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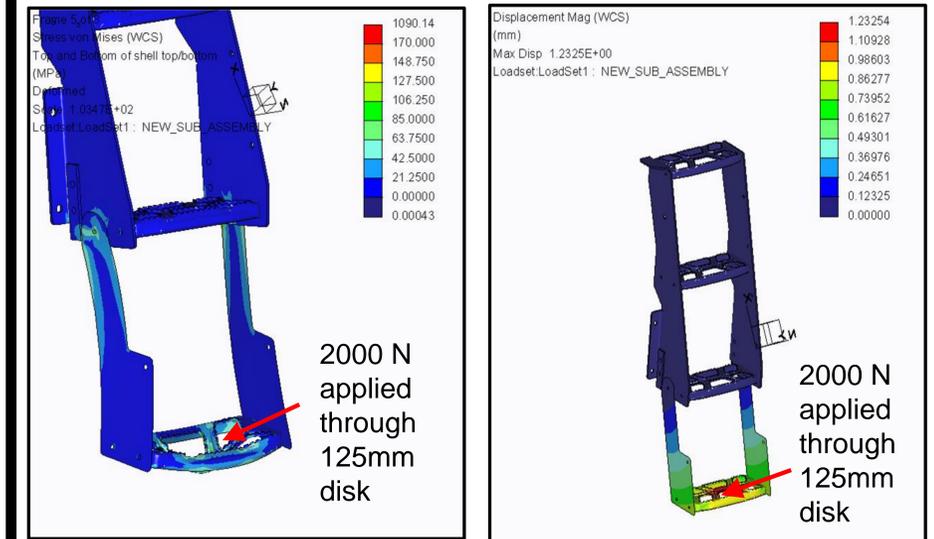
Background

- Caterpillar Medium Wheel Loaders include models 950-982, focus on 966
- Current design sometimes subjects bottom step of primary access ladder to damage
- Current bottom step height is 600mm from ground
- Changes in ISO 2867 could move bottom step height to 400 mm from ground
- Caterpillar is investigating retractable ladders to minimize damage to a ladder that is lower to the ground

Design Overview

- 400mm (15.7") from ground when extended
- 727mm (28.6") from ground when retracted
- Actuated by the operator
- 6.1kg (13.5 lbs.) estimated weight (retractable section)
- Retains 4 steps
- 396mm between steps, 400 mm max (ISO 2867)
- Retains original mounting points on machine

Creo Simulate Analysis



Statement of the Problem

If current ladder design is altered to meet changing ISO standards, it is likely that an increase in damage will be observed. The feasibility of a retractable ladder is being investigated to mitigate damage.

Full Scale Model



Current Design



Alternative Solutions

- Power
 - an electronically actuated folding ladder
- Telescoping
 - a ladder that extends from within itself
- Gas Shocks
 - a folding design assisted and retained by gas struts
- Hook
 - a hook and pin design on a track

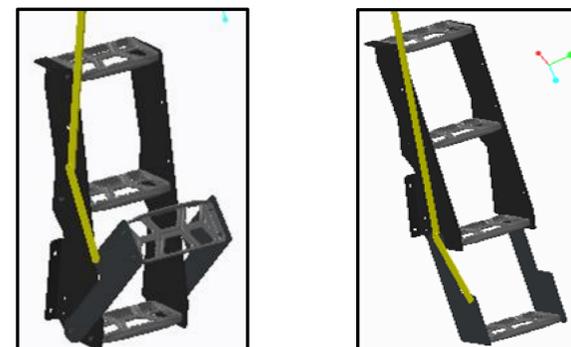
Economic and Societal Impact

- Customers will spend less money on repairs to the ladder system
- Design costs less than many of the alternatives
- Proposed changes require minimal retooling
- New design enhances safety due to being closer to the ground likely reducing the number of falls
- Retractable ladder encourages operators to exit the machine safely
- Proactively complies to proposed ISO standards

Solution Evaluation- Caterpillar Specifications

- When in the lowered position, the ladder system withstands 2,000N applied at the most unfavorable position through a 125mm diameter solid disc without permanent deformation.
- When in the lowered position for use, the ladder system withstands a uniformly distributed force of 4,500N per square meter of surface area without permanent deformation.
- When in the raised position, the ladder system adequately retains itself during the following G-load cases – 2G applied in the side-to-side direction, 3G applied in the fore-aft direction, 3G applied in the vertical direction.
- When in the raised position, the ladder system resides within the machine turning circle.
- When in the lowered position, the ladder maintains a uniform 75° inclination angle with respect to the ground, except for the bottom step.
- Budget did not exceed \$180

Creo Model



Ladder Extension Budget

Estimated Cost

23 lbs. prepared steel @ \$1.95/lb.....	\$44.85
4 Flat Head Machine Screws @ \$0.79/piece...	\$3.16
2 Bolts @ \$0.06/piece.....	\$0.12
10 Washers @ \$0.02/piece.....	\$0.20
6 Nuts @ \$0.07/piece.....	\$0.42
4 Spacers @ \$1.00/piece.....	\$4.00
4 Wear washers @ \$0.89/piece.....	\$3.56
TOTAL.....	\$56.31

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