Flexible Couplings Give Power Transmission Designs an Edge

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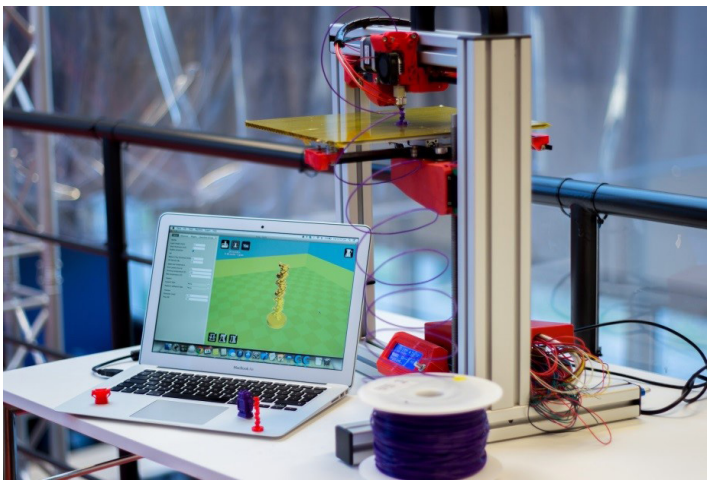
"Motor shafts and driven shafts are never perfectly aligned." That may be a pretty strong statement, but unless you have a deep budget and your equipment is destined for a space telescope or a nanoscale manufacturing facility, tolerance stacking and assembly accuracy will create misalignment between the driver and the driven shafts. Fixed couplings will provide the greatest efficiency of torque and power transmission, but they have their drawbacks. Even the smallest misalignment can create premature bearing and axle failure, especially at higher speeds. For instance, misaligned shafts that are connected with a fixed coupling can provide repetitive loading of bearing balls on bearing races. After a number of repetitions, the race or ball surface will fail or spall and separate from the parent metal—and end up looking like a boiled egg that has peeled poorly. This damage can occur in an accelerated timeframe when equipment operates at high RPMs.

3D printing can help to accelerate and optimize design and prototyping process and require accurate positioning of the print heads for accurate model reproduction.

Consider 3D Printers

Three-dimensional printing, or additive machining, is a fairly recent technology. The functioning principle is quite straightforward. Positioning is key in any of the many 3D printing technologies available, including Stereolithography (SL), Digital Light Processing (DLP), Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Electronic Beam Melting (EBM) and Selective Laser Melting (SLM). A deposition or activation head, or focus point, must be accurately positioned in a three-dimensional space. This can be accomplished by moving the 3D print "head" or by moving the workpiece stage. It is likely there are three linear actuators, each representing a dimension in Cartesian coordinates (x, y and z.) Each of these actuators must be controlled by a positioning driver powered by an electric motor.

Early in their inception, like most equipment research and development projects, 3D printer prototypes were built by hand in a lab. The basic construction techniques of assembling motors and actuators make flexible couplings a necessity for operating and testing of these prototypes. As 3D printer designs became proven and tested, the desire to maximize precision allowed for tighter alignment tolerance for the motion-control components in the system. With these tighter alignments, rigid couplings could be introduced. Low-volume production units were destined for academic and corporate labs that could afford and justify the cost premium of these precison-crafted machines.



Sample 3D Printer

Additive machining technology advanced and 3D printing grew in popularity; first in

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Flexible Couplings

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business as a way to creat physical models from 3D design files, and then as a consumer product for home use, to the point where it is now considered a high-tech teaching "toy." Increasing demand, especially at the lower precision end, put downward pressure on prices, creating the need for designs to have lower costs to produce. Simpler, lower-cost designs and construction tehniques increased tolerances and misalignment, and the flexible coupling once again became a logical component for this class of machines.

There are many considerations to evaluate when deciding whether a flexible coupling is the correct solution to your application, and which type of coupling would work the best. Many styles and types of couplings are available. For successful selection, application conditions must be clearly understood. Rigid couplings are appropriate when shafts are positioned in exact lateral and angular alignment. This design does not tolerate misalignment between shafts, but it can generally transmit more power than flexible couplings. Flexible couplings are designed to accommodate misalignment between shafts and various types of load conditions. The major considerations that will often come into play are operational speed, service conditions (environment), system torque and horsepower, and backlash-tolerated and rotational velocity error. Lateral and axial flexibility, shaft misalignment, and torsional flexibility should also be considered.

