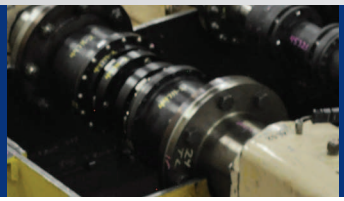
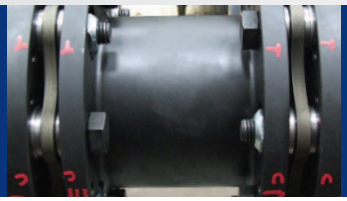
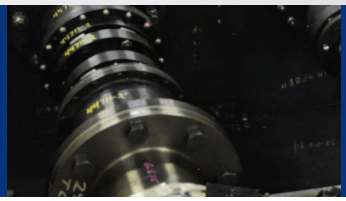

Disc Coupling Dilemma: Torque Density vs. Durability

Summary:
Although requirements are different for the countless applications for disc couplings, manufacturers must provide a line of products that will meet them. If a disc coupling manufacturer has not consciously optimized their products given the possible applications, they may be forced to recommend a heavy, over-engineered coupling in certain situations. Additionally, as disc coupling manufacturers attempt to stretch their product line to meet increasing torque ranges, they inevitably sacrifice strength and durability. Those who select and specify disc couplings should be aware that design durability requirements vary greatly between manufacturers.

There is a long list of factors that should be considered when selecting a flexible coupling. Many low-power applications, such as single speed small pumps and compressors, can be specified with the basic information of bore capacity, continuous torque load, peak torque load, misalignment, and distance between shaft ends (DBSE). However, as the torque and rotational speed increases there are several additional factors that must be considered.

There are many flexible coupling technologies available. This can be attributed to the fact that there is not a single solution for all applications. A prime example of this is the low power pump and compressor applications mentioned earlier where elastomeric designs are typically considered. As the speed and torque of these same applications increase, disc couplings become the industry standard. Disc couplings dominate this segment because of their high torsional stiffness, ability to be accurately balanced, relatively long operating life and high torque density.

This paper highlights that many products are too conservative in their torque ratings, while others are arguably too aggressive. Those who specify disc couplings should understand that manufacturers of disc couplings must strike a balance between maximizing torque density and durability, and different manufacturers' disc couplings are not designed to the same durability specifications. Those who specify and maintain disc couplings or manufacture equipment that utilizes disc couplings should be aware of the implications of this tradeoff as they can lead to costly and unsafe coupling selection.

Torque density matters

Historically, manufacturers have offered products with very conservative torque ratings to ensure that the coupling would last a very long time. While this may have given the customer peace of mind, it also results in a higher cost and a heavier coupling. While the impact of a higher cost is clear, a heavier coupling's impact is more subtle. Differences in coupling weight are often seen as negligible; however, a heavier coupling can be more difficult to design around. The heavier weight causes a greater bending moment on the pump or compressor shaft which leads to higher vibration levels, and may even increase wear on the bearings and seals.

By considering the coupling's torque density, those responsible for specifying disc couplings will avoid selecting an overly conservative coupling and will be closer to choosing the optimal coupling for their application. Torque density can be defined in a number of ways. One is the torque capacity per outside diameter of the assembled coupling. This metric is useful when concerned about the space limitations around the coupling. Another method of defining torque density is the customer application's continuous torque per unit mass of the coupling. This metric, which is used throughout this paper, is more relevant in the design of high-powered pumps, fans and compressors. Relative to many flexible coupling applications, these can have relatively high speed and torque requirements.

The highest torque density coupling meets the application's torque requirements while

minimizing coupling weight, but how confident can the specifier be in the manufacturers' abilities to properly rate the coupling? The following analysis highlights that some manufacturers aggressively rate their couplings, and their products may not last as long as expected, while others are more conservative for certain applications resulting in a heavier product with potential for accelerated bearing and seal wear.

Torque density analysis

A simple torque density analysis can be completed using the ratings from a variety of manufacturers' product catalogs. To demonstrate how this can be accomplished we will compare the torque density of a variety of disc couplings for a few standard NEMA motor frames commonly used to drive pumps, fans and some compressors.

While many factors require consideration, basic coupling sizing requires that the coupling can accommodate the required shaft sizes and nominal continuous torque. Figure 1 compares a variety of manufacturers' disc couplings versus the NEMA 449T frame size with a service factor of 1.5. The figure plots the torque and bore capacities of various coupling models, as well as the shaft diameter and maximum torque for the NEMA motor frame. A selection can be made from this chart by locating the NEMA requirements for these two parameters and choosing a coupling that exceeds them.

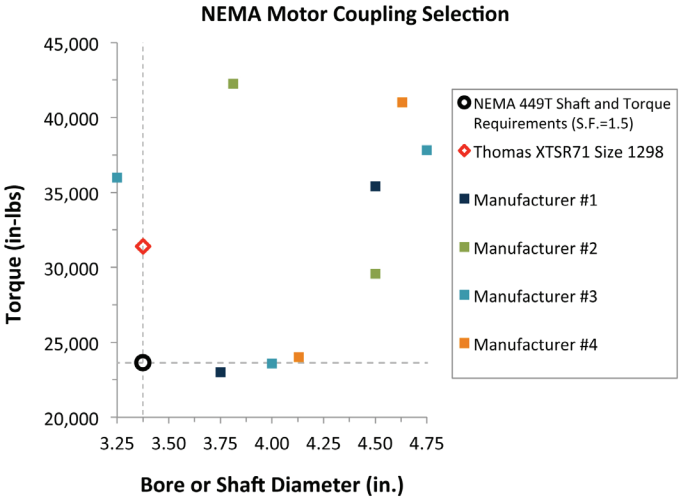

Figure 1 - NEMA 449T motor frame shaft and torque requirements (S.F. = 1.5) compared with leading manufacturers' coupling torque and bore capacities.

