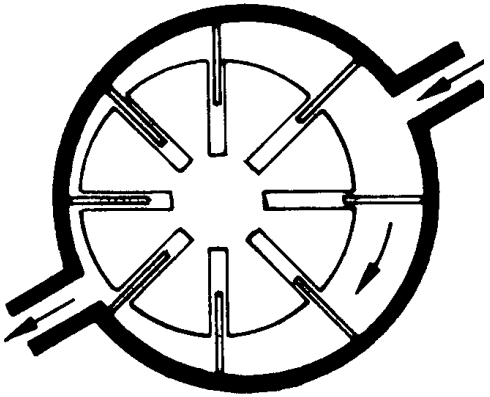
A Throttle Loss Recovery Supercharger For Natural Gas Engine Applications

S. M. Shahed
Honeywell International
Ron Driver
Driver Technologies

DEER Workshop, August 6-10, 01
Portsmouth, VA

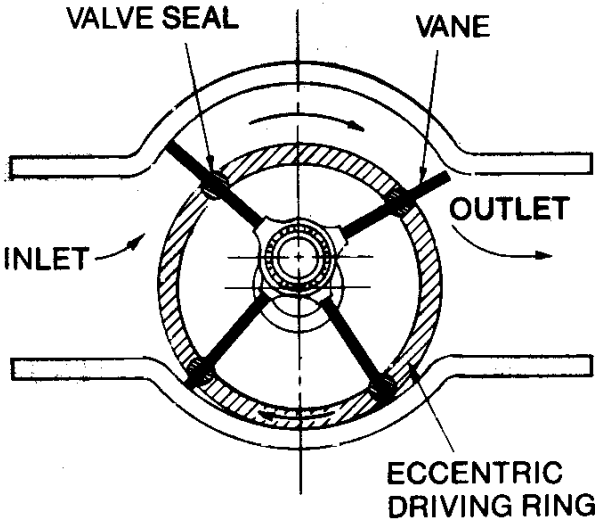
Rotary Vane Compressor as a Supercharger



Very High Friction & Wear
Needs Lubrication
NOT Recommended

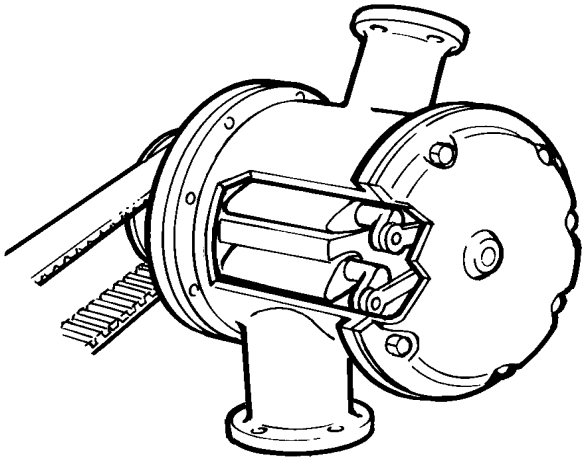
Rotary Slide Vane Pump/Motor

Bendix® Air Pump
Late 1960s



Manufactured for Oxidation Catalysts
Refined Design Pump/Motor
No Lubrication Needed
Low Friction

Garrett® VGS

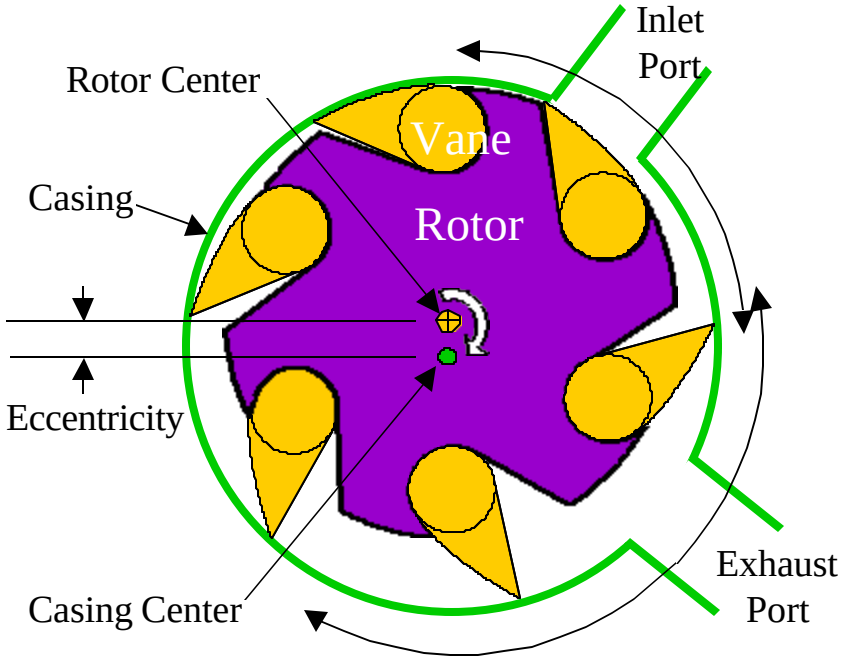


Pivoting Vane Compressor/Expander
Novel Mechanism Controls Vane Movement
Controlled Positive Tip Clearances
High Efficiency and Low Friction

