



Kettering University

Development of a Flexible Fueled Snowmobile
Operating on Ethanol Blended Gasoline for the 2012
SAE Clean Snowmobile Challenge

2012 Team and Snowmobile

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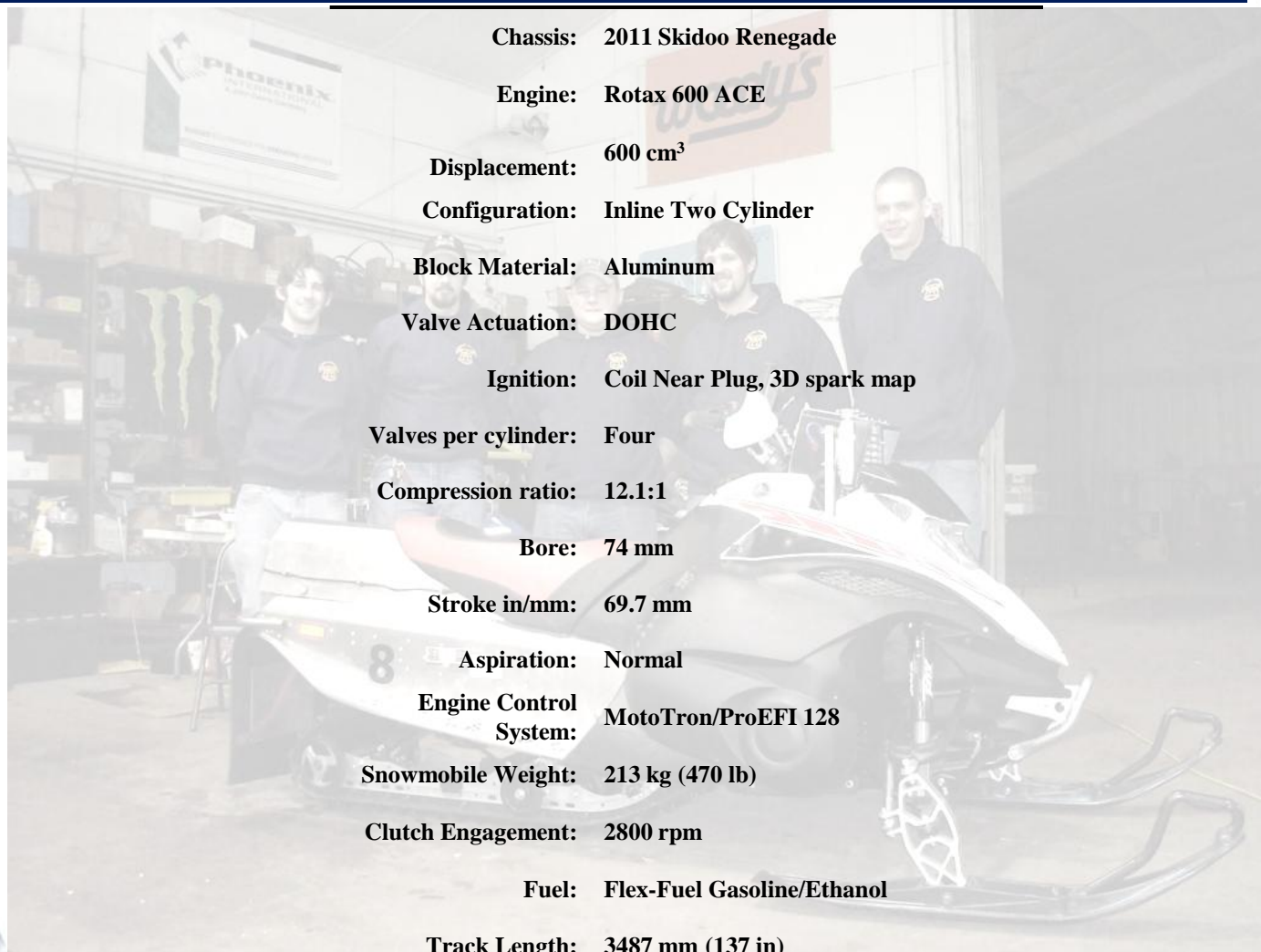
Andrew Phillips



2011 Skidoo Renegade
600 ACE



Kettering Skidoo Renegade



Chassis: 2011 Skidoo Renegade

Engine: Rotax 600 ACE

Displacement: 600 cm³

Configuration: Inline Two Cylinder

Block Material: Aluminum

Valve Actuation: DOHC

Ignition: Coil Near Plug, 3D spark map

Valves per cylinder: Four

Compression ratio: 12.1:1

Bore: 74 mm

Stroke in/mm: 69.7 mm

Aspiration: Normal

Engine Control System: MotoTron/ProEFI 128

Snowmobile Weight: 213 kg (470 lb)

Clutch Engagement: 2800 rpm

Fuel: Flex-Fuel Gasoline/Ethanol

Track Length: 3487 mm (137 in)



