MineOptimize – GCD for medium power
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Conveyor classification
MineOptimize – Gearless Conveyor Drive

High Power

GCD for high power

>10MW

2,5 – 9MW
50 – 60rpm/ 400 – 1700kNm

Medium power

GCD for medium power

3 – 10MW

0,1 – 5MW
10 – 800kNm

Low power

<4MW

0,1 – 1MW
Motivation – Provide a gearless solution for medium power ranges

MineOptimize – Gearless Conveyor Drive

Key facts of GCD

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

Cost Savings of Gearless Conveyor Drive

- Energy Saving
- Maintenance
- Faults/Repair
- Production Loss

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

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 power overland conveyors (<10MW)
Conveyors are moveable or without major foundation

Drive train requirements

- No rigid (e.g. concrete) foundation possible
- Space constraints in many cases
- Weight restrictions
  - Shaft mounting
  - Transportation of motor (haulage, lifting capacity)
  - Fast installation and easy to align on site
- More cost efficient than Synch Motor in medium power range

-> Several studies have shown, that conventional Synch Motor is not suitable for many of such conveyors

The driver for PM motor technology is compactness
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

- **Permanent Magnet**
  - (water jacket)

- **Synchronous**
  - (IC6A6A6; air to water)

<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>Lenght</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

Pulley

Geared drive (state of the art)

Low speed Permanent Magnet motor

Torque arm/ swing base

Cooler Module

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| Slide 9
### 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

FinFan cooler  Motor
**Typical 1000kW Conveyor Drive**

Concept – Install GCD instead of geared drive

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**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><strong>Geared</strong></td>
<td>9.359kg</td>
<td>6.100kg</td>
<td>3.500kg</td>
<td>18.959kg</td>
</tr>
<tr>
<td><strong>Gearless</strong></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>LV drive</th>
<th>MV drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage: 400 – 690V</td>
<td>Voltage: 3.300V, 6.000V</td>
</tr>
<tr>
<td>Cooling: air or liquid</td>
<td>Cooling: air or liquid</td>
</tr>
<tr>
<td>Single or MultiDrive</td>
<td>Single or MultiDrive</td>
</tr>
<tr>
<td>Compact and cost efficient solution</td>
<td>Fuseless design</td>
</tr>
</tbody>
</table>

ACS6000
ACS5000
ACS800 (retrofit)
ACS880

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

MineOptimize – Gearless Conveyor Drive for medium power

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%*

*Motor can be designed for higher efficiency (~98% for PM)

4.7% higher efficiency at rated power

Example: 2 x 2500kW
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

System Efficiency

P/Pn in %

Gearless PMSM
Geared SCIM
Gearless PMSM max possible design value

Design potential
200kW GCD (PM) - Results

Energy balance

> 5.2%...6.5% lower power consumption with gearless drive

Includes motor inverter, motor, gearbox
200kW GCD (PM) - Results

Lower motor currents

- Absolute pulley shaft torque are equal on both sides
- Motor current of PM-Motor is appr. 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>
</tr>
</thead>
<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

<table>
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<tr>
<th>Features</th>
<th>Benefits</th>
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<td>- Lower effort for monitoring and testing</td>
</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

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

- Less staff on site
- Increased safety

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

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

- Certification and approvals
- High profitability

- Easy installation
- Reduce hands on activities
- No combustables
- Low noise emission

- Low maintenance
- Energy performance
- Eco design guidelines
- Reduced environmental impact
- Low noise Level
Engineered GCD package

MineOptimize – Gearless Conveyor Drive for medium power

Converter transformer

Frequency Converter
(LV or MV)

Drives Engineering:
Safety and Performance

MCCP - PM
(conveyor drives control)

Gearless drive
(with Permanent Magnet Motor)