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 1/4 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

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

Puller simulation of different drivetrain configurations
Drivetrain

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

Frame

Objectives

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

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

Tractor Summary

Cost Breakdown for PQS010

<table>
<thead>
<tr>
<th>Section</th>
<th>Category</th>
<th>Purchased/Panished</th>
<th>Overhead</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Engine System</td>
<td>$3,998.96</td>
<td>0.00</td>
<td>$3,998.96</td>
</tr>
<tr>
<td>02</td>
<td>Transmission/Transaxle</td>
<td>$1,532.00</td>
<td>0.00</td>
<td>$1,532.00</td>
</tr>
<tr>
<td>03</td>
<td>Chassis</td>
<td>$509.99</td>
<td>0.00</td>
<td>$509.99</td>
</tr>
<tr>
<td>04</td>
<td>Tires &amp; Wheels</td>
<td>$291.55</td>
<td>0.00</td>
<td>$291.55</td>
</tr>
<tr>
<td>05</td>
<td>Steering</td>
<td>$154.92</td>
<td>0.00</td>
<td>$154.92</td>
</tr>
<tr>
<td>06</td>
<td>Frame</td>
<td>$99.99</td>
<td>0.00</td>
<td>$99.99</td>
</tr>
<tr>
<td>07</td>
<td>Body</td>
<td>$409.96</td>
<td>0.00</td>
<td>$409.96</td>
</tr>
<tr>
<td>08</td>
<td>Brake System</td>
<td>$296.96</td>
<td>0.00</td>
<td>$296.96</td>
</tr>
<tr>
<td>09</td>
<td>Electrical System</td>
<td>$507.00</td>
<td>0.00</td>
<td>$507.00</td>
</tr>
<tr>
<td>10</td>
<td>Fasteners</td>
<td>$21.79</td>
<td>0.00</td>
<td>$21.79</td>
</tr>
<tr>
<td>11</td>
<td>Safety Equipment</td>
<td>$17.99</td>
<td>0.00</td>
<td>$17.99</td>
</tr>
<tr>
<td>12</td>
<td>Tires</td>
<td>$46.99</td>
<td>0.00</td>
<td>$46.99</td>
</tr>
<tr>
<td>13</td>
<td>Miscellaneous</td>
<td>$9.99</td>
<td>0.00</td>
<td>$9.99</td>
</tr>
<tr>
<td>14</td>
<td>Final Assembly</td>
<td>$39.99</td>
<td>0.00</td>
<td>$39.99</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$5,099.95</strong></td>
<td><strong>0.00</strong></td>
<td><strong>$5,099.95</strong></td>
</tr>
</tbody>
</table>

Weight Allocation for PQS010

Market Analysis

- Cost to Produce: $7,553.00
- Suggested List Price: $10,750.00
- Profit Margin: 20.00%
- Estimated Full Production Units: 200
- Yearly Profit: $8,164,500.00
- Total Number of Parts: 200
**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

**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

**Operator's Station**

**Objectives**
- Easily enter/exit 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 rail system 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**
- Fail-safe wiring system for complete control of engines
- Available IQAN system records vital tractor parameters
- Stand-alone designs for independent operation of systems

**Team Sponsors**
- Applied Industrial Technologies
- BF&M Machining
- Cezana Welding
- Delphi Bodyworks
- Dr. Bernie Engel
- Hoosier Pulling Tire

- John Deere
- Motion Industries
- Purdue ASABE
- Purdue Engineering Student Council
- Scott Brand and Barry Williams
- Vogel Manufacturing

**Purdue University**

**Servo Throttle Control**

**IQAN display showing pull data**

**Electrical Schematic of engine control harness**