Design and Analysis of an Excavator Bucket

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ABSTRACT
An excavator is a typical hydraulic heavy-duty human-operated machine used in general versatile construction operations, such as digging, ground leveling, carrying loads, dumping loads and straight traction. After doing such operation, there is possibility of breaking of pin in tooth adapter assembly as well as bending of tooth point. The objective of this paper is to design an excavator bucket by using CREO-parametric 2.0 software. Model is exported through IGES file format for meshing in analysis software Boundary conditions and the forces are applied at the tip of teeth of excavator bucket. Static analysis is done in ANSYS 13.0 analysis software. In this paper the stresses developed at the tip of excavator bucket teeth are calculated. Percentage error between stress Analytical result and stress ANSYS result are calculated.

Keywords - Creo-parametric software, Digging Forces and F.E.approach.

I. INTRODUCTION
An excavator is a piece of heavy equipment that is commonly used in construction work, mining work and work that requires lifting that can be too heavy for humans. An excavator is a vehicle that is engineered and consists of things that can be used such as a backhoe and also has a cab that tends to be mounted to the back pivot near the undercarriage. It also has tracks and wheels that it is running on.

As the use of excavator in day to day life is increasing for many purposes but the applicable site is not inspected properly due urgency of work by the owner or the contractor due to which improper handling of it leads to damage of the ground engaging tool i.e. bucket teeth. The teeth of the excavator are main contacting part of it which comes first in contact with the soil while doing excavation at various sites. So in this case sometimes the tooth point of the bucket gets damage due to some improper handling by the operator, which leads to the damage of tip of teeth. Here I calculate the stresses at the tip of the teeth by analytically and Finite analysis approach and then compare their results.

II. CALCULATION OF DIGGING FORCES
Bucket penetration into a material is achieved by the bucket curling force (\( F_b \)) and arm crowd force (\( F_s \)). The rating of these digging forces is set by SAE J1179 standard “Hydraulic Excavator and Backhoe: Digging Forces.”

Bucket curling force (\( F_b \)) is the force generated at the tip of teeth by the bucket cylinder and tangent to the arc of radius \( d_p \).

\[
F_b = \frac{p \times \frac{\pi}{4} \times D_b^2}{d_p} \times \frac{d_a \times d_e}{d_b}
\]

Arm crowd force (\( F_s \)) is the force generated at the tip of teeth due to arm cylinder is the digging force generated by the arm cylinder and tangent to arc of radius \( d_x \).

\[
F_s = \frac{p \times \frac{\pi}{4} \times D_a^2}{d_x} \times (d_x)
\]

The calculated breakout Force (\( F_b \)) = 38690N and calculated Arm Crowd force (\( F_s \)) = 162478N. By using CST method and Maximum Shear Stress Theory the stress at the tip of the excavator Bucket teeth = 96.39 MPA.
III. GEOMETRIC MODELLING OF AN EXCAVATOR BUCKET

The geometry of the excavator bucket has been obtained by an extrusion in CREO PARAMETRIC 2.0. First, generate an excavator bucket, teeth, and rivet. Then, bucket, teeth, and rivet are assembled together in assembly tool of CREO PARAMETRIC 2.0. This model is now ready to be imported for preprocessing.

IV. FINITE ELEMENT ANALYSIS OF AN EXCAVATOR BUCKET

The model was developed in the CREO PARAMETRIC 2.0 software. Finite element analyses are used in design improvement and optimization purposes for many machine parts. In this project, my main emphasis is on the bucket tooth which comes first in contact with soil for its contact deformation as well as the stress generation for doing various types of operations at various sites in India. To achieve this, excavator bucket teeth have been analyzed under maximum loads and different boundary conditions. In ANSYS stress at each and every element are determined. Click on Main Menu > Project > Model > Static Structural > Solution. ANSYS displays the model with a color contours for stresses. Results of FEA as shown below:

V. RESULT AND DISCUSSION

From the above analytical as well as ANSYS software analysis it has been found that the maximum stresses are generating at the tooth point due to the regular and maximum contact with the soil. These stresses cannot be avoided but can be properly regulated with proper application of bucket for the excavation for various soil structures. Following fig’s shows the comparison between analytical result and ANSYS result. Percentage error between analytical result and ANSYS result are calculated.

Table 1: Comparison of Results

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Analysis</th>
<th>Analytical Result</th>
<th>ANSYS Result</th>
<th>% Error of Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Max Shear Stress</td>
<td>96.39 MPA</td>
<td>112.98 MPA</td>
<td>14.69 %</td>
</tr>
<tr>
<td>2.</td>
<td>Shear Stress</td>
<td>157.67 MPA</td>
<td>167.42 MPA</td>
<td>5.82 %</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

In this paper, we design an Excavator bucket by using Creo parametric software and analysis is done by ANSYS 13.0 software. The stress at the Tip of teeth of an Excavator bucket is calculated 96.39 MPA and stress due to shearing of rivet is calculated 157.67 MPA by analytically. The stress at the tip of the teeth is calculated 112.98 MPA and stress due to shearing of...
rivet 167.42 is calculated. Percentage error between analytical result and Ansys result are 14.69 % and 5.82 %.

As per the above analysis, it is suggested that the bucket used for the excavation purpose should be properly checked for its application on the basis of the soil strata. And considering the failure of the tooth and rivet due the impact loading, it is very much economical to change the rivet rather than changing the whole tooth assembly.

REFERENCES


