ASABE Quarter Scale Tractor Design Competition

Robert Caylor, Craig Cessna, Matt Duncan, Derek Hostetler, Josh Smith

Advisor: Dr. John Lumkes

Agricultural & Biological Engineering, Purdue University

4/22/2010

Problem statement:

Completely design and build a pulling tractor to compete against other teams at the International ¼ Scale Tractor Student Design Competition from June 3rd to June 6th

Design Objectives:

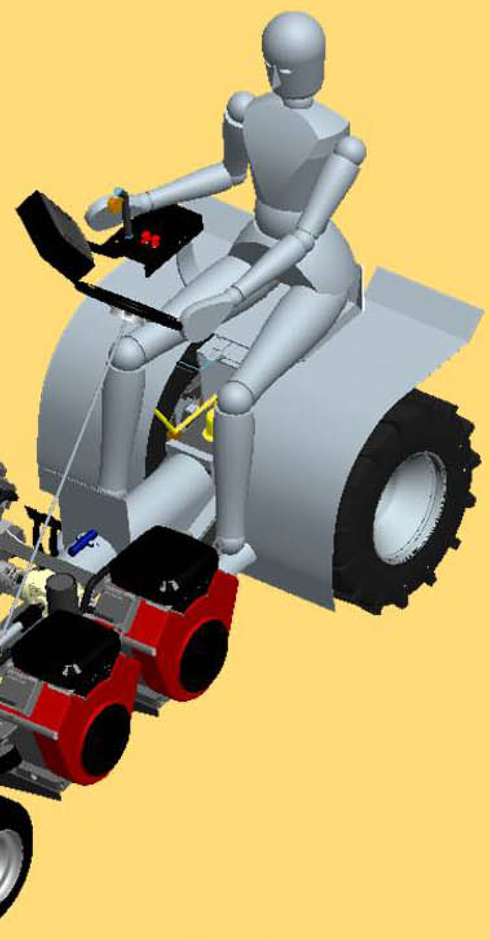
- Rigid, Lightweight Frame
- Efficient, Dependable Drivetrain
- Simple Steering
- Ergonomic Operator's Station
- Reliable Electronics

PQSo7, 2nd place finish

Coupled drivetrain, armrest instrument panel

PQSo8, 14th place finish

Steering Axle



PQSo10, Designed for a 1st place finish

PQSo9, 3rd place finish

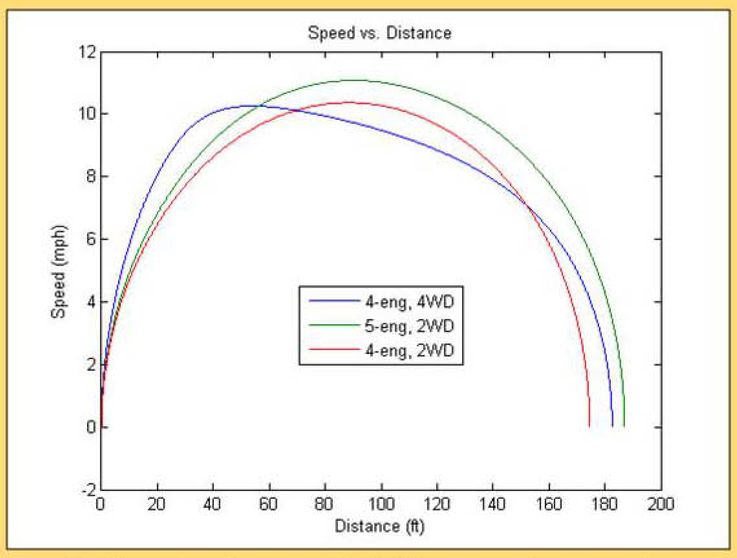
Gearbox drivetrain, bent sheet metal frame

Design Tools

Matlab Puller Model - Simulates tractor performance with varying inputs

- Pro/Engineer - Used for 3-D modeling of actual components
- Excel - Able to create design matrix & perform calculations
- ANSYS - Finite Element Analysis (FEA) of tractor components

