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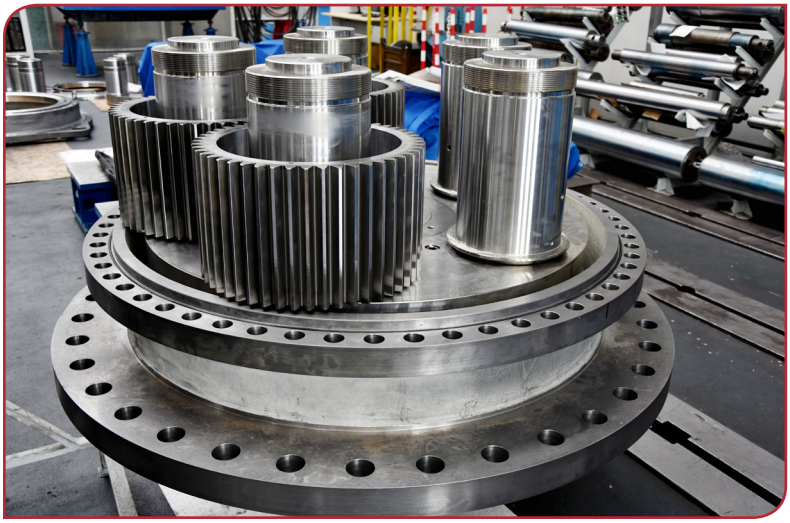
Planetary or helical?

Planetary or helical? This is often a question when speaking about price for a gearbox, maintenance costs, compact size and reliability. There are many prejudices and plenty of opinions too. Whatever the solution, many in the cement industry want to make their plants more efficient, both to save money and to hit sustainable development goals (SDGs). Here Wikov Industry presents its stance...

In short, the answer to the title's question must be simply 'planetary.' Planetary gearboxes are compact and occupy much less space than helical ones, while providing high power density. For many cement industry applications, selecting a helical gearbox automatically leads to high power drives in horsepower terms. The larger drive the more you pay for the steel. The compactness as a property of a planetary gearbox means a smaller weight, meaning (along with the size) a reduced demand for foundations. These facts can also help to justify the often higher acquisition costs for a planetary gearbox compared to a helical one. I used the term 'often' but perhaps I'd better use 'sometimes.' In fact, planetary gearboxes can cost less than a comparable helical gearbox in certain circumstances. It is dependant on the right choice of a gearbox supplier and a precise technical specification from the cement plant.

Parallel shaft gearboxes in different arrangements are a mainstay of the global cement industry. They are being improved by using the latest computer aided engineering (CAE) tools, the newest design standards, high-strength materials as well as manufacturing methods. However, radical improvement in terms of size and weight is limited, as significant material strength improvements (e.g. aerospace specification) would mean unacceptably higher costs.



Below - Figure 1: Multi-satellite planetary stage of the Wikov Orbi-fleX gearbox during assembly.

Helical gearboxes, from a design perspective, are reaching their limits. There seems to be no feasible revolutionary innovation of a helical gearbox design that would allow an increase in its power density as well as efficiency, which are key parameters nowadays. At the same time, the required torque is reflected in the size of the helical gearbox. They are large and the internals are large too. Larger internals for given speed means higher velocities, higher friction and thus higher losses. The larger parts and greater weights translate into higher costs for the material. This becomes topical in case of replacement when gears or bearings become worn out. This happens faster than with a properly designed planetary gearbox.

Planetary gearboxes represent a very robust solution with an excellent power-to-weight and size ratio. Gearbox durability is maintained at the same level or even increased, while the overall size and weight are significantly reduced. There is a clear cross-industrial trend for a shift from parallel shaft gearboxes to planetary ones, as those can offer reduction in terms of size, weight and cost with no compromise in the performance.

