MACHINE DESIGN

Custom bolt tensioners take the stress off users

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Just about all industries and equipment use bolted joints. But some applications are less forgiving of possible bolt failure than others. Examples of critical bolted joints are found in the Space Shuttle, bridge supports, oil pipe-lines, and nuclear power plants, to name a few.

The good news is, properly tightened fasteners can prevent such failures. Here, tension rather than torque is becoming the preferred method to tighten fasteners because it gives more accurate and repeatable loads. It works like this: A stud tensioner hydraulically applies a tensile load to a bolt or stud. The tensioner maintains this load while the nut is seated against the bolted surface. Releasing the tensioner transfers the load to the nut. This residual load is generally a function of applied force and length of the bolted connection or joint.

For best results, a tensioning tool should match the specific application. Off-the-shelf tools, although initially less costly than custom types, may actually cost more in the long haul and not produce the desired results. This is because most standard tensioners are designed primarily to assemble pipe flanges. They load bolts from about 40,000 to 50,000 psi or about half the minimum yield of common bolt materials. "But other applications with high-strength bolts push residual loads to 80 or 90% of yield," explains Rob Gregory of Biach Industries, Cranford, N.J. Biach builds custom-bolt and stud-tensioning equipment. "Still others have relatively short joint lengths and even higher tensioning loads. Moreover, tensioners that also unload bolts need additional capacity."

One application required 1.25-in.-diameter ASTM A490 bolts loaded to about 115,000 lb or 88% of minimum yield. This is not only beyond the load range of standard tensioning tools but extremely close to bolt yield. To prevent yield, Biach engineers designed a custom, high-capacity stud tensioner equipped with geared-nut seating. Here, the tensioner hydraulically loads the bolt just below the required residual load then applies a 100 lb-ft seating torque to the nut. The entire procedure was tested and refined using bolts fitted with strain gages.

Another concern involves stresses that develop during tensioning, especially in the stud, bolt, or bolt threads. Exceeding yield stress is rarely a design goal, and fasteners failing during tensioning pose a risk to personnel and may damage equipment. Excessive loads between the tensioner and joint surfaces may also "coin" fasteners into a flange. Flanges made from relatively soft materials are particularly vulnerable. Consider loads on the tensioner as well. Hoop, bearing, and tensile stresses all must be checked to ensure expected and safe operation. And just as loads vary with the application, so does geometry. A tensioner may have to work within tight confines, on closely spaced bolts, or both. Ergonomics also come into play. Excessively heavy tools or those with cumbersome controls can fatigue or injure users. Thoughtful design can eliminate such problems.

For example, one tensioner uses titanium construction to lower weight from 5 to 3 lb. An internal, sprung automatic piston return eliminates manual resetting after each tensioning cycle and streamlines the outside profile for easier handling. A built-in restraint protects the operator and surrounding equipment in the event the tensioner is improperly connected to a bolt. Foot-switch controls make the tool easier to use and an adjustable torque handle, along with a geared-nut seating assembly, boosts load accuracy and repeatability.

Finally, the hydraulics are run at a relatively low pressure to help minimize maintenance and reduce wear and tear. "This system has been in continuous use since delivery and has performed over 1.5 million bolt loading cycles without significant downtime," Gregory says. "Such reliability helps offset the higher initial cost of custom tools."