Testing of PQSo9



Puller simulation of different drivetrain configurations

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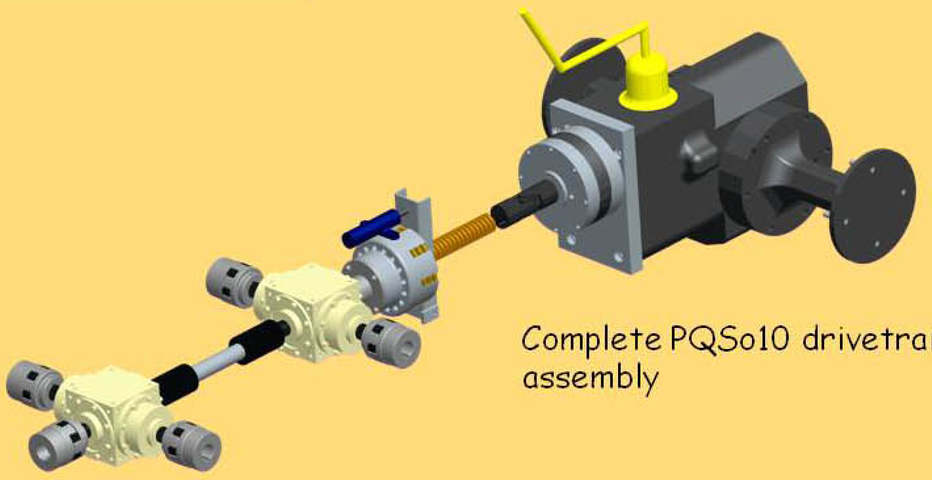
Drivetrain



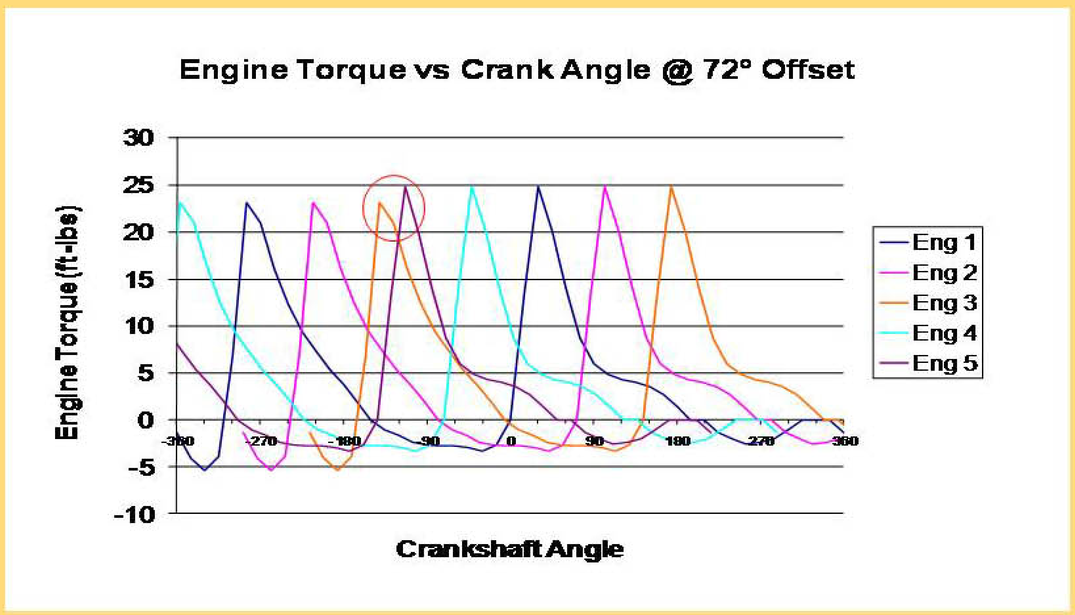
Complete PQSo10 drivetrain assembly

Objectives

- Develop a system that will be dependable on the track
- Efficient design to get maximum power to the rear wheels
- Require minimal routine maintenance
- Use components that will be quiet during operation
- Provide system to have multiple forward gears and reverse

Implementation

- Use of proven gearboxes and transaxle
- Completely shaft driven, direct coupled driveline
- No use of belts of chain assemblies
- Implement right angle bevel cut spiral gearboxes
- Cub Cadet transaxle gives operator selection of three forward and one reverse gear



