Development of a Flexible Fueled Snowmobile Operating on Ethanol Blended Gasoline for the 2011 SAE Clean Snowmobile Challenge
Design Objectives

• Increase sled efficiency
• Decrease noise
• Reduce emissions
• Please riders and outfitters
Design Approach

1. Efficiency
   - Smaller output engine
   - Lighter track
   - Aftermarket ECU

2. Noise
   - Exhaust system
   - Elimination of radiator fan
   - Sound deadening

3. Emissions
   - Flex-fuel
   - Catalytic converter

4. Riders/Outfitters
   - TrailTank
   - GPS feature
   - Ski alterations
Kettering Yamaha FX Nytro

Chassis: 2008 Yamaha FX Nytro
Engine: 2010 Yamaha Vector
Displacement: 1049 cm³
Configuration: Inline Triple Cylinder
Block Material: Aluminum
Valve Actuation: DOHC
Ignition: Coil on plug
Valves per cylinder: Three
Compression ratio: 11.3:1
Bore: 82 mm (3.23 in)
Stroke in/mm: 66.2 mm (2.61 in)
Aspiration: Normal
Engine Control System: BigStuff3
Snowmobile Weight: 237 kg (522 lb)
Front Suspension Travel: 216 mm (8.5 in)
Rear Suspension Travel: 368 mm (14.5 in)
Track Length: 3073 mm (121 in)
Efficiency

- Engine Swap
  - Replaced Yamaha Genesis 130 with Yamaha Genesis 120
  - Same displacement (1049 CC)
  - Different cams
    - Improve fuel economy
    - Reduce horsepower
Efficiency

- Aftermarket ECU
- BigStuff3
  - Microprocessor Performance
    - Quick computation ability
  - Sequential fuel control for up to 16 cylinders
  - Fuel and spark control
  - Self correction

![BigStuff3 Microprocessor Performance Comparison](chart.png)
## Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Stock Nytro Track</th>
<th>Camoplast Ripsaw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Ply</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Clip Configuration</td>
<td>Full</td>
<td>Every 3rd / open windows</td>
</tr>
</tbody>
</table>

Camoplast Ripsaw
Noise

- Dual muffler exhaust with tunnel exit
  - Reduces heat in engine compartment
- Elimination of radiator fan
- Dynamat sound-deadening material in body panels and engine bay
- Rubberized sound-deadening coating in tunnel
- Flexible snow flap
Noise

- Dynamat Sound-Deadening
  - 2008 Honda Element
  - 18.1 dB reduction

Source: Dynamat Test Results Material
Kettering University first demonstrated snowmobile operation using E85 during testing at Southwest Research Institute in 2002.
Emissions

- Flex-Fuel Capable
- System Modifications
  - Closed loop system
  - Ethanol compatible fuel lines and filter
  - In-line Walbro fuel pump
  - AEM fuel pressure regulator
Emissions

- Heraeus 3-way catalytic converter
  - Custom honeycomb built using emission testing data
  - Convert hydrocarbons, CO and NOx in parallel
  - Small quantities of precious metals used which considerably reduces cost
### Emissions

#### Comparison of 2010 Snowmobile Operating on E21 to the 2012 Federal Emissions Standards

<table>
<thead>
<tr>
<th>Snowmobile/Std</th>
<th>CO, g/kW-hr</th>
<th>HC+NOx, g/kW-hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 Standard</td>
<td>275</td>
<td>90</td>
</tr>
<tr>
<td>2010 KU CSC</td>
<td>59.1</td>
<td>9.5</td>
</tr>
<tr>
<td>% Difference</td>
<td>79%</td>
<td>89%</td>
</tr>
</tbody>
</table>

#### Detailed Emissions Results for 2010 Snowmobile Operating on E21

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO, g/kW-hr</td>
<td>59.1</td>
</tr>
<tr>
<td>HC, g/kW-hr</td>
<td>1</td>
</tr>
<tr>
<td>NOx, g/kW-hr</td>
<td>8.5</td>
</tr>
<tr>
<td>HC+NOx, g/kW-hr</td>
<td>9.5</td>
</tr>
<tr>
<td>CH4, g/kW-hr</td>
<td>3.22</td>
</tr>
<tr>
<td>Soot, g/kW-hr</td>
<td>342.8</td>
</tr>
</tbody>
</table>
Riders/Outfitters

1. TrailTank
   - Increase fuel capacity from 7.4 gal. to 10 gal.

2. GPS
   - Emergency situations
   - Outfitter tracking

3. Ski modification
   - Adjusted ski angle creates improved handling

4. Routing exhaust underneath seat
   - More weight rearward for better overall balance
Cost

- **MSRP**
  - Base snowmobile — $10,669
  - Modified snowmobile — $14,328
- **Price Disparity**
  - Custom catalyst honeycomb — $600
  - In-line Walbro fuel pump — $210
  - Additional Muffler — $250
Conclusion

- Low emissions
  - Noise
  - Exhaust
- Fuel efficient
- Rider friendly
- Cost competitive
Thanks to our 2011 Sponsors!

Yamaha
Heraeus
Corn Marketing Program of Michigan
Michigan Corn Growers Association
Big Stuff
Walbro
Trail Tank
Camoplast
Bosch
Department of Energy, Labor & Economic Growth