Locking Fasteners— Part 3

by Guy Avellon

The previous two articles described some of the more basic types of locking products using nylon inserts, chemicals, physical distortions of the nut and Belleville washers. Part 3 will include convenient fastening products with different types of washers.

Toothed Washers

Also known as a Shakeproof® washer, these washers are available as an internal tooth and external tooth design. The washers are hardened to produce a spring quality to the twisted teeth. As they are tightened against a surface, the teeth flex and bite into the surface and produce an opposite force against the compression of assembly. These toothed washers may not prevent loss of preload in some applications using hard surfaces and high preloads, but will work best when the teeth embed themselves into softer materials to prevent loosening. Therefore, these products are ideal for plastics, aluminum, electrical connections and sheet metal.

The internal tooth washers have a smaller outside diameter than the external tooth type. This allows for closer positioning in tight areas. The internal teeth can hold onto the threads of a screw and remain fast while positioning the screw for assembly. The internal tooth washers are perfect for small screw heads and for socket head cap screws, when used in non-critical applications.

It should be noted that the use of these washers is destructive in application. The bent teeth will mar and scratch the surface. This may promote the onset of corrosion if the protective surface coatings are destroyed.

Nuts with a Spring Washer

This type of nut has a conical spring washer crimped to a standard nut. The nut is free spinning and offers no prevailing torque feature. However, it is when the washer is tightened against the joint that resistance will be noticed. The washer's spring rate may cause some variation with the assembly torque.

This system is convenient as time and motion of assembling two parts are saved. However, this combination will not prevent loosening but will retain some preload. To prevent loosening, the fastener must be loaded to at least 70% of its yield strength and the washer must be compressed an equivalent to 30% of the fastener's preload. Unfortunately, standard conical washers will not meet these requirements and these are only recommended for shear joints or very low load applications.

Fig. 1. Nut with spring washer

Castle Nuts / Slotted Nuts

Called castle nuts because of their appearance and resemblance to the notched top of a castle's turret, similar to a chess piece. Also called slotted hex nuts, these notches are spaced wide enough to provide for the use of a cotter pin to be placed between the slots and should not be confused with a similar appearing prevailing torque nut with smaller slots on the top, which are actually bent inwards to produce drag against the male threads.

Safety wires are used with these slotted nuts to provide visual security and will keep the nuts from completely backing off when wired properly to an adjacent slotted nut. The ends of the fasteners are drilled to accept either a cotter pin or safety wire. Alignment of the drilled hole to the slots on the nut is extremely critical. Any rotational adjustment forwards or backwards, or movement from vibration, will cause a loss of clamp load from 55 to 100%. Therefore, this system is also recommended for shear joints, very low load applications and where the nut must remain attached to the fastener.

Serrated Washer Face

As the name implies, these are cold formed serrations that may be under the head of rivets, machine screw products, small bolts or on the underside of a flanged nut. These products are not to be used with a washer as the serrations are meant to bite into the joint material to form counter-rotational resistance.

Fig. 2. Serrated washer face

Serrated Flange Nut

The serrations are angled to provide very little resistance while being tightened clock-wise. The ramp angles on the counter-rotation side will provide resistance to loosening by digging into the joint material. The joint material needs to be soft enough to provide sufficient embedment of the serrations. The limitations would be the nut and screw cannot develop high clamp loads that would otherwise deform the joint material or cause the screw to break. The one-piece construction aides in the convenience of assembly.

Keps Nut

The Keps, or K Nut, is the trade marked name of ITW Shakeproof. This provides for a pre-assembled, free spinning, externally toothed washer.

Fig. 3. Keps nut— Ideal for quick assemblies for automotive use and sheet metal assembly.

Serrated / Ramped Washers

Rather than being an integral part of a fastener, this technology employs two serrated washers to be used together. The ramped sides are sandwiched together to provide counter rotation of the bolt head or nut by forcing the ramps to move against each other. The outside of the ramped washers has radial protrusions to further prevent the bolt head or nut from turning.

These products have been used successfully with blind hole applications and internal engine parts. However, recent studies have produced failures when the external service loads have been very high.

Fig. 4. Ramps on one side

In one application, an M30 10.9 bolt failed. The ramped parts of the washers were almost completely flattened. The high loads of an M30 10.9 bolt would produce 408 kN (91,722 pounds). This load and the service vibrations were enough to cause damage to the washer.

The external part of the washers has ridges which are supposed to hold the bolt head from turning. Instead, they have embedded themselves into the bolt head causing a loss of clamp load which induced metal fatigue.

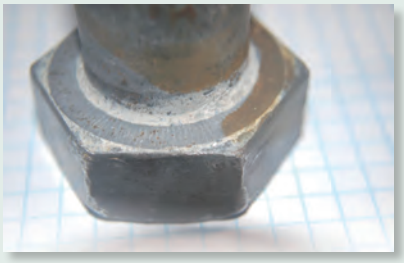

Fig. 5. Illustrating embedment of the ridges into the bolt head

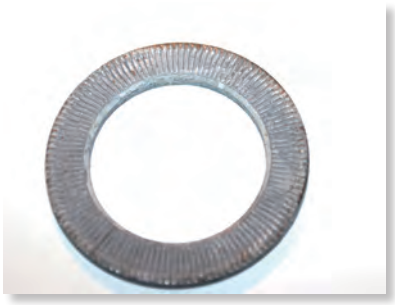

Fig. 6. Ridges on the washer

This system does not prevent the loss of preload but it will stop further loosening. Unfortunately, at that point, the joint has suffered relaxation and metal fatigue stress raisers will begin.

Depending upon the length of the bolt, one can apply Hooke's Law and visualize how much clamp load was lost due to compression and embedment.

Summary

As with any fastening system and joint connection, each must be treated as unique. One locking device is not better than others in all applications and it should be noted that no 'locking' device will ever prevent loss of preload. Each has its own unique application, don't use one product across the board for everything, it may be overkill. ■