Turbomachinery Considerations in Drilling and Fracturing

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Gas Electric Partnership 2013
Natural Gas production is expanding and is becoming the preferred fuel for powering our economy.
Overview

- Shale Gas Field Operations
- Applications with Large Power Demand
- Environmental Issues
- Fuel Options
- Use of Turbomachinery
  - Portability/Weight
  - Maintenance Requirements
- Conclusion
Fracturing

- Fracturing is ‘blasting the Rock with a mixture of water, sand and chemicals’, i.e high pressure injection.
- Increases the permeability of shale for gas (or oil).
- Necessary for any shale gas production in commercial quantities.
- Fracturing fluid is a mixture of about 90% water, 9.5% sand (or other components like ceramics) and 0.5% other chemicals (acids, chlorides, salts, isopropanol, etc.).
Frac Site

Manifold system (suction top, discharge bottom) for water/sand mix. The manifold runs the length of the pump/engine trailers and connects to all pumps.
Industry Needs

- Portability
- Ruggedness with Long Intervals between Maintenance
- Capability to use Field Gas as Fuel
- Meeting Emissions Requirements
Large Power Requirements

- Fracturing Pumps (20,000+ hp per site)
- Power Generation (1 – 3 MW)
  - If frack pumps are electric driven, power generation 15 + MW
Typical Operating Scenarios Frac Pumps

- Avg. 8 to 12 pumps with 1500 to 2000hp each
- Depending on the type of formation, fracturing is done in 9 to 16 stages, with the composition and viscosity of the fluid changing, at a rate of 40 to 80 barrels per minute.
- Discharge Pressures are as high as 7000+ psi
- Fuel consumption may be 2000 to 8000 gallons of Diesel per day.
Operating Scenarios, Power Generation

- Large Consumers can be Drill rigs, with 3 – 5MW electric power demand.
- Usually Power is generated on site
- Potentially, frac pumps could be driven by electric motors
## Environment: Emissions

<table>
<thead>
<tr>
<th></th>
<th>NOx+ NMHC</th>
<th>PM</th>
<th>CO</th>
<th>GHG (CO2 e)*</th>
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<tbody>
<tr>
<td>Tier 2 Diesel Engine</td>
<td>127</td>
<td>3.97</td>
<td>69.4</td>
<td>12889</td>
</tr>
<tr>
<td>Tier 4f Diesel Engine</td>
<td>73.2</td>
<td>0.79</td>
<td>69.4</td>
<td>12889</td>
</tr>
<tr>
<td>5.7MW Gas Turbine</td>
<td>11.2</td>
<td>Negligible</td>
<td>10.1</td>
<td>11095</td>
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</tbody>
</table>

Emissions in lb/hr per 10,000 hp

*Methane contribution to GHG from OEM data sheets
Spread between gas and diesel is driving demand for engines that can burn gas.
Gaseous Fuels for Gas Turbines

WOBBE INDEX, \( WI = \frac{LHV}{\sqrt{SG}} \)

- Associated Gas
- Coal and Coke Oven Gas
- Pipeline and LNG
- LPG
- Raw Natural Gas
- Natural Gas Liquids
- Landfill and Digester
- Refinery
- Gasified Biomass and Waste

0 (MJ/Nm\(^3\))

0 Btu/scf
Lean-Premix Combustion Concepts

Lean-Premixed

FUEL

60%

AIRFLOW

40%

2900°F
1870 K
16

Gaseous Fuel Considerations

- Heating Value
  - Skid Edge Pressure
- Flammability Limits
- Adiabatic Flame Temperature
- Dew Point
- Flame Speed
  \((C4^+ + H2 + Alkenes)\)
- Autoignition Delay Time
- Emissions
- Combustion Stability
- Contaminants
Dealing with Contaminants in Gas Fuels

- Scale, Rust, Slag, Dirt
  - Clean and Passivate Piping
  - Use Proper Filtration

- Condensibles, Oils, Water
  - Use Coalescing Filtration
  - Fuel Heating

Fuel Filters and Coalescers
Gas Fuel – Flame Stability

- Increasing Risk of Flameout
- Increasing Risk of Flashback
- SoLoNOx
- Conventional

- Coke Gas
- Coal and Coke
- Gasified Biomass and Waste
- Pipeline and LNG
- Raw Natural Gas
- Landfill and Digester
- Associated Gas
- LPG
Shale Gas

- A Good Gas Turbine Fuel
  - Ethane Content of up to 20% Is Not a Concern
- Primary Concerns With Shale Gas
  - Meeting Fuel Spec Quality Requirements
  - Provide Fuel to Skid Edge Above HC Dewpoint
- Elemental Sulfur Deposition Issue Increasing
  - Relation to Shale Gas Not Clear
  - Team Developing Strategy & Solutions
  - To Date Fuel Heating Proven Effective
    - 120 to 160F Specified in ES 9-98
Weight Comparison

- 7800 hp (ISO) Gas Turbine: 11,000 lbs
- 2250 bhp Diesel Engine: 15,000 lbs
## Evaluation Scorecard

<table>
<thead>
<tr>
<th></th>
<th>Gas Turbine</th>
<th>Diesel Engine</th>
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</thead>
<tbody>
<tr>
<td><strong>Cap Ex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Equipment Cost</td>
<td>-</td>
<td>+</td>
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<tr>
<td>Installation Cost</td>
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<tr>
<td><strong>Maintenance and Interval Costs</strong></td>
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<tr>
<td>Consumables</td>
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<td>Overhauls</td>
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<tr>
<td><strong>Performance</strong></td>
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<td>Altitude/Ambient Derate</td>
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<tr>
<td>Engine Efficiency</td>
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<td>Fuel Cost</td>
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<tr>
<td><strong>Packaging</strong></td>
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<tr>
<td>Weight and Footprint</td>
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<tr>
<td><strong>Emissions</strong></td>
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<tr>
<td>Exhaust</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Noise</td>
<td>+</td>
<td>-</td>
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</tbody>
</table>
Turbomachinery Concepts

- Gas Turbine Driven Generators
- Gas Turbine Driven Frac Pumps
Mobil Power Unit Concepts
Mobile Power Unit

1. Taurus 60 Gas Turbine
2. Plug and Play Connections
3. Control Panel
4. Turbine Air Inlet Filter
5. Stack
6. Service Air
7. Neutral Ground Resistor
8. Lube Oil Cooler
9. Auxiliary Transformer
10. Electrical Equipment Room

MOBILE POWER UNIT
5.7 MW (ISO)

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Specifications subject to change without notice.
Sizing

• Small Unit sizes favor Gas or Diesel Engines
  – Current Practices are based on available gas engine types and portability

• Larger Units Sizes Favor Gas Turbines
  – Even units above 5MW can still be trailer mounted and transported
Questions?