REMVue® Energy Optimization with SlipStream™

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Relevant Star Partner Topics

• Efficiency
• Diagnostics
• **SlipStream™**
  – Using fugitive emissions as fuel
• Challenges
EngineWorx Overview

• EngineWorx — a services company and wholly-owned subsidiary of John H. Carter
  – North American Representative: REM Technology
  – EngineWorx has installed 100+ REMVue® systems in Texas, Louisiana, Florida, Colorado, Alabama, Mississippi and the Gulf of Mexico
  – 7/24 Customer Service
• John H. Carter Co., Inc. established in 1933
  – Emerson Representative for US Gulf Coast
    • DCS systems
    • Asset Optimization and Management
  – 250 Employee Owners

REM Technology

• REM Technology Inc. provides technology solutions for engines and compressors
• Parent Company is Spartan Controls of Calgary, AB. Forty-five years in business and 600 employee owners.
• Focused on technology development applied to recip for better efficiency, reliability and emissions (regulated and GHG)
• REMVue® solutions reside in an integrated Engine/Compressor Control Platform with:
  – **Combustion Management**
    • Rich to Lean Conversions
    • Lean Burn
    • Stoichiometric with Catalyst
    • Low Horsepower - LHP
  – Safety Shutdown
  – Process/Unit Control
  – Diagnostics
    • Key Asset Performance and Health Indicators
  – **Advanced Applications – SlipStream™**
Let’s begin with the end in mind.

Fuel Savings and Emission Reductions

- REMVue® R-L conversion
  260mcfd – 20% = 52 mcfd

- Slipstream (Up to 50% of Fuel)
  50 mcfd
  - Vented Gases from Instrumentation: 5-10 mcfd – 5 mcfd
  - Compressor Packing Leaks: 5-15 mcfd – 10 mcfd
  - Flares and LP, Blanketed Vessels: 10-104 mcfd – 35 mcfd
    - Pipeline Pump Surge Tanks, Dehydration Units, Wemco’s, Chem-Electrics, Etc.

- Total Fuel Savings = **102 mcfd**

- Total GHG Reductions = **12,000 tonnes/yr CO2(e)**
RESULTS

• Fuel Savings
  – 102 mcfd at 97% runtime
  – 36 mmbtu/year at $8/mbtu
  – $289,000 revenue/year (much more if used for Gas Lift)

• Green House Gas Reduction
  – 12,000 t/yr CO2(e) for offset or trade
  – Potential trading values of $5 - $15 per tonne
  – $120,000 year at $5/t

Ideal Installations

• Highspeed, Turbocharged Engine such as a Waukesha 7042GSI

• Running at Stoichiometric – i.e. Rich Burning

• Located on a structure with pipeline pumps, oil and/or gas dehydration, water treatment, a flare or with other sources of vented gases and fugitive emissions
### Relevant Star Partner Topics

- **Efficiency**
  - Combustion Management
    - Rich to Lean Engine Conversion
    - Improving thermal efficiency
  - Compressor Capacity Control
  - Unit Cooling Control

- **Diagnostics**
  - Key Asset Performance and Health Indicators
  - Unit Efficiency “Gas Mileage”
  - Compressor Leaks

- **SlipStream™**
  - Using fugitive emissions as fuel

- **Challenges**

### AFR - Operating Zones

- Rich burn: low NOx, wasted fuel → high CO
- High NOx, low CO, wasted fuel → high CO2
- Moderate to low NOx, low CO, best fuel, lowest CO2

Typical Tuning point for 3 Way Catalyst
Adaptive Control

Operation in these zones is enabled by robust, adaptive control of the engine.

- Integrated AFR, Governor and Emissions Control
- Automatic Real-Time Compensation for:
  - Ambient Air Temperature
  - Load changes
  - Fuel BTU changes
  - Intercooler and Turbo performance degradation
- Multiple Adjustable Curves for Dynamic Adaptive Control
- Ignition Control and Integration
  - Advance or Retard ignition as conditions allow to maximize efficiency and minimize risk of detonation

REMVue - Rich to Lean Conversion*

- Provides improved thermal efficiency
  - Less unburned fuel, less CO emissions
  - Less heat loss from burned gases
  - No 3-way exhaust catalyst requiring energy
- Reduces fuel consumption
- Reduces greenhouse gases
  - Less fuel used
  - Less methane in exhaust gases
- Meets regulated offshore emission requirements
- Reliability improvement
  - Lower temperature operation i.e. lower peak burn temperatures and pressures
  - Tighter, more stable engine control
  - Lower occurrence of detonation
  - Significant reduction in head failures
- Improves engines “range” of operation (available horsepower)
- Verified by third party study – Accurata/PTAC
  - http://www.ptac.org/eet/dl/eetf0501p06.pdf

*A high fraction of existing NG engines in the oil and gas industry are “rich burn”.

PTAC – Petroleum Technology Alliance Canada
Typical REMVue Modifications

Reduced Exhaust Temperatures

- Reduced valve failure
- Reduced head damage
- Reduced oil wear metals
**REMVue™ Energy Optimization with SlipStream™**

**Turbo Temperature**

**Delta 210 °F**

**BEFORE**

**AFTER**

- Chevron’s compressor optimization fleet plan
  - 100 REMVue® AFR installations
- Realized annual fuel savings in excess of $15 million!