Variable Geometry Supercharger Concept

Positive Displacement Compressor/Expander

- Eccentric Rotor with Pivoting Vanes
- Uses Novel Vane Control Mechanism
  - Constant tip clearance
  - No running contact
- High Mechanical and Aerodynamic Efficiencies

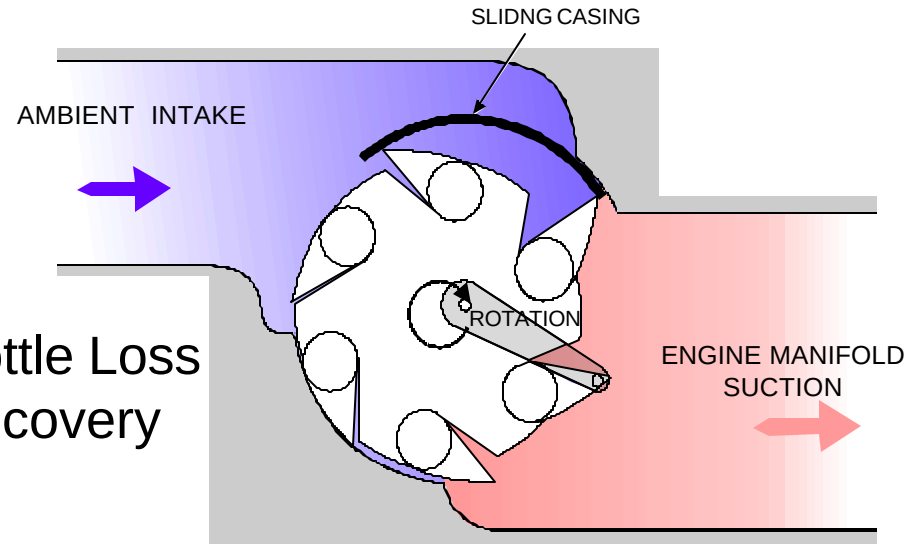


Continuously Variable Inlet and Exhaust Porting Allows Seamless Transition Between Two Modes of Operation:

- Operates as Power Recovery Expander Under Part Throttle Conditions (TLR)
- Operates as Compressor Under Wide Open Throttle (SC)

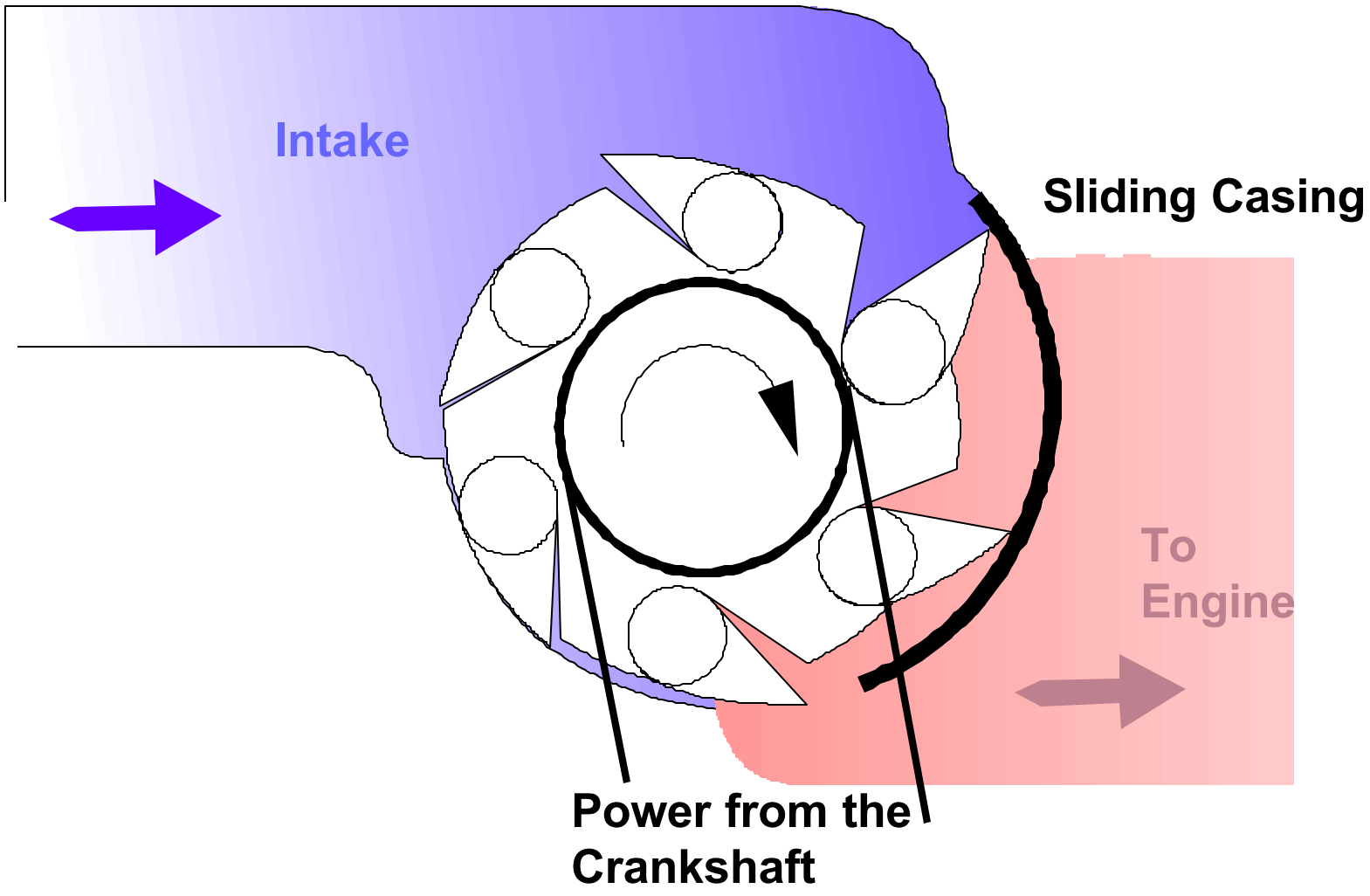
How the Device Works in Throttle Loss Recovery Mode