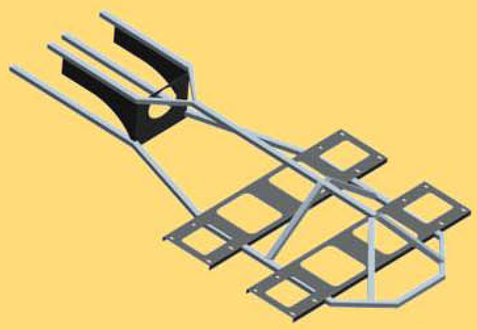
Plot of engine torque curves when set at 72° offset from other four

Vogel Mini Spline Clutch

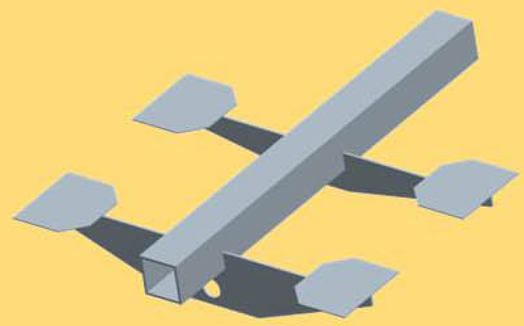
Frame

Objectives

- Lightweight to provide optimal ballast location
- Easily manufactured components
- Rigid structure to support other sub-assemblies
- Improved location of hitch attachment



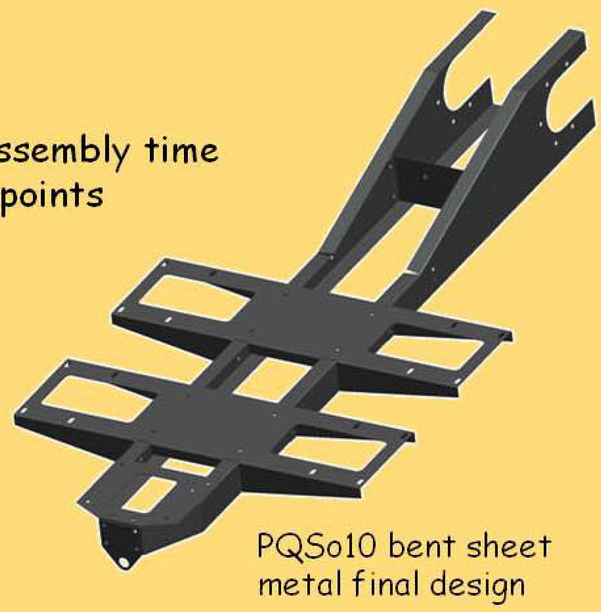
Chrome moly tube frame design



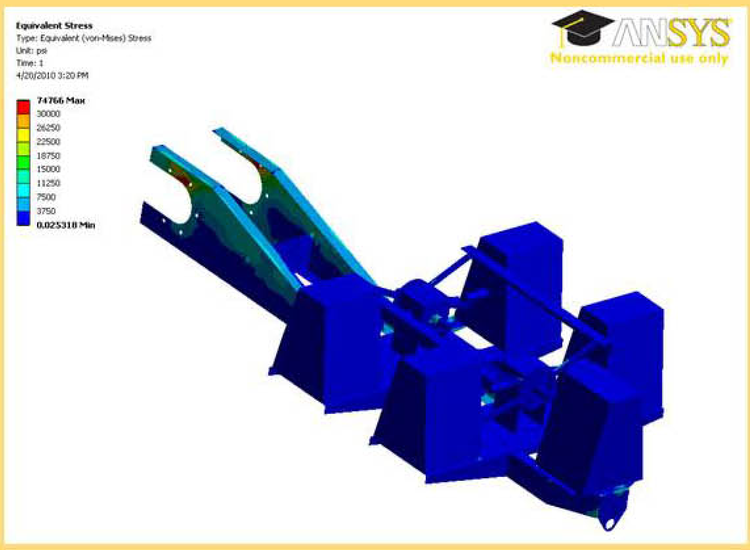
Aluminum mono-tube design

Implementation

- Thin gauge bent sheet metal for all frame members
- Bolted connections of CNC produced parts decreases assembly time
- Boxed-in frame provides strong platform for mounting points
- Relocated hitch from rear of transaxle to frame rails



