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Design Optimization and Analysis of Trenching Excavator Bucket

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Abstract

This research centers on the design optimization and analysis of a trenching excavator bucket using ANSYS engineering simulation software. The study explores modifications, such as decreasing bucket height by 35mm and increasing side plate width to 12mm compared to the stock configuration[1]. The analysis primarily focuses on evaluating Equivalent Elastic Strain and Total Deformation using ANSYS to ensure improved digging performance and structural integrity. Excavator buckets are vital components in earth-moving operations, and their efficiency directly affects productivity and operational costs. By leveraging ANSY advanced capabilities, this study aims to propose an optimized bucket design that enhances trenching efficiency and durability. The findings provide valuable insights for manufacturers and engineers seeking to elevate excavator bucket technology and improve construction and mining operations through enhanced performance and cost-effectiveness.

Keywords: *Design Optimization, Equivalent Elastic Strain, Static Structural Analysis, Trenching Excavator Bucket, Total Deformation.*

1.0 Introduction

The design optimization and analysis of trenching excavator buckets using ANSYS[2] is crucial to enhancing equipment performance and efficiency in construction and mining operations. This study focuses on improving the bucket's design[4,12] by decreasing its height by 35mm and increasing the side plate width to 12mm compared to the stock company excavator bucket. The analysis primarily involves evaluating both bucket configurations[3], Equivalent Elastic Strain and Total Deformation using ANSYS[2] advanced simulation capabilities. Excavator buckets are fundamental components in earth-moving tasks, and their design plays a vital role in achieving optimal trenching efficiency and reducing maintenance costs. By employing ANSYS[2], a leading engineering simulation software, this research aims to explore the impact of design modifications on the bucket's structural integrity and mechanical performance[5]. The decreased bucket height and increased side plate width are potential design optimizations that can lead to improved digging performance and enhanced bucket durability. ANSYS Equivalent Elastic Strain analysis enables the assessment of stress distribution, ensuring that the modified design can handle operational loads without experiencing excessive strain[6]. Furthermore, the Total Deformation

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Figure 1. Trenching excavator bucket.

Source: Adapted from[9]

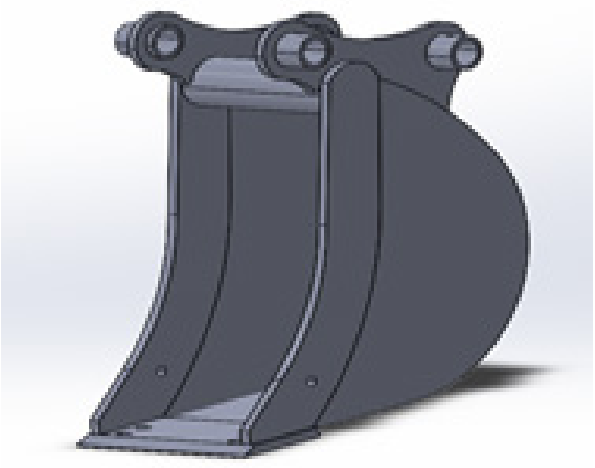


Figure 2. Stock trenching excavator bucket.

analysis in ANSYS provides valuable insights into how the bucket responds to varying loads[7], ensuring that any deformations remain within acceptable limits to maintain operational efficiency and longevity. By conducting a comparative analysis of the modified bucket against the stock configuration, this study seeks to determine the effectiveness of the design changes in achieving the desired improvements in trenching performance[8]. The insights gained from this analysis can offer valuable guidance to manufacturers and engineers seeking to optimize excavator bucket designs for maximum productivity and cost-effectiveness. Moreover, the research may contribute to sustainable practices in the construction and mining industries, promoting equipment efficiency while minimizing environmental impact.

2.0 Cad Modeling of Excavator Buckets

To perform the various types of analysis on the excavator bucket we need a CAD model. For this purpose, SolidWorks software is used. The following three buckets are created by using this software.

2.1 Stock Bucket

Figure 2 shows the CAD model of the Existing Stock Excavator Bucket, which is prepared on SolidWorks software.

