Driving simplicity

As throughput rates achieved by vertical roller mills are increasing, so are the demands placed on gear boxes and drives. The gears and drives industries have responded with increasingly complex designs, but some companies are bucking the trend with innovative motor designs that provide simplicity as well as efficiency.

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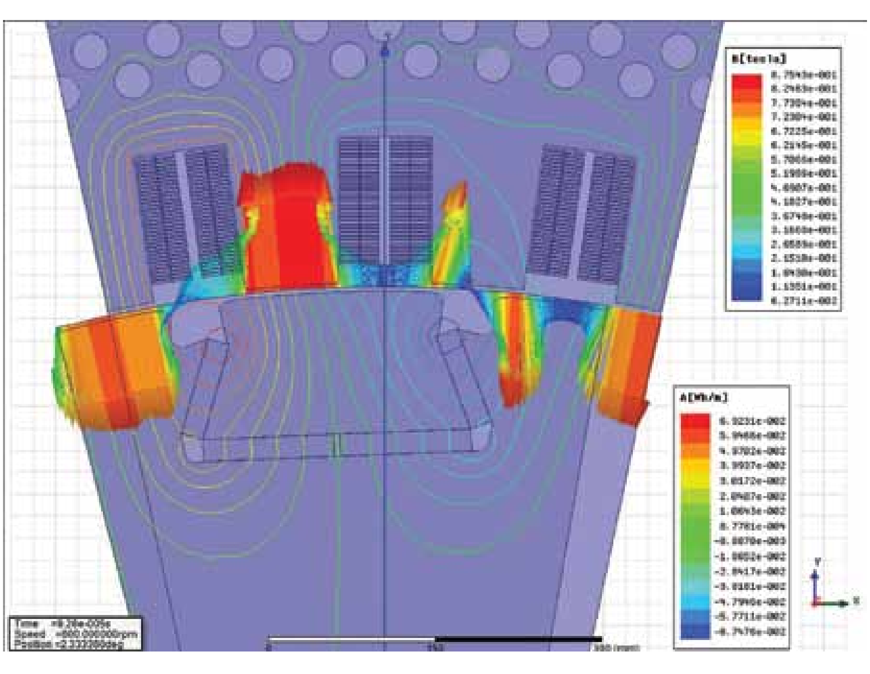
Vertical roller mills (VRMs) are established worldwide in cement plants for the production of raw meal and in the cement grinding process. Contrary to other comminution technologies, VRMs have not yet reached their limits of throughput rates. The move towards higher capacities, combined with the limitation of power transmission through conventional gearboxes, has resulted in the development of new drive systems.

While the majority of gear suppliers implemented drive systems with multiple motor designs and increased complexity, only FLSmidth MAAG Gear was able to reduce the drive's rotating parts and provide simplicity through its CEM Drive. Thanks to the drive's smart modularisation, which covers a power range of 4000-14,000kW, the drive system can be applied in cases were medium- to very high drive power is required.

Figure 1: air gab induction and magnetic flux density in a vertical electrical motor



Replacing convention

To make the required drive power available, FLSmidth MAAG Gear substitutes the bevel gear stage in the conventional MAAG WPV gearbox with a vertical electrical motor without increasing the dimensions, compared to conventional gear units of the same drive power.

The synchronous motor uses a permanent magnet-excited rotor. The embedded magnets guarantee an optimal magnetic flux density and the same design protects the magnets against demagnetisation by the magnetic saturation of the laminated rotor design in case of a short circuit. The space-saving single coils mounted in the stator part allow for a reduction of the overall dimensions to an absolute minimum and allow for the reducing of the resistive losses by simply minimising the amount of copper compared to distributed windings. This brings the motor losses down to ~1.5 per cent, a value supported by the factory acceptance test of the first unit.

The core part of this motor which ensures the extremely high power density is the cooling system. As the motor is totally enclosed in the gear unit, air cooling as used in other electrical motors cannot be applied. The risk of introducing dust and dirt into the motor and gear unit is too high and a big air cooler would be needed near the mill. Conventional water-jacket cooling is not efficient enough and the risk of water leaking inside the gearbox should be avoided. In response to these requirements, FLSmidth MAAG Gear invented a combined air and oil cooling system inside the motor casing itself. It consists of a direct stator cooling with gear lubrication oil and an internal air flow to cool the permanent magnets and the rotor. Cooling channels in the back of the stator allows fresh oil to circulate through the stator, cooling it directly. The ventilator on top of the rotor creates an internal air flow. By cooling down the rotor, the air temperature is increased. The ventilator aspirates the hot air and blows it to the back of the stator where it is cooled by the oil-cooled stator body. This innovative cooling system allows for building a totally enclosed motor inside the gear unit without the use of a second cooling media and its corresponding auxiliary system.