- Low Speed, Variable, Positive Displacement Compressor/Expander
- Recovers Power Required to Pump Air Through Throttle Restriction Under Part Throttle Operating Conditions and Channels That Power Back To The Crankshaft



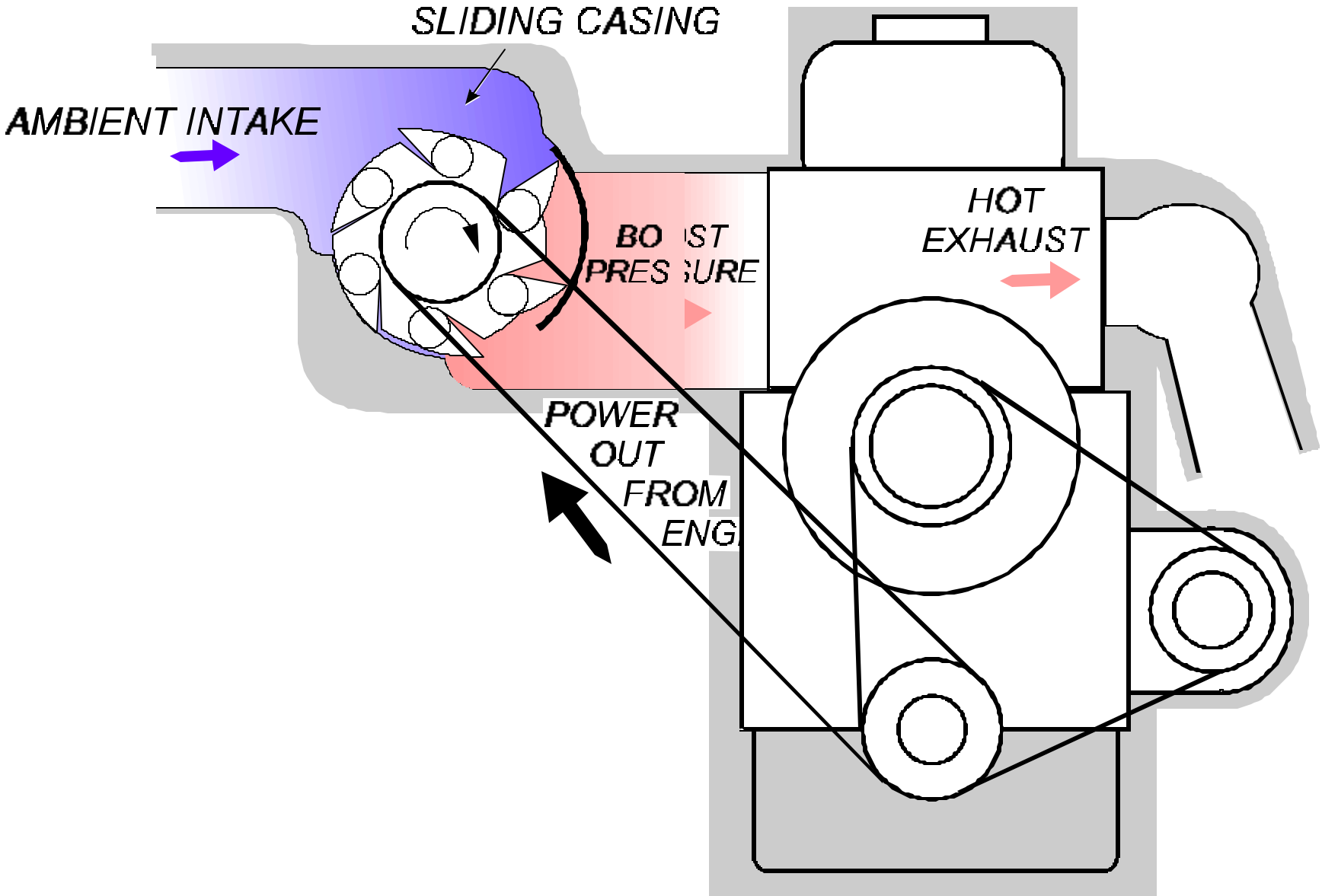
- Low Friction - Vanes Do Not Rub
- Fuel Economy Improvement at All Part Throttle Operating Conditions Translates to 7% Fuel Economy Improvement Over EPA Metro/Highway Driving Cycle

