CAPSTONE/SENIOR DESIGN EXPERIENCE 2018

Automatic Nose Ballasting (CNH)

Alex Mills (B.S. AE), Luke Kepler (B.S. ASM), Mitchell Newport (B.S. ASM), and Will Field (B.S. ASM)

Introduction

Problem Statement:

- Changing front end ballasting weights is a labor intensive and time consuming task. Thus, consumers neglect to properly ballast machinery.

Objectives:

- Design a quick exchange solution, utilizing the hydraulic front suspension's movement, to decrease the time required to gain proper ballasting weight.
- Provide an adequate storage rack for standby ballast weight.

Project Background:

- Current market demand is pushing for new agricultural equipment that provides less soil compaction and fuel consumption.
- The increasing age of farmers encourages the reduction of manual labor.

Target Ballasting

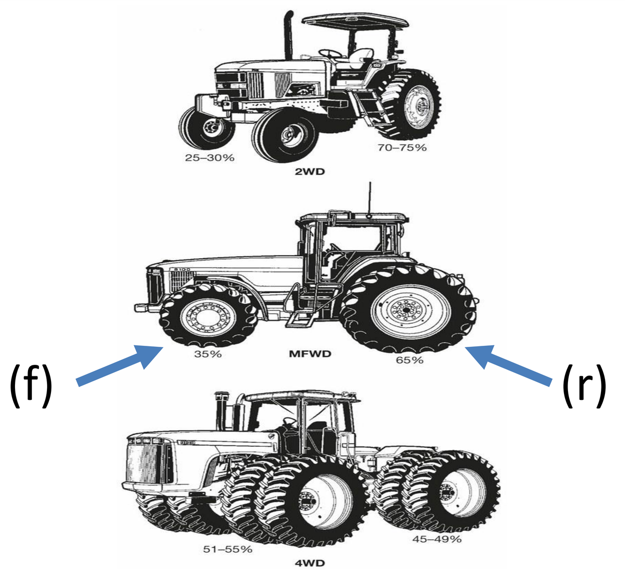


Figure 1: Recommended balancing proportions

Incorrect Ballasting

Over-ballasted(f):

- Greater Soil Compaction
- Increased Fluid Consumption

Under-ballasted(f):

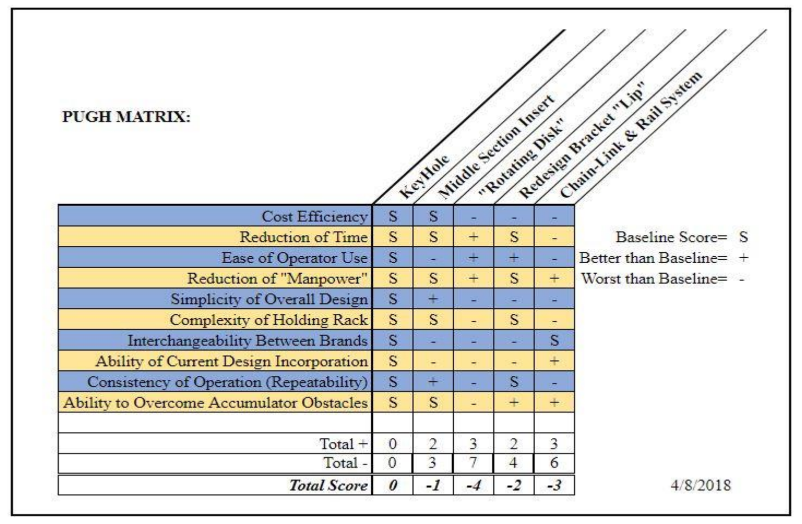
- Potential for Wheel Slip
- Risk of Injury from Turnover

Simple Ballast Equation:

- NF(f) x D(f) = NF(r) x D(r)
  - NF= Normal Force
  - D= Distance from Fulcrum

Alternative Solutions

Decision Matrix:



PUGH MATRIX:

	KeyHole	Middle Section Insert	"Rotating Disk"	Redesign Bracket "Lip"	Chain-Link & Rail System
Cost Efficiency	S	S	-	-	-
Reduction of Time	S	S	+	S	-
Ease of Operator Use	S	-	+	+	-
Reduction of "Manpower"	S	S	+	S	+
Simplicity of Overall Design	S	+	-	-	-
Complexity of Holding Rack	S	S	-	S	-
Interchangeability Between Brands	S	-	-	-	S
Ability of Current Design Incorporation	S	-	-	-	+
Consistency of Operation (Repeatability)	S	+	-	S	-
Ability to Overcome Accumulator Obstacles	S	S	-	+	+
Total +	0	2	3	2	3
Total -	0	3	7	4	6
Total Score	***0***	***-1***	***-4***	***-2***	***-3***

