Kratos the Cratermaker: Strengthened Shaft Shovel

Abstract

Shaft fracture accounts for the majority of shovel failures. Typical wooded handles at times can not endure the high stresses induced by the user. In addition, hand strain due to circular shaft geometries, and small boot-blade contact area were common complaints according to field research. It was our goal to design a shovel that both increased ergonomics and life cycle.

Current Designs

Our benchmark was the Ames True Temper Excavator, which is marketed as a top tier, ergonomic shovel. Flexure testing was undertaken to determine the maximum moment. It was determined that the product could support a 400 ft-lb moment before fracture (Fig. 1). Additionally, it was determined through market research and consumer interviews that an elliptical shaft to better fit the contours of the user's hands would be preferred. It was also indicated that a one inch step would an optimal boot-blade contact area.

Flexural Strength

<table>
<thead>
<tr>
<th>Material</th>
<th>Flexural Strength (psi)</th>
<th>Density (lbs/in³)</th>
<th>Approximate Cost (per lb)</th>
<th>Approximate Cost (per lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Ash</td>
<td>1.16*10³</td>
<td>0.0242</td>
<td>$1.82</td>
<td>1.16*10³</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>28*10³</td>
<td>.062-.070</td>
<td>$2.20</td>
<td>28*10³</td>
</tr>
<tr>
<td>Low Carbon Steel</td>
<td>41.3*10³</td>
<td>0.284</td>
<td>$0.32</td>
<td>41.3*10³</td>
</tr>
<tr>
<td>Aluminum</td>
<td>40*10³</td>
<td>0.0976</td>
<td>$0.82</td>
<td>40*10³</td>
</tr>
</tbody>
</table>

Our goal was to increase flexure strength of the shovel's shaft with ergonomic features. The final design required a step, elliptical shaft, and maximized rigidity. Both internal and external spines were considered. Internal spines were determined the most feasible. A number of internal spine geometries were evaluated. Of these, an I-beam inspired profile was found to have the best stress distribution. In order to concentrate stress on the spine, the profile incorporated a rounded profile to the flanges as seen in Fig. 3-B. Due to its low density, low cost and high strength, 6061-T6 Aluminum was selected for the spine (Fig. 4). The area between the flanges and web is to be filled with low density polyethylene.

Results

Our final design was a curved beam inspired by an I-beam, made of aluminum. Analysis showed it to be capable of supporting a 700 ft-lb moment without yielding, an increase of 175% over our benchmark. The requirements on shaft geometry were satisfied as well. All results were obtained with less than a 1.5 lb increase in overall weight.

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