2016-2017 SAE Baja Design/Manufacturing Project

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Introduction to SAE (Society of Automotive Engineers) Baja Competition-2017

• Four day long competition (May 25\textsuperscript{th} to 28\textsuperscript{th})

• Hosted by Pittsburg State University

• Multidepartment project (MECET, Automotive Technology)
Components of the Event

- Inspection
- Dynamic Event
- Endurance Test
- Design Finals
Problem Statement

• Car that can function pass SAE inspection

• Strategic car that perform well during the competition

• Meet the budget requirement
Material For The Tubing

<table>
<thead>
<tr>
<th>Material: ASTM A36 Steel</th>
<th>Yield Strength: Min. 36,000 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tensile Strength: 58,000 – 80,000 psi</td>
</tr>
</tbody>
</table>

The reason behind using this material?
Frame

Consideration for manufacturing phase:

• SAE Guideline

• Design compatibility
Manufacture Tools

CHOP SAW

STEEL BURR

BURR REMOVAL

Created By Mohannad Gazzaz
Manufacturing Tools

BURR REMOVAL AND SCUFFING

MILLING MACHINE

Created By Mohannad Gazzaz
Manufacturing Tools

BENDING MACHINE

WELDING MACHINE
Manufacturing Tools

TUPING COPING

WATER JET
## Frame Length, Height, and Width

<table>
<thead>
<tr>
<th>Objective</th>
<th>Outcome</th>
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</thead>
<tbody>
<tr>
<td>Maximum of 108 inches in length</td>
<td>91 inches</td>
</tr>
<tr>
<td>Height is based on the driver</td>
<td>60 inches</td>
</tr>
<tr>
<td>Maximum of 64 inches in width</td>
<td>59 inches</td>
</tr>
</tbody>
</table>
Frame Height and Width
Frame Length:
SAE Baja Suspension

• Overview
  • Definition
    Suspension is the term given to the system of shock absorbers and linkages that connects between a vehicle and its wheels.
  • Purpose:
    • to keep the wheel in contact with the road surface as much as possible
    • to protect the vehicle itself from damage
    • to keep the driver as isolated possible from bumps and vibrations
Front Suspension

• Objectives

<table>
<thead>
<tr>
<th>Objective</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 inches’ suspension travel (minimum)</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>No more than 64-inch distance between front wheels (maximum)</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>15 inches’ front clearance (maximum)</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Compatible dimensions for A-arms design</td>
<td>✓ Complete</td>
</tr>
<tr>
<td>Design and fabricate new suspension system</td>
<td>✓ Complete</td>
</tr>
</tbody>
</table>

Created By Sultan Alshammari
Front Suspension

• Design phase of the front suspension
  • A-arm suspension
  • Mounting tabs or brackets
  • Nylon solid stock inserts
  • Steel heim joint inserts
  • Knuckle spacer

• Material:
  • ASTM A36 Steel Pipes
  • Nylon
Front Suspension Outcomes

Lower A-arm on SolidWorks

Lower A-arm
Front Suspension Outcomes

Upper A-arm on SolidWorks

Lower A-arm

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Front Suspension Outcomes

a) Suspension travel is almost 9 inches (8 inches min.)
b) Distance between front wheel is 59 inches (64 inches max.)
c) Front suspension clearance is 15 inches (max.)
Front Suspension Outcomes

Nylon solid stock inserts on SolidWorks
Front Suspension Outcomes

Steel heim joint inserts on SolidWorks

Steel insert

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Front Suspension Outcomes

Mounting tabs or brackets (water jet)
Front Suspension Outcomes

Knuckle spacer designed by Azmi Awari

Knuckle head spacer designed by Azmi Awari

Knuckle spacer

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Rear Suspension

Three Links Arms:

• Purpose?

• What is the goals?
Rear Suspension

• How to link it to the frame?

The angle shape at the middle of the frame will be Used to link the trailing arm.
Rear Suspension

• Manufacture process:

Purchase Parts:
• 2 off road Tires
• 2 Knuckles
• 2 Shafts
• 2 Fox Racing shocks
• 2 Hubs
• 10 Heim joints
Rear Suspension

- Manufacture process:
  - Parts made in the shop:
    - 2 Trailing Arms (24”)
      (ASTM A36 Steel)
    - 4 Shock mount Brackets
      (ASTM A36 Steel)
    - 4 Support arms (17”)
      (ASTM A36 Steel)
    - 10 Heim inserts
      (ASTM A36 Steel)
Steering System

• Purpose
  • To control the direction of the vehicle direction by turning the front wheels.
Steering System

• Component Parts

• Steering Wheel Handel
Steering System

- Steering Shafts
- Steering Coupler
Steering System

• Rack and pinion & steering boot
Steering System

- Heim Joints
Steering System

• Heim Joints
Steering System

• The Safety in the steering system
  
  • Good component quality.
  