Baseline Score= S
Better than Baseline= +
Worst than Baseline= -

4/8/2018

Design Obstacles:

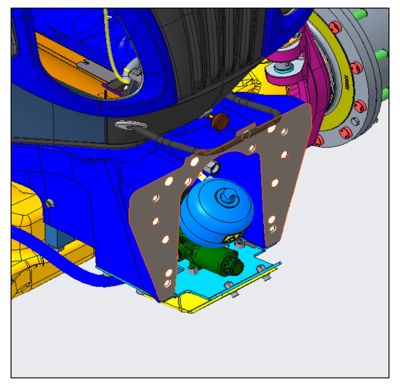


Figure 2: Isometric view of hydraulic suspension accumulators discovered within the frame rail

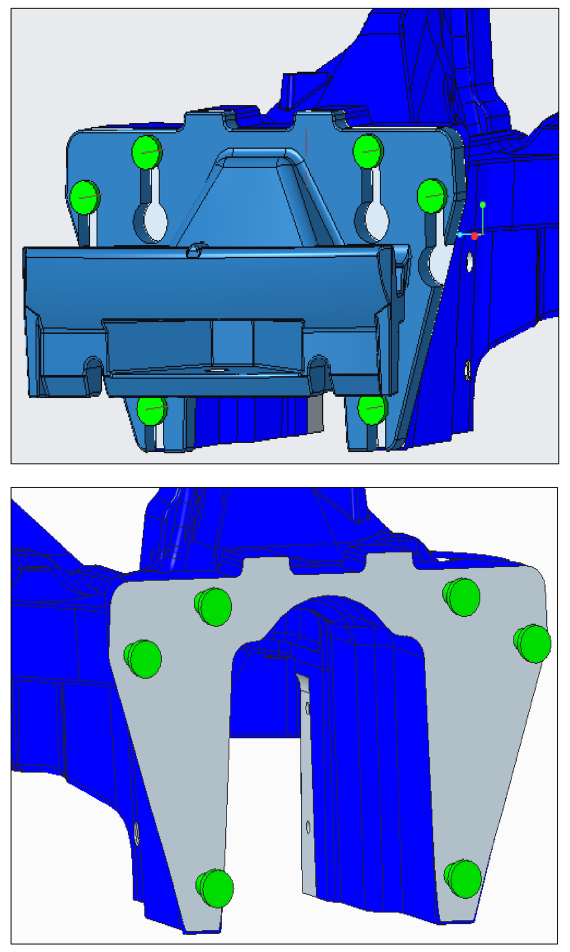


Figure 3: Initial design of sliding keyhole bracket and cast frame rail studs

Complete System

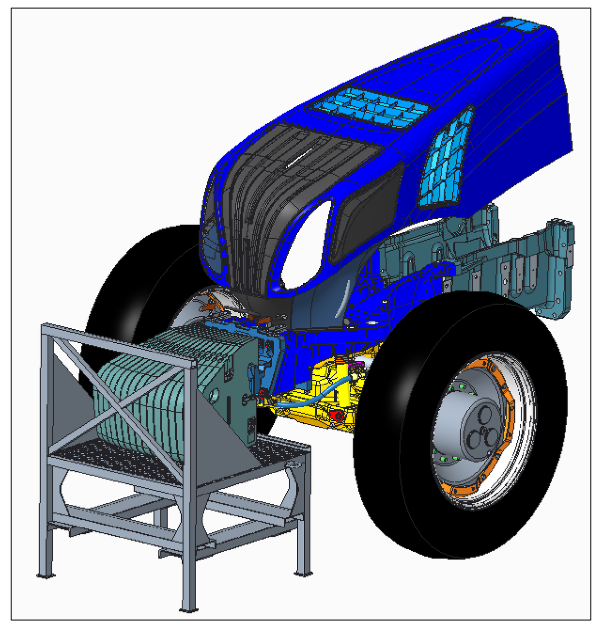


Figure 4: Isometric view of finalized design

Figure 5: Completed weight rack prototype

Final Design

Project Deliverables:

- Class 10.9 M20 Shoulder Screw
  - Six screws to be anchored in frame rail
- Redesigned Weight Bracket
  - Keyhole slots to allow easy attach / detach motion
- Updated Front Frame Rail
  - New hole locations created to accommodate weight bracket design
- Weight Storage Rack
  - Used in quick attach process
  - 4000+ lb. capacity
  - Movable from all sides

