



HOW DISC COUPLINGS WORK

COUPLING FUNDAMENTALS



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With the advent of new materials, manufacturing techniques and analysis tools, flexible couplings for industrial applications have advanced greatly since their invention in the early 20th century. Their primary functions, however, have remained the same. Specifically, they:

1. Transmit torque between equipment
2. Accommodate for different types of misalignment while reducing the reactionary forces on the equipment

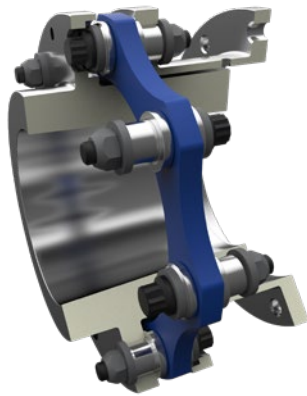


Image 1 – Disc Coupling

Additionally, couplings can be designed to:

3. Dampen damaging peak torques and torsional vibrations
4. Provide overload protection to prevent the transmission of damaging load
5. Prevent shorting between equipment by adding electrical insulation
6. Provide live torque and power readings, with less than 1% error

Couplings can be separated into two different types: mechanically flexible and flexible element couplings:

- **Mechanically flexible** couplings generally use clearance fit parts (ie. backlash between gear teeth) to allow relative movement between components and therefore require lubrication.
- **Flexible element** couplings accommodate for misalignment between shafts through the elastic deformation of components such as discs or diaphragms and therefore require no lubrication.

GEAR COUPLINGS

Given their power density, gear couplings (Image 2) are the preferred style when an extremely high torque capacity is required. As a mechanically flexible design, they transmit load through teeth on the hub and sleeve in order to accommodate for misalignment. The metal on metal contact is subject to wear and, while the rate can be mitigated through proper coupling sizing, case hardening and optimal lubrication intervals, they were designed with a finite service life in mind.

As both equipment speeds and the required time between maintenance intervals increased, so did the prevalence of flexible element couplings on new equipment trains.

Given their inherent dynamic stability, and reduced maintenance operation, their popularity has greatly increased for a wide range of applications, from low to high horsepower drives. Disc couplings are the most common flexible element coupling due to their excellent performance, high misalignment capacity, compact design, and cost. While there are many different disc couplings designs available on the market, they all operate under the same principals. Torque is transmitted circumferentially from driving to driven bolt, resulting in tension forces in the discs as seen in Image 3.



Image 2 – Kop-Flex® Fast's Gear Coupling

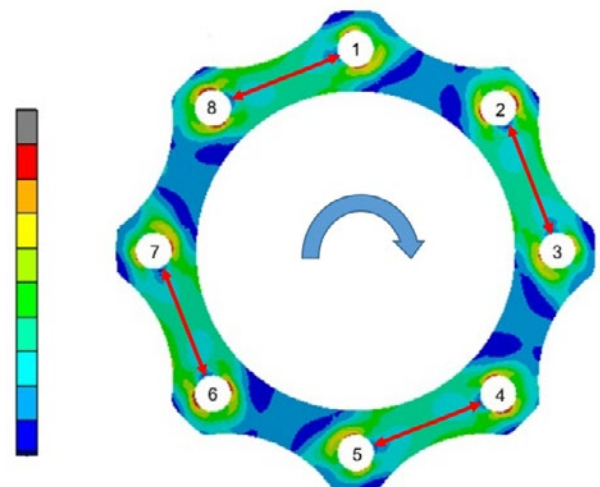


Image 3 – Torque transition through Kop-Flex disc pack.

MISALIGNMENT

Misalignment is accommodated through the bending of the disc as seen in Image 4. Since there is no wear between components, no lubrication is required. The discs are typically made of high strength stainless steel which are assembled in unitized packs for easy maintenance. The stacking of multiple thin discs versus a single thick disc of similar material increases the flexibility and reduces the reaction forces on the equipment, while providing a large cross section for torque transmission. The typical failure mode is for the discs to “unravel” and fail one at a time. The increased imbalance will cause the vibration response at the 1X frequency to trend up over time. With accurate vibration monitoring equipment in place, the equipment typically can be shut down safely before catastrophic failure of the disc pack occurs.

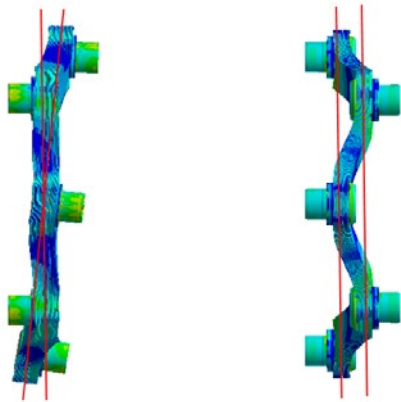


Image 4 – Angular (L) and Axial (R) misalignment accommodated by disc pack

As a disc coupling operates, minor movement between the discs occurs as the discs accommodate misalignment. This movement is not of great concern for applications below 3,600 RPM, but for higher speed applications, a PTFE based low friction coating is used to mitigate fretting corrosion as seen in Image 5.