  • Wheel alignment.
    1- To make the directions of the car more accurate.
    2- Avoiding the losing the control of the car.
Steering System

• Wheel alignment.
  Adjusting the angle of the Wheels.
  Toe out
  Toe in
Steering System

- Manufacture

<table>
<thead>
<tr>
<th>DRILL SIZE</th>
<th>DECIMAL EQUIVALENT</th>
<th>TAP SIZE</th>
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<tr>
<td>27</td>
<td>.4130</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>.4219</td>
<td>1/2 - 13</td>
</tr>
<tr>
<td>29</td>
<td>.4375</td>
<td></td>
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<td>64</td>
<td>.4531</td>
<td>1/2 - 20</td>
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<tr>
<td>31</td>
<td>.4688</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>.4844</td>
<td>9/16 - 12</td>
</tr>
</tbody>
</table>
Steering System

• Drawing

FineThreads
Size 1/2
Threads per inch 20
Pitch 0.0500
Steering System

• Manufacture
Steering System

- Ratio

Start

End

405°

30°
Powertrain: Design & Manufacturing Process

- Strategic (Torque vs Speed)
- Availability of products
- Cost
Powertrain Dynamic Test: Torque Requirements 1

- Uphill Climb

Fo = Force needed to be overcome

W = Weight (x and y components included)

Ff = Frictional Force

Fo = Wy + Ff

Torque = Fo * Radius of the wheel
Powertrain Dynamics Test: Torque Requirements 2

• Load carrying capacity test
• Functional requirement: **Overcome static friction**

\[ \text{Fo} = \text{Force needed to be overcome to put the car in motion} \]

\[ W = \text{Weight (Car + Driver)} \]

\[ CL = \text{Carried Load} \]

\[ F_f: \text{Frictional force} \]

\[ F_f = \text{Friction Coefficient} \times \text{Total Load} \]

\[ \text{Fo} > F_f \]

\[ \text{Torque} = \text{Fo} \times \text{Radius of the Wheel} \]
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Calculation</th>
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</thead>
<tbody>
<tr>
<td>Weight Cars (lbs)</td>
<td>450</td>
<td>Total Load to overcome</td>
</tr>
<tr>
<td>Weight Driver (lbs)</td>
<td>200</td>
<td>Total Torque on System</td>
</tr>
<tr>
<td>Max Inclination</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Friction Coefficient</td>
<td>0.28</td>
<td></td>
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</table>
### Dynamic Test: Load Carrying Capacity on a Flat Plane

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Attached Load (lbs)</td>
<td>200</td>
</tr>
<tr>
<td>Friction Coeff.</td>
<td>0.62</td>
</tr>
<tr>
<td>Load Overcome</td>
<td>527 lbs</td>
</tr>
<tr>
<td>Torque Needed</td>
<td>439.1666667 ft*lbs</td>
</tr>
<tr>
<td>Engine Speed (RPM)</td>
<td>Driving Pulley Diameter (in)</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>1315.00</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Driveshaft RPM</td>
<td>Engine Output Torque (ft*lbs)</td>
</tr>
<tr>
<td>292.222222</td>
<td>440.3292776</td>
</tr>
<tr>
<td>Ground Speed (Rear Tires)</td>
<td>11.3017</td>
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</tbody>
</table>
Manufacturing Process

1. Assembly (assembling the purchased parts together)
2. Fabrication (Safety cover)

Purchased parts:
- Engine
- Differential
- CVT Pulleys
- Transmission belt
Engine: Briggs & Stratton 10 HP OHV Intek, Model 19

Input shaft for the differential, prior to attaching the CVT driven pulley

Output shaft for the engine, prior to attaching the CVT drive Pulley

Differential
CVT Assembly

Drive Pulley

Belt

Driven Pulley
Fabricated Part: Safety Cover
## Drivetrain Speed Expectations Vs Manufacturing Outcome

<table>
<thead>
<tr>
<th>Values</th>
<th>Expected Value</th>
<th>Actual Output</th>
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</thead>
<tbody>
<tr>
<td>Overall Efficiency</td>
<td>80%</td>
<td>65%</td>
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<tr>
<td>Ground Speed</td>
<td>35</td>
<td>32</td>
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<tr>
<td>------------------</td>
<td>-----------------------------</td>
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</tr>
<tr>
<td>3800.00</td>
<td>7.00</td>
<td>3.00</td>
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</table>

**Driveshaft RPM**  
**Engine Output Torque (ft*lbs)**

| 844.4444        | 152.3771053                |

**Ground Speed (Rear Tires)**  
32.6588
Drawing:

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Machines Used to make Fuel Box:

Water Jet Cutter

Fuel Box

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Safety: Design Requirement

1- Brake Light:
Type: Polaris #2411450

2- Reverse Light:
Type: Backup light J759
Safety: Design Requirement

3- Kill Switches:
Type: Stock Polaris #4013381.
2 Kill Switches.
External Switch Mount.

4- Belt Restraint:
Metal to Metal Buckle (50 in).
Safety Harness at least (5 point).
Lab Belt and Shoulder Belt.

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5- Helmet & Head Restrain:
Driver helmet (6 in) clearance.
Shoulder, Knee, Hips, Arms Elbow, Hands (3 in) clearance.

6- Fire Extinguisher:
Quick Release.
Mount on the cockpit Labeled.

Head clearance for the driver
Other Safety Features:

7- Steering Wheel able to replace easily.
8- All wiring must be sealed.
9- Batteries mounted with sound engineering, and able to provide power to brake light etc.
<table>
<thead>
<tr>
<th>#</th>
<th>Item</th>
<th>Description</th>
<th>Subassembly Costs</th>
<th>Vehicle Assembly Labor</th>
<th>Subtotal</th>
<th>Judges Cost Adj.</th>
<th>Form Adjustment</th>
<th>Adjusted Cost</th>
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<tbody>
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<td>Material</td>
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<td>Time(min)</td>
<td>Cost</td>
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<table>
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<th>ILL</th>
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<th>ILL</th>
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</tbody>
</table>

Created By Hani Alnakhly
Conclusion

• How can we improve it better for next year?
• Causes for unmet expectations
• Better analysis
Short Video