Optimization of Component of Excavator Bucket

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ABSTRACT
A better design in excavation process has been challenging task for the engineers. Poor design gives always poor result in excavation process. Excavation tasks range from cutting a geometrically described volume of earth for a trench or foundation footing to loading a pile of soil. The main objective of this paper is to analyze the force calculation of excavator bucket and calculation of excavator bucket capacity, which are failing under the given operating conditions. During operation of excavator at different positions the stresses induced in the bucket.

1. INTRODUCTION
A bucket is a specialized container attached to a machine, as compared to a bucket adapted to the form of a human being. It is a bulk material handling component. The bucket has an inner volume as compared to other types of machine attachments like blades or shovels. The bucket could be attached to the lifting hook of a crane, at the end of the arm of an excavating machine, to the wires of a dragline excavator, to the arms of a power shovel or a tractor equipped with a backhoe loader or to a loader, or to a dredge. Excavators are intended for excavating rocks and soil. Excavators may have a mechanical or hydraulic drive. Hydraulic excavators are the most important group of excavators. It consists of four link members: the bucket, the stick, the boom and the revolving superstructure. A standard excavation process, on the construction side, can be seen as composed of two parts. The first one is the process of digging and filling the bucket with soil or other material. The second part of the operation consists in lifting the filled bucket, swinging it with respect to a vertical axis, stopping it at the place where it should be unloaded, and discharged.

2. FORCE CALCULATIONS
To find the forces at different points of the attachment is very important 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 Digging force for the given cylinder pressures, and this is done using Design View. The second stage is to find the forces at all pivot points of the attachment, this is done using MathCAD.

2.1 Calculation of Digging and Breakout Force
2.1.1 Digging Force (Rx)
The digging force is the available force at the tip of the bucket teeth created by the stick cylinder(s). Maximum digging force is calculated with dimension “a” at its maximum and with the bucket in a position calculated for maximum Breakout force.

\[ F_s \times \frac{R_x \times b}{a} \]

Fs -stick cylinder force
a - Perpendicular distance stick cylinder axis - stick pivot
b - Distance stick pivot - tooth tip

Fig.1 Digging Force

2.1.2 Breakout Force (L)
The breakout force is the available force at the tip of the teeth created by the bucket cylinder. Maximum breakout force is reached when the available tooth force reaches at its maximum.
3. MATERIAL FILL FACTOR
It is the factor by which the bucket is over or under filled.

Table 1: Bucket fill factor for backhoe bucket (SAE-Vol. 3)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>MATERIAL</th>
<th>Fill factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clay and sticky material, clay, mud, damp material</td>
<td>110%</td>
</tr>
<tr>
<td>2</td>
<td>Sand, sand gravel mixture, shale, not blasted</td>
<td>100-110%</td>
</tr>
<tr>
<td>3</td>
<td>Hard dry clay</td>
<td>90%</td>
</tr>
<tr>
<td>4</td>
<td>Rock, well blasted</td>
<td>70-90%</td>
</tr>
<tr>
<td>5</td>
<td>Rock, poorly blasted</td>
<td>60-90%</td>
</tr>
<tr>
<td>6</td>
<td>Rock, deteriorated, layered shale, not blasted</td>
<td>80-100%</td>
</tr>
</tbody>
</table>

4. CALCULATION OF EXCAVATOR BUCKET CAPACITY

4.1 Capacity calculation of excavator buckets according to SAE
SAE (Society of Automotive Engineers) and PCSA (Power Crane & Shovel Association)

\[
V = \frac{F(b_1 + b_2)}{2} + \frac{Ax_b}{4} - \frac{b_{13}}{12}
\]

4.2. Capacity calculation of backhoe buckets according to CECE
(Committee for European Construction Equipment)

\[
V = \frac{F(b_1 + b_2)}{2} + \frac{Ax_b}{8} - \frac{b_{13}}{24}
\]

Definition of used symbols
A = BUCKET OPENING, measured from cutting edge to end of bucket rear plate
B = CUTTING WIDTH, measured over the teeth or side cutters
b = BUCKET WIDTH, measured over sides of bucket at the lower lip without teeth of side cutters attached
b1 = INSIDE WIDTH FRONT, measured at cutting edge
b2 = INSIDE WIDTH REAR, measured at narrowest part in the back of the bucket
F = SIDE PROFILE AREA OF BUCKET, bounded by the inside contour and the strike

Plane of the bucket. Angular or curved indentation of the side leading edge from the strike plane is not being considered if less than A/12.
Table 2 Comparison of bucket specification and digging force

<table>
<thead>
<tr>
<th>Name Of Manufacture</th>
<th>Komatsu</th>
<th>Hitachi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Name</td>
<td>PC-09</td>
<td>Zaxis-8-1</td>
</tr>
<tr>
<td>Bucket Specification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity (m³)</td>
<td>0.025</td>
<td>0.022</td>
</tr>
<tr>
<td>NO. Of Teeth</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>15</td>
<td>15.7</td>
</tr>
<tr>
<td>Digging Force (N)</td>
<td>10546</td>
<td>10300</td>
</tr>
</tbody>
</table>

5. CONCLUSION
The capacity of bucket has been calculated according to SAEJ296. The bucket specification is the most superior when compared to all other standard model. The breakout force is calculated by SAEJ1179. The SAE provide the breakout and digging force. For max. breakout force condition but for autonomous application it is important to understand. Which are improved bucket geometry for more efficient digging and loading of material. And heavy duty robust construction for increased strength and durability.

REFERENCES


