The Lowdown on Low Angle

By Frank Mathews, Motion

A common misunderstanding, especially in the paper industry, is that a universal joint driveline (or Cardan shaft) must operate at three degrees minimum misalignment. This concept causes mills and plants to spend unnecessary resources to create this minimum misalignment value. Additionally, this three-degree-or-greater value causes decreased reliability in the application.

The concept of three degrees of misalignment or greater originated from applications involving a prime mover (e.g., a motor) with vibratory power input, such as a diesel or gasoline engine. In these applications, the driveshaft must operate at three degrees to effectively transmit this vibrational power.

The driveshaft does not need to operate at three degrees or greater in applications with smooth power input (e.g., an electric motor). In these applications, low angle will increase the total operational lifetime of the driveshaft. A bearing lifetime equation is below.

$$Lh = \frac{Lc * 10^{10}}{n * \beta * T^{\frac{10}{3}} * K1}$$

Where:

Lc = Bearing Capacity Factor
n = Operating Speed (rpm)
β = Operating Deflection (angle)
T = Operating Torque
K1 = Shock Factor

The operating deflection angle (β) is in the denominator of this calculation. If zero degrees were inputted, the value would become infinite. As the angle approaches zero, the bearing life equation becomes unstable. For this reason and general selection purposes, lifetime calculation is done using three degrees or true operating angle if above this value. At low angle with an electric motor driving, the rolling elements will have very little oscillation on the journal trunnion on whichit rides. This will decrease overall internal friction and reduce wear over its lifetime. In some cases of extreme low angle, the rolling elements will become static, which would theoretically provide an infinite bearing lifetime. **Image 2** shows a cutaway view of a Cardan shaft bearing assembly's general configuration and operation.

A Cardan shaft can be used in many locations; most will accept up to 15 to 20 degrees of total misalignment. If space permits, they can offer a very long operational lifetime with decreased maintenance costs and greater flexibility in operational constraints. This can be an excellent alternative to replacing gear coupling floating shafts, disc coupling assemblies and many other rotating coupling types.

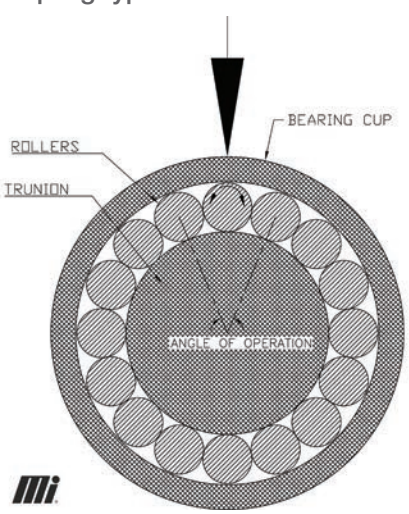

Image 2. Cardan shaft assembly cutaway.

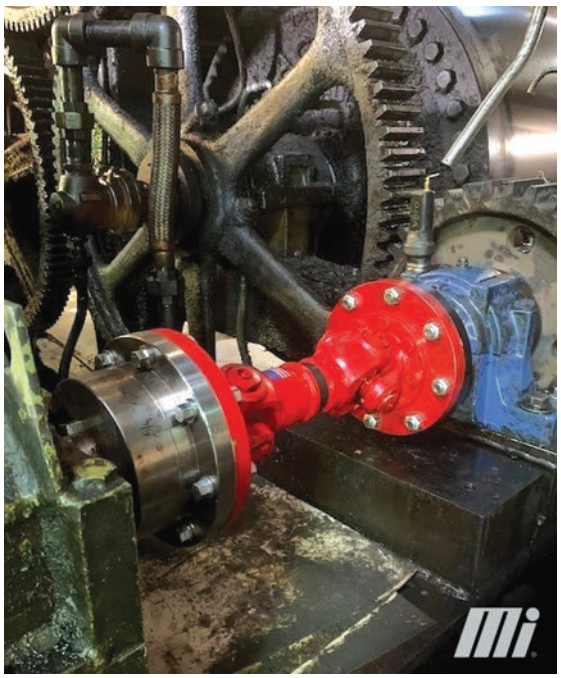

Image 1. Installed in a paper mill, this driveshaft features new universal shaft joints that fixed a misalignment issue. The gear couplings were also replaced.

Another benefit to implementing Cardan shaft assemblies would be advance warning of impending failure. Unlike other rotating couplings, driveshaft issues can typically be caught before complete failure using temperature measurements, deflection checks, and detecting vibration during operation.

Though this article has concentrated on minimum operating angles, focus is needed to confirm that parallelism of the mating flanges is within specification. In any existing or new application where a Cardan shaft can be implemented, please contact the experienced engineering team at Motion's Mill Services. They can help determine the proper fit and series for the application.

A certified mechanical engineer, Frank Mathews is the branch manager of Motion's Mill Services and has more than ten years of experience with driveshafts and their applications. For more information, visit Motion.com/paperage or the Mill Services' webpage motionind.biz/3AFM8Ug.