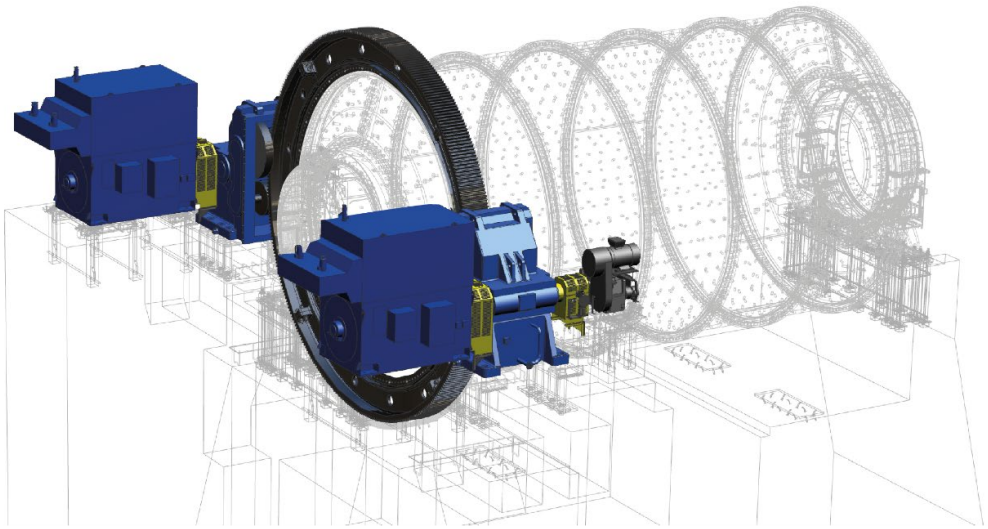
Modern Mechanical Drive System for Tumbling Mills up to 28MW



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Abstract

In December 2011, CEMTEC was contracted to supply a 10,4m x 6,1m, 2x 7,5MW SAG mill and a 8,2m x 14,0m, 2x 9MW Ball mill for a new gold ore processing plant in Siberia. The mills were designed and utilized with a state of the art gear driven design, which minimize civil work, installation and start-up time. After successful commissioning in 2017 a process optimization, carried out by CEMTEC in 2019, led to a Ball mill power increase from 18 to 21MW.

The design of the drive with total 4 self-aligning pinions allowed the power increase without any affect to the mechanical design criteria of the mill. The equal power distribution avoids any load peaks to the girth gear and enables the usage of well-proven materials for it. A closed oil lubrication is reducing the operational costs and guarantees a higher efficiency compared with conventional mechanical drives. A modern mechanical drive solution for power rates up to 28MW is a good alternative to gearless design.

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1 INTRODUCTION

The biggest concentrators with the highest throughputs have been increasing the requested mill power rates over the last years. Mill power rates of 20 to 28MW are getting more and more common. In the past this power class was dominated by gearless drive solutions. Improvements in gear manufacturing and design capabilities are going to change this situation. New developed materials and more precise machining of girth gears are opening the way for gear driven solutions also in this upper power class. CEMTEC was one of the pioneers in this market and already realized a gear driven ball mill with an originally installed power of 18MW and a SAG mill with 15MW. The mills were designed and utilized with a state of the art gear driven design, which minimize civil work, installation and start-up time. The drive concept consist of a casted girth gear and a double direct-mesh gear box. After successful commissioning in 2017 a process optimization, carried out by CEMTEC in 2019, led to a Ball mill power increase from 18 to 21MW.

CEMTEC is now ready to take the next step and design a similar drive concept up to an installed power rate of 28MW. From the electrical side this solution will be extended by an intelligent mill power supply consisting of VFDs and multi-motor switches.

2 TECHNICAL DETAILS

2.1 DIFFERENT DRIVE CONCEPTS FOR BIG TUMBLING MILLS

In general there are 3 different drive concepts for this size of tumbling mills available in the market:

- **Gearless drive solutions**

Gearless drive solutions (GMD) are so-called ring motors. By mounting the rotor poles directly onto the mill, the mill becomes the rotor of the gearless motor. Advantages of this drive type are less mechanical parts and a reduced maintenance. From CAPEX point of view this type is far above the gear-driven solutions. Historically, one of the big arguments for GMDs was the higher efficiency. Today, due to improved electrical concepts for conventional motors and also highly developed lubricants, the efficiency difference is minor – in the vicinity of 0.5%.

