MineOptimize – GCD for medium power
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- market acceptance of new products and services
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This presentation contains non-GAAP measures of performance. Definitions of these measures and reconciliations between these measures and their US GAAP counterparts can be found in the ‘Supplemental reconciliations and definitions’ section of “Financial Information” under “Quarterly results and annual reports” on our website at www.abb.com/investorrelations.
Conveyor classification
MineOptimize – Gearless Conveyor Drive

- **High Power**
  - GCD for high power
  - Per conveyor: >10MW
  - Per motor: 2.5 – 9MW
  - 50 – 60rpm/ 400 – 1700kNm

- **Medium power**
  - GCD for medium power
  - Per conveyor: 3 – 10MW
  - Per motor: 0.1 – 5MW
  - 10 – 800kNm

- **Low power**
  - Per conveyor: <4MW
  - Per motor: 0.1 – 1MW
Motivation – Provide a gearless solution for medium power ranges

MineOptimize – Gearless Conveyor Drive

- Permanent Magnet Motor for mining
- >50% lower failure rate
- >30% reduction of losses
- The cost saving solution
- Lowest OPEX/ lowest cost per ton

Key facts of GCD

- 4 flights
- 12 drives in total
- 1000kW Motors
- 8.800tph production
- 10ct/kWh for energy
- 6.900 hours p.a. operation

Cost Savings of Gearless Conveyor Drive

<table>
<thead>
<tr>
<th>Years</th>
<th>Energy Saving</th>
<th>Maintenance</th>
<th>Repair</th>
<th>Production Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2.0 USD</td>
<td>100 USD</td>
<td>200 USD</td>
<td>1200 USD</td>
</tr>
<tr>
<td>10</td>
<td>4.0 USD</td>
<td>200 USD</td>
<td>400 USD</td>
<td>3200 USD</td>
</tr>
<tr>
<td>20</td>
<td>8.0 USD</td>
<td>400 USD</td>
<td>800 USD</td>
<td>6400 USD</td>
</tr>
</tbody>
</table>

Gearless drive
(advanced solution)

Geared drive
(state of the art)
The challenges of medium power conveyors

MineOptimize – Gearless Conveyor Drive for medium power

Open Pit Mining (OPM); In Pit Crushing & Conveying (IPCC)
Medium capacity overland conveyors
Conveyors are moveable or without major foundation

Requirements

− No rigid / concrete foundation possible
− Space constraints in many cases
− Drive train weight restrictions
− Fast installation and easy to align on site
− Cost efficient

− Several studies have shown, that conventional Synch Motor is not suitable for many of such conveyors
The solution: Permanent Magnet (PM) GCD motor

MineOptimize – Gearless Conveyor Drive for medium power

- Conventional low speed Synchronous Motor cannot meet requirements in the medium power range
- Another type of motor is needed
- The solution: Permanent Magnet Motor

Easy implementation because of...

- Low weight
- Compact size
- Low maintenance
- Foot or shaft mounting
- Air or liquid cooling
- Mining specific heavy duty design
- High degree of protection marking (up to IP66)

< 3000kW
18 – 36 Poles
< 800kNm
Comparison of motor types

MineOptimize – Gearless Conveyor Drive for medium power

<table>
<thead>
<tr>
<th></th>
<th>PM</th>
<th>Sync</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>1500KW</td>
<td>1500kW</td>
</tr>
<tr>
<td>Speed</td>
<td>131rpm</td>
<td>131rpm</td>
</tr>
<tr>
<td>Weight</td>
<td>15 tons</td>
<td>31 tons</td>
</tr>
<tr>
<td>Length</td>
<td>1600mm</td>
<td>3500mm</td>
</tr>
<tr>
<td>Width</td>
<td>2200mm</td>
<td>2100mm</td>
</tr>
<tr>
<td>Height</td>
<td>2200mm</td>
<td>3300mm</td>
</tr>
</tbody>
</table>

50% lower weight
Construction of gearless drives

MineOptimize – Gearless Conveyor Drive for medium power

Gearless drive (advanced solution)

- Low speed coupling and disk brake
- Permanent Magnet motor
- Torque arm/swing base
- Cooler Module
- Pulley

Geared drive (state of the art)
Basic installation principles

MineOptimize – Gearless Conveyor Drive for medium power

Mounted to pulley shaft

(shaft mounted with torque arm)
- Easy to align
- No axial forces
- Quick installation
- Torque arm required

Foot mounted motor

(pad mounted)
- Geared or flexible coupling needed
- Motor alignment necessary
- Motor foundation needed
- Less load on motor shaft and bearing