Design Approach

1. Efficiency

- 600 ACE lean-burn engine
- Lightweight chassis
- Standalone ECU

2. Seamless Flex Fuel

- Advanced 32-bit ProEFI 128 ECU
- GM/Siemens Flex fuel sensor

3. Emissions

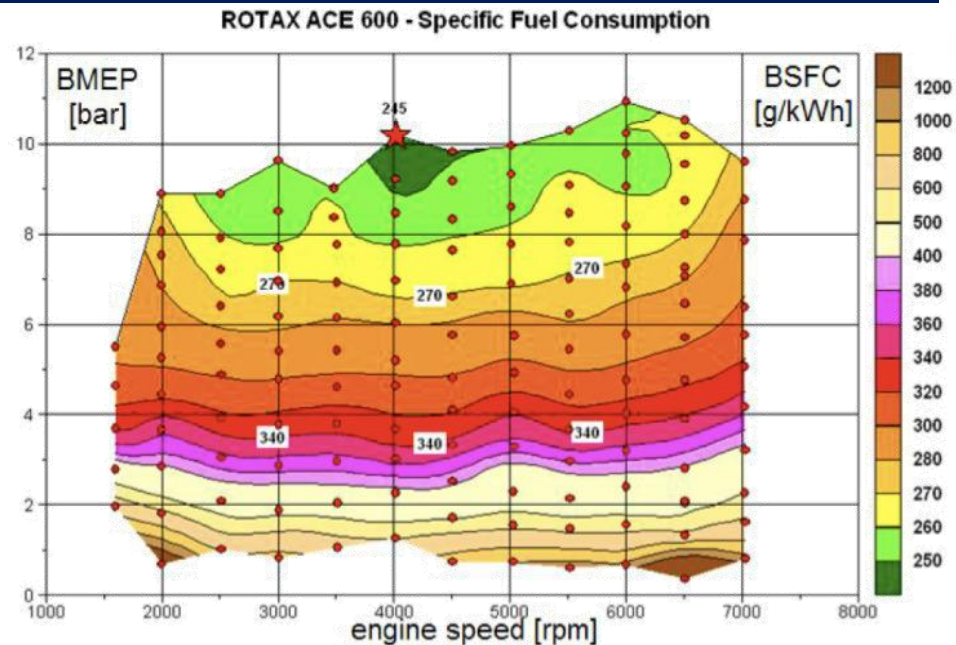
- Close-coupled 3-way catalysts
- Extended lean-burn calibration
- HC-LNC NO_x abatement

4. Noise Attenuation

- Lightweight triflow muffler
- Tunnel lining



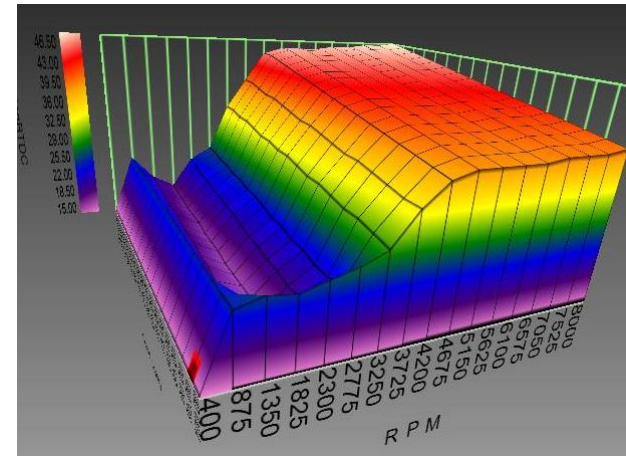
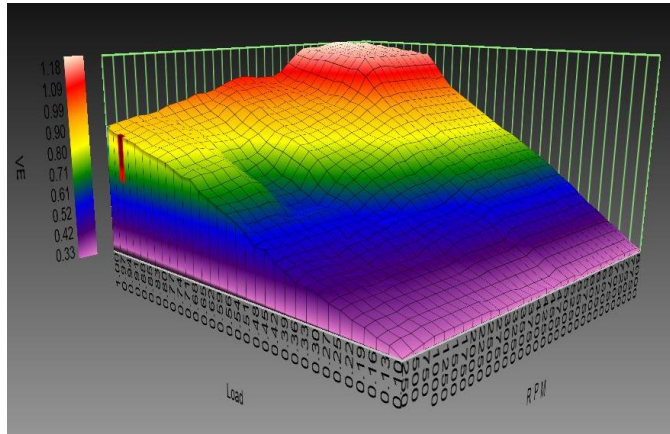
Rotax 600 ACE Engine



4-stroke 600 ACE engine for maximum efficiency

- Diamondlike carbon coatings
- Efficient hemispherical combustion chamber with steep valve angles
- Dry sump and reduced pumping losses

