

University of Wisconsin Madison 2007 SAE Clean Snowmobile Challenge

Design Presentation



Presented by:

Steve Lukas Adam Schumacher





- Engine emissions from current snowmobile engines
- Ski-doo SDI system reduces two stroke emissions by 50%¹
- Stock Polaris FS engine meets 2012 Emissions Certification

Engine Selection

Snowmobile Engine Emissions Testing

	HC g/kW-hr	CO g/kW-hr	NO _x g/kW-hr
Two-stroke average (SwRI 2002)	189	517	0.72
Arctic Cat 660 (4s) (SwRI 2002)	6.2	79.9	10.6
Polaris Liberty (4s) (SwRI 2002)	3.2	79.1	7.0
Polaris FS (4s)	9.3	38.6	1.5

1: http://www.ski-doo.com/media/2004_SOTY.pdf



Powertrain Implementation

- Engine Mounts
 - Rubber vibration isolation mounts in non-parallel planes
 - Optimal center to center clutch distance





- Air Box
 - Shaped to maximize air flow and minimize size
 - Covered with sound dampening rubber
 - Intake location chosen to minimize induced air temperatures

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Engine Management

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Mototron's Motorola Powertrain Control Module

-40° to 130 ° C 18 g Shock Load Up to 3 Meters Under Water Simulink Engine Model MotoHawk Auto-code Generation





E85 Calibration

- DYNOmite Water-Brake Dyno
- Horiba CO & CO₂ Analyzer
- HEGO sensor
- Chemiluminest NOx Analyzer
- Exhaust Thermocouples
 - Calibrated Spark Advancement and Volumetric Efficiency utilizing E10 Gasoline
- Changed Global Air/Fuel Ratio
- Refined Spark and VE Tables

8.69% Gain in Peak Power!



Emissions Reduction



Emissions Benchmark

Comparison of Emissions Before and After Catalyst

2006 Emissions Testing Results•96% reduction from stock•Best Emissions Award in 2006 CSC







Emissions Reduction

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Improvements for 2007

- Engine calibrated to run stoich at all engine speeds and loads
- Exhaust system re-designed to minimize weight, engine back-pressure and risk of pre-catalyst leaks
- Four W.C Heraeus GmbH Catalyst





Sound Testing



Contributions of Components to Overall Noise

Clutch

Plus skirt

Exhaust Clutch

Front Bogies

Only

Exhaust

Exhaust Clutch

Plus skirt

and hood

Test Type

Exhaust Clutch

Without

Bogies

68

66

Exhaust Clutch

With Bogies

Exhaust Clutch

Plus skirt

Exhaust Clutch

Plus hood

cover







Sound Reduction

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Engine

- Three Stage Exhaust System
 - Catalysts
 - High Frequency Diffuser
 - Arctic Cat T660 Muffler









Total Sound Reduction

- Track noise greatly decreased by installation of Arctic Cat Silent Track
- Engine noise appears to be the only audible snowmobile sound, showing reduction of track noise
- Measured sound level of 73.2 dBA sound level based on pass by testing, which meets SAE Standard J192
 - 4 dBA reduction from 2006 CSC

Weight Reduction / Additional Feature

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- Evaporative Emissions System
 - Reduces HC Emissions from thermal cycling of fuel tank

- Muffler
 - T660 muffler is approximately 7 Ibs lighter than stock FS muffler
- Front Suspension
 - 12 lbs lighter
 - Shorter turning radius
- Polycarbonate Hood
- Hollow Drive Shaft





- Sled modifications
 - Trailing arms
 - Arctic Cat exhaust
 - Rapid prototype battery-box
 - Larger fuel injectors
 - Moto-tron ECU system
 - E-85 compatible fuel components
 - EVAP system
 - Arctic Cat Silent Track
 - LED headlights and taillights
 - Raw materials for custom fabricated parts
 - Sound damping materials
 - Lightweight Drive Shaft

ltem	2007 UW-Madison Bucky Classic 750	2003 Polaris Frontier Classic
2003 Frontier Classic	\$5,899	\$5,899
Sled Modifications	~\$5,190	None
FS Engine	~\$3,000	None
Engine Coating	\$142	None
Catalysts (4)	\$238	None
Prototype Cost Retail	\$14,469	\$5,899

Projected Cost



Questions?



Emissions Testing Modes

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Clean Quiet FAST

	Engine Speed (rpm)	Torque (N-m)	Power (kW)
Mode 1 (WOT)	8000	54.9	46.0
Mode 2 (85%)	6800	28.0	19.9
Mode 3 (75%)	6000	18.1	11.4
Mode 4 (65%)	5200	10.7	5.8
Mode 5 (idle)	1700	1.4	0.2





	Gasoline Injector	Ethanol Injector
Bosch Part #	0 280 156 236	0 280 156 290
Body Color	Yellow	Black
60 Sec Flow	213 g	400 g
Impulse Flow	6.3 mg	11.2 mg
Impulse Time	2.5 ms	2.5 ms
Rail Pressure	300 kPa	300 kPa
Driver Stage	SEFI	SEFI



Frictionless Coatings





Exhaust





Drive Shaft





LED Headlights

