Design and Assembly of Carbon Fiber Professional Scooter

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Abstract

After reviewing the current professional grade scooter market, it was concluded that there is a definite need for weight reduction. The current market consists of rigid aluminum and titanium structures. This design is made primarily of unidirectional carbon fiber in an epoxy resin system. The deck of the scooter will be made with a high density foam core. Using carbon fiber to replace metal will provide a substantial weight reduction in the final assembly. Testing will be done to ensure that the scooter meets all required safety and dimensional requirements.

Design Concerns

<table>
<thead>
<tr>
<th>Design</th>
<th>Concern</th>
<th>Assessment Measure Definition</th>
<th>Required Value</th>
<th>Design 1 Value</th>
<th>Design 2 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Lightweight</td>
<td>Percentage reduction of weight to R regulation (lb)</td>
<td>&lt;30%</td>
<td>-15%</td>
<td>-20%</td>
</tr>
<tr>
<td>Physical</td>
<td>Deck length</td>
<td>Percentage reduction of standard pro scooter deck (in)</td>
<td>19 - 22</td>
<td>-21</td>
<td>-22</td>
</tr>
<tr>
<td>Physical</td>
<td>Handlebar width</td>
<td>Percentage reduction of standard pro scooter handlebar (in)</td>
<td>35 - 36</td>
<td>-36</td>
<td>-35</td>
</tr>
<tr>
<td>Physical</td>
<td>Handlebar depth</td>
<td>Percentage reduction of standard pro scooter handlebar (in)</td>
<td>14 - 19</td>
<td>-16</td>
<td>-16</td>
</tr>
<tr>
<td>Structural</td>
<td>KE024</td>
<td>Tensile strength of materials applied Up - Bar (lbs)</td>
<td>1000 lbs</td>
<td>950</td>
<td>900</td>
</tr>
<tr>
<td>Structural</td>
<td>KE024</td>
<td>Compressive strength of materials applied Up - Bar (lbs)</td>
<td>800 lbs</td>
<td>720</td>
<td>700</td>
</tr>
<tr>
<td>Environmental</td>
<td>High Durability</td>
<td>Flexure strength retained after UV exposure ASTM D485 Lamp 6 hrs UV at 60oC 4 hrs of condensation at 50°C</td>
<td>30%</td>
<td>&gt;28%</td>
<td>&gt;26%</td>
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<tr>
<td>Human Engineering</td>
<td>Velocity Abec</td>
<td>BECC rating of bearings (Number)</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Life cycle</td>
<td>Abrasion resistance</td>
<td>Number of points (Four Raters)</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Test</td>
<td>Fatigue Life</td>
<td>Load at 75% Proof stress (in)</td>
<td>30700</td>
<td>30500</td>
<td>30400</td>
</tr>
</tbody>
</table>

Design Alternatives

Design 1:

- Design 2:

Meet the Team

Pictured from left to right: Nicole Tincher, Maria Wrage, Tyler Ross, Austin Houska, Reese Sager

Manufacturing

Handlebars and Up-bar (pictured on left):
- Filament winding was used to fabricate the handlebars and up-bar
- Carbon fiber rovings were wrapped around a mandrel
- Used a pattern of 45, 20, 90, 45 for the up-bar
- For the handlebars a pattern of 45, 20, 90, 45 was used
- Both were cut to length on the chop saw

Aluminum Joint (pictured on right):
- An aluminum block was milled to the desired dimensions (pictured on left)
- The existing neck joint was taken from a purchased scooter
- The two pieces were welded together to make the final aluminum assembly

Scooter Deck (pictured on left):
- Carbon fiber unidirectional prepreg with a dense foam core was utilized
- Sandwich composite was cured in a heated press
- A lay-up pattern of [0.0,0.0,0.90]4 / Core / [90.0,0.0,0.0] was used
- Scooter was cut to final dimensions on the bandsaw and sanded to produce clean edges

Qualification Testing

All parts were visually and dimensionally inspected based on drawings made in SolidWorks. In addition flexural, compression, and UV testing were performed on specific parts.

- The deck was tested in 3-point bend flexure
- Held a max load of 1485 lbs
- This satisfies the design requirement

- The up-bar was tested in compression using a 2 in sample
- Held a max load of 2404 lbs which met the required value

- Samples from the deck were exposed to UV and condensation
- The max load of the exposed sample was compared to the max load of the untreated sample in flexure
- Resulted in a 99.4% strength retention after 3 days

Final Design

Conclusions

The final design has multiple parts that are all assembled together. Most of the parts are adhesively bonded to one another. The intent was to reduce the overall weight of a pro scooter while maintaining the expected quality. The final weight of the design was just over 6 lbs which was about a 20% weight reduction compared to the average pro scooter.