Different possibilities for torque arm mounting.
Motor cooling

MineOptimize – Gearless Conveyor Drive for medium power

**Liquid cooled**
- Water jacket motor
- Water with anti-freeze (N or L)
- Simple radiator cooler unit (fin fan)
- More compact motor
- Low noise level

**Air cooled**
- No liquid
- Higher noise level
- Less compact and higher weight
- Foot mounting only
Typical 1000kW Conveyor Drive

Concept – Install GCD instead of geared drive

Drive including surrounding structure and pulley

<table>
<thead>
<tr>
<th></th>
<th>Gearbox</th>
<th>Motor</th>
<th>base</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geared</td>
<td>9.359kg</td>
<td>6.100kg</td>
<td>3.500kg</td>
<td>18.959kg</td>
</tr>
<tr>
<td>Gearless</td>
<td>--------</td>
<td>16.700kg</td>
<td>2.000kg</td>
<td>18.700kg</td>
</tr>
</tbody>
</table>

Summary:
- With a little lower weight the gearless drive would fit into the same space as the typical geared drive
- If conveyor design is optimized to support gearless drive, the gearless version can be even lighter
## Low or medium voltage drives

MineOptimize – Gearless Conveyor Drive for medium power

<table>
<thead>
<tr>
<th></th>
<th>LV drive</th>
<th>MV drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>400 – 690V</td>
<td>3.300V, 6.000V</td>
</tr>
<tr>
<td>Cooling</td>
<td>air or liquid</td>
<td>air or liquid</td>
</tr>
<tr>
<td>Single or MultiDrive</td>
<td></td>
<td>Single or MultiDrive</td>
</tr>
<tr>
<td></td>
<td>Compact and cost efficient solution</td>
<td>Fuseless design</td>
</tr>
</tbody>
</table>

Low voltage is the more efficient for up to ~1.500kW
Failure rate assumption

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Key facts

- Elimination of gearbox
- Gearbox has shorter live time than motor
  - Life time gearbox: 15 years
  - Life time motor: 25 years
- Random failures are reduced by more than 50%

Failure simulation

- 4 conveyor flights
- 12 drives
- 1000kW motors
- 8.800tph
- 6.900 operating hours p.a.
Noise emission of typical gearboxes
MineOptimize – Gearless Conveyor Drive for medium power

Sound pressure levels of geared drives is higher than 90dB(A)

Sound frequency mix of geared drive is „unpleasant“

Geared drive has a high sound pressure level >>85dB(A)
200kW GCD motor

Noise measurement at motor factory under load

The measured sound pressure level is 66.3 dB(A)
### Highest Drive Train Efficiency

**MineOptimize – Gearless Conveyor Drive for medium power**

<table>
<thead>
<tr>
<th>Component</th>
<th>Geared with Frequency Converter</th>
<th>Gearless with Frequency Converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>50kW</td>
<td>42kW</td>
</tr>
<tr>
<td>Frequency converter</td>
<td>119kW</td>
<td>104kW</td>
</tr>
<tr>
<td>Motor</td>
<td>184kW</td>
<td>175kW</td>
</tr>
<tr>
<td>Motor excitation</td>
<td>0kW</td>
<td>0kW</td>
</tr>
<tr>
<td>Gearbox</td>
<td>250kW</td>
<td>0kW</td>
</tr>
<tr>
<td>Total losses</td>
<td>603kW</td>
<td>321kW</td>
</tr>
<tr>
<td><strong>Total Efficiency</strong></td>
<td><strong>89,2%</strong></td>
<td><strong>94,00%</strong></td>
</tr>
</tbody>
</table>

**Component efficiencies**

- Squirrel Cage Induction Motor: 96,50%
- Gearbox: 95,00%
- Transformer: 99,20%
- Converter: Losses calculated by DrivesSize tool
- Permanent Magnet Motor: 96,50%*

4.7% higher efficiency at rated power

* Motor can be designed for higher efficiency (~98% for PM)
200kW GCD (PM)
Pilot installation

Principal setup of the pilot installation
- One out of two existing drives changed to gearless (retrofit)
- Geared and gearless drives running in parallel
- Perfect case for benchmarking and demonstrate advantages
- Main goal was to present running reference
- Demonstrates at the same time retrofit possibility

- Rated Power: 200kW
- Rated Speed: 80rpm
- Pole number: 18
- Rated torque: 23,8kNm
200kW GCD (PM) - Results

Efficiency – measured and projected – includes converter, motor, gearbox

Possible efficiency increase is 6 to 8% points
> 5.2%...6.5% lower power consumption with gearless drive

Includes motor inverter, motor, gearbox

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Slide 21
200kW GCD (PM) - Results