VGS Supercharger Function



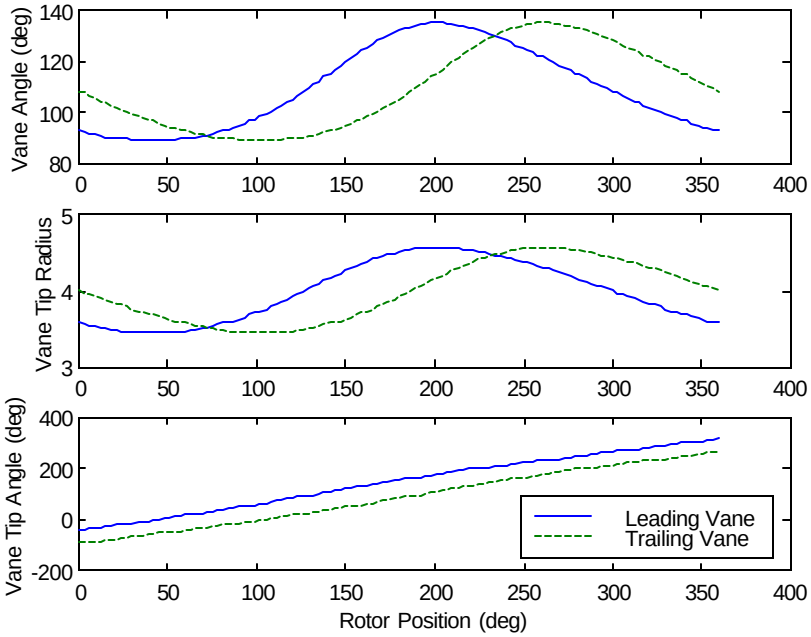
Controlled Clearance Rotary Vane Compressor

VGS in Place of Throttle

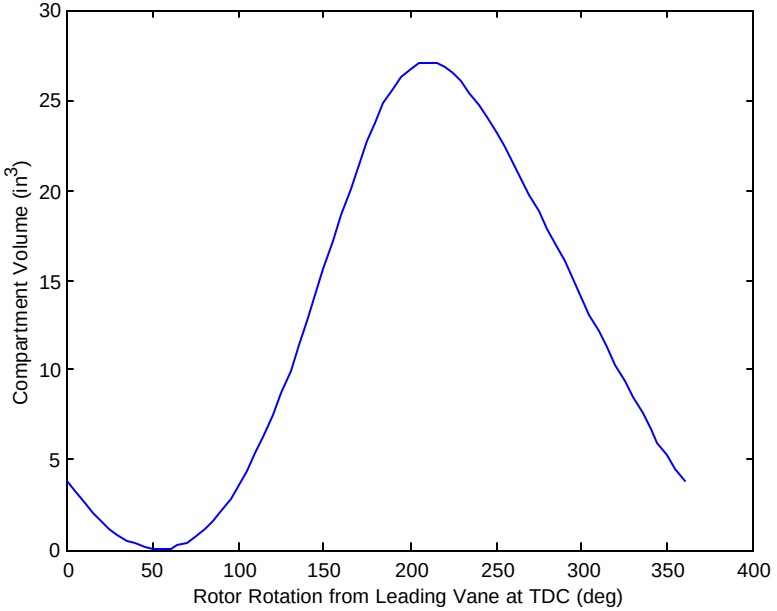


Device Compartment Volume Analysis

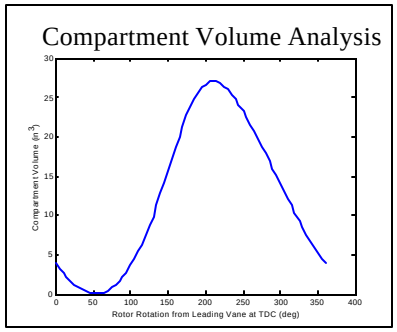
- Tip clearance control mechanism analysis
  - Determine vane motion
  - Allow parametric study of device parameters
  - Required for volume analysis



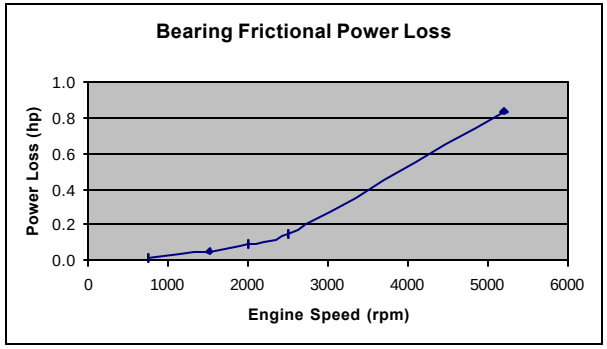
- Compartment volume analysis
  - Variation of compartment volume with rotor rotation
  - Required for performance model



