Selecting the Best Hub Fastener for a Power Transmission Application

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Gears, pulleys, couplings, shaft extenders, shaft reducers, flexible shafts and shaft accessories are critical rotating and power transmission components. They are found in assemblies for applications as diverse as robotics, 3D printers, machine tools, automobiles, military and defense equipment and aircraft controls.

A key aspect of the proper design and operation of these assemblies is how components are fastened to the rotating shaft in order to maintain position and alignment. To optimize manufacturing and operating functionality, many criteria should be considered during the design phase, including some that are frequently overlooked.

Timing pulleys from SDP/SI with a variety of hub fastening methods. Source: SDP/SI

Holding force: Understanding the required holding force is critical to ensure that the component will not slip or move during operation. Designers should determine the operating torque and holding force required to prevent slippage.

Alignment and phase adjustment: Assemblies that require greater control and accuracy in axial positioning and angular alignment (phase adjustment) may dictate the type of hub fastener used. If phase adjustment is necessary, methods such as machine keys that fix the orientation of the component on the shaft should be avoided.

Costs: Cost is always a concern. Design engineers should consider manufacturing, purchasing, assembly and maintenance costs when specifying the best hub fastener for an assembly. While the initial cost may seem small, it can add up over the life of the product and for high-volume production.

Machining variables that contribute to higher costs are shaft tolerances and features, such as keyways, drilled or tapped holes, flats and shoulders on shafts. Purchasing additional components such as clamps, keys and pins add to the overall cost of the design.

Fairloc® is completely self-contained and the unique design allows the hub to fully and accurately support the component on the shaft, reducing any motion and misalignment after clamping the hub.

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Assembly and maintenance costs should be considered as well. Ease of maintenance is sometimes overlooked but may be important, especially on assemblies that require routine or frequent maintenance. Hub locking methods such as set screws may mar the shaft, requiring repair upon removal or replacement. Pinning a part to a shaft can result in having to replace multiple components during removal.

Standard vs. custom product: Many designers think they are always better off selecting a standard product over a custom design. While this may be true for one-off or very low production designs, it is not the case in all situations. When all of the design variables have been taken into consideration, a custom solution may be the optimal choice.

Hub Fastener Alternatives

Engineers have several fastening options to choose from when selecting the proper configuration for their design, each with advantages and disadvantages. Among these are set screws, keys, clamps and pins.

Set screws are one of the oldest and most common methods to lock a component to a shaft, either on the shaft radius or on milled flat. Tightening the set screw sufficiently to secure the component may result in marring the shaft. Flats add to the manufacturing cost and do not allow for phase adjustments of the component. Pins can be added to secure the component and avoid slippage. Assemblies that use machine keys can withstand relatively high torques without slipping and are easy to manufacture and assemble, however they also do not permit any phase adjustment, require additional manufacturing costs and may add backlash.

External clamping devices are a commonly used hub fastening method. Clamps do not mar the shaft and allow for the component to be easily adjusted both axially and radially. However, they do not fully support the component and cannot be pinned.

Pins provide a rigid, fixed location for the component, but once pinned they cannot be adjusted and they permanently alter the shaft.

Fairloc® — A Better Way to Fasten Rotating Components

Fairloc®, by Stock Drive Products/Sterling Instrument (SDP/SI), has been trusted by engineers for over 40 years. It is a component fastening system that is built into the hub of the part and can be integrated into miniature-to-medium-sized (up to 2 in. bore diameter) gears, pulleys, couplings, shaft adapters and other products.

Fairloc uses two slots machined into the hub; one oriented radially and the other angularly. Unlike some similar designs, the hub remains in one piece. The slots create a transverse wedge that remains attached to the solid portion of the hub on one side. The resultant cantilevered clamping section has a tapped hole to accept a cap screw which passes through a clearance hole in the solid portion of the hub, and into a threaded hole in the transverse wedge section. Turning the cap screw clamps the cantilevered wedge section securely against the shaft. The screw can be tightened and released repeatedly without marring the shaft or affecting its torque transmitting abilities.

Fairloc can be incorporated into a variety of product types. Source: SDP/SI

Fairloc eliminates many of the issues associated with other fastening methods. Fairloc is completely self-contained and the unique design allows the hub to fully and accurately support the component on the shaft, reducing any motion and misalignment after clamping the hub. Fairloc keeps the shaft centered and mounted components perfectly aligned.

Holding force: Lab tests have proven Fairloc to be superior in high-torque applications, as high as 400 lbf/in. for a hub with a 5/8 in. bore. The charts below show the slip torque values for stainless steel gears mounted on stainless steel shafts. All gears and shafts were made of 303 stainless steel. Gear bores were within +/-0.0003 in. of nominal values. Shafts had a maximum surface finish of 16 µin. and were within -0.0002 in. of the nominal diameters.

