KOP-FLEX®

COUPLING SELECTION AND DESIGN

COUPLING FUNDAMENTALS

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COUPLING SELECTION AND DESIGN

In order to decrease the time required to specify a coupling for an application, significant analysis is devoted to determining ratings for standardized sizes. A torque capacity is determined for the disc pack operating at a given speed, angular and axial misalignment. This is referred to as the maximum continuous torque (MCT) rating and the coupling is designed for infinite life if it is operated at or below these limits. In order to determine the coupling rating, the torque, axial and angular misalignment, and speed are used in combination to determine the Safety Factor. The relationship between mean and alternating stresses are plotted using a modified Goodman diagram as seen below (Image 1).

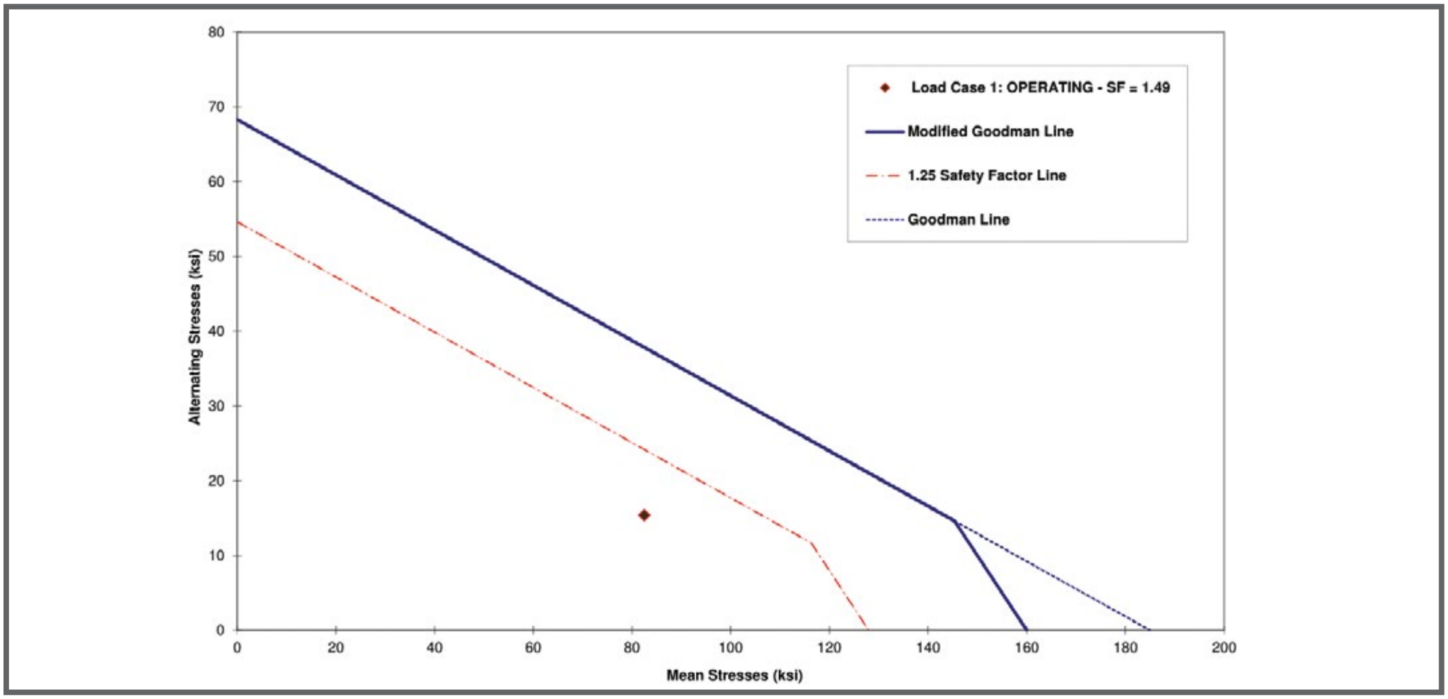

Image 1 – Goodman diagram

Mean stresses include the torque induced stress, centrifugal stress, and axial compressive or tensile stresses. Alternating stresses are typically given as a function of angular misalignment but can include torsional oscillations as well. When using a modified Goodman diagram, API 671 requires that the Safety Factor may not be less than 1.25. The catalog MCT rating is determined with the coupling running at maximum rated speed and maximum rated angular/ axial misalignment, which is based on the disc pack geometry. If the axial and angular misalignment ratings are reduced the MCT rating can be increased; if a greater misalignment capacity is required, the MCT rating and/ or speed rating can be reduced.

The requirements for selecting the proper coupling for a new application are typically the same. The design engineer will need to know the driving and driven equipment, the power and speed rating of the equipment/application, as well as the shaft separation (DBSE). The shaft sizes of the driving and driven equipment are not required to make a selection, but are necessary to finalize a coupling drawing. If a preliminary or budgetary selection is satisfactory, the above information is all that is required when specifying a coupling. This information, along with the controlling specifications, allow the design engineer to effectively select the right coupling for the application.

High performance coupling selections for high speed, critical equipment, are not only designed as specified by API 671 and customer requirements but also take into account application specific information. The design engineer will need to know if any transient torques are present due to the type of equipment and/or process.

