RE-COUPLING FOR RELIABILITY

STEVE ROGAN, ARTEC MACHINE SYSTEMS, USA, PRESENTS A CASE STUDY WHERE A GEAR TOOTH COUPLING WAS REPLACED WITH A FLEXIBLE DISC COUPLING.

Introduction

This article details the successful replacement of a problematic gear tooth coupling with a flexible disc coupling. The system is comprised of an electric motor driving a horizontal double stage planetary gearbox, which drives a horizontal ball mill operating at 5850 kW. The recurring problem was repeat failures of the input coupling at a few sites on similar sized equipment. Artec Machine System's long history of sales and service support for the cement industry provided the expertise and experience necessary to ensure a viable solution to this problem.

Although the problem occurred at only a few locations, one particular site is worth detailing to understand the situation. Five years after the mill's commissioning a replacement gear tooth input coupling was ordered; two years later the first failure occurred and six months after that a second failure occurred, which prompted the customer to seek an alternate solution. After consulting with Artec, the plant ordered a Euroflex flexible element disc coupling. In the meantime, a used gear tooth coupling spacer was obtained, refurbished, and installed as a temporary solution.

Couplings

Basically, a coupling is required to transmit torque and accommodate misalignment between two shafts. Flexible element disk couplings operate through flexure of a disk pack and are designed to operate within the fatigue life of the flexing material. Historically, gear type couplings have dominated industry for use in most torque transmission

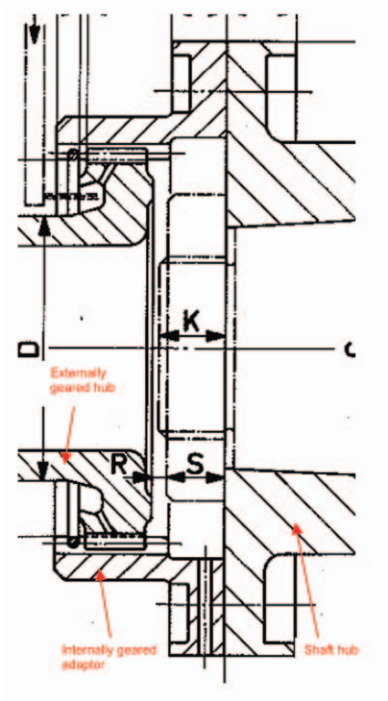

Figure 1. Hub schematic.

Figure 2. Refurbished gear tooth spacer ready to re-install as a temporary solution.

Figure 3. Installation of flexible disc coupling.

applications. Modern increases in horsepower, speed, and operating temperature have caused the development of many problems with the gear tooth coupling, with lubrication problems being the most common. Today's rotating equipment demands have led manufacturers and users of rotating equipment to increase the coupling requirements to include:

- No lubrication.
- Higher torque capability without increasing coupling size.
- Accommodation of greater misalignment and greater axial motion.
- High temperature operation.
- Adaptability to all types of shaft/coupling connections.
- Predictable low moment and force production.
- Ease of balancing.
- Long term operation without maintenance.
- Low production of vibratory inputs into equipment.

The flexible element disc coupling meets this list of modern requirements.

Important factors influencing the consideration of a flexible disc coupling for this application were the dry operation with no sliding surfaces, requiring no periodic maintenance, and the ability to easily install the equipment without altering the physical mounting of the coupling spacer to the coupling hubs.

The original coupling design was a marine style gear tooth coupling with both internally geared rings bolted to the coupling hubs, which are dual keyed and shrunk fit onto straight shafts (Figure 1). The marine style design, which was implemented for ease of emergency replacement, enabling all of the geared components to be removed without disturbing the coupling hubs, also enabled the design and installation of a drop in replacement flexible disk type coupling.

Lifecycle costing and failure analysis

Interestingly, the new replacement gear coupling cost about 10% of the newly commissioned cost of the gearbox and couplings together while the new flexible disc coupling price was about one third of the gear tooth coupling cost. These prices are not insignificant, but compared to the value of the entire production line equipment, process, and the incurred losses from unexpected downtime, they are minimal.

Because these failures recurred on only a few medium sizes and do not seem to be a problem on the smaller or larger models, the question of a marginally sized coupling arises. Resizing the gear tooth coupling for new equipment would be a viable solution for new installations, but for existing equipment a larger gear tooth coupling may not be possible to install without changing the whole system foundation footprint, which is not an acceptable solution.

The most probable root causes for these failures can be attributed to several factors that have had a combined effect. Gear tooth couplings are packed with grease, which is a lubricant that requires maintenance; the harsh environment encountered with ball mills exposes the equipment to vibration, load, and abrasive contaminant. Grease can become contaminated with external infiltration or wear particles and must be monitored and changed periodically. Also, grease lubrication properties change with temperature.

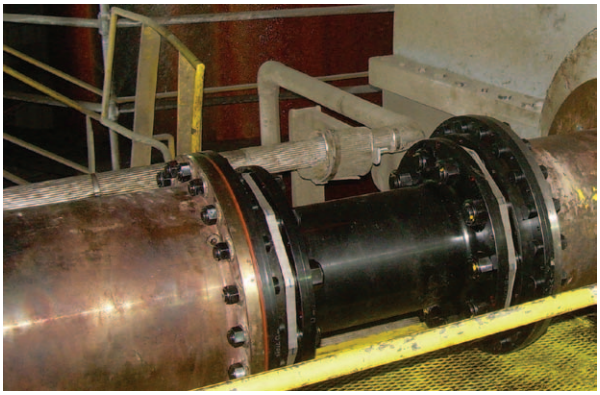

Figure 4. Flexible disc coupling installed.

A coupling in service always encounters a certain misalignment and with a gear style coupling, relative motion exists between the teeth of the hub element and the floating member. Several factors may have contributed to the possible causes but the most likely contributor to these failures is the stress created from misalignment and lubrication during cold start ups, and frequent cold start ups could explain why this problem did not occur at all installations.

- During a cold start several factors contribute additional stresses that are generally not experienced by a coupling when it is operating at steady state conditions. The forces required to overcome the system static inertia and friction are considerably higher than the forces encountered from system kinetic inertia and friction, and can easily overcome the lubricant properties of grease.

- Greater misalignment than when operating at thermal equilibrium. Centreline displacement due to thermal expansion is quite considerable and varies in magnitude between the mill gearbox and the motor. Growth constants are calculated by the manufacturers and published in the equipment manuals. During cold alignments each individual thermal expansion value is used to calculate one combined total cold offset, which self adjusts to a misalignment within the equipment specifications once the temperature stabilises to a steady state condition.

Conclusion

In general, with any failure, there are always multiple causes that have a combined effect that lead to the end result. When confronted with a retrofit application of a coupling there are many things to consider, and they all raise the question 'is it necessary to replace the coupling?' The repetitive failure of the gear tooth couplings created an unacceptable situation of unsatisfactory operation for the customer, and an alternative solution was necessary. The replacement of a gear tooth coupling with a flexible disc coupling addressed a system weakness, implementing a more durable component capable of withstanding the various physical system wear mechanisms and creating a reliable solution for the customer.