Flexibility squared

In addition to low energy consumption VRMs have a further considerable advantage when compared with other mill systems. With a handful of parameters it is possible to influence the grinding process and adapt it to changing raw material composition or different cement qualities.

The MAAG CEM Drive is equipped with a variable frequency converter supplying the power for the motor. For this component FLSmidth MAAG relies on industrial converters used in many other

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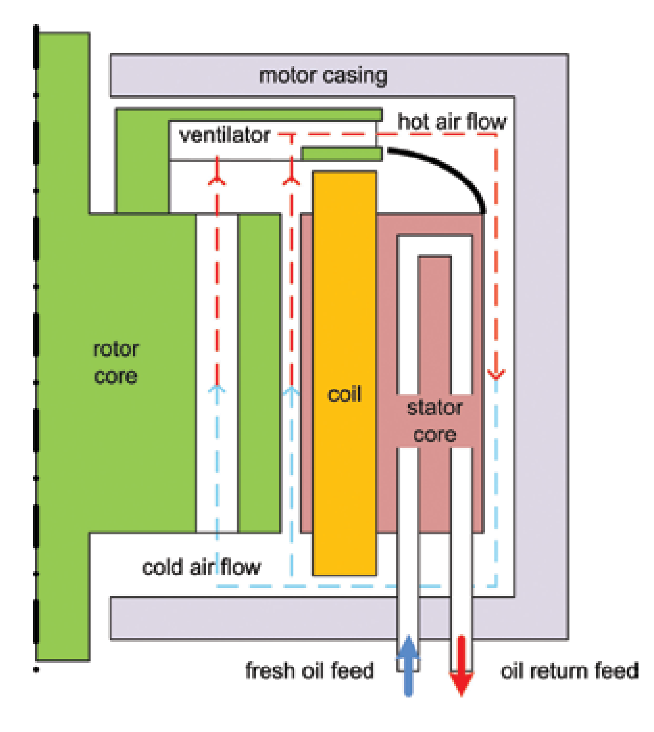
Figure 2: motor cooling system



crucial applications where reliability and space savings are decisive factors (ie, ship propulsion). The variable frequency converter used for the CEM Drive gives a cement producer the freedom to adapt the mill table speed according to its individual needs to guarantee the best and most economical production. The dynamic torque control together with the direct mechanical connection between motor and gear stage allows for a very good electrical damping of excitation frequencies coming from the grinding process. Compared to mechanical spring-damper elements, the electrical damping is not exposed to aging and it can be customised when changing process parameters. The mill can be tuned out of resonances if necessary and therefore, unexpected shutdowns and peak loads caused by vibration can be reduced. All control and monitoring parts inside the CEM Drive are built with a 100 per cent redundancy to ensure reliable operation.

For existing and new VRMs

The overall dimension of the CEM Drive strictly follows the size of conventional gear units where an overlap in drive power exists. The casing is always divided into two parts with a horizontal split line located at the top of the integrated motor. This makes installation and access to the motor very easy. The gear design and the bearing system to support the grinding table is the same as that used in the well-known MAAG WPV gear units. The motor is equipped with hydrodynamic slide bearings which makes the shaft grounding device the only wear part in the entire drive system. This device is easily accessible from outside and can be exchanged in less than an hour. An advanced condition monitoring system allows for supervising of the operating behaviour of the drive system. Regular maintenance tasks and inspections can be carried out without removing the drive unit from the mill.

The consequent use of medium voltage for the frequency converter and the motor makes the installation extremely convenient compared to other new drive systems for large power application. Other systems may use 3-8 motors, where each has to be connected to a local motor control centre and a separate circuit breaker. The recommendation of using a low-voltage motor design increases the power cable cross-section compared to medium-voltage design. This results in a high cost for cabling work and limits the accessibility underneath the mill.

The CEM Drive with its variable speed and compact overall dimensions can replace nearly every conventional gear unit for a VRM. To exchange an existing gear unit with the CEM Drive requires just three days of mill shutdown. The first prototype of this drive system is in operation under a raw mill (see Figure 3). It operates with a drive torque of around 41,800Nm in a very smooth and stable way.

Conclusion

Multi-motor drive systems for large VRMs allow for part-load operation in case of unexpected failure of one of the motors or drive units. However, this may give the cement producer a false impression of the reliability of the drive system. Motors of the type in use should not fail when they are built to a good quality. Therefore, increasing the number of motors only increases the complexity of the power supply and of the controls, while the promised redundancy is only available when the motor fails. In case of damage to the central part of the drive where all motors are connected, eg the axial bearing supporting the mill table, the entire drive system has to be taken out of operation.

The MAAG CEM Drive reduces the number of rotating parts and auxiliary systems to an absolute minimum. The industrial frequency controller with its flexibility in variable speed and electrical damping makes the drive system fit for any type of grinding process, from raw meal to slag or cement, and is designed for the best efficiency. ■

Figure 3: first MAAG CEM Drive in operation under a raw mill

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