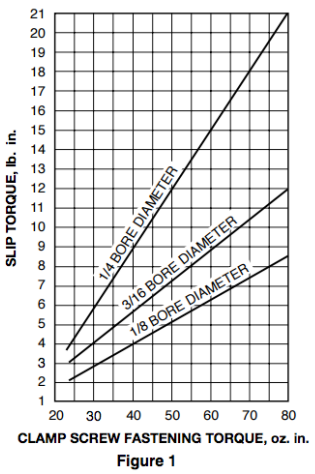


Figure 1

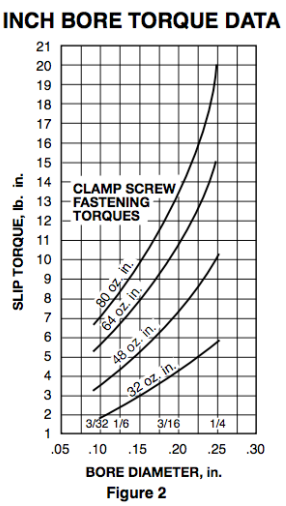


Figure 2

Figure 1 *shows the torque at which the component starts to slip for various bore sizes and clamp screw fastening torques.*

Figure 2 *compares the slip torque for different values of the clamping screw fastening torque.*

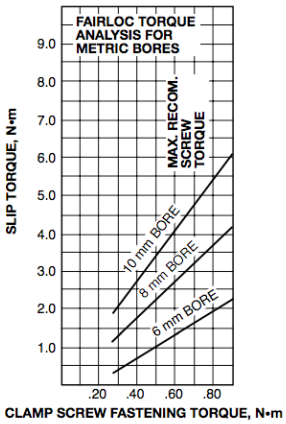


Figure 3

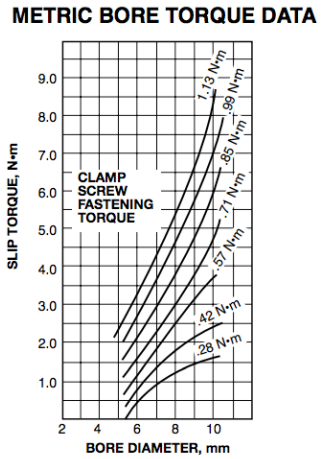


Figure 4

Figure 3 *shows the torque at which the component starts to slip for various bore sizes and clamp screw fastening torques.*

Figure 4 *compares the slip torque for different values of the clamping screw fastening torque.*

Alignment and phase adjustment: Fairloc does not require any modification to the shaft and allows for infinite and easy phase adjustment as well as axial adjustments. The component maintains perfect alignment with the shaft. The Fairloc design also facilitates pinning the hub, if desired.

Costs: Purchasing costs for components with Fairloc hubs are comparable to competitive products, however, the assembly and maintenance costs can be considerably lower. There are no keyways or flats to mill, no holes to drill or tap and no extra parts to buy. Phase adjustments are easy — loosen the cap screw, adjust and tighten. The Fairloc design also ensures that the shaft will not be marred, eliminating shaft repair costs.

There are other self-locking hubs with integral fasteners, but none of them offer all of the benefits of the Fairloc design. Fairloc solves the problems associated with alternative designs and checks all of the design criteria boxes.

Fastening Method	Shaft Remains Smooth	Self-Contained	Component is Fully Supported	Easy Adjustment	Can be Pinned if Desired
Clamps	YES	NO	NO	YES	NO
Fairloc®	**YES**	**YES**	**YES**	**YES**	**YES**
Keys	NO	NO	NO	NO	NO
Pins	NO	NO	NO	NO	YES
Set Screws	NO	NO	NO	NO	YES

Hub fastening comparisons. Source: SDP/SI

Standard vs. custom product: SDP/SI manufactures a broad line of standard inch and metric-series components with a variety of hub fastening methods in addition to Fairloc. Plastic products with steel Fairloc hubs can also be purchased off-the-shelf. Standard components with Fairloc hubs include:

- Gears
  - Stainless steel gears: 48, 32, 24DP (module 0.5, 0.8, 1)
  - Plastic gears: 72, 64, 48, 32, 24DP (module 0.5, 0.8, 1)
  - Mini-lash gears
  - Miter and bevel gears
  - Anti-backlash gears

- Couplings
  - Miniature bellows couplings
  - Bellows couplings
  - Neo-Flex® couplings
  - Rigid couplings

- Timing pulleys
  - Aluminum pulleys: MXL, HTD, GT®2/GT®3
  - Plastic pulleys with aluminum inserts: XL, HTD

- Shaft reducers and extenders
- Shaft collars
- Precision gear and dial hubs

For those occasions when a standard product isn't available, SDP/SI offers value-added application, design and manufacturing services. Application engineers are available to help find the best solution for all simple to complex design problems and can furnish cost-effective custom products that meet the customer's requirements. Do not compromise the integrity of a design by designing around standard products. If off-the-shelf products are not suitable, SDP/SI is here to help.