- **Dual-pinion drive with low-speed synchronous motors**

New materials and improved manufacturing possibilities for girth gears are enabling single-pinion power rates up to 9MW. This power rate can be doubled to 18MW by using a double-pinion drive. Nevertheless it required girth gear widths of more than 1m and a very accurate pinion alignment. Only small deviations can cause high load peaks and pitting on the teeth flanks. Especially for AG/SAG mill operation with a wide range of power draw during operation this effect can have a strong impact. An advantage of this system are less mechanical parts and a slightly higher efficiency compared to the DMG drive.

- **Double-DMG drive with high-speed asynchronous motors**

The power transmission with a double DMG2 drive is done by 4 pinions which are driving one girth gear. The total mill power is divided by 4. This reduction allows to use well-proven materials for girth gear design and a smaller width compared to a dual-pinion drive. Since the gearbox itself and the 2 pinions per gearbox are combined in one housing, a closed lubrication circuit can be used. This compact unit together with high-end lubricants, developed especially for this type of drives, reduces the transmission losses to a minimum and guarantees a very high efficiency, similar to the dual pinion

drive. Another advantage is the self-alignment mechanism of the pinions which guarantees a better load distribution along the teeth.

The investment costs for the double DMG drive are lower compared with the dual-pinion solution.

2.2 ARRANGEMENT COMPARISON DMG2 – PINION DRIVE

The following figure shows the arrangement of the 2 possible gear-driven solutions. The foot print and the girth gear are smaller at the DMG2 drive compared with the pinion drive.

