Variable Flow Rotor Pump

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Unmet Market Needs

- Fixed displacement pumps dominate charge circuit applications
  - Fixed displacement pumps sized based on full flow and pressure under worst case conditions
    - Excess power wasted when power demand is low
- Cost sensitive applications operating at low pressure (up to 50 bar)
  - Cannot justify additional cost of piston pump for power/fuel savings benefits
Proposed Solution

• Variable Flow Rotor Pump
  – Features:
    • Infinitely variable flow control
    • Hydraulic control with electronic control option
    • Utilizes proven technology
    • Inherently failsafe
  – Potential Benefits:
    • Power savings
    • Improved pressure pulsation levels
    • Lower component loading
    • Improved system pressure control
    • Lower system cost (downsize accumulator, reduce valve count)
Operating Principle

- Split Inner Rotor
  - One rotor supported by drive shaft
  - One rotor supported by eccentric shaft
Animation
Control Options

• Hydraulic Control
Control Options

- Electronic Control
Demonstrator Design Parameters

• Full Displacement = 39cc
  – 70/30 rotor split
  – Flow control to 20% flow
    • 75° eccentric shaft rotation
• Operating Speed = 2400 RPM
• Target Pressure = 30 bar
Performance Results

- Fixed Displacement vs. Variable Flow

Power Savings = 1.5 kW
Performance Results

- Response Time
Performance Results

%Flow vs Overall Efficiency
2400 RPM & 30 Bar

Overall Efficiency

% Flow

ISO 32 @ 70 deg C
(10.8 cSt)

ISO 32 @ 21 deg C
(80 cSt)
Payback Analysis

- Payback dependent on duty cycle

### Payback Analysis Summary

**Power Savings Estimate:**

<table>
<thead>
<tr>
<th>RPM</th>
<th>duty</th>
<th>% time @ reduced flow</th>
<th>Power w/ Full Flow (kW)</th>
<th>Power w/ VF (kW)</th>
<th>Power Savings (kW)</th>
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**Payback Analysis:**

- Power Saving Potential: 1.134 kW
- Avg. diesel Engine BSFC: 213 g/kWhr
- Avg. diesel mass: 3175.147 g/gal
- Avg. diesel cost: $2.40/gal
- Assumptions:
  - VF Pump Cost Adder: $150.00
  - Operation per year: 2000 hr/yr
- Calculations:
  - Operating Savings: $0.18/hr, 152.15 gal/yr, 1.58 metric ton CO2/yr
  - Payback period: 4.93 months

**Power Savings Estimate (2nd page):**

<table>
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**Payback Analysis (2nd page):**

- Power Saving Potential: 0.486 kW
- Avg. diesel Engine BSFC: 213 g/kWhr
- Avg. diesel mass: 3175.147 g/gal
- Avg. diesel cost: $2.40/gal
- Assumptions:
  - VF Pump Cost Adder: $150.00
  - Operation per year: 2000 hr/yr
- Calculations:
  - Operating Savings: $0.08/hr, 65.21 gal/yr, 0.68 metric ton CO2/yr
  - Payback period: 11.50 months
Development Status

- Testing in field
  - Quantify power savings in real world testing
- Optimize efficiency
  - Vary rotor split
Second Generation

- Variable Flow Gear Pump
  - Move gear centers by rotating idler gear carrier
  - Control pressure to one side of carrier
  - High contact ratio gears
CFD

- 50% flow reduction
- Overall efficiency gain
Development Status

• Currently validating in low pressure applications (engine lubrication)
• Feasibility in high pressure applications (50 bar)
• Optimize pump efficiency through CFD
  – Potential new pumping gear forms
Thank You

Questions?