Medium Voltage Drives, High MW Motors
Chemical Oil & Gas (COG) industry Applications

Extracts from presentations by Adrian Guggisberg, Thomas Schmager, Heinz Lendenmann, John Petrolove
Chemical, oil & gas industry

Upstream
- Offshore production
- Onshore production

Midstream
- Pipelines & terminals

Downstream
- Gas plants
- LNG plants
- Storage
- Refineries
- Jobbers
- Sales terminal
- Gas distribution
- Chemical plants
- Sales terminal

Chemical industry
- Terminals

Source: ABB
LNG

Drivers
- Gas price
- Cost of Liquefaction
- Global gas demand

Gas Field
- Gas production
- Gas processing
- Gas gathering

Liquefaction
- Onshore
- Offshore

Transportation
- Sea
- Land

Regasification
- Onshore
- Offshore

Distribution
- Pipelines
- Power plants
- Industrial plants
MV AC drives in upstream oil and gas

- FPSO (Floating Production Storage and Offloading)
- Re-built tankers with drilling equipment, pumping, compression and generating units on deck. Compact process modules due to limited space on deck required
- For marginal field development or deep-water production
- Marine certified equipment (ABS, DnV, BV, Lloyds etc.)

- Pumps and compressors
- Onshore plant installations
- Offshore platforms
- Reliable operation in harshest industrial environments (Ex)
- Redundancy requirements (usually 3 x 50% or 2 x 100% installed capacity)
Gas liquefaction

LNG (Liquefied Natural Gas)

About five per cent of gas is shipped as LNG.

Liquefaction of methane by cooling it down to minus 162°C makes it occupying about 1/600 of the original volume.

One LNG train consists of

- two main compressor strings for the MR mixed refrigerant
- one PR propane refrigerant, as pre-cooling cycle
- one feed-gas compressor (FG)
- one end-flash-gas compressor (EFG) for enhanced utilization by recovery.
Gas Liquefaction

Composition of Natural Gas and LNG

Natural gas is composed primarily of methane, but may also contain ethane, propane and heavier hydrocarbons. Small quantities of nitrogen, oxygen, carbon dioxide, sulfur compounds, and water may also be found in natural gas. The liquefaction process requires the removal of some of the non-methane components such as water and carbon dioxide from the produced natural gas to prevent them from forming solids when the gas is cooled to about LNG temperature (-165°C). At this temperature it occupies about 1/600 of the original volume of gas.
Gas transmission

With each successive step in the chain of production, processing and gathering, natural gas is incrementally increased in pressure and cumulatively in volume. By the time that it is ready for transmission to the consumer market, its pressure and flow rates are optimized for the most economical levels for long distance transmission.

Gas is transported through pipeline networks

Booster stations are arranged at intervals to compensate for friction loss.
Refinery Applications

- Fluidized catalytic cracking (FCC)
- Wetgas (WGC)
- Hydrodesulfurisation (HDS)
- Hydocracking (HDC)
- Hydrotreating (HDT)
- Reforming
- Platforming (PLAT)
- Isomerisation (ISO)
- Visbreaking (VB)
- Delayed Coking (DC)
- Alkylation (ALK)
- others
### Application know-how in COG industry

#### Applications

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Pumps</th>
<th>Compressors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &amp; gas production and gathering</td>
<td></td>
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<tr>
<td>Oil &amp; gas separation</td>
<td></td>
<td></td>
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<tr>
<td>Gas treatment</td>
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<tr>
<td>Gas liquefaction (LNG/CNG)</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Midstream</th>
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</thead>
<tbody>
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<td>Oil &amp; gas storage</td>
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<table>
<thead>
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<th>Compressors</th>
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</thead>
<tbody>
<tr>
<td>Petroleum refining</td>
<td></td>
<td></td>
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<tr>
<td>Petrochemical plants</td>
<td></td>
<td></td>
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<tr>
<td>Air separation plants</td>
<td></td>
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<tr>
<td>Chemical industry</td>
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Why High Speed Motors

**Market Drivers**

- High Speed Motors + Drives have a much higher power density → smaller motors
- Eliminate gear boxes, smaller space requirements
- Reduce emissions & maintenance
- Increase efficiency & reliability, process availability
- New applications (e.g. subsea and inline compressors)
- Package solutions => better optimization for variable speed direct drive of centrifugal gas compressors & injection pumps in COG, CCS, Power, and for turbo-machinery

**Market Threats**

- Electric power availability in gas pipeline applications
- Motors are not yet available for all power and speeds e.g. LNG compressor drivers are far larger. However, the most compressor population is below 40MW
- Market acceptance of Variable Speed Drives
- Reliability of high-speed motors in general
- Capital cost of high-speed motor and magnetic bearings
Variable speed drives in chemical, oil and gas

Power consumption for various pump control methods

<table>
<thead>
<tr>
<th>Comparison of...</th>
<th>Hydraulic coupling</th>
<th>Variable speed drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>low (varies with load)</td>
<td>high (over entire load range)</td>
</tr>
<tr>
<td>Cooling requirements</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Initial investment cost</td>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>Maintenance</td>
<td>high to high</td>
<td>low</td>
</tr>
<tr>
<td>Availability</td>
<td>medium to high</td>
<td>high</td>
</tr>
<tr>
<td>Total life-cycle cost</td>
<td>high</td>
<td>very low</td>
</tr>
<tr>
<td>Influence on power supply</td>
<td>none</td>
<td>minimal with suitable topology</td>
</tr>
<tr>
<td>Inrush current from supply</td>
<td>up to 100% of rated current</td>
<td>less than rated current</td>
</tr>
<tr>
<td>Dynamic response</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Environmental influence</td>
<td>high oil volume hazard</td>
<td>none</td>
</tr>
<tr>
<td>Space requirement at motor</td>
<td>extended shaft length</td>
<td>none</td>
</tr>
<tr>
<td>Weight</td>
<td>very high</td>
<td></td>
</tr>
<tr>
<td>Speed control range</td>
<td>limited</td>
<td>wide and easy to adjust</td>
</tr>
<tr>
<td>Mean time to repair</td>
<td>several days</td>
<td>few hours</td>
</tr>
</tbody>
</table>