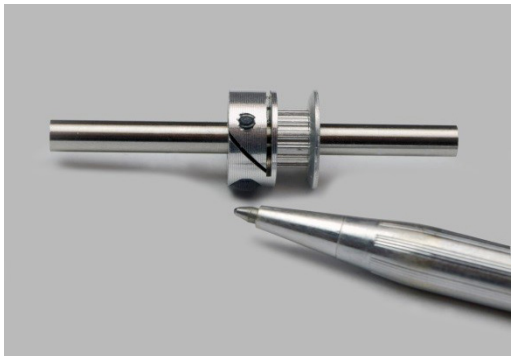
For example, a common custom need is for a non-standard bore size. Modification of the bore by the end-user is not recommended for Fairloc hubs, as it could compromise the hub locking characteristics. SDP/SI can custom engineer a solution and furnish the exact bore size required. Due to the many benefits of the Fairloc design, a custom solution is frequently more cost-effective than adapting the design for a catalog product.

In addition to components with an integral hub, SDP/SI also manufactures a line of Fairloc hubs and sleeves that can be adapted to an existing product, furnishing a specialty or proprietary product with all of the advantages that Fairloc has to offer.

Custom Case Studies

Medical Pumps and Drives

Miniaturization is a driving factor for change in medical devices. In response to customer requirements, SDP/SI has successfully developed a more compact Fariloc pulley. The efficiency and integrity of a belt drive is closely attributed to the quality of the pulleys involved. The miniature Fairloc pulley and belt drive system will provide years of uninterrupted service.



Aluminum timing pulleys. Source SDP/SI

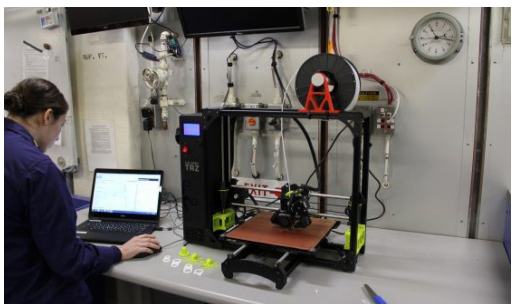
Aerospace

When designing an actuation/positioning system for a satellite, our customer was concerned about the need for accuracy during deployment. The resulting gear assembly was built using Fairloc hub gears, ensuring precise alignment and positioning. The project proved to be highly successful and has resulted in years of repeat and new business, always specifying the Fairloc design.

Applications

Fairloc couplings are appropriate for virtually any industry. Typical applications include military and aerospace gear trains, aircraft instrumentation and controls, machine tools, medical equipment, business machines, military fire control systems, optical equipment and power transmission drives.

Fairloc hubs are also used in two of the fastest rising markets today: 3D printers and robotics. Robots and printing equipment each rely on many gears, pulleys and couplings to provide accurate and repeatable motion control. These applications are ideally suited for components with Fairloc hubs.



3D printer aboard the U.S. Coast Guard Cutter Healy. Source: U.S. Coast Guard

Conclusion

When specifying a power transmission component, design engineers should look beyond the operating specifications. Factors such as holding force, positioning accuracy after clamping, alignment and phase adjustment and purchasing, machining and maintenance costs should also be considered. Selecting the best hub fastening method is a critical aspect that affects all of these criteria. The Fairloc hub fastener, by SDP/SI, addresses these items and is a better choice than pins, keys and other methods.

If a standard catalog product is not available, do not compromise the design. The application engineers from SDP/SI are available to help develop a custom solution at a competitive cost to solve your unique design challenges.

Visit the Fairloc product page on the SDP/SI website for additional information:
http://www.sdp-si.com/products/Fairloc/index.php

SDP/SI design, engineering or manufacturing services:
http://www.sdp-si.com/resources/sdpsi-capabilities.php

SDP/SI

250 Duffy Avenue,
Hicksville, NY 11801
Tel: USA +1 800 819 8900

ENGINEERING 360 MEDIA SOLUTIONS

201 Fuller Road, Suite 202
Albany, NY 12203-3621
Tel: +1 518 880 0200