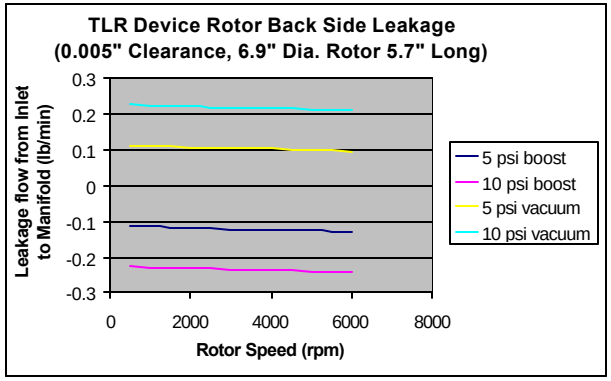
VGS Performance Model



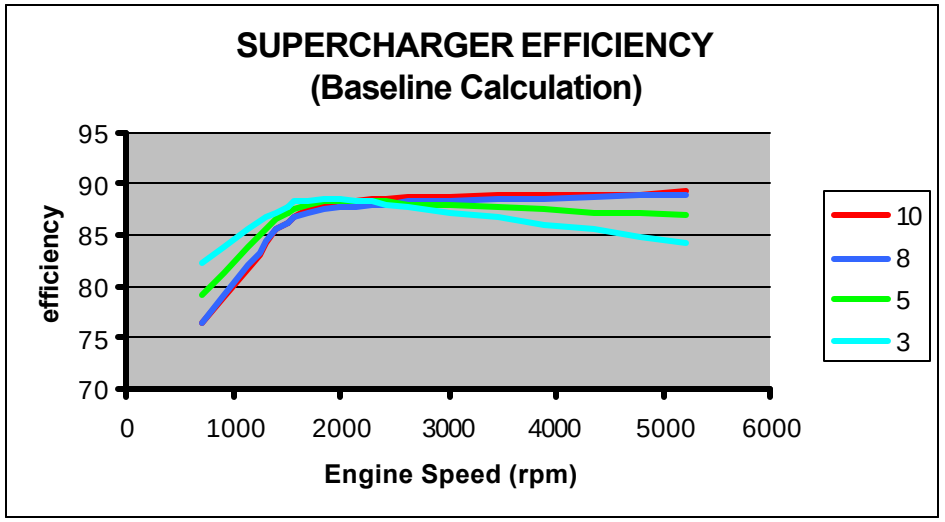
Vane Tip Leakage Model

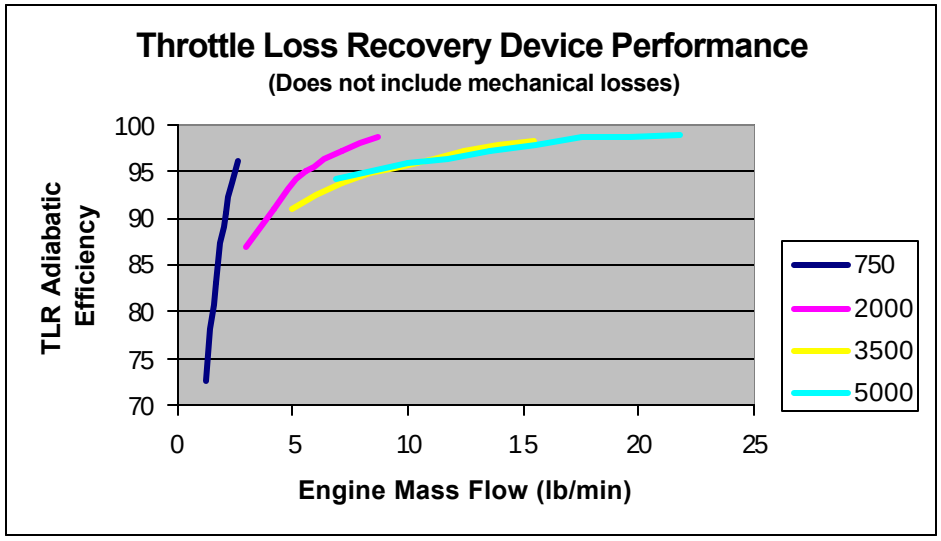


96% Belt Drive Efficiency

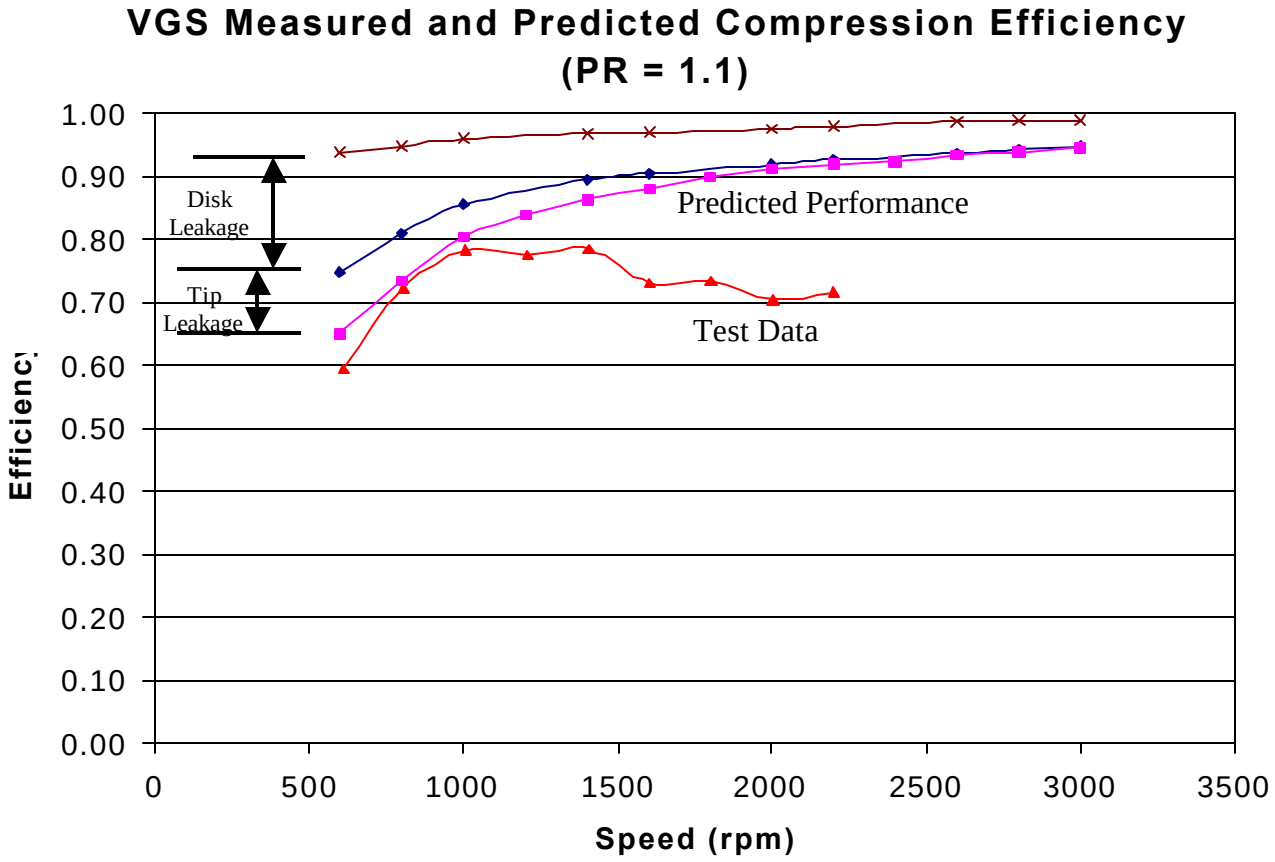


Supercharging and Recovery Performance