2.2 Modified Excavator Bucket

Figure 3 shows the CAD model of the Modified Excavator Bucket, which is prepared on SolidWorks software. Here Figure 4 depicts the Change in Bucket Height which is reduced by 35mm from 758.60mm and Figure 5 depicts the thickness of the side plate increased to 12 mm[10]. This is done as hairline cracks are observed on side panels even before the end of the life cycle of the bucket.



Figure 3. Modified trenching excavator bucket.

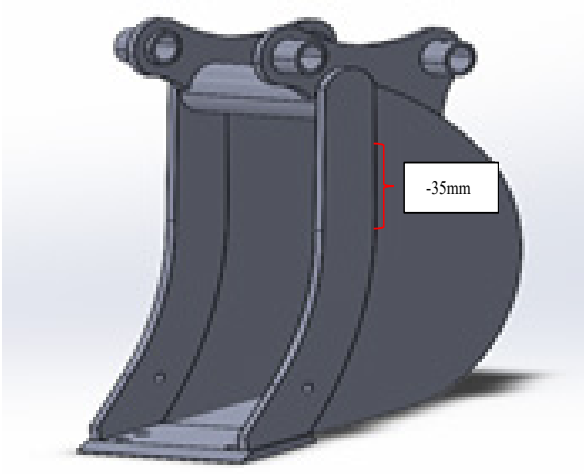


Figure 4. Height Reduction by 35mm.

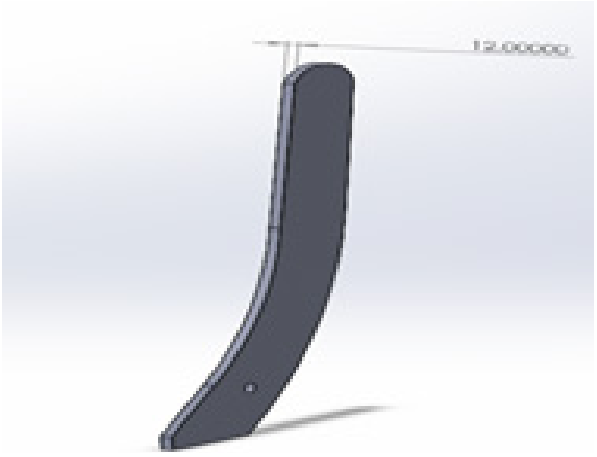


Figure 5. The thickness Increased to 12mm.

3.0 Boundary Conditions

These are the analysis conditions that are applied as input to perform any analysis[8,11]. It mainly contains metal properties, the number of nodes and elements, meshing and forces applied[4], etc.

Table 1. Properties of structural steel for structural analysis

Property	Value
Density	7850 kg/m^3
Tensile Yield Strength	2.5E^4 Pa
Compressive Yield Strength	2.5E^4 Pa
Tensile Ultimate Strength	4.6E^4 Pa

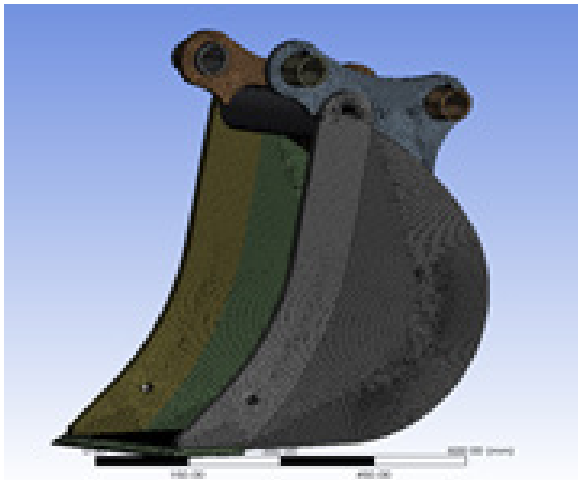


Figure 6. Meshed view of modified bucket.