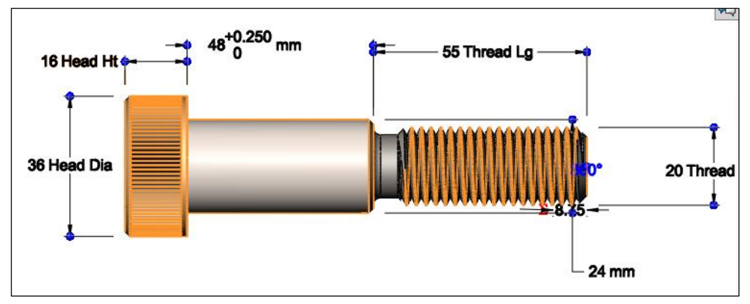


Figure 6: Proposed M20 shoulder screw

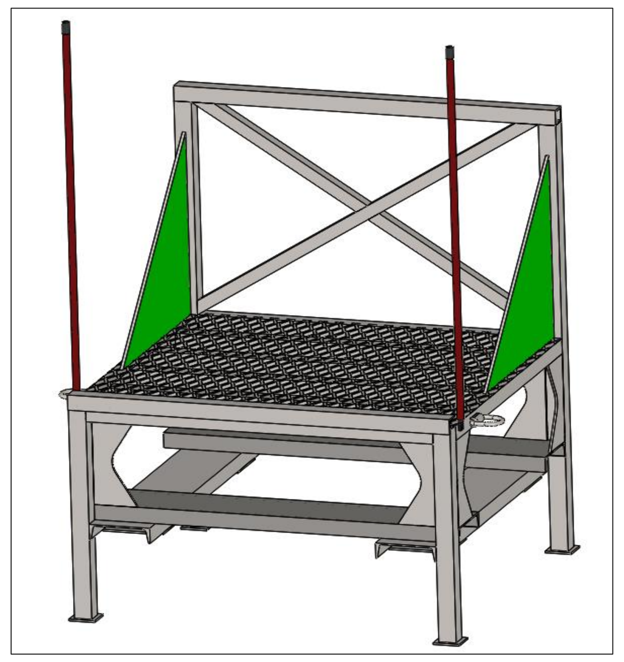


Figure 7: Heavy duty weight rack

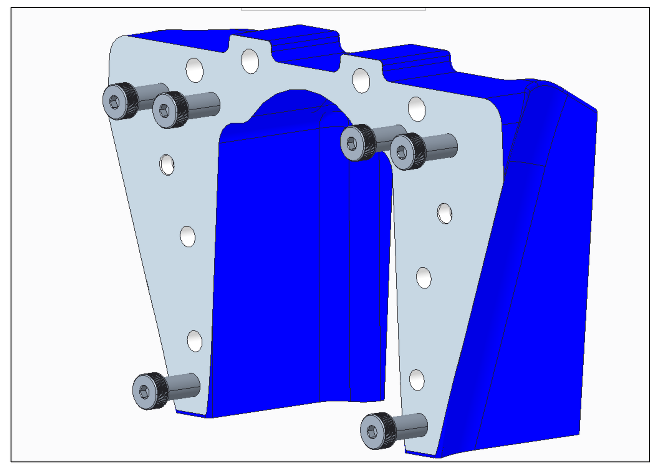


Figure 8: Tractor frame rail with shoulder screws

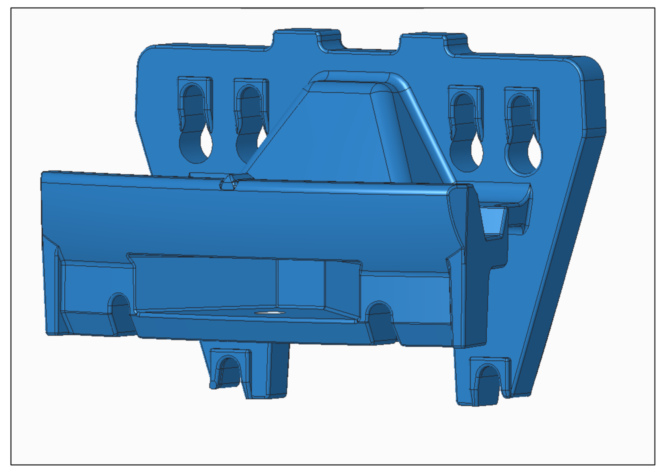


Figure 9: Redesigned weight bracket

Design Analysis

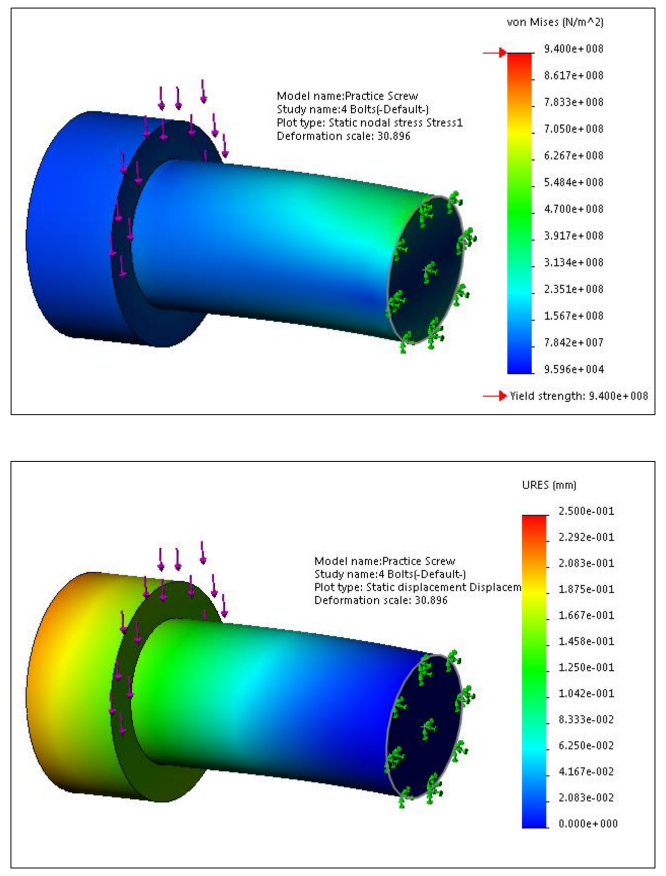


Figure 10: FEA of 3G on four load bearing bolts

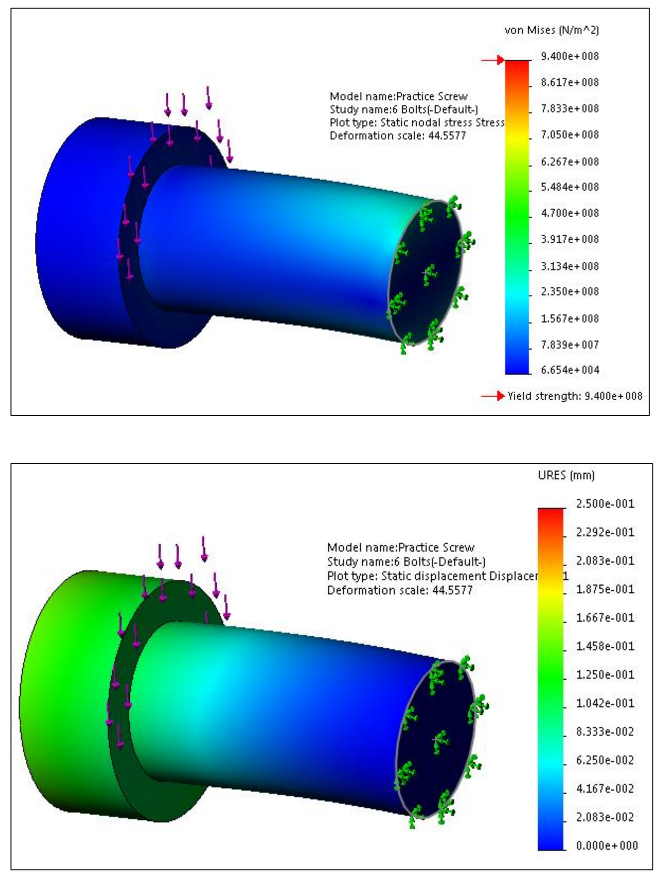


Figure 11: FEA of 3G on six load bearing bolts

Four Bolt Scenario:

- Maximum Stress – 499.3 MPa
- Maximum Deflection – 0.2185 mm
- Factor of Safety - 2

Six Bolt Scenario:

- Maximum Stress – 346.2 MPa
- Maximum Deflection – 0.1515 mm
- Factor of Safety – 2.9

Impact

Benefits:

- Gives the consumer another tool to help manage compaction and fluid consumption.
- Improve overall ballasting efficiency
- Provides consumers with a low cost alternative to a front three point hitch system
- Reduces operator fatigue and improves customer satisfaction.
- Simple design changes should streamline the retooling of the assembly line

Disadvantages:

- Additional storage room is required
- Stud bolts may become damaged and require replacement
- Added cost to consumer compared to standard equipment
- Rusting of steel, especially bolt holes in mechanical designs, may decrease the overall durability of the product

Economical Analysis

Table 1: Projected cost of system

Cost of rack material:	$468
Estimate of quick exchange:	$330
Cost of machining:	$70
TOTAL cost of system:	*$868*

Recommendations

Testing:

- Further FEA testing to ensure safety and reliability
- Prototype trials to prove repeatability

Future Improvements:

- Latching Mechanism
- Weight Rack Height Adjustability

Sponsor:
Bryan Nannet (CNH)
Jason Prickel (CNH)

Technical Advisor:
Dr. Saraswat

Instructors:
Dr. Lumkes
Dr. Stwalley

Acknowledgements:
Scott Brand, Purdue University
Lanty Armstrong, Ag Technologies
Design Review Judges
New Holland Rochester Inc.