However, the cement industry is fairly conservative. It can take a long time to convince it of the benefits of a new technology. The resistance for change does not push towards identifying new solutions and benchmarking them against traditional technologies. This is understandable and represents a very comfortable attitude for the cement plants. It can also be perceived by plants that the maintenance staff who repair the helical gearboxes are familiar with the technology, so the service costs *must* be lower. If we speak about maintenance costs alone, this may be true on a case by case basis. When speaking about life-cycle costs, however, this attitude may lead to big mistakes. Mere calculations of the savings achievable by increased efficiency are completely self-explanatory (See Table 1).

Planetary gearboxes are well suited for the central drives of ball mills. However the majority have historically been fitted with very large helical gearboxes. These helical gearboxes are wide-spread, known by the operators and maintenance staff but, as nothing

Motor power (kW)	2000	
Daily operation (hr)	24	
Annual operation (days)	300	
Electricity price (Euro/kWh)	0.114	
Gearbox type	**Helical**	**Planetary**
Gearbox efficiency (%)	95.05	96
Annual power consumption (kWh)	14,400,000	14,263,200
Total annual costs	1,641,600	1,626,005
Difference / Year (Euro)	15,595	
Savings after 10 years	**155,950**	

Left - Table 1: A comparison of helical and planetary gearbox power costs.

Left - Figure 2: A carrier with flexible pins during assembly of a planetary gearbox Orbi-fleX.

lasts forever, they eventually become worn-out. The apparent ideal solution often appears to be replacement of rotating parts. Casing and bearing housings can be reused and there is no engineering needed. It can be carried out in a reasonable timeframe without loss of cement production. However, the price for the spare parts that match the gearbox brand can exceed 165% of the price for a planetary solution from an alternative manufacturer. Additionally, the new gearboxes certainly offer better warranty conditions to those provided for replacement parts.

Further technical advantages

Apart from the size, weight and efficiency parameters mentioned above, there are other design aspects that make a planetary solution the more appropriate choice. Coaxial input and output shafts mean the same sense of rotation on high and low speed shafts. It means that the offset between the gearbox and motor and thus larger package space is eliminated. Coaxial execution is more reliable.

Even load distribution on gear teeth in comparison with helical gearboxes can be considered as another user benefit if we speak of the use of a flexible pin in a planetary stage. This is subject to the application and other specifics of the operation. When a flexible pin planetary stage is used, extra flexibility in the specially-designed pin allows the planet to float under load in a limited manner. By the nature of the pin design (double-cantilever arrangement), the planet stays parallel to both sun and annulus (ring) gear. Equal planet bearing load sharing, as well as even gear contact pattern, is achieved for various loads, including overload. Both gear and bearing life are significantly improved as the load is always equally spread. The risk of failure is significantly reduced. This results in their extended lifetime and savings on operational expenditure.[1]

References

1. Steiner, L. 'A fresh wind for the cement industry,' in *Global Cement Magazine*, September 2016.

Below - Table 2: Advantages and disadvantages of helical and planetary gearboxes.

	Helical	Planetary
Advantages	**1.** Proven conventional solution; **2.** Better service access to the internals.	**1.** Compact dimensions and lower weight: • Smaller foundation; • Easier handling during installation / repair; **2.** Higher power density; **3.** Increased reliability means less frequent service; **4.** Lower power consumption; **5.** Lower oil consumption; **6.** Longer gear life at similar loads; **7.** Coaxial: No offset output shaft.
Disadvantages	**1.** Larger and heavier; **2.** More expensive foundation; **3.** Higher installation/on-site handling costs; **4.** Lower efficiency; **5.** Higher power consumption; **6.** Higher oil consumption; **7.** Parts are larger and replacement parts are more expensive; **8.** Very sensitive to the alignment; **9.** Shorter gear life; **10.** Offset between the gearbox and electric motor, thus larger package space required.	**1.** Cooling: worse heat dissipation due to smaller surface area; **2.** Noisier operation; **3.** Worse access to the planetary stage internals in case of no horizontal split line in the gearbox casing. This can be adjusted by the gearbox producer.