VSD vs. hydraulic coupling

- Break-even point: 1.5 years
- Net return on investment: 900%
- Net present value of savings: $7,000,000
- Life-cycle cost savings: 20%

The calculation is based on the following data:
- Power: 9 MW; service life: 15 years; cost per kWh: $0.07; operating time per year: 8,000 hours

Benefits of variable speed drives:
- High performance and reliability increases plant availability and decreases maintenance costs
- Smooth torque over the entire speed range reduces noise and vibration levels, which minimizes mechanical stress
- Better efficiency, particularly at partial load results in lower energy costs
- No inrush currents and voltage drops during starting
- Regeneration of rotating power and braking capability
- Improved speed control and process optimization
- Enhanced operating flexibility to suit the process needs
- Lower impact on piping/valve system results in longer equipment life and less maintenance
- Better dynamic performance during starting and during supply grid turbulences
- No on-site emissions
All electric LNG plants
Better, safer, more reliable - and profitable

Comparison of gas turbine and electric drive characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Gas Turbines</th>
<th>Electric drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight and space</td>
<td>Light unit but space and weight</td>
<td>Similar to that for gas turbines</td>
</tr>
<tr>
<td></td>
<td>consuming auxiliaries</td>
<td></td>
</tr>
<tr>
<td>Minor maintenance cycle</td>
<td>4,000 hours</td>
<td>25,000 hours</td>
</tr>
<tr>
<td>Major maintenance cycle</td>
<td>20,000 hours</td>
<td>100,000 hours</td>
</tr>
<tr>
<td>Minor maintenance duration</td>
<td>6 – 10 days</td>
<td>1 – 2 days</td>
</tr>
<tr>
<td>In operation system MTBF</td>
<td>~ 4,000 hours</td>
<td>&gt; 25,000 hours</td>
</tr>
<tr>
<td>Control response</td>
<td>Slow</td>
<td>Medium to quick</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Narrow peak range</td>
<td>High over wide range</td>
</tr>
<tr>
<td>Logistics (delivery time)</td>
<td>3 – 4 years</td>
<td>1 – 2 years</td>
</tr>
<tr>
<td>Average operational efficiency</td>
<td>25%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Table 1 Comparison of gas turbine and electric drive characteristics

Annual savings using an All Electric Drive system

- Breakeven Point: 4/5 months

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>A. Electric Drives</th>
<th>B. Gas Turbines</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX system cost(^{1})</td>
<td>Main drives $30 million</td>
<td>Main GT $25 million</td>
<td>$26 million</td>
</tr>
<tr>
<td></td>
<td>Power plant $35 million</td>
<td>Power plant $14 million</td>
<td>$21 million</td>
</tr>
<tr>
<td></td>
<td>Aux. drives $7 million</td>
<td>Aux. drives $7 million</td>
<td>$0 million</td>
</tr>
<tr>
<td>LNG production</td>
<td>6,250,000 tons/year</td>
<td>6,250,000 tons/year</td>
<td>$0 million</td>
</tr>
<tr>
<td>Maintenance costs</td>
<td>$5 million/year</td>
<td>$10 million/year</td>
<td>$5 million</td>
</tr>
<tr>
<td>Shaft power efficiency</td>
<td>32%</td>
<td>29%</td>
<td>$3 million</td>
</tr>
<tr>
<td>Fuel gas consumption</td>
<td>450 mmSCM</td>
<td>648 mmSCM</td>
<td>200 mmSCM</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>800,000 tons</td>
<td>1,160,000 tons</td>
<td>360,000 tons</td>
</tr>
<tr>
<td>CO₂ quota cost</td>
<td>$13 million</td>
<td>$19 million</td>
<td>$6 million</td>
</tr>
<tr>
<td>where applicable (EU)</td>
<td>$100 million</td>
<td>$145 million</td>
<td>$45 million</td>
</tr>
<tr>
<td>Value of fuel gas</td>
<td>$45 million</td>
<td>$45 million</td>
<td>$0 million</td>
</tr>
<tr>
<td>Ten additional production days</td>
<td>$36 million</td>
<td>0</td>
<td>$36 million</td>
</tr>
<tr>
<td>Recirculation losses</td>
<td>0</td>
<td>$5 million</td>
<td>$5 million</td>
</tr>
<tr>
<td>Annual savings</td>
<td></td>
<td>$91 – 97 million</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Annual savings using an All Electric Drive system

\(^{1}\) main drives, auxiliary drives and power generation
Main components of a variable speed drive system

The Complete Picture

Higher system complexity

- Hazardous environments
- Filters
- Simulations and mechanical calculations
- Recooling equipment
- Switchgear
- Outdoor control houses
- Testing

Reliability and availability is a must
Full drive package responsibility

High speed direct drive for gas compressors

ABB supplies high-speed variable speed drives for compressor applications. Combined with a high-speed motor (above 200 Hz), the motor can be coupled to the compressor without using a gearbox. This compact solution requires less space and maintenance, has a lower noise level and a considerably higher availability compared to a solution utilizing a step-up gearbox.