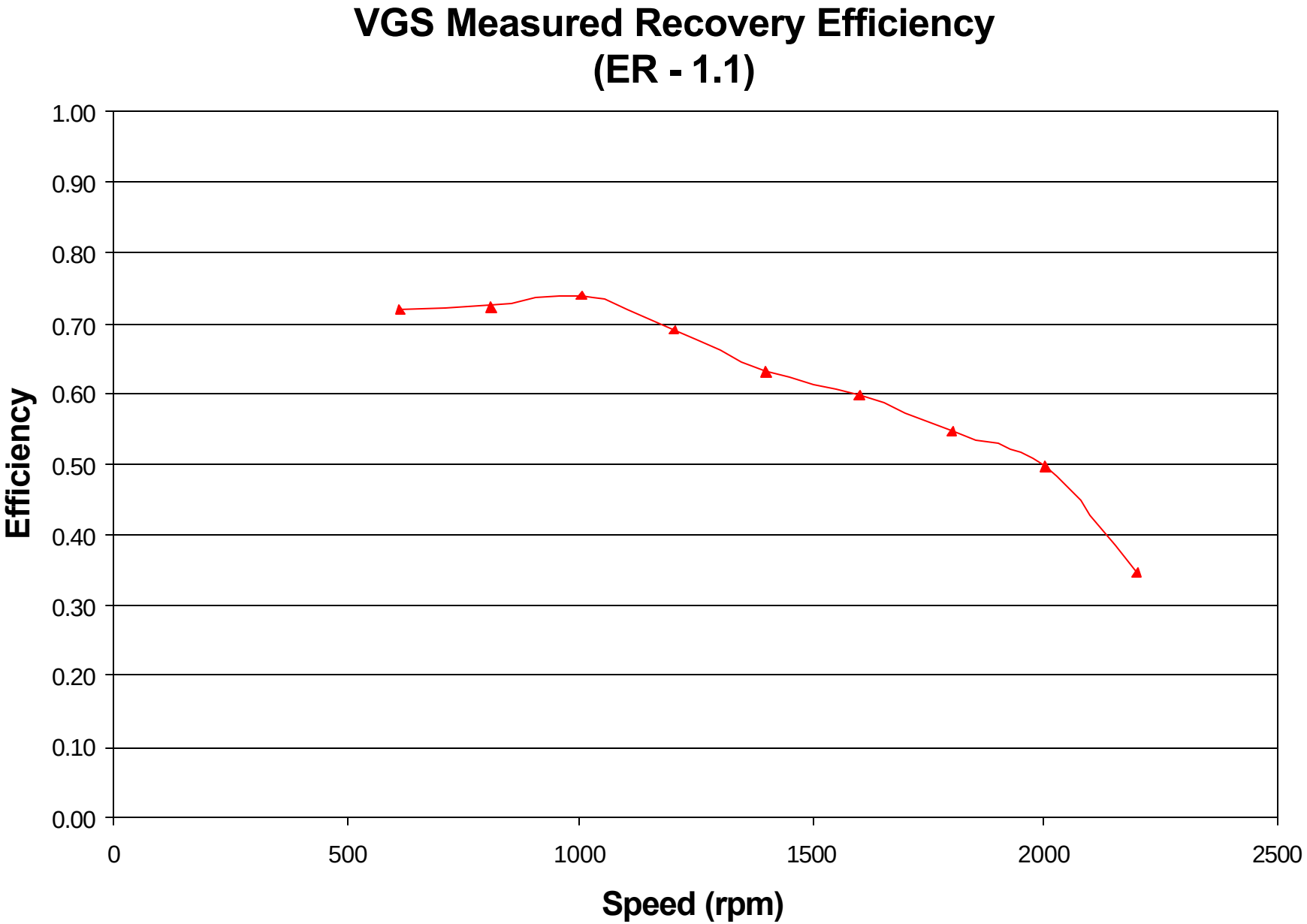




VGS™ Generation I Supercharger Performance



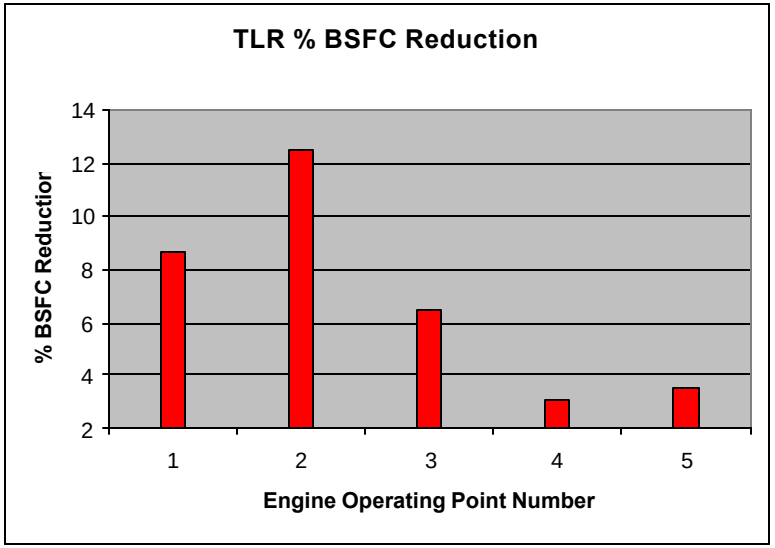
VGS™ Generation I Throttle Loss Performance



Calculated Fuel Economy Benefits
Throttle Loss Recovery

- Initial focus - light trucks /SUVs
- Device performance evaluated for 4.6L SUV engine
- Fuel economy benefits based on 5 steady state operating points representative of EPA combined metro/highway driving cycle

Point Number	Speed (rpm)	Power (hp)
1	750	2.52
2	1500	7.71
3	1500	20.19
4	1500	38.54
5	2000	51.39