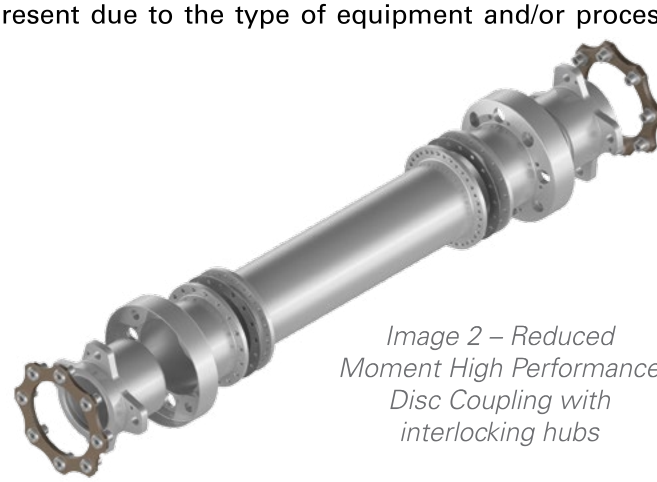

Image 2 – Reduced Moment High Performance Disc Coupling with interlocking hubs

Additionally, axial thermal growth values the coupling will experience are required so the coupling can be designed to accommodate the thermal growth. The customer can request special features to be included such as an integrated torquemeter, shear section for torque overload protection, and electrical insulation to name a few.

For a given application, some uncertainty in operating conditions will remain. For this reason, API 671 requires a Service Factor to be applied to the nominal steady state torque of the equipment. The Service Factor can account for any unknown vibratory torques, transient torques or any other abnormal operating conditions which could be more demanding on the coupling than anticipated

With the coupling type and size determined, a few other steps are required to determine the final design. The coupling can be designed with a number of different interface connections including: straight or tapered keyed shafts, straight or tapered keyless shafts, integral flange connections or splines (Image 4). Calculations are performed to determine the load carrying capacity of these connections and confirm they meet customer requirements.

Once the design has been completed for a given application, the mass elastic data (M.E.D) is provided on the coupling drawing. The data included is the half weight and center of gravity (CG) location, the moment of inertia as well as coupling stiffness – axial, angular, and torsional. M.E.D. is used when performing the lateral and torsional analyses on the drivetrain.

Current turbomachinery design trends force compressors to operate at higher speeds to achieve increased efficiency. This highly engineered equipment can achieve the same pressure ratios as larger equipment and can therefore perform the same process in a smaller package. A reduction in casing size results in the use of smaller shafts and therefore smaller bearings. Long slender shafts with increased bearing spans operated at higher speeds are significantly more sensitive to rotordynamic issues.

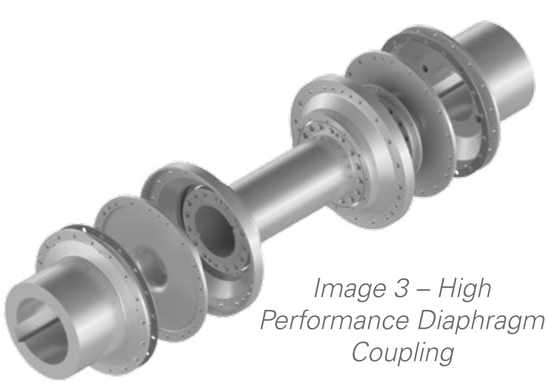

Image 3 – High Performance Diaphragm Coupling

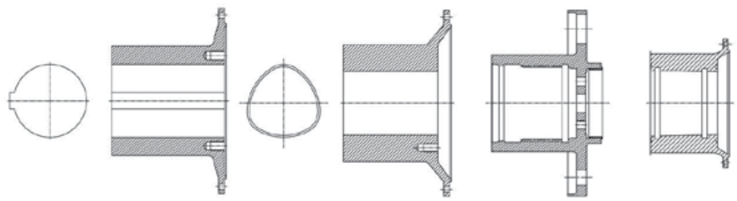

Image 4 – Hub (L-R) keyed straight bore, polygon bore, splined, keyless tapered keyed tapered hub

These rotordynamic issues can be mitigated through the use of a smaller lighter weight coupling. A lighter weight coupling also lowers the imbalance, providing better dynamic stability and improving the system response. The flexible elements of a reduced moment style coupling are mounted on the coupling hubs which decrease the load on the bearing when operated at high speeds. Since the center of gravity is moved closer to the bearing, the overhung moment is reduced which directly effects the lateral critical speed (LCS) of the train. The larger the overhung moment, the lower the LCS.

Given the adjustability of the coupling design, it is typically the most convenient and lowest cost location to tune the drive train. Because the coupling is typically the least torsionally stiff component of the drive train, its stiffness greatly affects drive train performance and makes it the perfect component to modify. Whether this means using a larger, stiffer tubular spacer, a softer, smaller solid spacer, or changing the coupling component material to lightweight titanium, all of these options can be used in order to achieve optimal drivetrain performance.

Coupling design continues to advance as the modeling and testing technologies improve. Kop-Flex has developed proprietary software (Coupling Automation Program) to assist with streamlining coupling selection for our engineers. Based off the required inputs discussed previously (DBSE, Speed, HP, Bore Sizes and Interface connections), the software selects the coupling and creates a drawing which can then be fine-tuned by our engineering team as necessary. While fairly simple in theory the actual steps required to complete a selection and design can be extensive. As equipment continues to increase in horsepower and speed, requiring a reliable design is of even greater importance.

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