



Kettering University

Development of a Flexible Fueled Snowmobile for the
2013 SAE Clean Snowmobile Challenge

Design Approach

1. Versatility

- Performance 90 hp class snowmobile
- Mode switch increases fuel economy, limits power for inexperienced riders

2. Advanced Controls

- Electronic Throttle
- New affordable flex fuel sensor
- Intelligent boost control

3. Noise Attenuation

- Affordable, lightweight silencer with acoustic valve
- Tunnel lining

4. Emissions

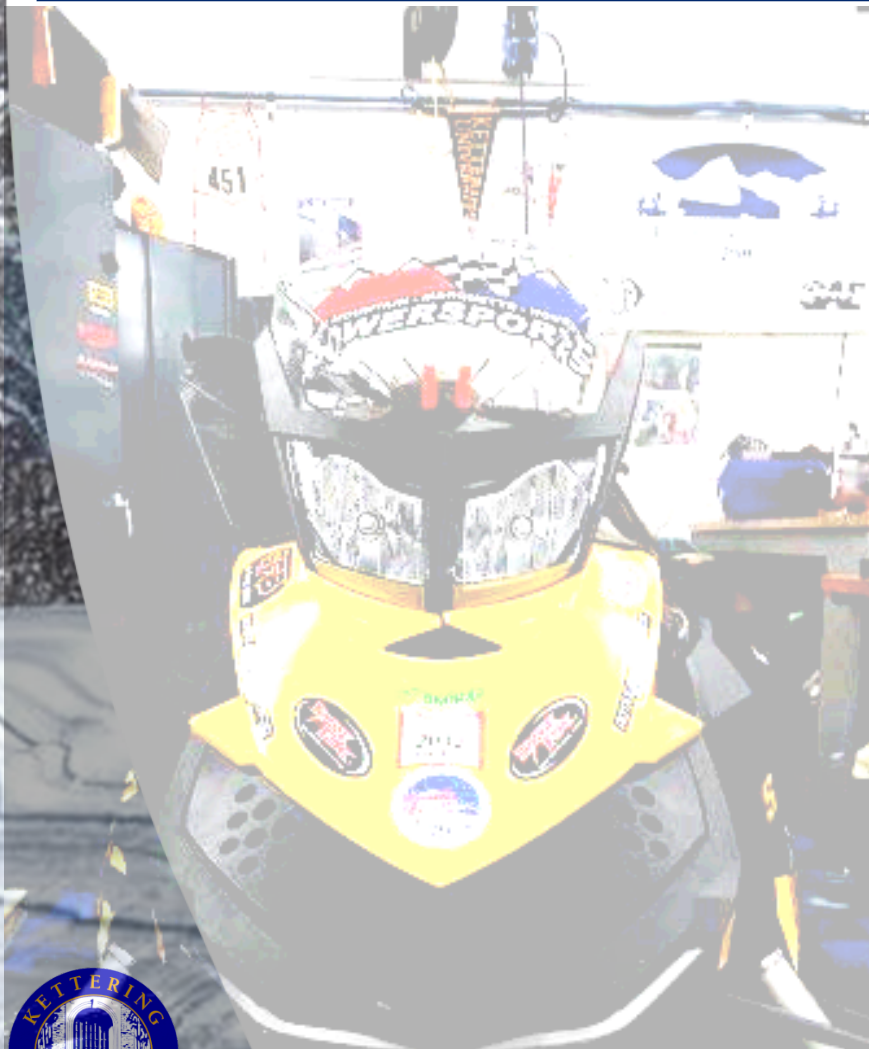
- Three way catalyst with application-specific washcoat
- Extended lean-burn calibration

