

A photograph of a person riding a snowmobile through deep snow. The rider is wearing a blue and white jacket and gloves. The snowmobile is blue and black, with 'Nitro' visible on the side. The background shows snow-covered trees. The text 'Kettering University' is overlaid in a large, white, serif font with a black outline.

Kettering University

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
Genesis 120

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)



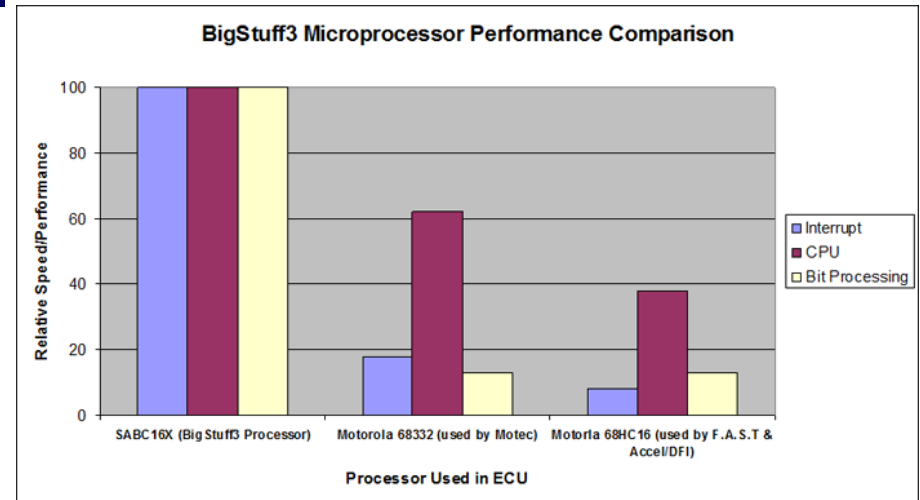
Efficiency

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



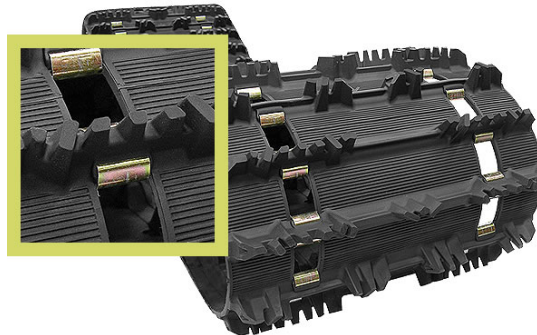
Efficiency

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



Efficiency

	Stock Nytro Track	Camoplast Ripsaw
Single Ply		X
Weight (lbs)	39	35
Clip Configuration	Full	Every 3rd / open windows



Camoplast Ripsaw

Noise

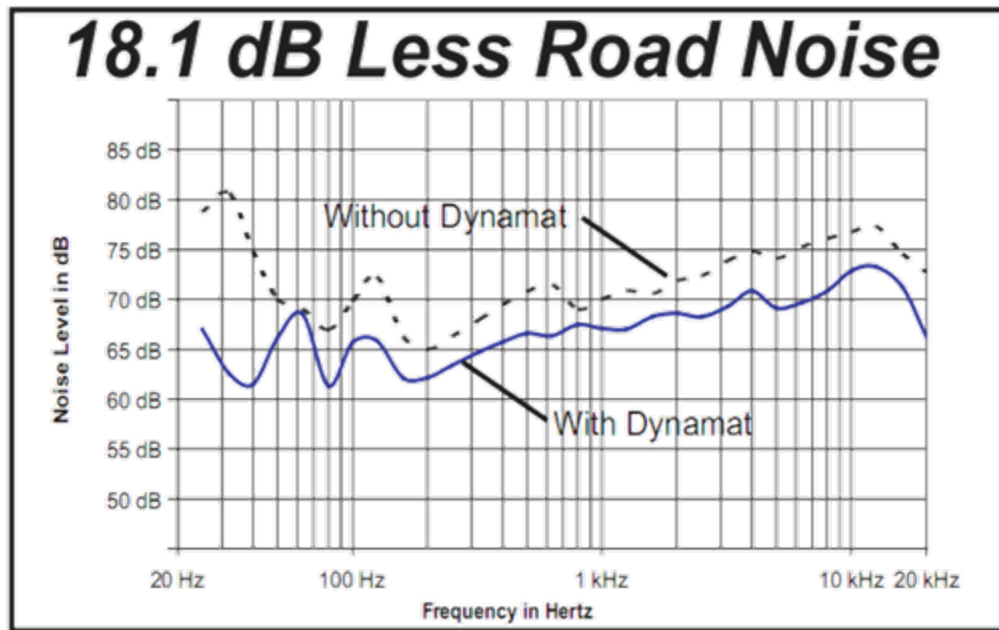
- Dual muffler exhaust with tunnel exit
 - Reduces heat in engine compartment
- Elimination of radiator fan
- Dynamat sound-deadening material in body panels and engine bay
- Rubberized sound-deadening coating in tunnel
- Flexible snow flap