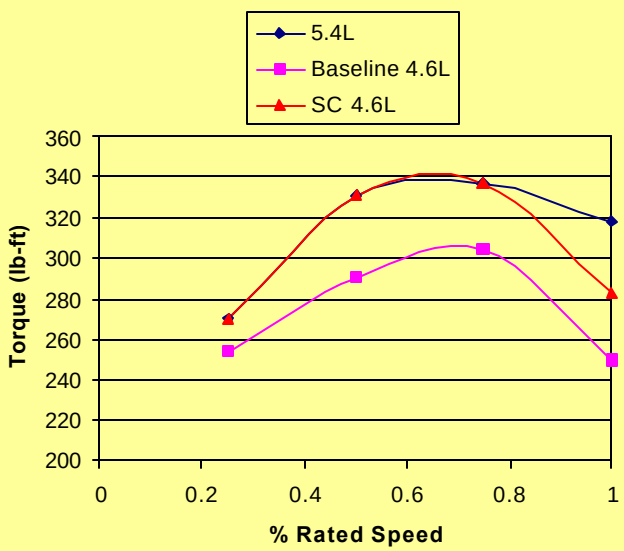


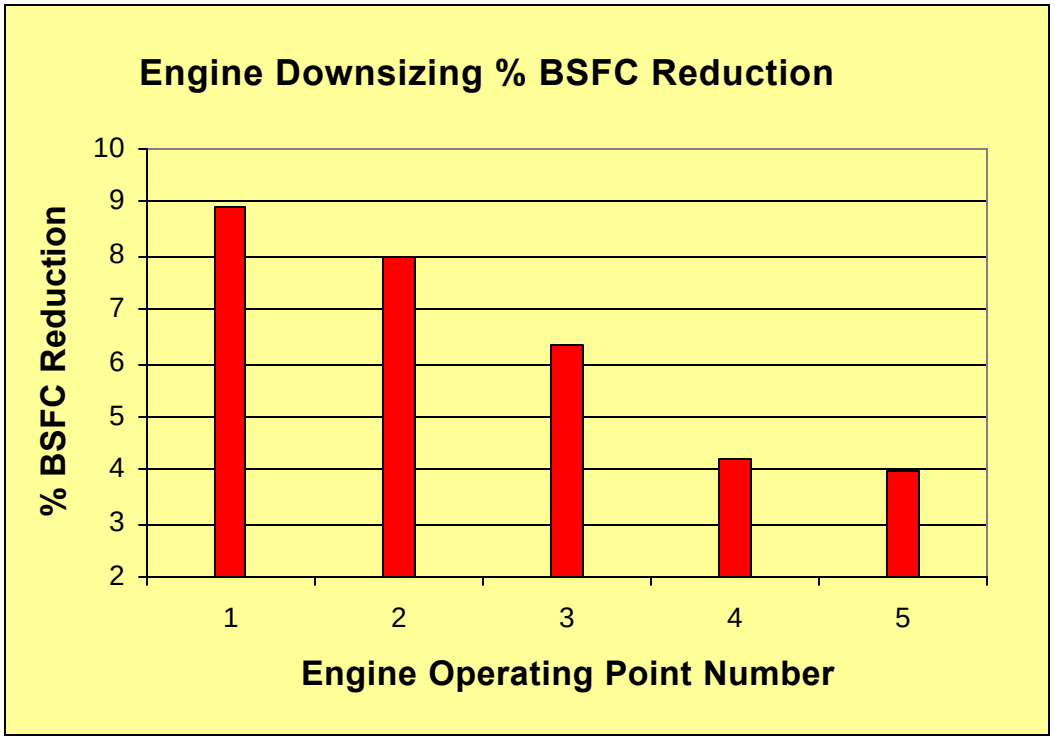
Combined metro/highway fuel economy improvement from throttle loss recovery ~ 7%

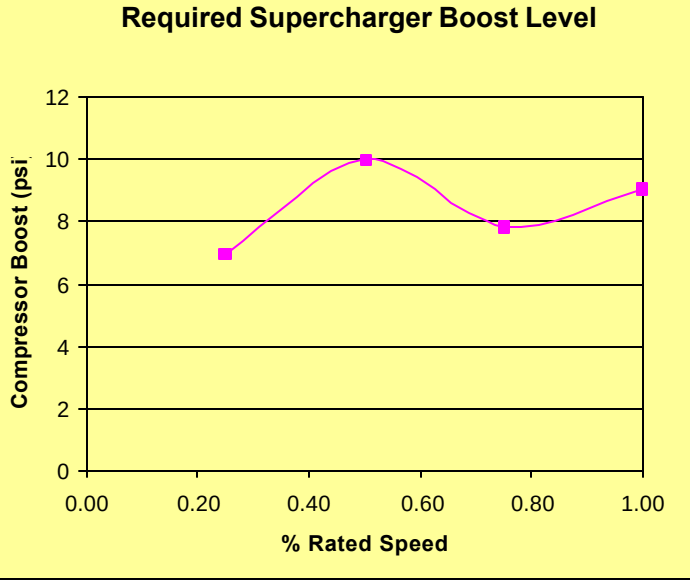
Benefits of Engine Downsizing

Variable boost and low end compressor efficiency

- Downsize engine while maintaining torque curve and peak power output (5.4L to 4.6L)
- Weight/size effects provide more benefits







6% Improvement in Combined Hwy-Urban Fuel Economy
Additive to Throttle Loss Recovery - Total 13%

Summary

Gasoline Engines/Vehicles:

- 30-35% Engine Downsizing
- Rationalize & Simplify Engine Product Line
- Turbocharging - 8% Improvement in Fuel Economy
- Electrical Assist Turbocharging - 12%
- Throttle Loss Recovery Supercharging - 13%

Natural Gas Engines

- Throttle Loss Recovery Supercharging
- 13% Improvement in Fuel Economy - Light Duty
- XX% Improvement in Fuel Economy - Heavy Duty
- Low Speed Torque Improvement
- Emissions Reduction - Exhaust Temperature Effects