5. Dynamic Performance

- Light weight, adjustable FAST air shocks
 - Light weight carbon synchronous belt drive
 - Camoplast Ice Attack XT prestudded track
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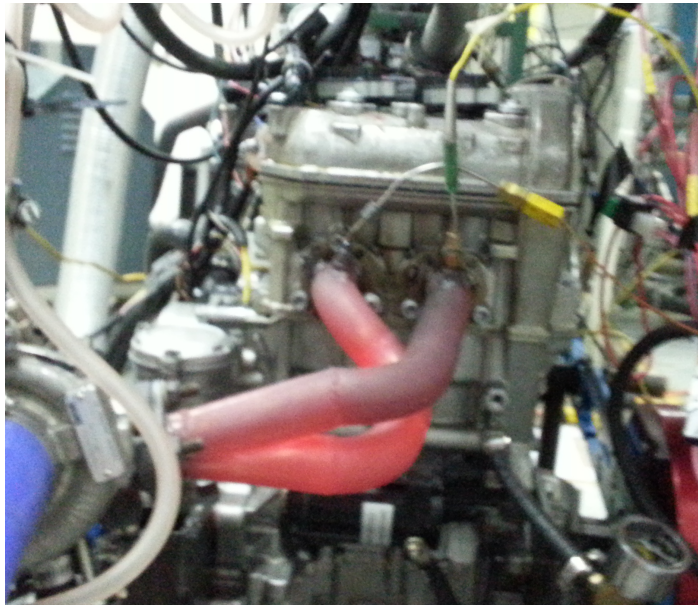


Kettering 2011 Skidoo MXZ Sport

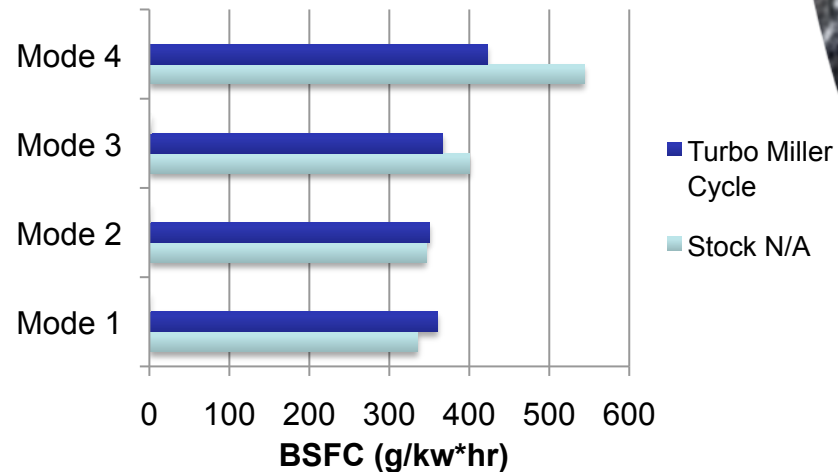


Chassis:	2011 Skidoo MXZ Sport
Engine:	Rotax 600 ACE Miller Cycle Turbo
Displacement:	600 cm ³
Configuration:	Inline Two Cylinder, Odd-Fire
Block Material:	Aluminum
Valve Actuation:	DOHC Cam on Bucket
Ignition:	Bosch Coil on Plug, 3D spark map
Valves per cylinder:	Four
Compression ratio:	12:1
Bore x stroke:	74 x 69.7 mm
Turbocharger:	Garrett MGT1238
Max Boost Pressure:	8.7 psi
Engine Controller:	Woodward MotoTron/ProEFI 128
Snowmobile Weight:	482 lb with fluids, no fuel
Clutch Engagement:	2800 rpm
Fuel:	Flex-Fuel Ethanol
Track:	120x15x1.5 Camoplast Ice Attack XT