Table 2. FEM properties of modified bucket

Type of Element	3D Tetragonal
Number of Nodes	599033
Number of Elements	125392

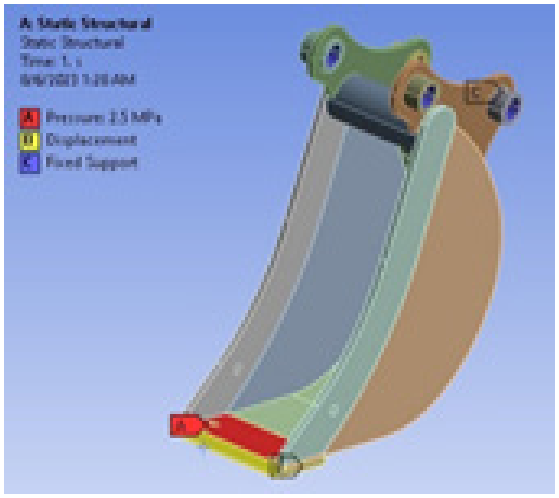


Figure 7. Boundary conditions on bucket.

4.0 Structural Analysis Results

4.1 Results for Existing Stock Bucket

By performing Structural Analysis on the existing bucket, the following results are obtained. The total deformation by the application of structural load is shown in boundary conditions. It is observed that the maximum deformation

is 0.89295 mm only. This deformation is having an acceptable range.

Table 3. Equivalent elastic strain results of stock bucket

Result Type	Value
Minimum	5.34^{-09} mm/mm
Maximum	$1.457e^{-02}$ mm/mm

4.2 Results for Modified Trenching Excavator Bucket

By performing Structural Analysis on the modified excavator bucket the following results are obtained.

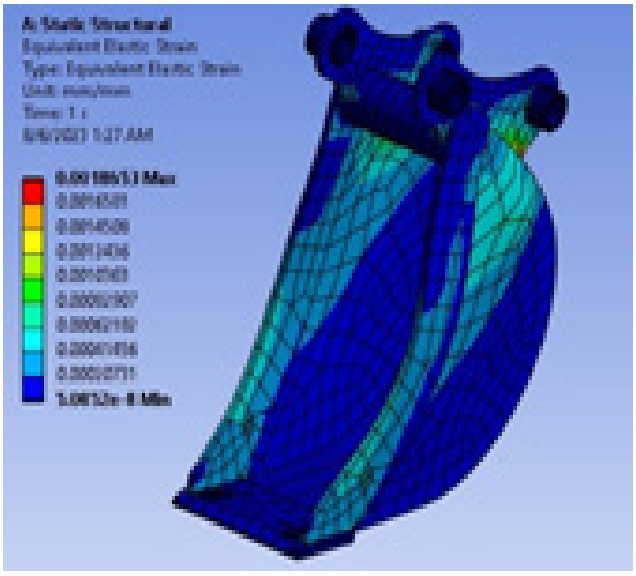


Figure 8. Equivalent elastic strain.

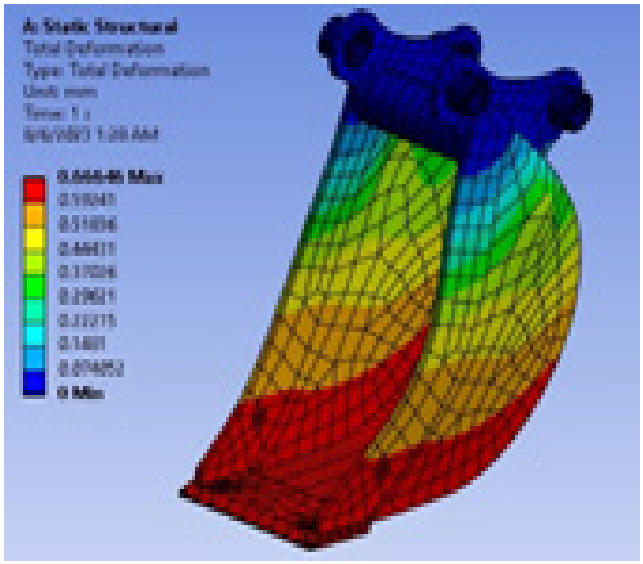


Figure 9. Total deformation.

Figure 8 shows the total deformation and Figure 9 shows equivalent elastic strain by the application of structural load as shown in boundary conditions. Here mesh size is varied by increments of 1.5mm up to 4.5mm

The average maximum equivalent elastic strain is $1.8655E^{-03}$ mm/mm, the average minimum equivalent elastic strain is $6.06E^{-08}$mm/mm and the average total maximum deformation is 0.6663mm.