Noise

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

ROAD NOISE TEST

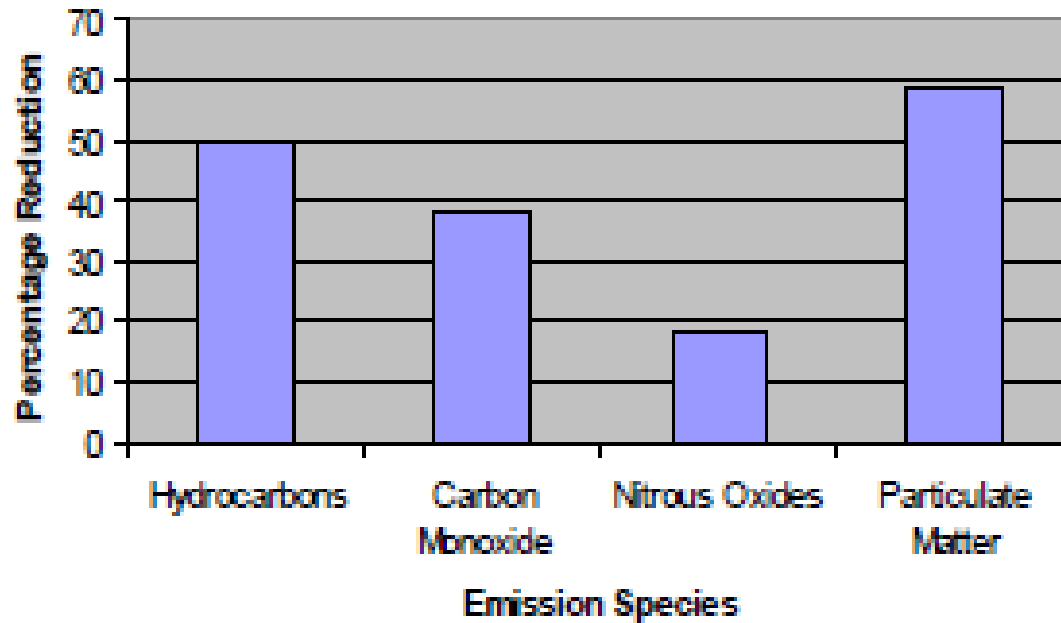


Source: Dynamat Test Results Material



Emissions

Reduction in Snowmobile Engine Emissions
Using E85 as Compared with Gasoline



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

Snowmobile/Std	CO, g/kW-hr	HC+NOx, g/kW-hr
2012 Standard	275	90
2010 KU CSC	59.1	9.5
% Difference	79%	89%

Detailed Emissions Results for 2010 Snowmobile Operating on E21

CO, g/kW-hr	59.1
HC, g/kW-hr	1
NOx, g/kW-hr	8.5
HC+NOx, g/kW-hr	9.5
CH ₄ , g/kW-hr	3.22
Soot, g/kW-hr	342.8



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



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