This selection will return coupling models from each of the manufacturers that will meet or exceed the requirements, but it is important to then compare other factors prior to selecting a coupling from this group, such as the coupling weight. Figure 2 below shows a weight comparison of several manufacturers' couplings that meet or exceed the torque and bore requirements for a NEMA 449T motor frame. Note that the coupling weights have been normalized to a 7" DBSE and both hub bores to the corresponding motor shaft diameter. The chart shows that the heaviest coupling for this application is over 45 percent heavier than the lightest. The weight of the coupling can vary significantly and the impact of this additional shaft load should be considered.

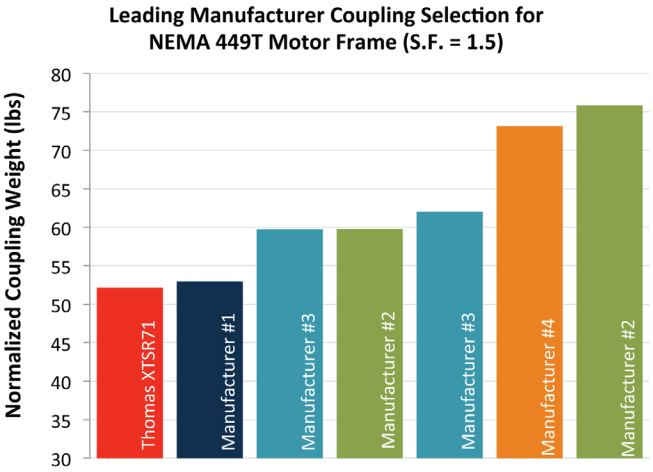

Figure 2 - Normalized weight comparison of the couplings from various manufacturers in Figure 1 for the NEMA 449T motor frame.

As Figure 1 and Figure 2 show, the couplings on the left will have the highest torque density for these applications because they meet the torque and bore requirements while minimizing weight. Therefore, they are the most efficient designs for this application. While it may not be essential to select the most torque dense coupling from the group, those who specify disc couplings should be aware that a single manufacturer's best product for a certain application can be much heavier than another manufacturer's best product.

Durability testing

While we often take the catalog torque ratings for granted, it is important to verify that the durability of each of these disc couplings is up to expected levels. Some end users have requested certain durability requirements, or compliance with the DIN-740 coupling specification that calls for the ability to withstand 100,000 load cycles. Even if the end user does not request certain levels of durability, it is good practice for manufacturers to have internal requirements for cycle testing based on system start and stop expectations. Cycle testing was completed on four major brands of disc couplings to compare durability and to understand if all manufacturers are compliant with this standard.

The test stand utilized a hydraulic actuator to rotate a shaft and apply the catalog rated peak torque load to one end of the coupling, while holding the other end of the coupling static. This unidirectional test cycled between zero load and catalog peak torque load for 11 disc coupling samples from four different manufacturers. One load cycle is defined as an applied load of zero to catalog peak torque rating. While many product samples experienced disc pack flaring or buckling at some point in the test, the samples were not deemed a failure until the disc packs had fractured.

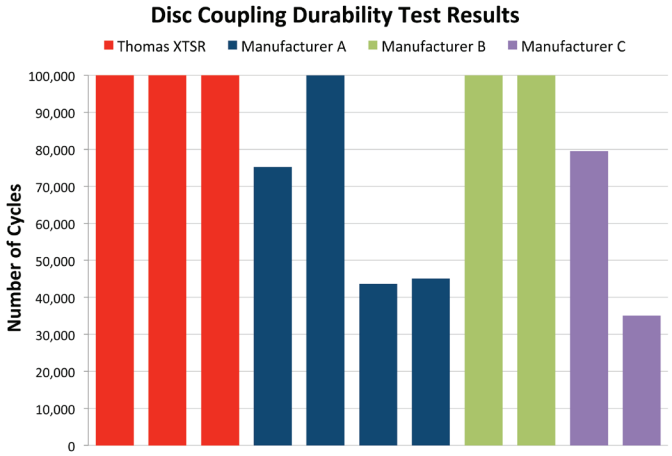

Figure 3 - Coupling peak torque cycle test results.

Figure 3 plots the results of each of the eleven samples tested from four leading disc coupling manufacturers. Note that two manufacturers, Thomas and Manufacturer B, passed all of the samples tested, while the others' samples failed to meet the 100,000 cycle requirement. The results show that samples from two of the four manufacturers only withstand 50 percent of the start and stop cycles compared with other manufacturers. These findings highlight that regardless of catalog ratings, not all products can withstand the durability requirements referenced by many coupling specifiers.

While selecting a disc coupling does not have to be complicated, it is important to understand the trade-offs that coupling manufacturers make between torque density and durability. It is always prudent to opt for the coupling with the highest torque density to minimize the coupling's inertia and impact on bearing and seal wear; however, those who specify and maintain disc couplings or manufacture equipment that utilize disc couplings should be aware of the differences in coupling durability between manufacturers. Simply taking the couplings' catalog ratings for granted without understanding the design criteria used by the manufacturer can result in the selection of an inadequate coupling, particularly for critical applications that require highly durable products.

CP4-004 Printed in USA 05/13