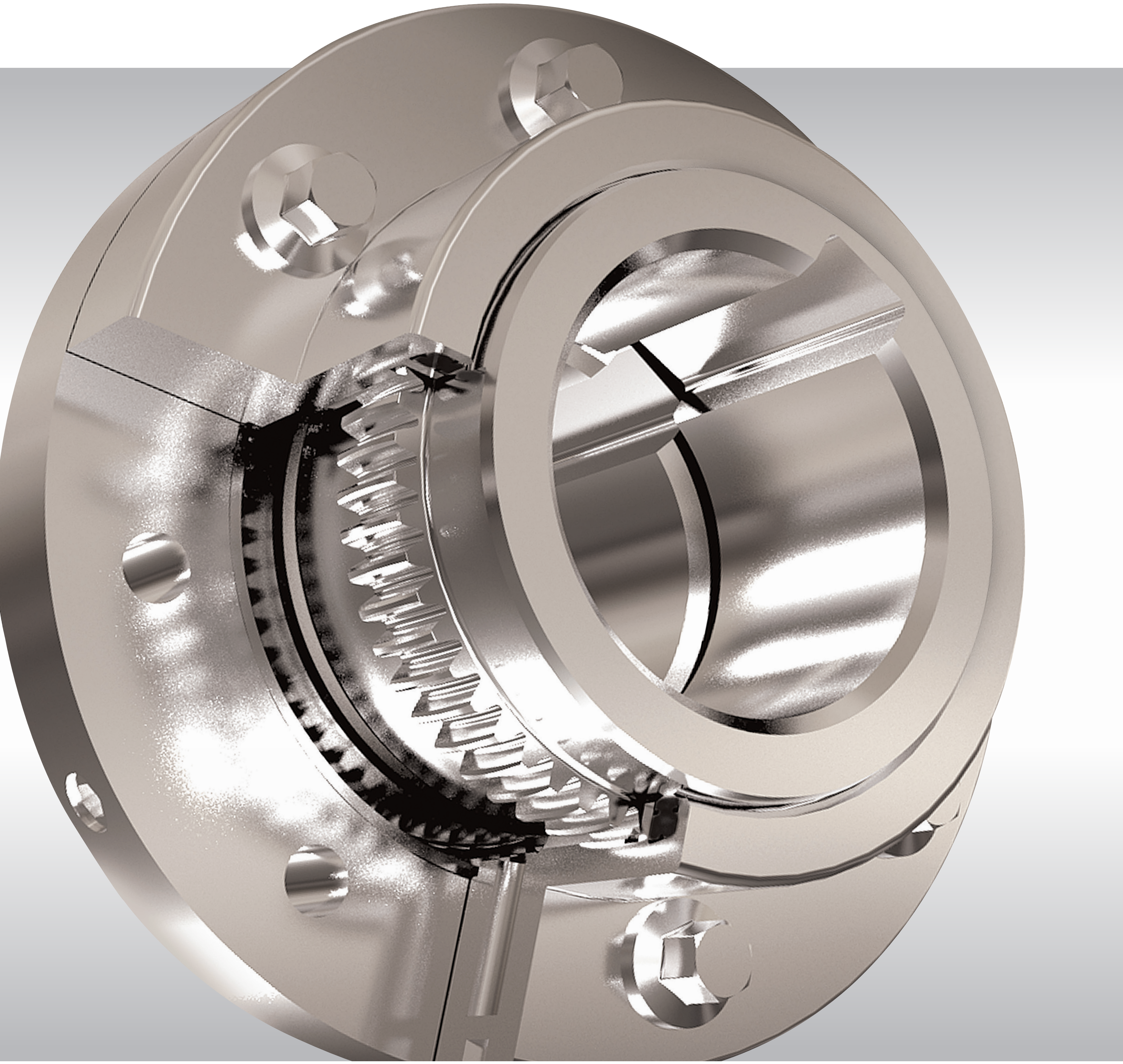
HercuFlex by Lovejoy

Whitepaper



# The Reinvention of the Gear Coupling

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Gear-couplings are the foremost coupling type. They can do things that many other coupling types are unable to perform, or that need expensive modifications and de-rating to function. Gear couplings have the highest power density, offer more variations, a wider size, torque, and bore capacity than any other coupling type. They are easily modified for shear pin service, floating shaft type, vertical applications, electrical isolation, limited end float, and can have a brake drum or disc added. While some features may be available on other couplings, it is typically easier and cost effective to modify a gear coupling. With all these advantages, the gear coupling is used on more applications versus the nearest competing coupling type.

