PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2014

Purdue Quarter Scale (PQS14)

Agricultural & Biological ENGINEERING

Nathan Chupp (MSE), Adam Cross (MSE), Dalton Harbison (ASM), Rebecca Kallal (MSE), Samantha Schmelz (MSE), Tucker Stout (MSE), and Jason Strasemeir (MSE)

Problem Statement

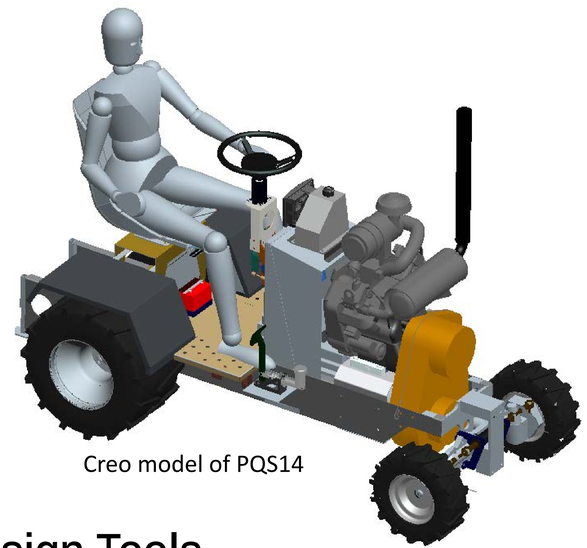
The goal of this project is to design, fabricate, and test a pulling tractor that meets all rules and regulations of the American Society of Agricultural and Biological Engineers (ASABE) 2014 International ¼ Scale Competition (IQS). The tractor has been divided into five distinct areas: Drive Train, Frame, Electronics and Data Acquisition, Operator Station, and Exhaust.

PQS14 Cost Analysis

Section	Category	Purchased	Fabricated	Total Cost
1	Engine System	$ 1,416.00	$ 8.15	$ 1,424.15
2	Transmission/Transaxle	$ 2,335.00	$ -	$ 2,335.00
3	Drive Train	$ 519.75	$ 115.50	$ 635.25
4	Tires & Wheels	$ 202.80	$ -	$ 202.80
5	Steering	$ 378.50	$ 16.83	$ 395.33
6	Frame	$ -	$ 534.09	$ 534.09
7	Body	$ 36.79	$ 122.89	$ 159.68
8	Brake System	$ 222.89	$ 34.89	$ 257.78
9	Electrical System	$ 192.00	$ -	$ 192.00
10	Fasteners	$ 90.00	$ -	$ 90.00
11	Safety Equipment	$ 17.00	$ 120.04	$ 137.04
12	Trim	$ 46.00	$ 150.00	$ 196.00
13	Miscellaneous	$ 13.00	$ -	$ 13.00
14	Final Assembly	$ -	$ 50.63	$ 91.63
15	Overhead	$ -	$ -	$ 41.00
	TOTAL			**$ 6,704.75**

Design Criteria & Constraints

- Weight limit of 800 lbs
- Must be easily manufactured with low overhead costs
- Drive train must be durable and robust
- Operator's station must be comfortable and safe
- Sound produced by tractor must be less than 91 dB
- Electronics must be reliable and versatile



Creo model of PQS14

Design Tools

Software Packages Utilized:

- Creo (Pro/Engineer)
- Mechanica (FEA)
- ANSYS Workbench (FEA)
- Microsoft Excel
- IQAN Design Studios
- ETS – National Instruments (Dynamometer Software)

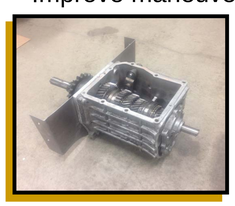
Drive Train

Objectives

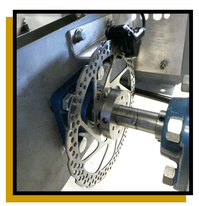
- Provide more than 2 gear selections
- Allow for smooth shifting
- Contain necessary reductions to achieve required operating speeds
- Improve ease of manufacture
- Improve maneuverability

Solutions

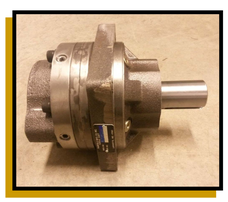
- A four speed synchromesh transmission coupled with a planetary
- Simple mounting brackets that minimize manufacturing costs
- A shaft brake after the CVT