PQSo10 bent sheet metal final design



Finite element analysis of frame under 3g loading

Tractor Summary

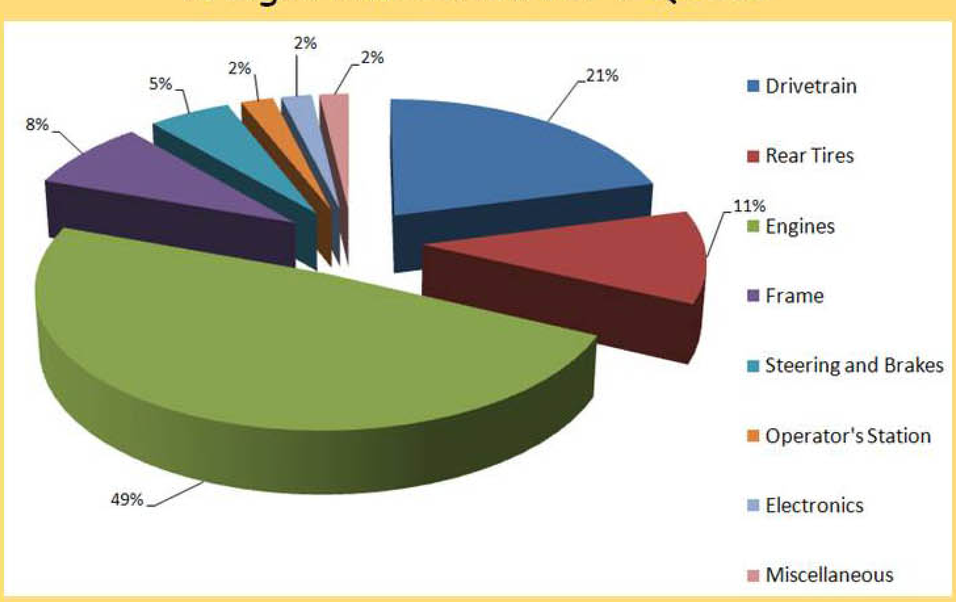
Cost Breakdown for PQSo10

Section	Category	Purchased	Fabricated	Overhead	Total Cost
1	Engine System	$3,299.18	$0.00	$0.00	$3,299.18
2	Transmission/Transaxle	$1,532.00	$0.00	$0.00	$1,532.00
3	Drivetrain	$539.97	$118.82	$0.00	$658.79
4	Tires & Wheels	$231.53	$0.00	$0.00	$231.53
5	Steering	$124.05	$119.91	$0.00	$243.96
6	Frame	$0.00	$432.72	$0.00	$432.72
7	Body	$108.99	$109.98	$0.00	$218.97
8	Brake System	$268.96	$21.94	$0.00	$290.90
9	Electrical System	$307.00	$0.00	$0.00	$307.00
10	Fasteners	$21.71	$0.00	$0.00	$21.71
11	Safety Equipment	$17.35	$2.63	$0.00	$19.98
12	Trim	$46.00	$150.00	$0.00	$196.00
13	Miscellaneous	$9.79	$0.00	$0.00	$9.79
14	Final Assembly	$0.00	$50.63	$40.50	$91.13
	TOTAL	$6,506.53	$1,006.63		$7,553.66

Market Analysis

Cost to Produce	$7,553.66
Suggested List Price	$10,275.24
Profit Margin	36.03%
Estimated Full Production Units	3000
Yearly Profit	$8,164,745.69
Total Number of Parts	287