As implied by the name, gear couplings use the meshing of gear teeth to transmit torque and provide for misalignment. External gear teeth are cut on the circumference of the hub. Two of the toothed hubs fit inside of a tubular sleeve that has matching gear teeth cut around its interior circumference, with each tooth extending axially the full length of the sleeve. Hub and sleeve teeth mesh, so torque transfers from the driving hub's teeth to the sleeve teeth and back to the driven hub's teeth.

Gear couplings achieve their misalignment capability through backlash in the teeth, crowning on the tooth surfaces, and a major diameter fit. Backlash is the looseness-of-fit that results from gear teeth being narrower than the gaps between the teeth. In addition to contributing to the misalignment capabilities, the backlash provides space for the lubricant. The loose fit provides misalignment capability by allowing the sleeve to shift off-axis without binding against the hub teeth. Crowning, or curving the surface of the hub teeth, further enhances this capability. The crowning can include tip crowns, flank crowns, and chamfers on the sharp edges. This also helps improve tooth life by broadening the contact area along the "pitch line" (where the gear teeth mate and transfer torque), thereby reducing the pressure of torque forces. In addition, it prevents the sharp squared edges of the tooth from digging in and locking the coupling. Variable Crowning, which varies the curvature radius along the tooth flank, maintains greater contact area between teeth during misalignment compared with standard crowning, and reduces those stresses that cause wear. Note that crowning applies to hub teeth only; sleeve teeth are straight except for a chamfer on the minor diameter edge.

While the hub and sleeve teeth are cut to fit loosely side to side, they fit closely where the tip diameter of the hub teeth meet the root diameter of the gaps between the sleeve teeth. That is called a major diameter fit. Minor diameter fits (where the tips of the sleeve teeth meet the root diameter of the hub teeth) are purposely avoided, because a close fit would prevent suitable misalignment and torque transmission capability.

Gear coupling sleeves can be a single piece, termed a "continuous sleeve", or can be split radially into two half sleeves, one for each hub. The split version is termed a "flanged sleeve", because each half has a flanged end which is drilled for connecting fasteners.

Gear couplings use the AGMA standard naming convention to specify the size of the coupling starting at size 1 and increasing to size 30; with a corresponding increase in size (a flanged size 1 gear coupling is approximately 4 ½ in diameter while a flanged size 30 gear coupling can approach 78 inches in diameter). AGMA specifies that flange gear couplings from size 1 to size 9 will match up half for half with other flange type gear couplings made to the AGMA standard dimensions. However, while the dimensional standard ensures compatibility of the face to face match between sleeve flanges, it does not assure matching torque or bore capacity.

It was noted earlier that gear couplings are power intensive. That means more torque is transmitted per coupling mass and space consumed than other coupling types. The resulting relatively small size of the gear coupling allows the addition of attachments without having the coupling grow to excessive proportions.

Despite the popularity of the current gear coupling marketplace offerings, we received inquiries from customers who wished to understand if product enhancements were available. Detailed discussions with multiple users ensued to gain an understanding of key product features. While increased torque capacity was routinely requested, it was linked to the desire for an increased coupling service life. Interrelated was the request to continue to offer a large number of design varieties yet still retain interchangeability with existing gear coupling sleeve flanges per the AGMA standard dimensions.

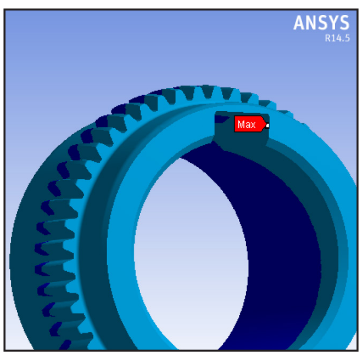
Based on the input from the customer base, engineering concentrated on developing a robust gear coupling design. The first phase concentrated on increasing the torque capacity while simultaneously enhancing the fatigue life. A design of experiments (DOE) was commenced to understand what factors influenced the design and to the extent a change would impact the desired characteristics. Variations in the crowning of the gear tooth profile, lubricant effectiveness, grade of material, permitted manufacturing tolerances, fastener grade & clamp load generation were just a few of the parameters included in the study.

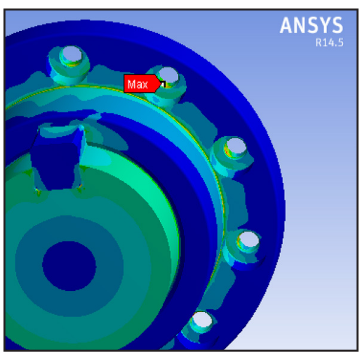
Additional design features were included based on the analysis. Upgraded seal geometry to reduce the influence of wear on the seal was linked with an elastomer material upgrade to reduce loss of performance from aging. Increased cavity area around the gear teeth to provide additional grease volume to ensure lubrication effectiveness in the harshest environments. Modified fasteners to increase the generated clamp force while still permitting interchangeability with existing designs.