Because it is nearly impossible to completely eliminate all misalignments between power and powered shafts, and shaft misalignments always lead to eventual fatigue failure of bearings and shafts, replacing rigid couplings with flexible couplings is a prudent consideration. A flexible coupling will allow for imperfect alignments of the two joining shafts and absorb impact from changes in torsional movement or angualar speed in the system. Ideally flexible couplings are rigid under torsion, but they allow the correction of alignment errors in the drive and driven shafts. They are widely and successfully used in the fields of robotics and automation applications because they perform well for exact system positioning. These attributes give them the alternate designation of "precision couplings."

Flexible Couplings in Use

Flexible couplings are primarily used to connect a rotating power source to a piece of rotating equipment. A common industrial application involves connecting electric and other types of motors to a pump. In electrical generation and transmission, couplings connect turbines to generators, and electrical switchgear is actuated by a servo motor through a flexible coupling. In process facilities, valves are operated by an electric motor through a flexible coupling. Machine tools and other factory automation rely on flexible couplings transmitting power from a motor source. Modern aerospace applications include many fly-by-wire systems like those incorporated in the Boeing 787 Dreamliner and the Airbus 380. State-of-the-art commerical airliners have hundreds of motor-driven actuators in flight control and other systems that use flexible couplings to mitigate misalignments, providing longer and safer performance for critical components. Flexible couplings can be found in transportation systems and agricultural equipment, and virtually every application where rotating energy is transmitted from one unit to another.

Airbus A380 Flight Deck

Flexible couplings make sense in many industrial applications. A rigid coupling can cause premature bearing failures if used in an application with misalignment. Consider a packaging machine that cannot be kept in tight parallel alignment. The connected shafts are transferring excessive forces to other components in the system. Connecting the shafts with a rigid coupling will likely cause the motor and gearbox bearings to fail or become damaged. Motor and gearbox replacement is expensive and production time will be lost. In this case, a flexible coupling designed for handling the parallel misalignment in the shafts would produce low bearing loads and act as a mechanical fuse, failing under excessive stress and sparing the motor and gearbox from damage.

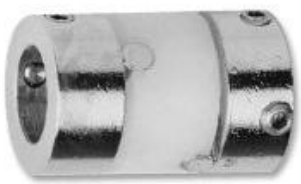
Types of Flexible Couplings

Most flexible couplings can be orgainized into the following groups: Mechanical Flexible Couplings, Material-Flexible Couplings and Magnetic Couplings. Mechanical Flexible Couplings compensate for misalignment between the connected shafts by means of clearances incorporated in the design of the coupling. They also can compensate for angular misalignment through multiple axis rotation, such as a universal joint. Material-Flexible Couplings rely on the flexing of the coupling components to counter shaft misalignment. The working element may be any suitable flexible material that resists fatigue failure enough to provide acceptable life. Helical beam-style, bellows and elastomeric couplings fall into this category. Magnetic Couplings transfer torque between shafts using a magnetic field rather than a mechanical connection. Although this can allow some slippage, a major advantage is the ability to seal one component from the environment of another.

Universal Couplings are designed for use with wide-angle power or control applications with angular misalignment up

to 40°. The universal coupling operates on a precision ball bearing in concert with hardened and ground dowel pins to transmit high torque. Universal couplings can be used for manual or medium-duty usage, such as multi-spindles, farm equipment, conveyors, process machinery, snow throwers and other equipment. Their strong points are low cost, high misalignment accommodation, high torque transmission and long life.

Flexible Beam Couplings (also known as helical or slit couplings) prevent backlash and provide constant velocity with angular misalignment. They are designed for high speeds and do not require lubrication. Helical and slit couplings are flexible beams machined from a solid piece of material with a bore through the center. Slit couplings have several slits, machined on the periphery of the coupling, that allow the beam to flex. A helical coupling is a type of slit coupling that has a continuous, helical slot machined through the bore in the center section. Both coupling types have no backlash and constant velocity with angular misalignment. They can operate at high speeds with no lubrication.