Miller Cycle 600 ACE Engine



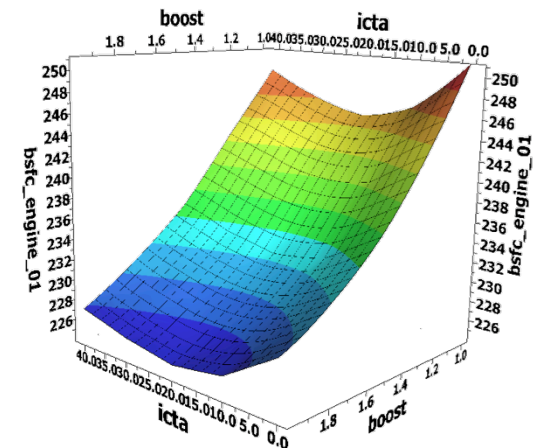
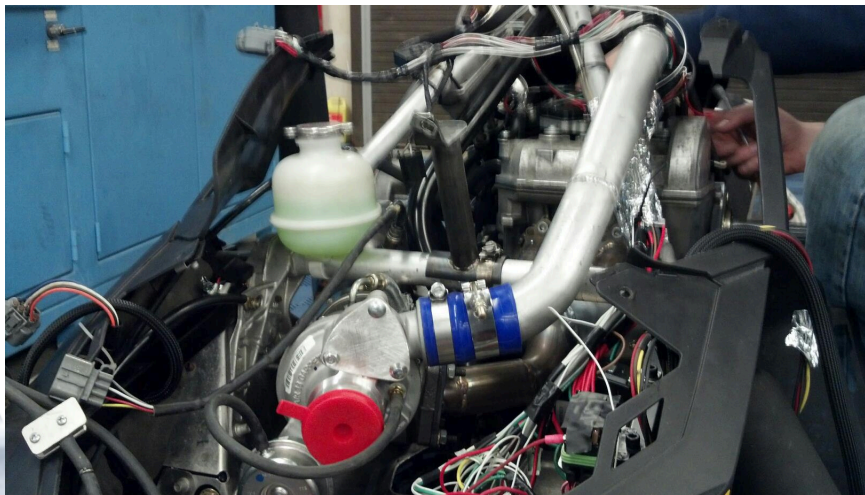
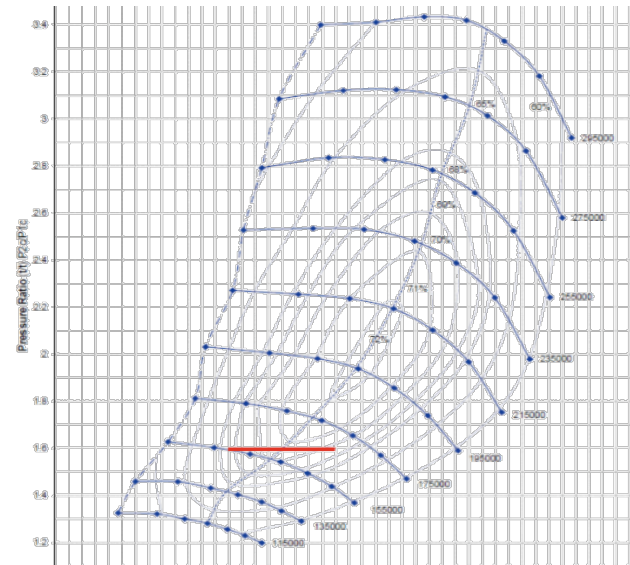
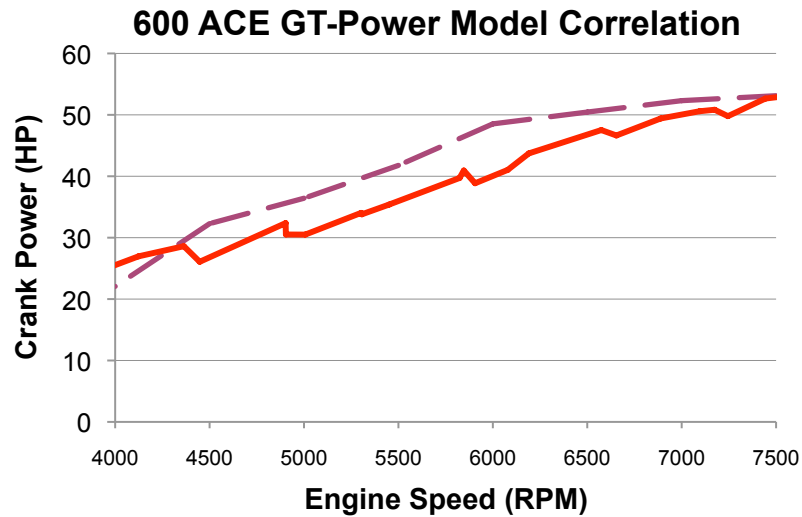
Emissions Mode BSFC--E65 fuel



