Should Jam Nuts Be Used?

by Guy Avellon

There has been an ongoing debate on the issue of the use and positioning of the jam nut for many decades: should the jam nut be placed first against the joint surface, then followed by the standard nut, or should the standard nut be tightened against the joint surface first with the jam nut tightened against the first nut?

I recalled that a friend had pointed out that long ago an article was published in a book by the IFI titled "Fasteners Data Handbook", circa 1950, which made an engineering and illustrated case for the jam nut to be placed on first, then the standard nut on last. The author is unknown. However, one must remember that in the 1950's, a Grade 5 fastener was high strength. I had written an article about jam nuts awhile back and I was very skeptical about their use. I therefore decided to find out for myself what actually happens when you put two nuts together.

I began by purchasing several jam nuts from the hardware store. I tried searching for different strength grades of jam nuts, but could not find any, even among some MRO suppliers. They all appear to be Grade 2. In fact, the IFI Handbook only states the material requirements are that of an SAE Grade 2 or ASTM A563 Grade A. This is also borne out by the material requirements for metric hex jam nuts, which are to be either property class 4 or 5, as per ASTM A563M. No general formula is given for the thickness differences, but the jam nuts appear to be on the average of 2/3 the thickness of a standard nut.

The tests were conducted on a digital load cell using 3/8-16 SAE Grade 2, Grade 5 and Grade 8 bolts with matching nuts against a hardened flat washer. In all cases, none of the nuts or bolts was used twice. As stated before, the jam nuts were a standard grade purchased from a hardware store.

Standard Nut First, Grade 2:

Using the Grade 2 bolt with a target clamp load of 3,200 lbs, I torqued the standard nut to 20 lb-ft. The clamp load reading indicated 2,680 lbs, which relaxed to just 2,625 lbs. I then tightened the jam nut and the clamp load jumped to 3,528 lbs, which relaxed to only 3,506 lbs. When I loosened the jam nut, the clamp load had dropped to 2,960 lbs.

When I tightened the jam nut, I noticed the jam nut was causing the standard nut to also move from compressive friction. I then installed a new Grade 2 bolt, washer and standard nut. This time the initial reading from the standard nut was 2,500 lbs. At this time I used an open-end wrench to prevent the first nut from turning as I tightened the jam nut. The clamp load jumped to 3,775 lbs, producing a greater clamp load than before. This time when I loosened the jam nut, the load dropped to 2,345 lbs.

Jam Nut First:

Still using the Grade 2 bolt, I tightened the jam nut first at the same 20 lb-ft and recorded a reading of 3,000 lbs, stabilizing at 2,956 lbs. I then added the standard sized nut at the same torque and recorded a clamp load of 3,500, relaxing to 3,480 lbs. When the standard nut was removed, the load dropped to 2,900 lbs. This was my first round of testing where I noticed the bottom nut turning as the top was tightened, so I tested another while keeping the jam nut from turning.

Tightening the jam nut first this time produced only 2,000 lbs. Holding the jam nut and tightening the standard nut produced a clamp load of 3,060 lbs. Removing the top nut dropped the clamp load to 1,946 lbs.

Standard Nut First, Grade 5:

The target clamp load for a 3/8-16 Grade 5 fastener is 4,950 lbs at 30 lb-ft. Installing the standard nut first at torque produced a clamp load of 5,800 lbs, relaxing to 5,733 lbs. Tightening the jam nut increases the clamp load to 6,060 lbs. Removing the jam nut dropped the reading only to 5,886 lbs. However, the nuts were hard to remove.

Using a new standard nut and bolt, the clamp load was recorded at 6,260 lbs. While keeping the bottom nut from turning and tightening the jam nut, the load increased to 6,444 lbs. Removing the jam nut reduced overall clamp load to only 6,422 lbs.

Jam Nut First, Grade 5:

Tightening the jam nut to 30 lb-ft produced a clamp load of 5,800 lbs but relaxing more to 5,677 lbs. Adding the standard nut increased the clamp load to 6,235 lbs. Removing the standard nut lowered the clamp load to 5,903 lbs.

Now using a new nut and bolt, but keeping the jam nut from turning, the jam nut recorded a clamp load of 4,500 lbs. Tightening the standard nut produced 4,856 lbs. Removing the standard nut drops the clamp load to just 4,615 lbs.

Standard Nut First, Grade 8:

The target clamp load is now increased to 7,000 lbs. At a torque of 43 lb-ft, the clamp load recorded 7,165 lbs. Tightening the jam nut increased the clamp load to 7,455 lbs. Removing the jam nut dropped the clamp load to 7,254 lbs. However, both nuts were hard to remove.

Jam Nut First, Grade 8:

Tightening the jam nut only produced a clamp load of 5,600 lbs, which relaxed to 5,525 lbs. Adding the standard nut brought the clamp load up to 6,356 lbs, which dropped to 5,500 lbs when the top nut was removed. It was decided that the top nut had no effect on the bottom nut at this strength level and tests were not done with holding the bottom nut with a wrench.

All tests were repeated several times. The values given were from an average sampling.

SUMMARY:

In all tests with three different bolt grades, the clamp load does increase when tightening the top nut. Normally, it would seem that when the bottom nut turns while tightening the top nut, the increase in clamp load was due to the friction at the interface between the two nuts, causing the bottom nut to be the one that is increasing the clamp load. However, this is only the case with the Grade 2 bolt. Proportionately speaking, the increase was just over 400 pounds difference regardless which nut was used first.

Using a second nut on the Grade 2 fastener did increase the clamp load from a low of 524 lbs to 1,275 lbs. The increase was not that significant with the Grade 5 or Grade 8 fasteners, averaging little more than 300 lbs.

The jam nut being first does not work at all with the Grade 8 fastener because it is only 2/3 the thickness of a standard nut, so it is not designed to carry the full load of a higher strength fastener. When used first, it produced less than 1,400 lbs less than the target clamp load. This is due to the increase in thread friction, as the much softer threads of the nut began to collapse and the material plastically mushroomed at the joint interface. The jam nut works better with the lower grades because it is similar in proof load capacity.

CONCLUSION:

The second nut (top) is assuming it is being tightened against the joint surface and not another nut. It was originally hypothesized that the compressive force of the top nut would unload the pressure of the bottom nut, causing relaxation. Instead, it is apparent that, while a compressive unloading is occurring; further tensile loading is being allowed to take place in the top nut from its additional threads, thereby increasing the joint clamp load. This is illustrated by the massive loss in clamp load with the Grade 2 fasteners while the bottom nut was held stationary; 1,430 lb. and 1,114 lb. drop respectively. The Grade 5 did not lose very much, but it didn't gain that much either.

While it appears that the 1950 hypothesis where the jam nut should be used first is true, it is only effective with Grade 2 bolts and to some extent, Grade 5 bolts. Jam nuts should never be used with any SAE Grade 8 or 10.9 Property Class fasteners.

However, another perspective must also be examined: a longer fastener must be used to accommodate the extra nut. The longer fastener and extra nut will cost more, not to mention the extra time in assembly. Using a longer fastener may also have greater stresses applied to the few remaining threads, which may lead to metal fatigue. The desired 'locking' ability may be accomplished by using a shorter fastener and a lock nut, especially with an SAE Grade 8 or Property Class 10.9 fastener.