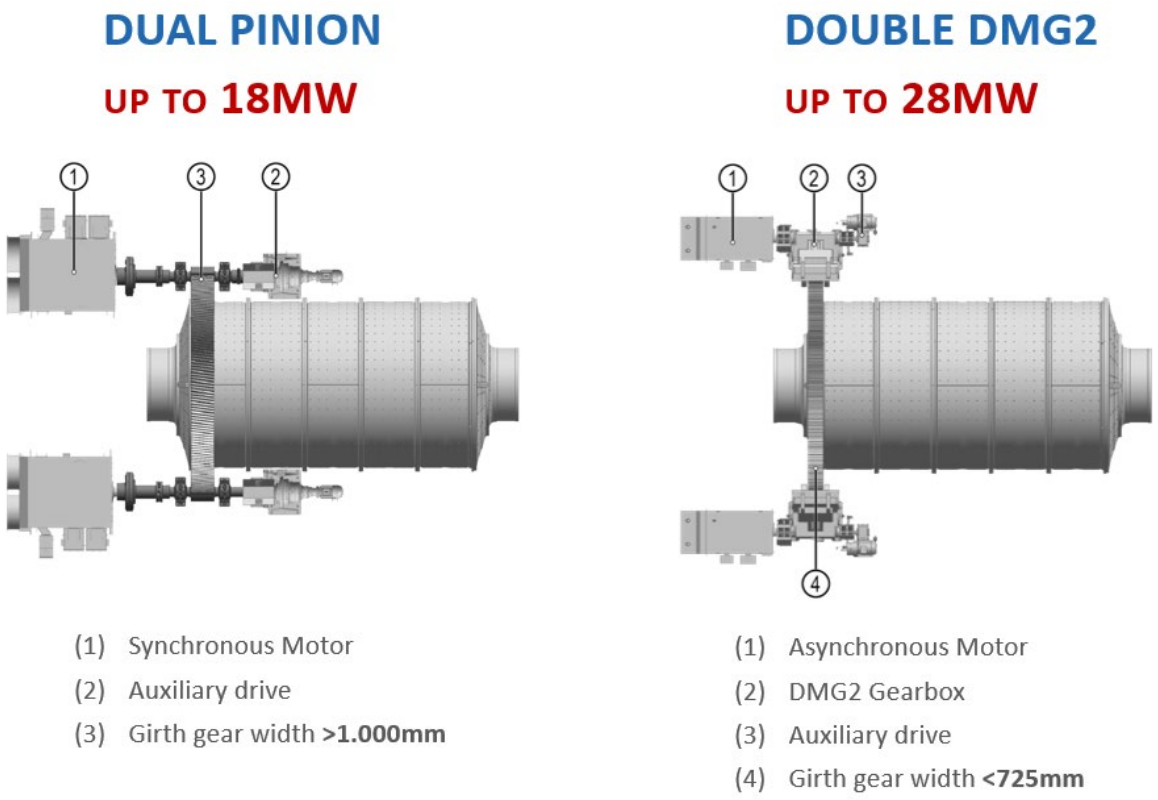

Figure 1 Arrangement comparison DMG2 – pinion drive

2.3 DMG DRIVE CONCEPT

The DMG2 gearbox from Flender is a 2-stage gearbox and consists of following main parts: high-speed input shaft, intermediate shaft and 2 output shafts including the pinions which are driving the girth gear. In order to have an equal load distribution between lower and upper output stage the intermediate shaft is floating and moving axial during operation. It equalizes any run-out errors of the girth gear and distribute the load 50:50.

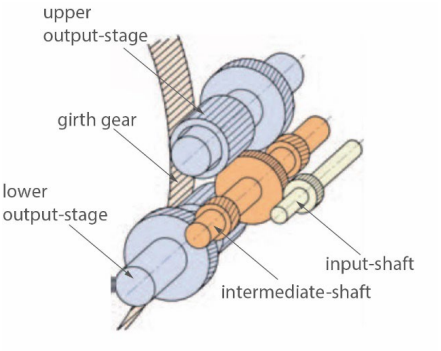

Figure 2 DMG2 drive concept

2.4 SELF-ALIGNING PINIONS

Girth gears of tumbling mills are flanged to the mill shell and part of mill drive. Due to following reasons all girth gears have some tolerable misalignment (see also figure below):

- Manufacturing and assembling errors (axial and radial run-out)
- Static deflection by machine weight and filling
- Thermal expansion
- Displacement of main bearings (due to foundation problems)

This effects have a huge influence to the load distribution along the pinion width and can cause load peaks at the tooth flank and creates pitting, which will reduce the lifetime of the girth gear and also pinion. Therefor the output-pinions of the DMG2 gearboxes are equipped with a self-alignment mechanism and ensure a proper load pattern at the teeth. This mechanism is only possible for spur gearing but not for helical gearing. Since the mill power at dual-pinion drive is just divided by 2 and not 4 like for DMG drive, the pinions are bigger and need a helical gearing. Out of this reason dual-pinion drives cannot be equipped with this self-alignment and have a higher risk for some load peaks at the teeth.