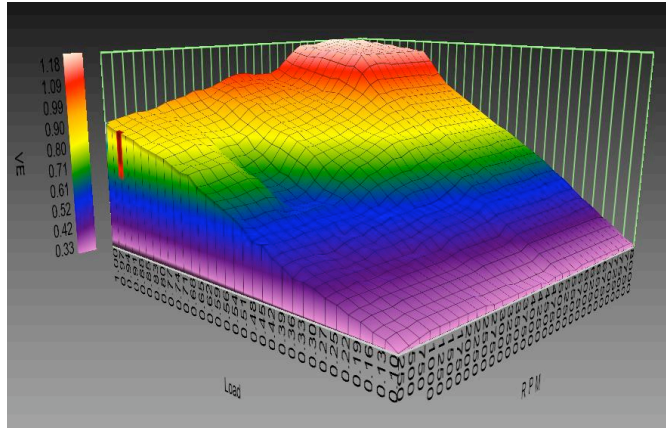
- Stock 12:1 compression ratio to preserve efficiency
- Late intake valve closing for reduced pumping losses
- Increased torque with turbocharger boost
- Decreased modal BSFC from stock naturally aspirated
- Improved vehicle performance—appeals to more riders



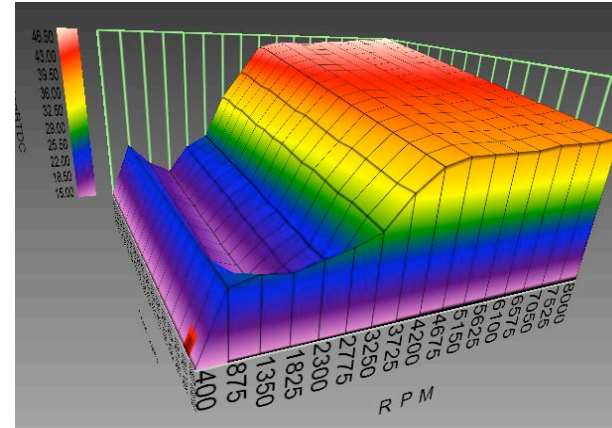
Engine Simulation and Compressor Matching