Four Speed Transmission

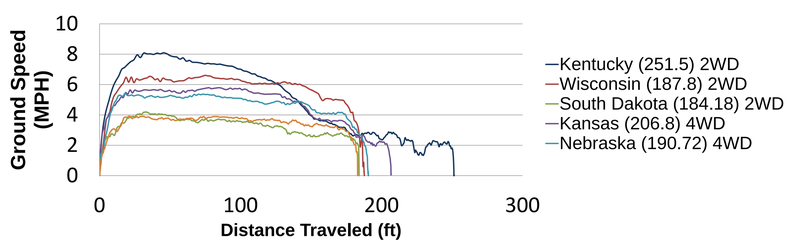


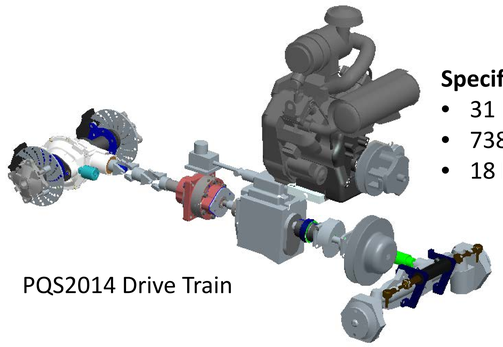
Shaft brake



Oerlikon Fairfield Planetary

Best 2 and 4 Wheel Drive 1000 lb Hooks, 2013





PQS2014 Drive Train

Specifications

- 31 hp engine
- 7380 ft-lbs; 2800RPM
- 18 MPH max ground speed

	Weight	Sound	Cost	Serviceability	Maneuverability	Safety	Ergonomics	Efficiency	Reliability	Performance	Variability	Score
	10	6	6	6	12	6	6	9	9	20	10	100
CVT	9	9	8	9	8	8	7	9	7	8	9	83
IVT	6	5	7	6	9	7	8	6	7	7	10	72
Hydrostat	6	5	6	5	9	7	9	6	6	6	10	69
Mechanical Gear	8	8	10	8	6	9	8	10	9	9	8	84

Decision matrix for alternative drive train solutions

Sponsor: Dr. John Lumkes
Faculty Advisor: Dr. Bob Stwalley
Graduate Advisor: Daniel Skelton
Special thanks:
Dr. Bernie Engel, Scott Brand
Garry Williams, John Andruch

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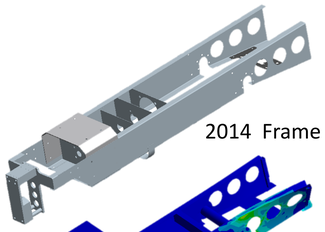
Frame

Objectives

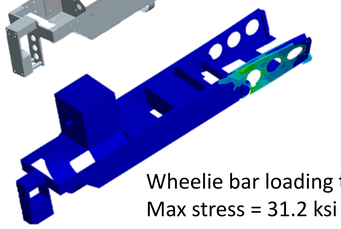
- Provide adequate support and mounting points for drive train and operator station components
- Provide shielding for rotating parts
- Contribute minimally to overall tractor weight
- Simplify manufacturing and reduce cost where possible

Solutions

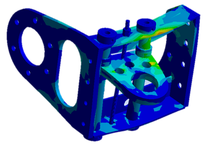
- 14 gauge bent sheet metal frame rails
- 1/4” aluminum plate components met shielding requirements.
- FEA analysis verified component strength, and was utilized to determine ways to remove weight and material cost from components.
- Manufacturing and design changes saved nearly $70/tractor



2014 Frame Design

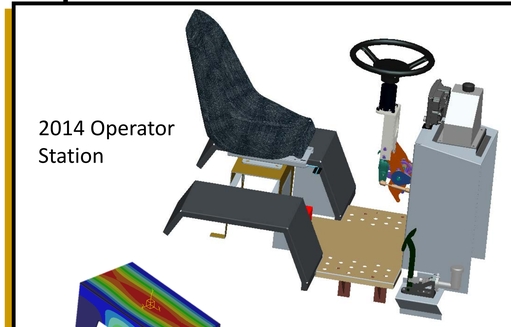


Wheelie bar loading test
Max stress = 31.2 ksi

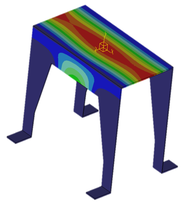


Hitch assembly with strategic material removal

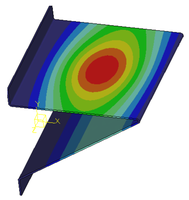
Operator Station



2014 Operator Station



Seat frame FEA
Deflection @ 600 lbf= 0.16 in



Brake mount FEA
Deflection at 350 lbf= 0.12 in

Objectives

- Provide a comfortable ride and an enjoyable driving experience
- Protect operator from hazardous tractor components
- Minimize machining costs
- Make electronic interface user-friendly

Solutions

- Comfortable and well-supported seat assembly
- Aluminum firewall that adheres to ASABE Standards
- Adjustable seat slide and hydraulic steering column
- Refined fabrication process that uses fewer cuts, bends, and welds
- Easy-to-use IQAN interface

Exhaust System

Double – walled pipe exhaust

Sound testing of previous exhaust systems

Objectives

- Provide an exhaust system that decreases noise without adversely reducing power
- Shield hot surfaces properly to avoid operator injury
- Divert exhaust emissions away from operator

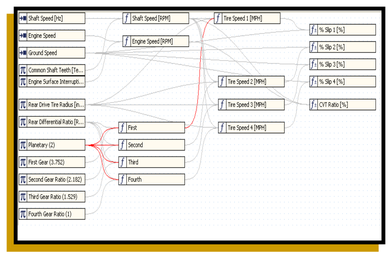
Solutions

- Implemented factory exhaust with modifications
- Created shielding that allowed for maximum heat escape without operator being harmed
- Added dual walled pipe to force exhaust to exit above operator

Electronics and Data Acquisition

Objectives

- Install a data acquisition system using low cost components
- Meet the customer’s preferences with several mechanical/electrical packages
- Output data for visual reference and use that data to evaluate the efficiency of tractor operation

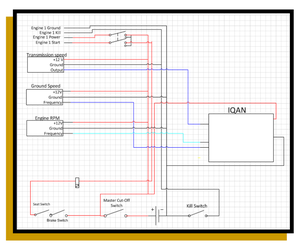


Code developed for speed calculations

Solutions

- Implemented Parker IQAN electronic components
- Utilized both electrical and mechanical components, which can be swapped on or off the tractor
- Utilized large display screens, from Parker IQAN, to display important data

Screenshot of IQAN display



Tractor wiring diagram

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