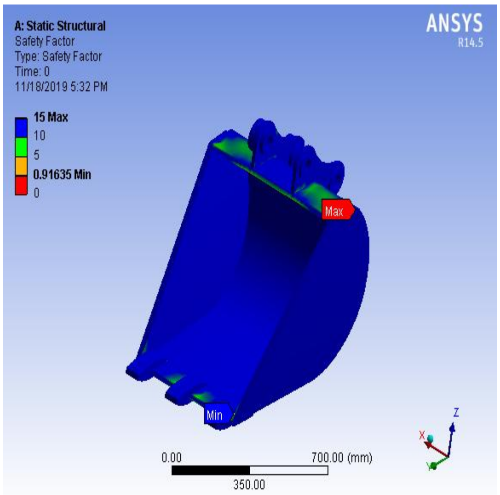
Total deformation



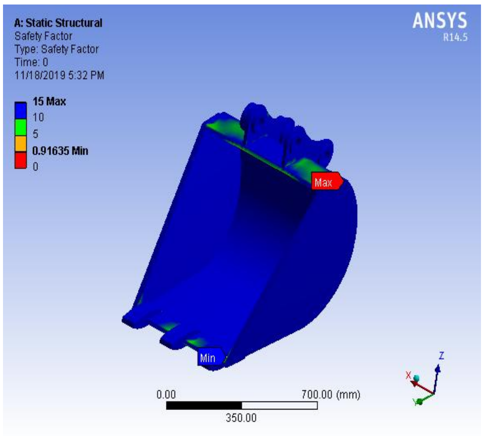
Life factor



Safety factor

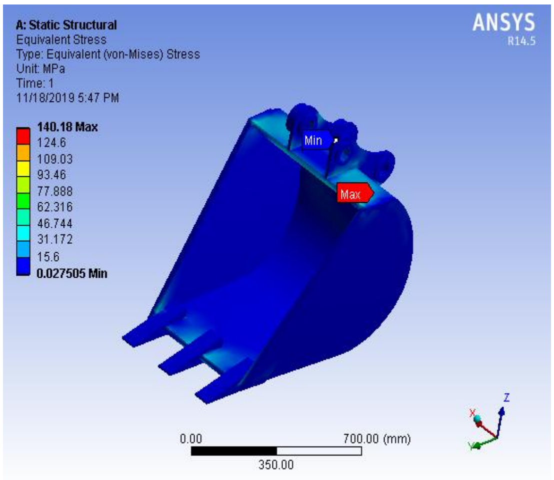


Damage

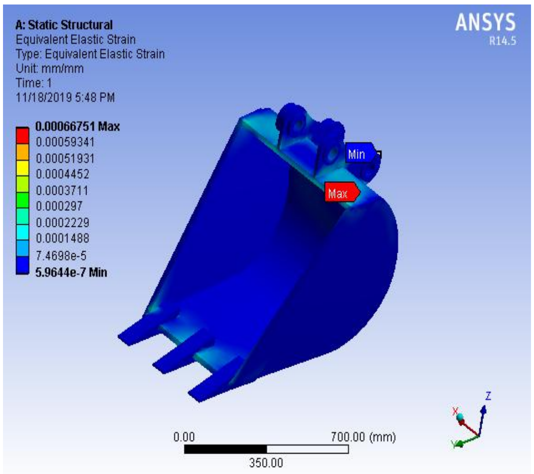


FATIGUE ANALYSIS OF MODOFIED MODEL-1 DIGGER ARM USING HARDOX 400 GRADES

Stress



Strain



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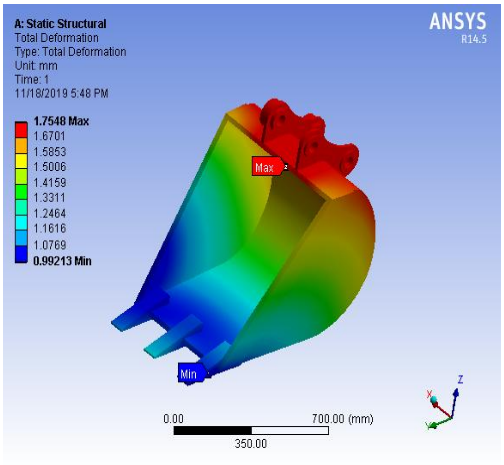
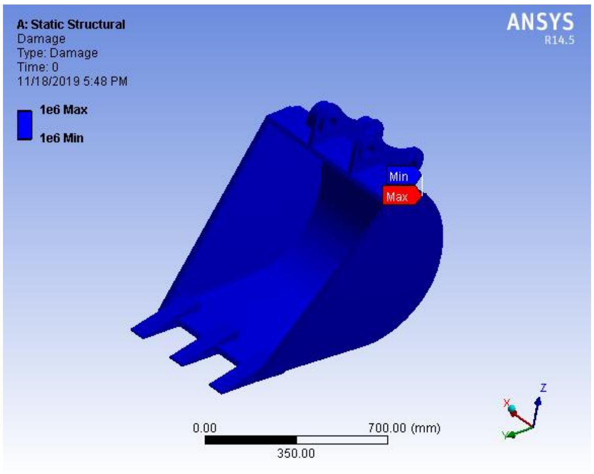
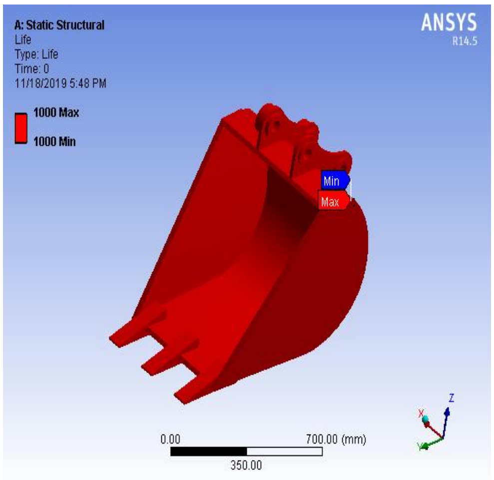
Total deformation