5.0 Conclusion

By observing the results obtained by static structural analysis on existing and modified trenching buckets following conclusive statements can be given

Table 4. Values of total deformation and equivalent elastic strain of modified bucket.

Mesh Size	Equivalent Elastic Strain		Total Deformation
in(mm)	Maximum in mm/mm	Minimum in mm/mm	Maximum in mm
1.5	$1.8656e^{-003}$	$6.5541e^{-008}$	0.66636
3	$1.8656e^{-003}$	$6.5541e^{-008}$	0.66636
4.5	$1.8653e^{-003}$	$5.0852e^{-008}$	0.66646

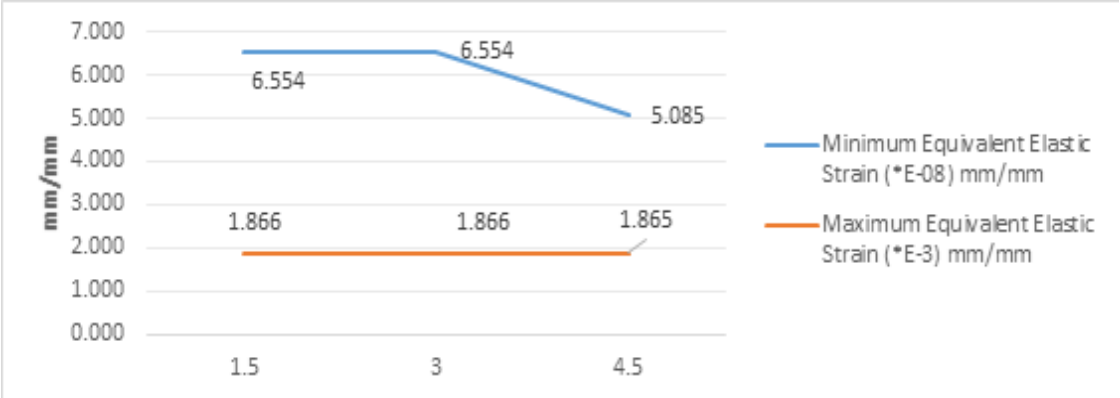


Figure 10. Graphical representation of minimum and maximum equivalent elastic strain.

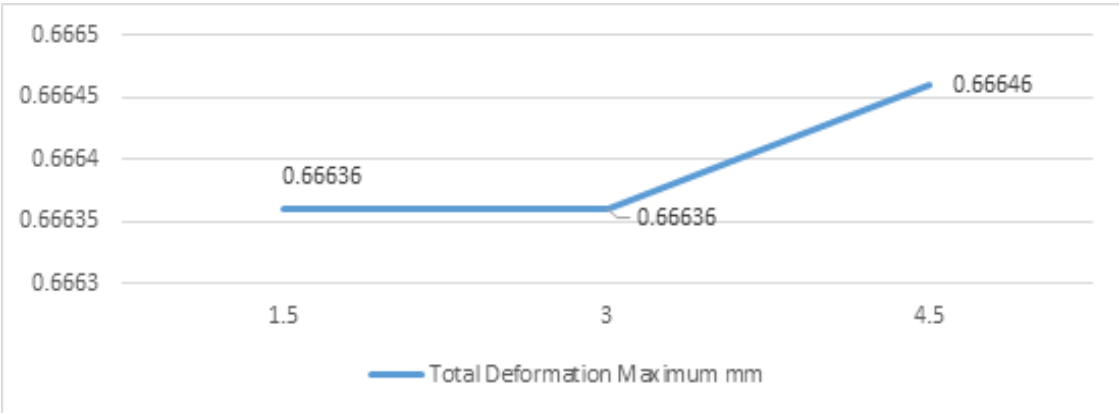


Figure 11. Graphical representation of maximum total deformation.

- Results Obtained in the case of the modified bucket are better than a stock bucket.
- As modification is done on the bucket due to the occurrence of hairline cracks on the side panel and bending of side panel, Modified Bucket will show the solution to this problem.
- By comparing the results of the Stock Bucket and Modified bucket, we can conclude that the modification done on the bucket has delayed crack propagation and bending.

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