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Celebrating 150, the Fifth Generation Plots the Company's Future Course

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Cardan Shafts

Review of the basics & Why Precision Alignment is a Must

When it comes to mechanical failures and downtimes, the premature wear of cardan shaft joints is a very common culprit. What causes this premature wearing of the joints? Misalignment. The maintenance of cardan shafts, unfortunately, is often challenging due to their size, function, and accessibility, making their alignment one of the most commonly overlooked, and misunderstood issues a ship's operator can experience.

A cardan shaft is a type of coupling that connects two machines that are offset from one another. One is usually a stationary machine, a motor, or the driver, the other is the machine that will be "driven." Cardan shafts are specifically utilized to allow for the parallel misalignment caused by these two machines being offset. This configuration makes up a drive train, with the cardan shaft transmitting torque, and rotation. In vessels, cardan shafts are placed between the engine and gear box. They are not able to be directly connected to either piece of equipment because movement must be allowed, so it is attached using "universal," or u-joints. A "single" cardan has two u-joints, one at each end. A "double" cardan has three or more of these joints. These allow for necessary movement without becoming uncoupled. To understand the true function and workings of a cardan shaft, it's important to have a good overview of the u-joint's construction, and how they work. The basic makeup of a u-joint consists of two yokes and four pivot pins. A hole in the yoke carries the pivot pins which oscillate as the joint rotates. All of the bearing actually occurs in the tiny space between the pins and the yoke holes they lay within. Because of the movement these joints sustain, ample lubrication is required at all times. To prevent these joints from seizing, lubricant must remain in constant circulation around them, if not, you run the risk of disaster striking. For this reason, cardan shafts are typically installed with a three to six degree angle present at the u-joints. This, however has been challenged time and time again, where case studies have shown that the difference between the angles should be less than 0.25 degrees. And, of course, in a perfect world, with a perfect precision alignment having been performed, the angles would be equal.

Given the way cardan shafts are constructed, and the role they play, do they actually require alignment? Despite the "flexibility" of cardan shafts, and their ability to allow for offset, they are not able to absorb angular misalignment between the shafts. Offset has been shown to have no affect on alignment. Angularity on the other hand, can produce misalignment that results in excessive vibration and speed fluctuations. Angular misalignment can be vertical or, horizontal. If the angular misalignment present is vertical, the motor shaft is under an angle with the pump shaft, but both shafts are still in the same vertical plane. Angular horizontal misalignment is similar, however, both the motor, and pump shafts or on the same horizontal plane. In the situation where a cardan shaft is experiencing angular misalignment, there will be a significant change in rpm's of the driven shaft. The inconsistency of the rotations is commonly referred to as cardan error. This deviation causes vibration, which, triggers a fluctuation in bearing loads, ultimately resulting in premature wearing of components and reduced mechanical life of machinery. The greater the difference in the yoke angles, the worse the misalignment. The greater the misalignment, the worse the variance in speed. When prop-

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erly aligned, yoke angles are equal to one another when both ends of the shaft are on parallel planes, for both the vertical and horizontal axis.

Besides angularity, phasing is another important concept when it comes to the alignment of cardan shafts. Here, the position of the yokes on both ends must be set parallel, so they fall in line with one another. When the yokes are not set parallel, every time the drive revolves, the driven machine will speed up and slow down twice.

Cardan shafts are, by design, constructed for tight spaces that are not easily accessible. Traditional laser alignment procedures required that the cardan shaft be completely removed in order for alignment to be achieved. An "offset" fixture, or bracket would be mounted on the coupling flange of the driven machine, with a laser sensor mounted on the rotating part. A second laser sensor would be mounted on the driver. The bracket would allow for virtual positioning of the rotational axis that connects the two machines. Alignment data would then be collected from both the vertical and horizontal planes to determine what adjustments were needed. This method was also necessary when the shafts were not able to be rotated.

Fortunately, technology is ever evolving, and cardan shaft alignments are becoming easier, safer, faster, and, more cost effective. Laser alignment systems, such as those recently acquired by Advanced Mechanical Enterprises/AME, a mechanical engineering services firm for rotating machinery, based in Fort Lauderdale, FL, now have advances that allow for these complex alignments while leaving the cardan shaft in place.

"Our newest system a laser-optical measurement function that now makes in-place alignment possible with the use of two specially designed brackets, along with the standard, handheld computer, laser transmitter, and receiver," said Rich Merhige, President, AME. "One of these brackets is referred to as a chain type, and has a third 'arm' allowing it to be directly mounted to the driver's shaft. The other new bracket has a rotating arm where a sensor is mounted."

As the shafts are turned, the bracket arm, in turn, rotates, allowing for the sensor to move up and down the posts, thus picking up the laser being transmitted. This method is very similar to the traditional alignment performed on standard couplings.

"One of the advantages we have always had in our market is the equipment and knowledge to do cardan shaft alignments," said Merhige. "Now, we are even better equipped to provide our customers with this service since we've upgraded our laser systems. With this equipment, we can still carry out the same precision cardan shaft alignments, but there is no longer a need to remove the cardan shaft. This means reduced service time, which translates into savings for our clients."

Investing in this new equipment, is a significant expense, but has been shown to have a substantial return for companies such as AME. For example, a Gulf-based tow boat that is heavily utilized in the oil industry was in desperate need of a cardan shaft alignment.

"They had needed an (cardan shaft) alignment for some time, put had put it off to avoid taking a financial hit, for what the operators thought would be an extended service period," said Merhige. "When they were finally referred to us, they were relieved to know that we had the technology and Field Service Engineers capable of performing the alignment in less than a day. Needless to say, they were extremely happy with the results, and plan on having us return to perform the same service on the other vessels in their fleet."

While the mechanics of the cardan shaft are complex and can make one timid when it comes to securing proper maintenance services, the reality is, there is now technology in place that makes this alignment nearly fool proof. Now, all that is necessary to prevent cardan shaft joint wear is the right contractor, with the correct equipment. With this, precision cardan shaft alignment can fit any maintenance budget, and prevent headaches of catastrophic failures and premature machinery replacements.

Laser Set-up.

Cardan Shaft Alignment.