Controls and Calibration

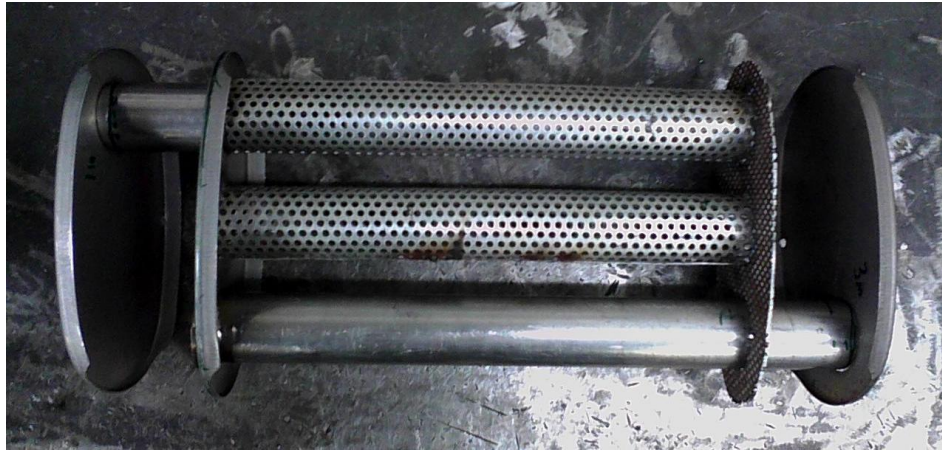


3D Volumetric Efficiency Map 3D Ignition Timing Map

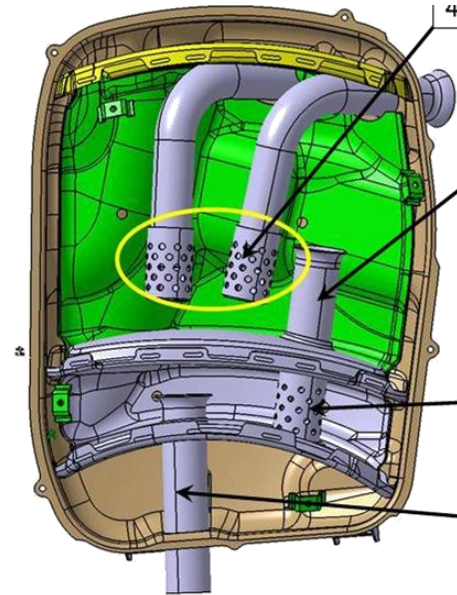
- Lean calibration of standalone ProEFI 128 ECU maintains and betters stock fuel efficiency
- Flex fuel sensor integration ensures accurate fueling E0-E85
- Closed-loop wideband oxygen sensor control
- 20.5 mpg CSC 2012 60 mi test



Triflow muffler design



- KUCSC: 9.5 lbm
- Highly manufacturable and affordable stuffed-cartridge oval design with cont. roving fiberglass
- Broadband reflective, absorptive tuning



- Stock: 16.75 lbm
- Complex stamped shells and partitions
- Resistive tuning--forced flow through perforation

Aftertreatment

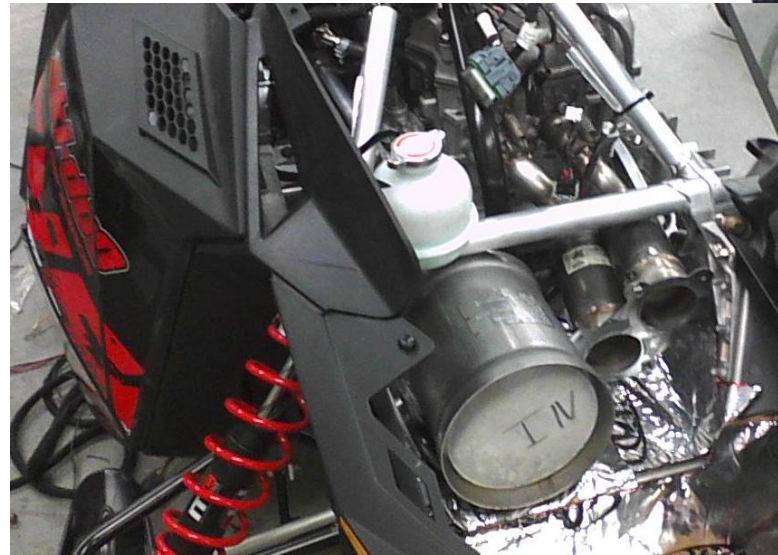
HC-LNC

- Selective catalytic reduction of NO_x to N₂
- Uses E85 as reductant
- Requires no heating element—better suited for cold than urea
- Testing has shown 85-95% NO_x reduction
- Uses onboard fuel in E85-intent application

CC-TWC

- Production Harley-Davidson metallic substrates for suitable space velocity

Platinum/Rhodium loading



Close-couple three-way catalysts and hydrocarbon lean NO_x catalyst



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