Weight Allocation for PQSo10



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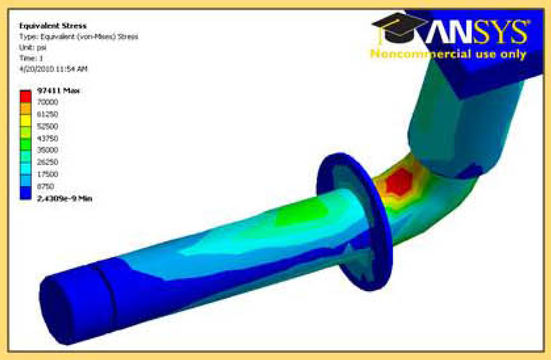
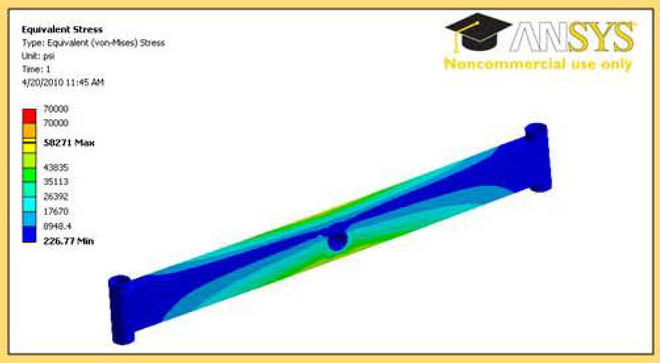
Steering

Objectives

- Reduce number of piece parts
- Easily navigate competition maneuverability course
- Ability to handle forces during pulling competition
- Provide operator with realistic feel of steering



PQSo9 spindle stress analysis

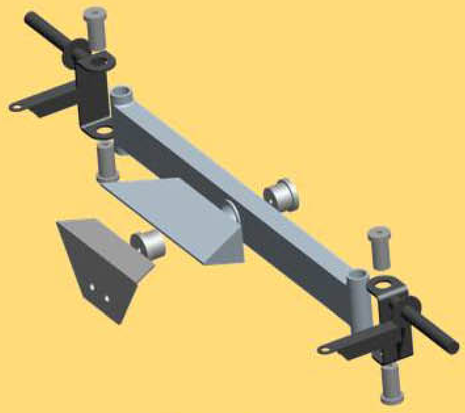


PQSo10 axle stress analysis

Implementation

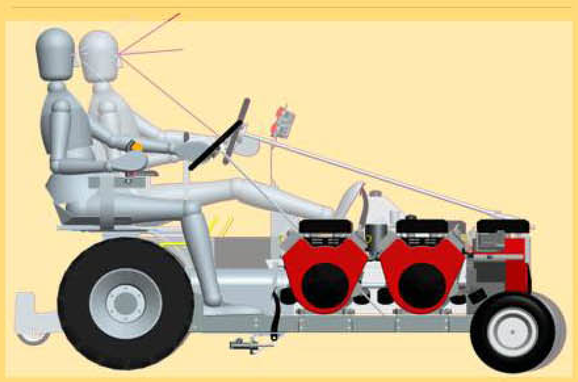
- Use of traditional front axle and spindle design
- Combination of short wheelbase and steering angle produce tight turning radius
- Selection of 4130 steel tube to withstand front-end loading
- Mechanical steering provides feedback to operator

PQSo9 exploded steering view



PQSo10 exploded steering view

Operator's Station



Comparison of PQSo10 to PQSo9 showing improved enter/egress

Sliding seat range of motion for multiple drivers

Armrest with finger tip controls and available IQAN mount

Objectives

- Easily enter/egress tractor operator's position
- Control of tractor at fingertips
- Improved field of vision
- Adjustable to a variety of operators

Implementation

- Lower frame rails allow better clearance
- Armrest instrument panel contains throttle and ignition switches
- Open frame allows visibility of front tires
- Sliding seat and folding steering column provides comfort for all operators

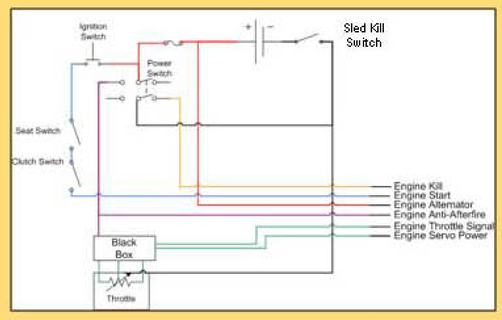
Electronics

Objectives

- Reliable engine control
- Data acquisition during competition pulls
- Separate wiring harness for data acquisition and tractor control

Implementation

- Failsafe wiring system for complete control of engines
- Available IQAN system records vital tractor parameters
- Stand-alone designs for independent operation of systems



Electrical Schematic of engine control harness

IQAN display showing pull data

Servo Throttle Control

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Applied Industrial Technologies
BFM Machining
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Delphi Bodyworks
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