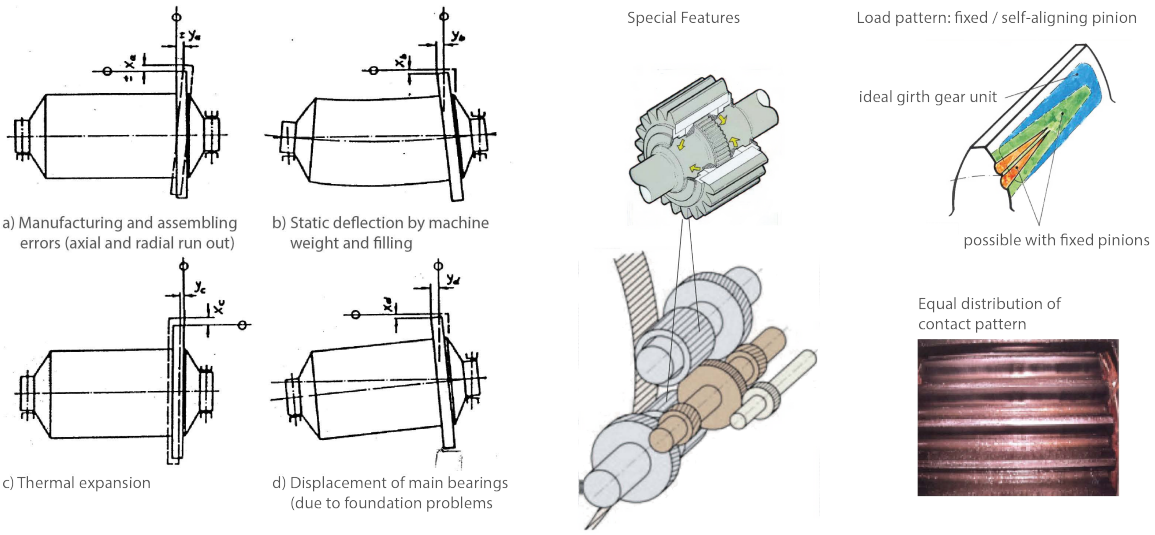

Figure 3 Self-aligning pinions – possible misalignment of tumbling mills

2.5 DMG SIZES

Figure 4 DMG sizes, power and torque rates

DMG gearboxes are designed for a wide range of power and torque. CEMTEC's biggest reference has an installed power of 21MW and is in operation for the last 5 years without any problems. Improvements in manufacturing and new design capabilities enables today power rates for tumbling mills up to 28MW with all the above mentioned advantages.

2.6 ELECTRICAL CONTROL PHILOSOPHY

The below shown figure shows a typical single line diagram for a grinding circuit consisting of 1 SAG and 2 Ball mills. Each mill is equipped with a Double DMG gearbox and a high-speed squirrel cage motor. For starting up 2 VFDs are required, a third one can be installed for redundancy. The VFDs are used for starting-up the Ball mills and for speed-regulating of the SAG mill. After starting the Ball mills with the VFDs they are switched direct on-line via special designed multi-motor switches. The SAG mill motors remain connected to the VFDs and enables an optimal process control. This design guarantees not only full flexibility regarding plant performance but also low investment costs without any technical limitations.

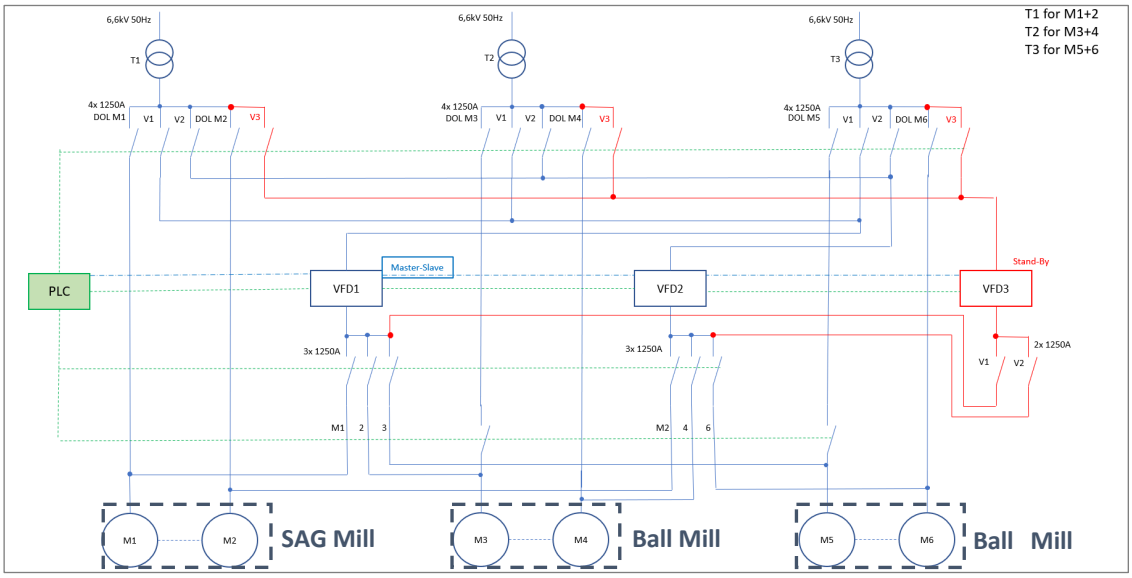

Figure 5 Single Line Diagram for a grinding circuit consisting of 1 SAG Mill and 2 Ball Mills

3 CONCLUSION

Going back 20 years, gearless drive solutions were dominating the tumbling mill market with power rates above 15MW. Today the geared drive power has caught up and is ready to overtake the GMD solutions in the power range up to 28MW. From CAPEX point of view the gear drives are unbeatable and the slightly reduced efficiency of 0.5% is negligible. New VFD control philosophies are also enabling now technical features like frozen charge detection and inching mode for the gear driven division. CEMTEC will continue its pioneer way and is already working on a gear-driven mill design with an installed power of 28MW, the new limit for this drive type.

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Minerals_ Drive Application_ Flender GmbH 2017:

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