Controls and Calibration



3D Volumetric Efficiency Map

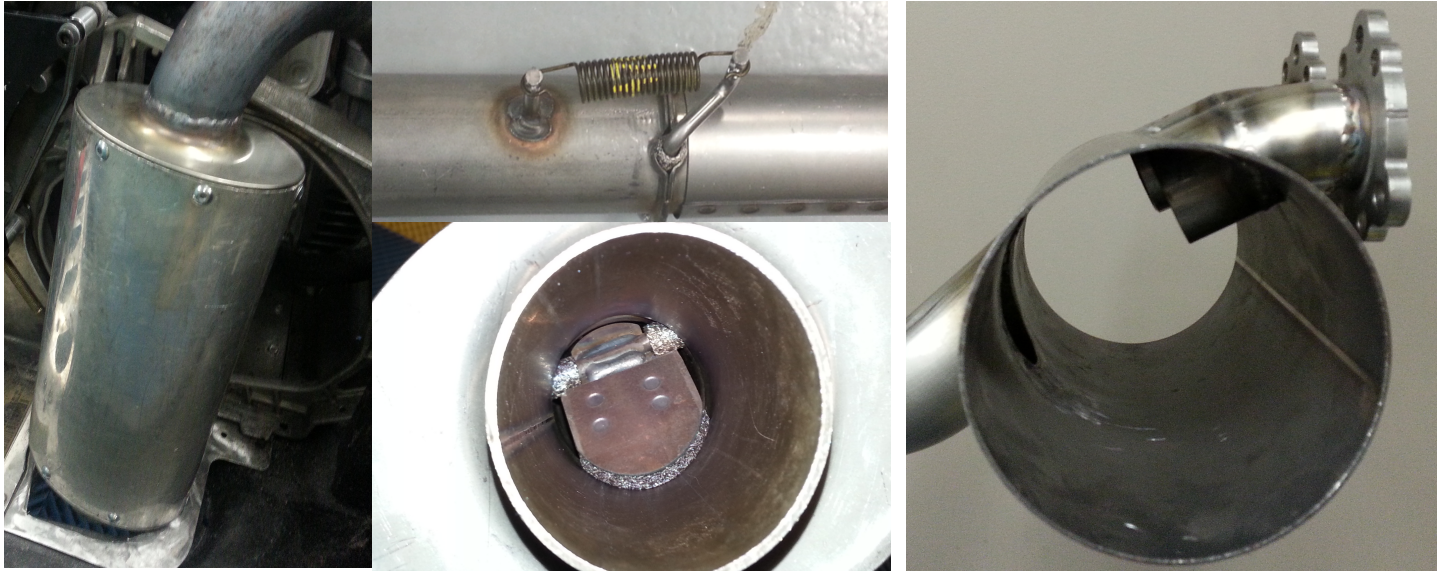


3D Ignition Timing Map

- Lean calibration of standalone ProEFI 128 ECU maintains and betters stock fuel efficiency
- New-generation GM flex fuel sensor costs only \$50
- Closed-loop wideband oxygen sensor control
- 21 mpge on 90 mile trail test