The design characteristics identified in the DOE were not optimized by isolated product designers. Operations was a key member of the product development team as they provided information that allowed for design changes that would not only influence the performance characteristics, but improved the internal tasks necessary to create the product. Combining manufacturing steps to reduce work in process inventory. Creating standard gear coupling hub components to reduce inventory levels by half. Establishing a dedicated work station for the final manufacturing step allowing for a reduction in the time of delivery to the customer.

The resulting gear coupling design had undergone countless FEA iterations, statistical fatigue life studies and performance analysis. To link the theoretical with the actual physical performance, validation testing was required. The validation testing program underwent a similar enhancement process as the design phase. Validation of the design, product manufacturing and production suppliers were combined into a single step. With the involvement of Purchasing early in the development process, key suppliers were vetted, selected, and were able to provide design input prior to design release. This allowed production suppliers to provide samples for testing that were prototype in name only as the intended production processes were used. To ensure the samples were fully representative of the product a customer would receive, Operations completed all manufacturing steps on the intended production equipment.

Validation testing consisted of a series of individual component experiments in addition to subjecting fully assembled couplings to

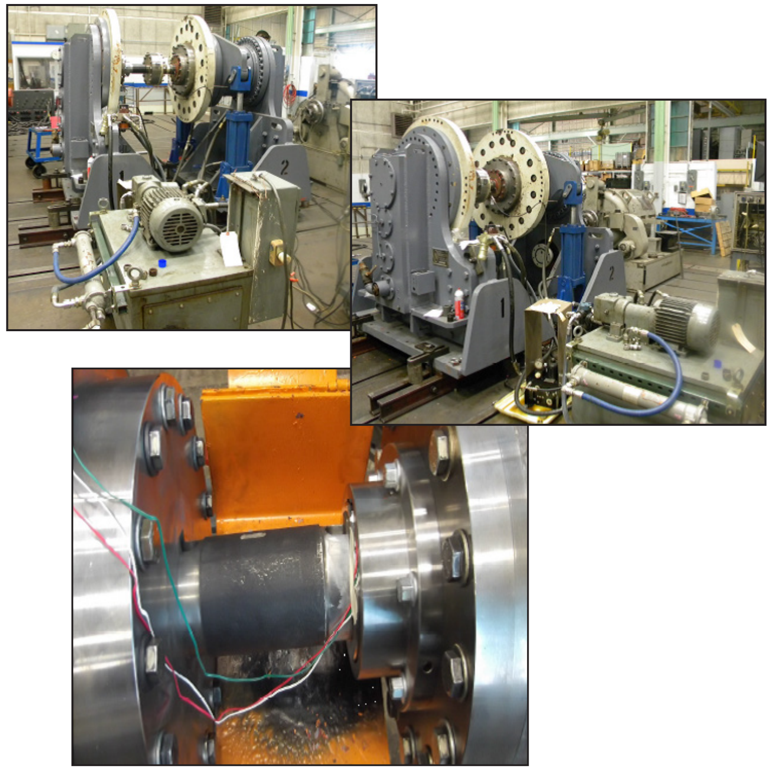



a battery of worst case conditions. High cycle coupling fatigue, high misalignment tooth fatigue, ultimate torque capacity, high torque reverse loading and seal contaminated environment life performance are just a sampling of the extensive validation testing performed. Comparing the results achieved during the physical testing to the predicted analytical performance confirmed the validity of the analytical models.

Achieving a gear coupling design with increased performance and service life was no easy task. By concentrating on establishing a robust design, the customer will receive a significantly improved coupling without sacrificing features they have grown accustom to. With the multiple upgrades in the new gear coupling, including increased torque and bore capacity, most applications now have the ability to downsize the coupling and still meet system requirements. This allows the end user to obtain a gear coupling that is physically smaller and at a reduced price point while still achieving an increase in the service life.

To differentiate the new gear coupling in the marketplace, Lovejoy introduced the HercuFlex trademark to signify the increased capabilities.



With increase torque and bore capacity combined with a robust design that increases service life, the HercuFlex coupling gives the customer the ultimate choice. Use the increased capacities to maximize the abilities of the system or downsize the coupling to gain a cost reduction without sacrificing performance.

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