Image 5 – No coating on top, low friction coating on bottom

To maximize the life of the coupling and the connected equipment, some manufacturers use a scalloped disc design. By removing unnecessary material from the disc, a scalloped design allows for a more flexible disc radially and axially. Verifying both models with Finite Element Analysis (FEA), a scalloped disc reduced reaction loads on connected equipment up to 25% in some cases (Image 6).

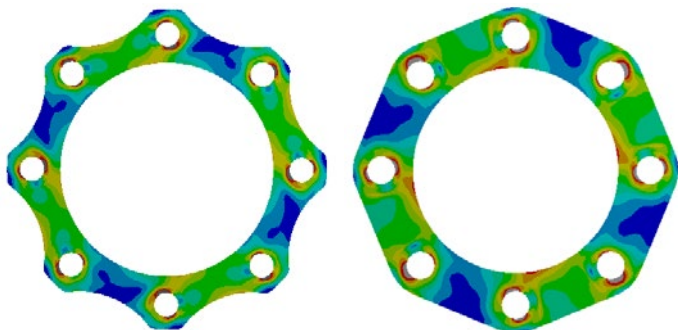


Image 6 – Scalloped vs. Non-Scalloped disc

This increases the flexibility of the disc pack with no loss of torque capacity. Optimization of the stress distribution through the disc is achieved, since the cross section of material at the bolt hole and the center of the link are equivalent.

For a given diameter, the torque rating and misalignment capacity of a disc coupling can be considered a function of the number of disc pack bolts used in its design. As seen in Image 7, a 3 bolt disc has long links between bolt holes thereby increasing the effective bend length which decreases the stiffness and increases misalignment capacity of the coupling. A 5 bolt disc pack design increases torque capacity since the bolts evenly distribute the torque, but the shorter link length increases the angular stiffness and decreases the misalignment capacity. As a general rule, 3 bolt designs provide high misalignment capacity, but low torque capacity while 5 bolt designs provide high torque capacity, but low misalignment capability. A 4 bolt design balances both torque and misalignment and is the most common configuration, operating successfully on a wide variety of applications from pumps to centrifugal compressors.

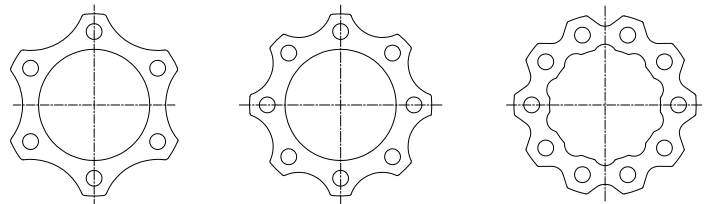


Image 7 – Disc Pack design comparison

Although fairly simple in theory, coupling design continues to evolve as increasingly accurate modeling and testing technology becomes available. By using state of the art finite element analysis and extensive in-house static and dynamic testing, coupling design continues to be optimized for a variety of applications. Through identification and analysis, disc couplings can be designed to reliably transmit torque and account for misalignment of today's critical applications.

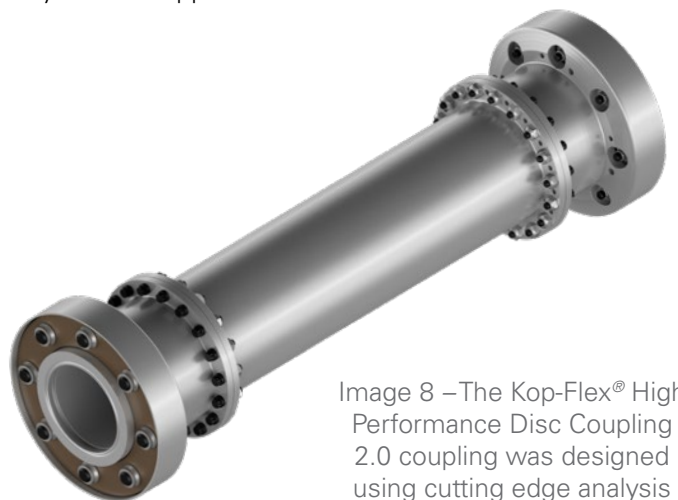


Image 8 – The Kop-Flex® High Performance Disc Coupling 2.0 coupling was designed using cutting edge analysis tools and techniques



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