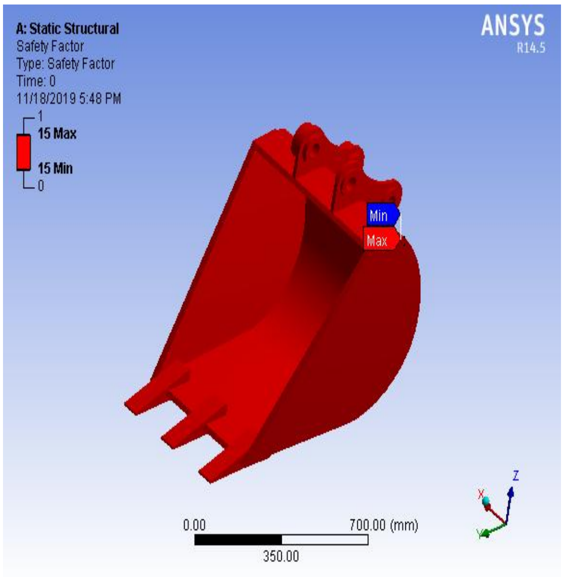
Damage



Life factor



Safety factor



RESULTS

Original Model:

Materials	Steel A 36	Hardox 400
Stress (MPa)	270.64	270.95
Strain (mm/mm)	0.0015725	0.0015023
Total Deformation (mm)	1.7567	1.7555
Life Factor	2000	1000
Safety Factor	15	15
Damage	7.9327E+5	1E+6

Modified Model-1:

Materials	Steel A 36	Hardox 400
Stress (MPa)	139.81	140.18
Strain (mm/mm)	0.00069907	0.00066751
Total Deformation (mm)	1.7561	1.7548
Life Factor	2000	1000
Safety Factor	15	15
Damage	5E+5	1E+6

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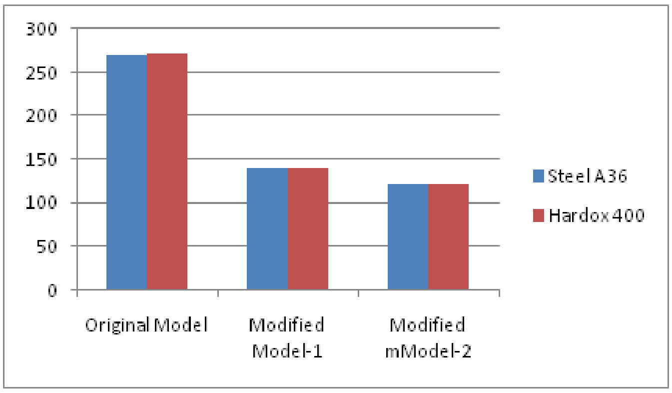
Modified Model-2:

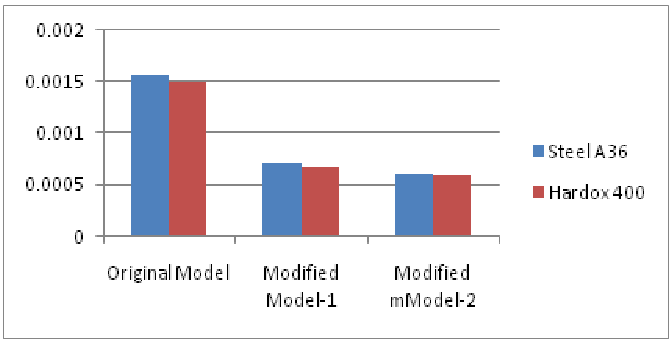
Materials	Steel A 36	Hardox 400
Stress (MPa)	120.77	121.08
Strain (mm/mm)	0.00060385	0.00057659
Total Deformation (mm)	1.7562	1.7549
Life Factor	2000	1000
Safety Factor	15	15
Damage	5E+5	1E+6

GRAPHS

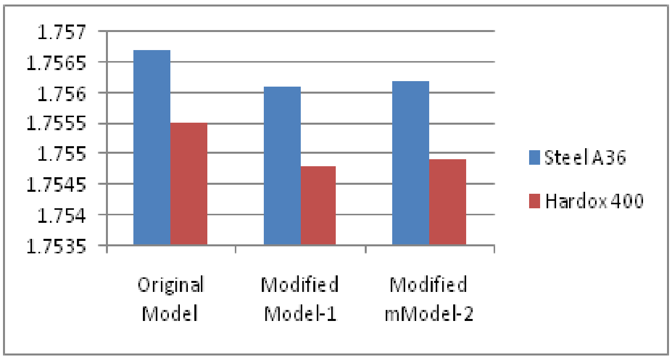
Stress (MPa):



Strain (mm/mm):



Total Deformation (mm):



CONCLUSION

In this paper, we have used Finite Element Analysis (FEA) as a tool for static analysis of backhoe excavator bucket for existing as well as optimized excavator bucket. And to find out the maximum stress point and deformation and the method to minimize it with increasing the life of backhoe excavator bucket by changing the profiles of the bucket.

Here we have designed two modified models apart from original model and the materials considered here are Steel A36 and Hardox 400. As here we have analysed the life factors and the damage with factor of safety. By verifying the results in the graphical format, the Hardox material has obtained the best results in all the models like in the original and 2 modified models. So as per the stress and deformations also here it is clearly observed that the modified models have very near results and has a major variation from the original model.

So from this all the results we can conclude that he modified model 1 with the Hardox 400 material has obtained the best results with the safety factors.

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