Operational Experience with a Gas-Diesel Engine running on flare gas

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The subject/object: Secoya

- Secoya (Dygoil), Equador
  - Engines: 2 x Wärtsilä 16V32GD
  - Electrical output: 11 MW
  - Type: Fuel sharing, Island mode
  - Location: Ecuador
  - Owner: Petro Ecuador
  - Delivered: 2003
  - Speciality: Operates on either associated gas or CRO, or both simultaneously.
2 x Wärtsilä 16 cylinder GD engine

Electrical output: 5.5 MW per unit
The gas – diesel (GD) working principle

Air Intake
Exh. Air

Compression of Air
Exh. Air

Injection of Gas and Pilot Fuel Ignition
Exh. Air

Diesel fuel serves as the igniter
Gas is injected simultaneously with the diesel
Knocking can not occur
Essential components

Diesel spray
Gas spray
Operation in ‘full’ gas mode

- Constant liquid fuel amount 3 - 5 % of energy input at 100 % load
No power problem if the gas flow varies

Gas share %

Diesel share %

Transfer window

Fuel Sharing

Fuel oil operation

GD operation

diesel pilot

gas and oil share adjustable
The engine needs compressed gas

Gas of 30 MJ/m³ (n) → 350 bar

43.5 * 0.954 = 41.5%

4.6% of power
Varying gas composition

- CO2
- N2
- C1
- C2
- C3
- i-C4
- n-C4
## Varying gas properties

<table>
<thead>
<tr>
<th>year</th>
<th>LCV MJ/m³</th>
<th>Wobbe MJ/m³</th>
<th>Density kg/m³</th>
<th>Air req. m³/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>35.4</td>
<td>41.9</td>
<td>1.12</td>
<td>9.47</td>
</tr>
<tr>
<td>2004</td>
<td>41.8</td>
<td>45.1</td>
<td>1.33</td>
<td>11.14</td>
</tr>
<tr>
<td>2005</td>
<td>36.0</td>
<td>37.4</td>
<td>1.44</td>
<td>9.59</td>
</tr>
</tbody>
</table>
Compressors don’t like liquids

Extreme example of a mixture of propane, butane, CO2 and hydrogen

Tin (max) = 50 °C

Learning Process:

Use liquid separators before entering the compressors

Heat the gas after separation

Use liquid separators at the high pressure stages

Beware of sulphur corrosion in the supply line in case of condensation
### Performance Sep 29, 2008

<table>
<thead>
<tr>
<th>running on crude</th>
<th>UNIT 1</th>
<th>UNIT 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>produced kWh</td>
<td>114119</td>
<td>114899</td>
</tr>
<tr>
<td>load factor</td>
<td>86.45</td>
<td>87.04</td>
</tr>
<tr>
<td>availability</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>reliability</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>net fuel efficiency</td>
<td>39.9</td>
<td>39.9</td>
</tr>
</tbody>
</table>
Performance  
1-1-2008 until 31-10-2008

- Fuel use: 49% gas, 51% crude (defective part in gas line; no stopping ordered by operator)

- Availability: 96.08% per unit
- Reliability: 98.75% per unit

- Electricity produced: 65 GWh
- Maintenance costs: US$ 349,200 = < 0.5 cts/kWh
- Load factor: 81%
Learning points Gas-Diesel

1. GD fuel sharing works: varying gas flows can be compensated for with crude oil (or other fuels)
2. Liquids should be removed from the gas, but this is state-of-the art technology
3. Large variations in gas composition pose no problems for the engines
4. A well-designed gas compression system is crucial for this application
Proof of the pudding

Running hours:

ENGINE 1: 35,904    ENGINE 2: 36,316
(both at October 31, 2008)
(May 27, 2005: viz. 7,519 and 7.988 hours)

Lowest possible fuel costs due to use of local fuel
Flare gas is utilised with high efficiency (40% net)
(with absorption chilling 64% net)

The owner asked Wärtsilä for an extension for more than doubling the power capacity