1. Project Background

SAG Mills use a cone to feed recirculated ore back into the mill for additional grinding. The cones wear out with use and require replacement. The current process of changing SAG mill cones is dangerous to personnel and equipment. The project goal is to enhance the safety of replacing the cone in a SAG mill. The improvement aims to address the challenges posed by the current difficult and unsafe process, primarily due to equipment limitations and clearance issues in the mill feed-end. The designed tool aims to integrate directly into the currently used equipment (i.e. a telehandler).

The team, in conjunction with subject matter experts, developed a CAD design influenced by FEA analysis.

2. Device Design

The main assembly provides the main structural strength of the device. It integrates directly into the blank provided by Wheeler and contains the rails along which the sliding assembly travels. The sliding assembly serves as the main load force-transfering device. The nose extends into the cone and aims to support the cone directly underneath the cone's center of mass. The assembly makes use of Delrin friction blocks to ease the movement of the entire assembly. The sliding assembly uses low-friction HDPE blocks (i.e. Delrin) to reduce friction and allow easy sliding. The sliding assembly includes horizontal stabilizer arms and a chain mount pass-through. These features are intended to ease the process of rotating the cone to line up the bolt holes of the SAG mill with the bolt holes of the cone.

The piston assembly provides the pushing force required to hold the cone at the end of the telehandler boom. The hydraulic piston was selected to provide 33,000 lbs of pushing force at the 3007 psi provided by the auxiliary hydraulic line of the telehandler. The piston assembly is attached to the main assembly and sliding assembly via welded eyelets. The wheel assembly serves to allow the device to roll across the rough environment of the SAG Mill. The axle is a hollow cylinder that integrates directly with a wheel/spindle hub assembly. The axle is attached to the bottom of the main assembly via brackets. Wheeler has agreed to take on the wheel/spindle selection and integration.

3. Design Requirements

<table>
<thead>
<tr>
<th>Requirement #</th>
<th>Requirement Description</th>
<th>Units</th>
<th>Goal Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Device must be able to lift the cone</td>
<td>lbs</td>
<td>≥ 33,000</td>
<td>lbs</td>
</tr>
<tr>
<td>2</td>
<td>Device must be able to rotate the cone</td>
<td>deg</td>
<td>≥ 180</td>
<td>deg</td>
</tr>
<tr>
<td>3</td>
<td>Device must be able to support the cone</td>
<td>lbs</td>
<td>≥ 33,000</td>
<td>lbs</td>
</tr>
<tr>
<td>4</td>
<td>Device must be able to support the cone</td>
<td>lbs</td>
<td>≤ 2407</td>
<td>lbs</td>
</tr>
<tr>
<td>5</td>
<td>Device must be able to support the cone</td>
<td>deg</td>
<td>≥ 3</td>
<td>deg</td>
</tr>
<tr>
<td>6</td>
<td>Device must be able to support the cone</td>
<td>times</td>
<td>≥ 1,000,000</td>
<td>times</td>
</tr>
</tbody>
</table>

4. Device Iterations

The primary design changes:
- Reinforce the structure via gussets
- Design welds and bolts
- Change the plate thickness
- Additional needs (e.g. nose cone, weld anchor points, chain pass through)

Based on the work of last semester, the team pivoted to a 'forklift' style design, using fixed axle and pushing a sliding portion upward via a hydraulic piston to provide a lifting force for the cone.

5. Main Load Case

The main load case is meant to demonstrate the device’s ability to hold the cone alone. This included figure is the result for a device holding a 33,000 lb load, which is a safety factor of 3. The device does not yield for this load case.

The close-up views depict the reinforced gusset on the backside. This gusset underwent several size iterations during the design process due to its critical structural role.

6. Rotation Load Case

During cone install, the craftsmen need to rotate the cone to line up the bolt holes of the cone with the bolt holes of the mill. The rotation load case is meant to demonstrate the device’s ability to resist the forces applied during this procedure.

Crafstmen typically burn holes into the cone and to attach chains. The eyelets on the end of the horizontal stabilizers facilitate this process.

The figure shows the close ups of highest stress on the horizontal stabilizers. The model shows yielding, but it is surface yielding and considered safe.

7. Wall Pull Load Case

During cone removal, the craftsmen need to pull on the cone if it has become stuck. The wall pull load case is meant to demonstrate the device’s ability to resist the forces applied during this procedure. Again, Craftsmen burn holes in the cone to attach chains.

The figure shows the close ups of highest stress on the horizontal stabilizers. The device does not yield under this load case.

8. Fatigue Life

Fatigue life calculations are essential for predicting the durability and reliability of the device under repeated loading conditions, ensuring its safety and longevity throughout its intended lifespan. By accurately assessing fatigue life, the team designed and optimized components to withstand cyclic stresses and prevent unexpected failures.

The team performed the following to calculate fatigue life:
- Use Neuber and Ramberg-Offgoed equations to account for non-linear FEA.
- Strain life methods can be used when the loading is a combination of elastic and plastic. It is based on observations in critical locations (e.g., notches).
- Use Smith, Watson, and Topper stress correction to account for the effect of non-zero mean stresses.

9. Next Steps

- Device design was delivered to Wheeler for fabrication on 3-29-2024. (OpsCon, FEA results, and a bill of materials)
- Wheeler responsible for selecting and integrating wheels and axle into the device.
- Team will communicate with Wheeler to ensure design integrity during fabrication
- Rio Tinto to perform a field test of the device before use in operating environment. High stress points reported to Rio Tinto for observation during field test.

Special Thanks: Carter Oman, Rio Tinto Craftsmen, Team at West Valley Wheeler, Andy Gill

Figure 9: Picture of 3D printed device holding a 3D printed cone at a 1:6:1 scale, attached to 1:6:1 scaled CAT toy.