PURDUE UNIVERSITY

CAPSTONE/DESIGN EXPERIENCE 2019

OM-3 Wagon Suspension

Agricultural & Biological ENGINEERING

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Introduction

Problem Definition

- A local farmer needs a suspension system installed on his farm wagon that will prevent damage to produce during transport to and from selling points.

Background Information

- Payloads range from 3000 lbs when hauling sweet corn to 30 lbs at the end of the day.
- Damaged produce reduces customer satisfaction and is a financial loss for the farmer.
- Estimated losses are $20 a day.
- Farmer has 8 wagons that he uses to sell produce.

Constraints and Criteria

- Must dampen when fully loaded and empty
- Must attach to current wagon
- Must be towable behind truck
- Minimal cost
- Ease of installation
- Easily replicated

Final Design

- Double eye trailer leaf springs with a 1250 lb. capacity mounted above the axle to frame of the bed.
- Shock absorbers to dampen leaf spring oscillations.
- Ride height will be increased by 7.75” unloaded and 6.75” when fully loaded.

Alternative Designs

- Airbags with Lateral Stabilization
- Coilovers
- Magnetic Adjustable Shocks
- Hydraulic Shocks
- Torsion Bar
- Stabilization In Bed

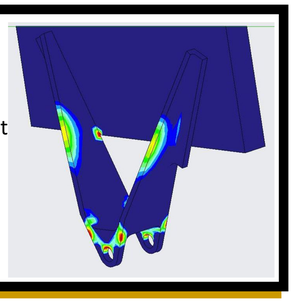
Economic Analysis

Component	Specifications	Quantity	Unit Cost	Total Cost
Leaf Springs	US-1041 1250 lbs. Capacity	4	$ 33.95	$ 135.80
Shock Absorbers	Magnum 65177 Gas Shocks	4	$ 50.00	$ 200.00
Mounting Brackets	1018 Steel	N/A	$ 62.58	$ 62.58
U-Bolts and Nuts	1/2"-20, 2" inside width, 6" leg	8	$ 5.95	$ 47.60
Shackles	2" Shackle	8	$ 1.62	$ 12.96
Shackle Bolts	9/16"-12, 3" Long, w/Locknut	12	$ 5.71	$ 68.52
			Total Cost	$ 527.46

Return On Investment	
Loss Per Day	$20
3 Days/ Week	$60
18 weeks/ year	$1,080
ROI at 25% reduction	35 weeks of use

FEA Analysis

- Ran finite element analysis on leaf spring hangers to validate design.
- Analysis was run with a 5000 lb vertical load on the bolt holes representing a 4g shock loading in a fully loaded condition, twice what was encountered in test
- The max Von Mises Stress from the analysis was 24,000 psi.
- Brackets manufactured using 1018 steel which yielded a factor of safety of 8.
- This maximum stress was below the fatigue limit of 1018 steel of 27,000 psi.

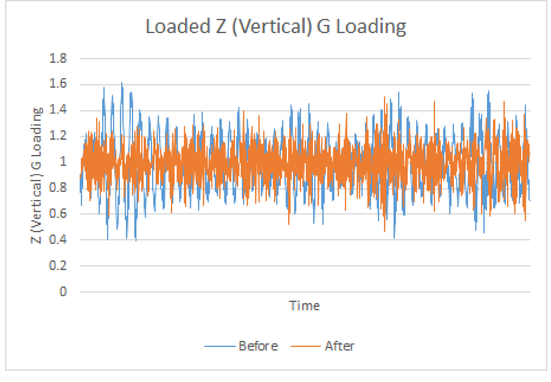


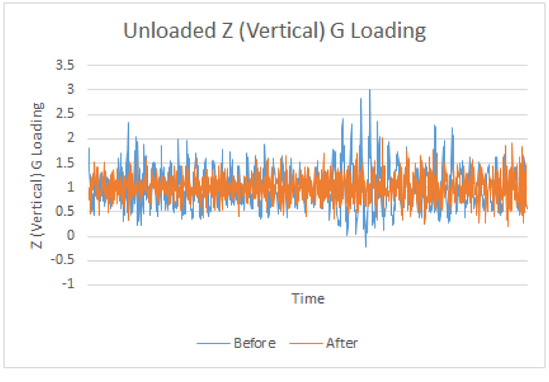
Design Matrix

- Matrix developed to determine optimal solution
- Scoring and criteria based on desired outcome
- Highest scoring design used in finished product
- Similar design matrix used to determine location for suspension system

	Cost	Dampening Effect	Payload	Durability	Ease of Installation and Replication	Adjustability	
Score	0.25	0.25	0.1	0.1	0.2	0.1	Total Point: 1 Point
Airbags with Lateral Support	4*(0.25) = 1.0	8*(.25) = 2.0	7*(0.1) = .7	3 *(0.1) = .3	3*(0.20) = 1.0	10*(0.10) = 1.0	Sum Total: 6.0
Hydraulic Shocks	4*(0.25) = 1.0	5*(.25) = 1.25	6*(0.1) = .6	6 * (0.1) = .6	7*(0.20) = 1.4	7*(.1) = .7	Sum Total: 5.55
Leaf Springs with shock absorbers	8*(.25) = 2.0	6*(.25) = 1.5	10*(0.1) = .5	8 * (0.1) = .8	10*(0.20) = 1.2	2*(0.10) = 0.2	**Sum Total: 6.2**
Magnetic Adjustable Shocks	1*(0.25) = 0.25	10*(0.25) = 2.5	8*(.1) = .8	5 * (0.1) = .5	2*(0.20) = .4	10*(.10) = 1.0	Sum Total: 5.45
Torsion Bar	5*(0.25) = 1.25	6*(0.25) = 1.5	5*(0.1) = .5	8 * (0.1) = .8	5*(0.20) = 1.0	5*(0.10) = 0.5	Sum Total: 5.55
Coilovers	5*(0.25) = 1.25	7*(.25) = 1.75	5*(0.1) = .5	6 * (0.1) = .8	3*(0.20) = 1.0	2*(0.10) = 0.2	Sum Total: 5.5

Accelerometer Testing





- Wagon was tested before suspension was installed and after suspension was installed with an accelerometer.
- Tested both empty and loaded with 3000 lbs to simulate real conditions.
- Tested in gravel parking lot by ADM at 10 mph to replicate roughest conditions the farmer sees.
- Saw a 25% average reduction in peak G loading in the vertical direction.

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