“…..The increase in production from reliability and efficiencies will far exceed the fuel savings.”

Robert E. Ingraham Jr.
Hatters Pond & Chunchula Plants
Senior Process Engineer

Initial installation of the 100 systems cost Chevron around $13 Million. The $15 million in fuel savings is annual, year after year, after year .... These systems have been installed since 2002, making the total ROI to date well in excess of $75 million.
Compression Optimization

- Control asset to minimize energy waste
  - Minimize recycling
  - Minimize suction throttling
  - Minimize blow downs
  - Cooling fan speed/pitch control
    - Minimizes horsepower losses to parasitic load
    - Minimize liquid/flash gas recycling

- Engine loading
  - High % load (100% vs. 50%) gives up to 18% more efficiency

- Recip Compressor RPM
  - Lower RPM (750 vs. 1200 RPM) can give 19% more efficiency
    (less valve loss)

REMVue Diagnostics

- Provides a well/unhealthy indicator
- On-line 24/7 monitoring
- If well, no action is required;
- If unhealthy, provides an indicator of the problem type;
- If serious, provides alarms or shutdowns;
- Can provide an operating (Opportunity) cost of the problem.

Prompt correction of a problem
Can save fuel and avoid lost production
REMVue Diagnostics BSFC
Real-time Graph on engine HMI

The line shows expected performance;
The yellow dot shows current performance

BSFC “Gas Mileage”

On the line = OK
Off the line = problem
   Engine or compressor not healthy

Brake Specific Fuel Consumption (BSFC) is the fuel heat per hour to generate 1 HP of mechanical power; a low BSFC means high fuel efficiency

REMVue Leak Diagnostics
Real-time Graph on engine HMI

A compressor leak causes lower compressor throughput and wasted engine fuel

- Compressor leak detection
  - Valve leak
  - Packing leak
  - Ring leak
  - Unloader leak

- Lost production estimate is $2,443
• SlipStream™ is the REM Technology product designed for utilizing vented hydrocarbons as a supplementary fuel source for natural gas engines
  – Vented HC gas into engine intake
  – Can be diluted with air or undiluted
  – Suitable for carbureted engines
  – Does not require vented gas compression - VRU
  – Vented fuel that is recovered can be considered “free”
  – Using SlipStream™, up to 50% of engine fuel can come from the vented sources
  – Substantial GHG(e) reduction
  – Advanced control allows for variability of Fugitives
  – Can burn BTEX* (> 99.5% reduction)

* Patents Pending
Design Requirements for SlipStream™

- Develop a technology that would allow vented hydrocarbons to be used as supplementary fuel for natural gas engines
- Must be safe — **Safety First**
- Must not reduce performance or reliability of engine
- Must be scaleable from low volumes of supplementary fuel to high volumes
- Must be able to compensate (Air-Fuel Ratio and Governor) for variable flow and BTU value of the supplementary fuel through the REMVue Combustion Management System

The Opportunity!

**Potential Savings!!**

- Venting ($40 Million)
- Reciprocating Engines ($220 Million)
- Heaters & Boilers ($180 Million)
- Flaring & Incineration ($60 Million)
- Fugitive Emissions Leaks ($20 Million)
- Value of gas recovered based on 12% improvement

Total GHG Emmisions by Type in Upstream Oil &Gas

- Venting: 33%
- Reciprocating Engines: 14%
- Heaters & Boilers: 14%
- Flaring & Incineration: 20%
- Fugitive Emissions: 8%

(from BP presentation Feb 05)
Typical REMVue® Modifications

Offshore Fugitive Sources

- Major Sources – Blanketed Vessels
  - Surge Tanks
  - Chem-Electrics
  - Reboilers
  - Water treatment units

- Minor Sources
  - Instrument gas vents
  - Compressor packing leaks
  - I/Ps and pneumatic devices
  - Engine starting, purging, blow-downs
  - Crankcases
Offshore Specific Implementation Issues

- Air Intake configurations varied
- Vent pipe routing/expense
- Panel vent devices typically not run to a common manifold exiting the panel
- Field Instruments vent locally

Control

- SlipStream™ uses advanced feed forward control algorithms proven with hundreds of R-L conversions to anticipate changes in SlipStream™ fuel flow and adjust the governor and air control accordingly
- The result — no impact to engine reliability or speed from:
  - Load changes
  - SlipStream™ Flow
  - Fuel gas or SlipStream™ gas BTU swings
  - Ambient temperature
REM/Vue™ Energy Optimization with SlipStream™

SlipStream™ Results

Real-time Graph on REM/Vue™ HMI
SlipStream Technology*

- Level 1 < 10% of engine fuel
- Level 2 < 30% of engine fuel
- Level 3 < 50% of engine fuel

* Patents Pending

Challenges

- Fuel cost accounting
  - Important but not urgent
  - Perceived as small cost relative to production
  - “The fuel doesn’t appear on my books.”

- Industry adoption of fuel efficiency is sporadic
  - Where are gas prices going?
REM Vue™ Energy Optimization with SlipStream™

Moving from an island solution to integrated solutions

- Regulatory Compliance
- GHG Reductions
- Engine/Compressor Controls
- Reliability and Operability
- Energy Efficiency
- Obsolescence (and Expertise)

Fuel Savings and Emission Reductions

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Thank You!