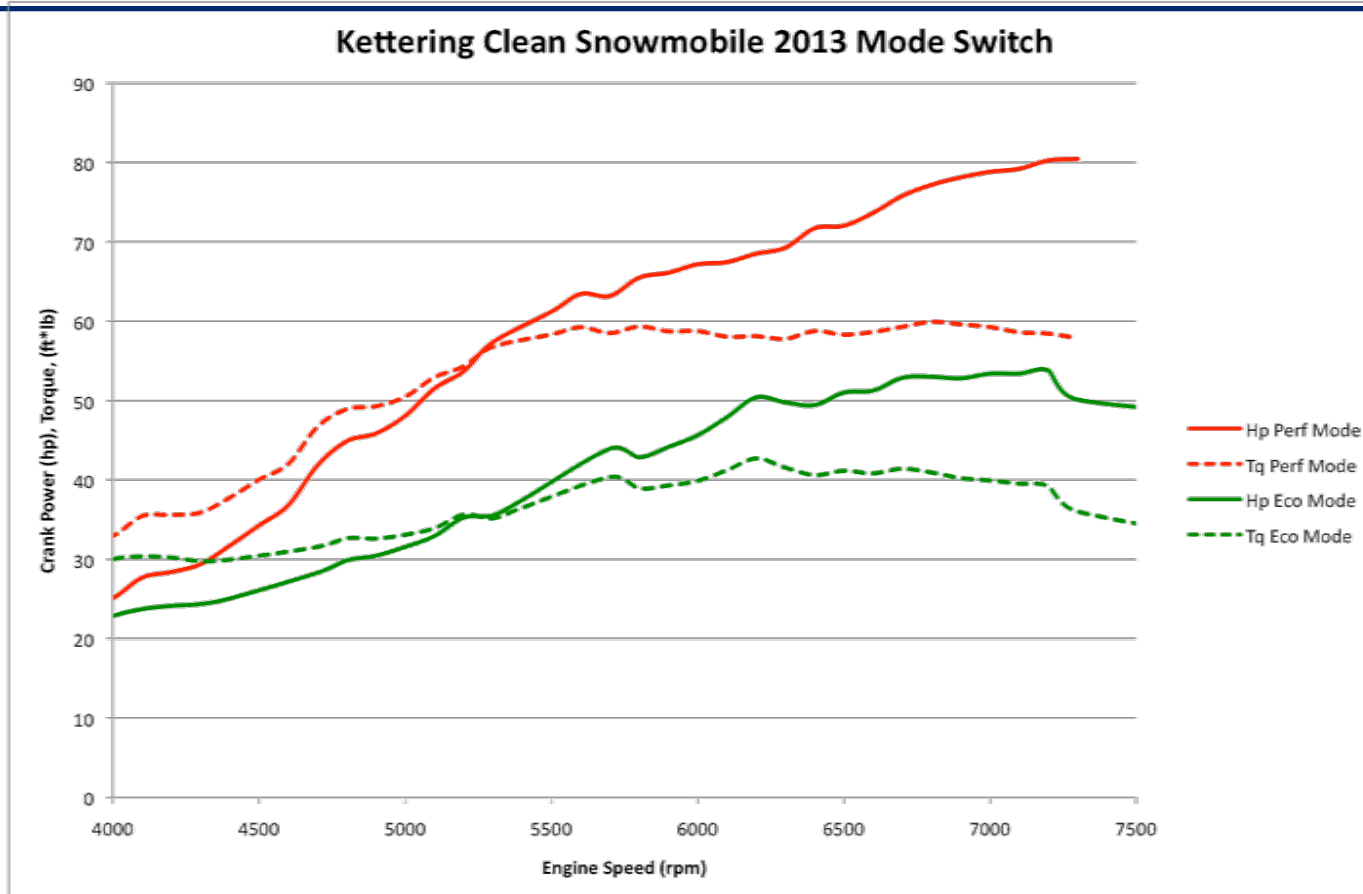
Silencer design



- Silencer weighs 3 lb, cost is \$50
- Passive acoustic valve is in production on passenger cars
- Resistive tuning attenuates low-frequency content
- Valve opens with increased mass flow in performance mode
- Pre-turbo plenum provides noise attenuation and prevents wastegate boost creep
- Stock muffler weighs 16.75 lb, costs \$1171 to replace