Lower motor currents

- Absolute pulley shaft torque are equal on both sides
- Motor current of PM-Motor is approx. 37A lower (25%)
- Less motor cables are required for gearless drive
- Smaller converter can be choosen

Appr. 25% lower motor current → 25% less motor cables
200kW GCD (PM) - Results
Resume of 1.5 years operation

- No single issue, 100% availability
- 6.5% saving of energy
- 2 hours of inspection after 1 year
Cost of Total Ownership (TCO) – ROI Example 2

MineOptimize – Gearless Conveyor Drive vs. VFD drive with gearbox

Conveyor System with 4 flights
- 12 Drives (VFD type) á 1000kW/80rpm
- Cost of energy 6ct/kWh
- Mine life time 25 Years
- Buffer capacity 10hours
- Man hour rate 30US$
- Operating hours 6348hours p.a.

The solution for
- Greenfield or brownfield
- OPEX Orientation
- 1 ... 3 years ROI

Return on investment after less than 2 years
## Value – High profitability

MineOptimize – Gearless Conveyor Drive for medium power

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Lower energy consumption (more than 5% higher efficiency)</td>
<td><strong>Low CAPEX threshold</strong></td>
</tr>
<tr>
<td>– No higher frequency oscillations/ vibration issues</td>
<td>– Premium on price is low compared to conventional drive</td>
</tr>
<tr>
<td>– Reduced number of wear parts</td>
<td><strong>Reduced OPEX</strong></td>
</tr>
<tr>
<td>– Less assets</td>
<td>– Reduced asset management</td>
</tr>
<tr>
<td>– Less sensors</td>
<td>– Lower cost for maintenance, energy and repair</td>
</tr>
<tr>
<td>– No gearbox oil</td>
<td>– Lower effort for monitoring and testing</td>
</tr>
<tr>
<td>– Motor lifetime 25 years, 10 years longer than gearbox</td>
<td><strong>Increased production</strong></td>
</tr>
<tr>
<td>– Less motor cables due to lower motor current (better power factor)</td>
<td>– Lower failure rate - higher availability</td>
</tr>
<tr>
<td></td>
<td><strong>Reduced Total Cost of Ownership</strong></td>
</tr>
</tbody>
</table>
Value – Certification and approvals

MineOptimize – Gearless Conveyor Drive for medium power

Features

More than 5% higher energy efficiency
- Lower energy consumption
- Lower carbon dioxide (CO2) emission

Low noise level
- Sound pressure <<80dB(A)
- 65 dB(A) measured for pilot motor

No combustables, no hazardous liquids
- No gearbox oil
- Cooling liquid is water with antifrogen (Antifrogen L for sensitive environment)

Benefits

- Meet energy performance requirements
e.g. ISO 50001 Energy management systems — Requirements with guidance for use

- Meet eco design requirements
e.g. EN50598 Ecodesign for power drive systems, motor starters, power electronics & their driven applications

- Meet noise emission requirements
## Value – Increased safety

**MineOptimize – Gearless Conveyor Drive for medium power**

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Reduced number of wear parts</td>
<td>Reduced number and time of hands on activities on site decreases the probability of accidents</td>
</tr>
<tr>
<td>Less sensors</td>
<td>– Less maintenance and repair</td>
</tr>
<tr>
<td>No gearbox oil</td>
<td>– Lower effort for monitoring and testing</td>
</tr>
<tr>
<td>No oil leaks</td>
<td>Reduced fire load</td>
</tr>
<tr>
<td></td>
<td>Reduced risk of fire</td>
</tr>
</tbody>
</table>
Value – Less staff on site

MineOptimize – Gearless Conveyor Drive for medium power

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</tr>
<tr>
<td>Less assets</td>
<td>– Reduced asset managements</td>
</tr>
</tbody>
</table>
Value proposition – “Reliable, safe and efficient”

MineOptimize – Gearless Conveyor Drive for medium power

- Low maintenance
- Easy installation
- Reduce hands on activities

- Low maintenance
- Reduce hands on activities
- No combustables
- Low noise emission

- Energy performance
- Eco design guidelines
- Reduced environmental impact
- Low noise Level

- Reduced TCO*
- Low CAPEX threshold
- Lower OPEX
- Increased production

Less staff on site
Increased safety
Certification and approvals
High profitability
Engineered GCD package

MineOptimize – Gearless Conveyor Drive for medium power

Converter transformer

MCCP - PM (conveyor drives control)

Drives Engineering: Safety and Performance

Frequency Converter (LV or MV)

Gearless drive (with Permanent Magnet Motor)