Oldham Shaft Couplings handle high degrees of parallel misalignment owing to their sliding element design. They provide uniform velocity, regardless of shaft misalignment. In their original form, Oldham-type couplings had backlash, needed lubrication, and accepted little angular misalignment. Modern improvements now greatly enhance their performance. A nylon centerpiece virtually eliminates backlash, noise and the need for lubrication. The cylindrical cross pins permit greater angular misalignment (up to 5°).

Flexible Disc Couplings are assembled with no moving parts, reducing the risk for coupling failure and backlash. They utilize thin, stainless-steel disc springs that allow for a substantial amount of shaft misalignment while remaining rigid under torsional loads. Torque is applied through sheet metal plates mounted to shafts and intermediate plates by two-point supports. This coupling type is suitable for light- to moderate-duty applications. Flexible Disc Couplings, with their torsional rigidity, low inertia and zero-backlash operation, are ideal for precision instruments, encoder drives, robotics, aircraft equipment, radar, laser, optical/mechanical devices, computers and precision remote controls.

Metal Bellows Couplings are designed for high speeds and light-duty applications. They prevent backlash and do not provide cyclic speed variation. The bellows are often made of stainless steel, which makes them ideal for transmitting torque. Due to the bellows' thin walls, the coupling is able to flex easily while remaining

Flexible Coupling Comparison

Coupling Type	Axial Tolerance	Angular Tolerance	Parallel Tolerance	Torsional Tolerance	Comments
Helical	Some	Large	Some	None	No backlash and one-piece design
Bellows	Some	Large	Medium	None	May experience fatigue failure
Flexible Disc	Some	Some	Some	None	Absorbs shocks with no backlash
Universal	Some	High	None	None	High torque, must be lubricated
Oldham	Some	Some	High	Some	New design with elastomer center

rigid under torsional loads. Axial movement, as well as angular and parallel misalignment, is accommodated by the metal bellows coupling.

There are four basic types of shaft misalignment; you should review your application to determine your design needs. **Parallel misalignment** occurs when the two shafts do not have the same rotational axis. **Angular misalignment** applies when shafts are neither coaxial nor parallel. **End (axial) float** occurs when one or both shafts display axial movement, moving in and out. Some motors do not have axially fixed shafts that will "float" in and out during motor operation. Thermal expansion and contraction may also cause differences in the position of the end of the shaft. **Torsional flexibility** is the resistance to torsional movement in planes perpendicular to the axis of the shaft. A coupling with torsional flexibility will take up and absorb these movements.

Renbrandt, Inc. — Manufacturer of Custom and Stock Couplings

Renbrandt manufactures high-quality stock and custom flexible couplings in Gloucester, Mass., from domestically-sourced materials. All parts are produced in the United States. Starting with the Fleximite™ Flexible Disc Coupling in 1951, the company has expanded its product line to include One-Piece™ Flexible Beam Couplings, Tinymite™ Oldham Shaft Couplings and Unimite™ Universal Couplings. Renbrandt also offers precision collar clamps for mounting couplings to shafts. The company not only builds flexible couplings, but also it has a flexible manufacturing facility that stocks finished product and maintains a large inventory of components for immediate assembly. This allows speedy design and production of special designs, which gives customers the ability to specify alternative bore sizes without an additional charge.

Renbrandt Inc. can provide clients with customized dimensions on all of its main flexible coupling product lines: Fleximite™, One-Piece™, Tinymite™ and Unimite™. It can customize bore size, overal length and other dimensions according to client design preferences in inches or metric. Renbrandt Inc. flexible couplings are fabricated in brass or aluminium. As part of the company's custom services, clients can be provided CAD drawings of any custom-designed coupling.

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ABOUT RENBRANDT, INC.

Rembrandt, Inc. is a highly regarded, high-quality flexible coupling manufacturer. It serves varied industries including aerospace, military, transportation, mining, quarrying, mineral processing and metal manufacturing. The company has become a trusted supplier to many high-profile companies, both domestic and international. Companies that rely on high-quality stock and custom flexible couplings delivered in an expeditious manner include Boeing, Brookhaven National Labs, GE, Lockheed Martin, NASA, IBM, General Motors and Harley Davidson, to name a few. A more extensive client list can be accessed **here**.