Performance/Economy Switch

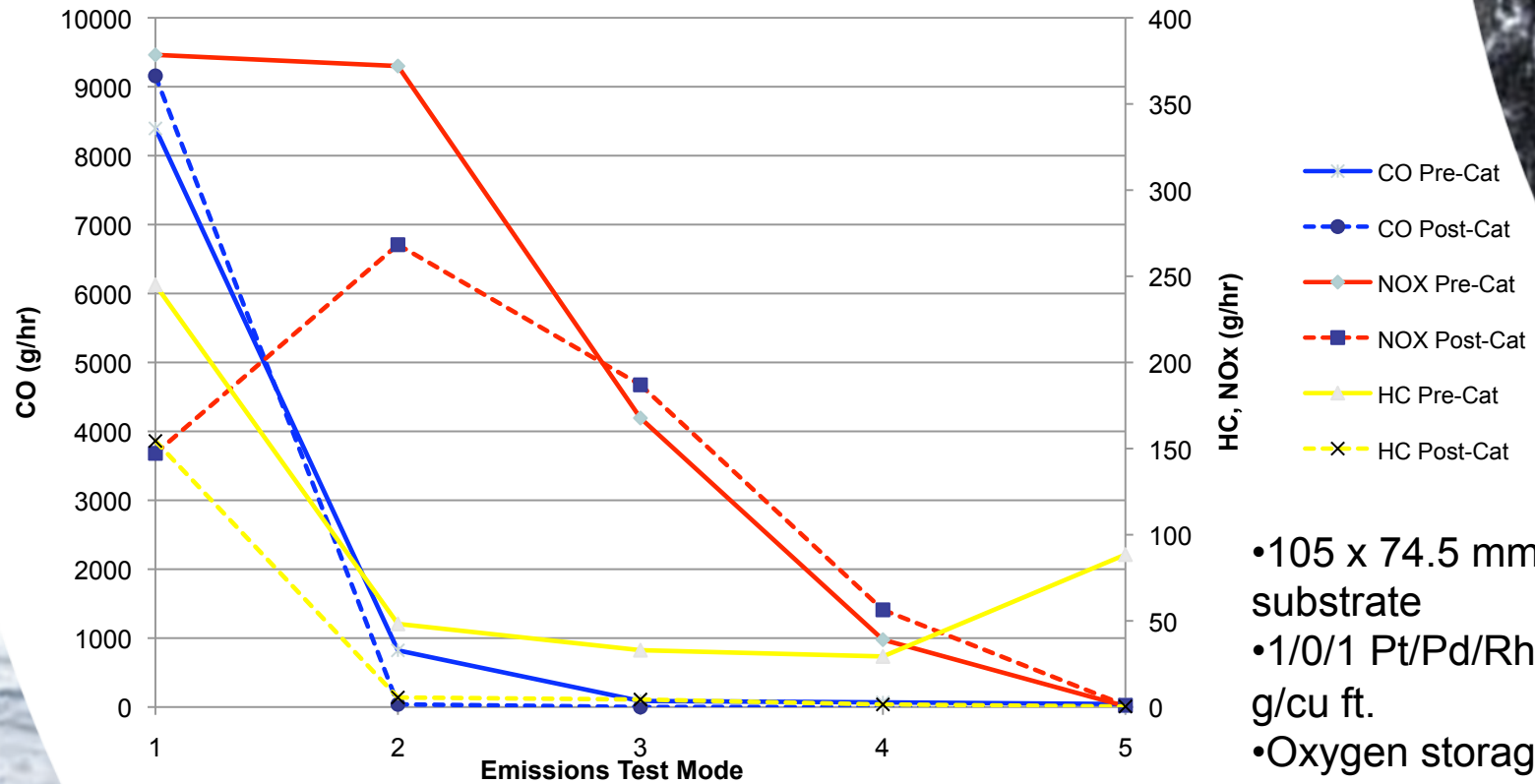


- Switches throttle mapping and maximum boost pressure
- Performance mode capable of 93 hp
- Economy mode limits snowmobile to 50 mph on trail



Results—Emissions

Kettering CSC 2013 Emissions--Pre and Post Catalyst



- 105 x 74.5 mm substrate
- 1/0/1 Pt/Pd/Rh, 33 g/cu ft.
- Oxygen storage for NOx conversion

- E-score with catalyst: 203
- E-score for BAT: 170
- E-score without catalyst: 190



Dynamic Performance--Light Weight

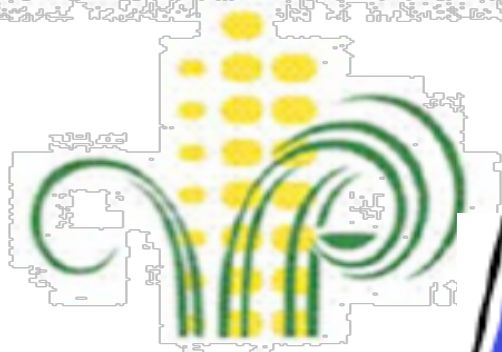
- 482 lb with fluids, without fuel
- Lightest snowmobile at CSC 2013
- Camoplast Ice Attack XT track
 - 120x15x1.22 size, prestudded
 - Increased traction for all-condition performance
 - Single-ply, 36 lb weight
- Carbon synchronous belt final drive
 - 5 lb reduction in rotating mass
 - Quick final drive ratio change
 - Easy belt change, no oil
- Team FAST TRI-Tek Air Shocks
 - 3 lb weight savings
 - Adjustable rate with air pressure for rider customization

An efficient, quiet, low-emissions performance trail sled to enjoy in fast company!



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