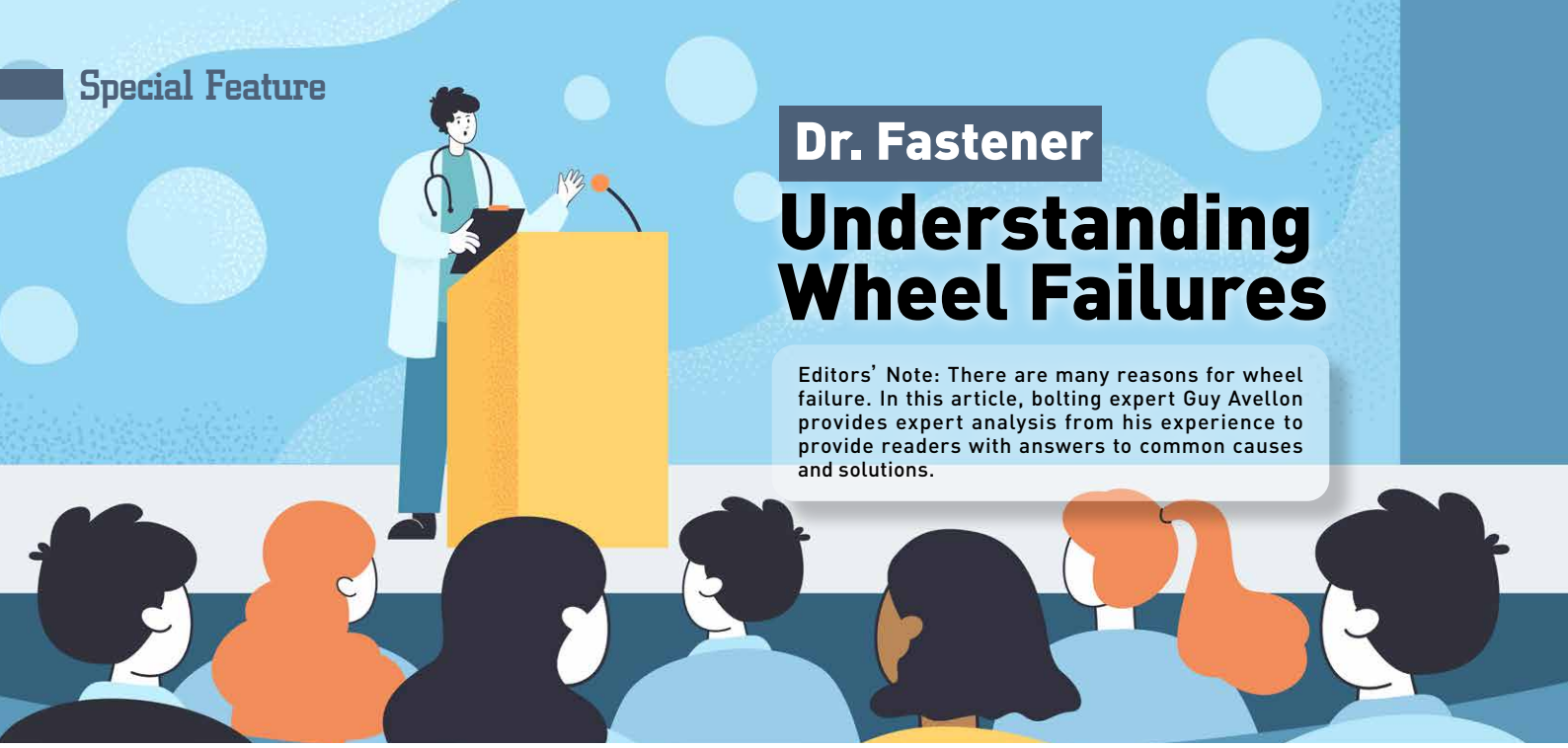

Dr. Fastener

Understanding Wheel Failures

Editors' Note: There are many reasons for wheel failure. In this article, bolting expert Guy Avellon provides expert analysis from his experience to provide readers with answers to common causes and solutions.

When analyzing a wheel failure, most of all failures are due to metal fatigue. Fatigue can be exacerbated from normal tractive loads and bending to prying loads from cornering. However, the root cause may come from several sources.

When the clamp loads are lost or reduced and the service loads exceed the remaining clamp load, the threads of the fasteners must absorb the excess load. In time, a stress raiser develops in the thread root causing a microcrack which grows and propagates through the material until a complete fracture occurs.

Stress cracks will begin at the weakest area on the wheel stud; the thread run out of the wheel stud, which is the last incomplete thread towards the head, or at the first thread outside the nut when the wheel contacts the joint surface. Both stress initiation points were observed. The action of metal fatigue may be compared to the continual flexing of a coat hanger wire several times until it breaks.

There are five major reasons for how wheel clamp load is lost: road hazards; rust; not retorquing the wheel nuts after remounting and driving a minimum of 25 miles; reusing the same wheel nuts and incorrect wheel installation, which will significantly damage the wheel nuts.

Road hazards are generally on the right side of the vehicle in the form of frost heaves **(Fig. 1)**, road grates, pot holes, etc., but will affect the left side when the wheels are rotated. Impact and shock loads to the wheel will cause embedment of the wheel lug nut into the wheel boss surface and affect wheel alignment. During tire rotations, the wheel is now rotated to another location where different wheel lug nuts are used that have a different mating seat impression. Most vehicles have a conical seated wheel nut. This is why tire mounting technique and retorquing the wheels after driving at least 25 miles are important.

Fig. 1. Frost heave

Corrosion can also inhibit proper tightening or seating of any fastener and joint connection. Rust / corrosion formation products will cause a cushion layer which will compress under loads, thereby relaxing the clamping force of the connection. **It only takes 0.001" of joint relaxation to lose 30,000 psi of clamp load between the hub and rotor.** Corrosion products may be removed from the surface but they easily return and continue to form. In some cases, the corrosion products grow to the point where it can actually cause separation of the joint. During the stress of this separation, the threads of the wheel nuts and wheel studs will become damaged.

When the wheel lug nut is used again during tightening, torsion produces friction as the distorted thread flanks engage each other to stretch the fastener during rotation of the nut. It is this increase in friction between the threads that will reduce the work energy available to stretch the fastener and provide clamping force, because friction must be overcome first before any work can be performed. Torque is a function of friction; therefore, any amount of torque output from a torque wrench, hand wrench to an impact gun will decrease due to the increase in friction between the threads.

Each time the nut is retightened, the threads deform a little more, causing a further increase in thread friction and further loss of clamp load. The clamp load will continue to decrease upon every reuse of the nut and cause stress raisers in the threads. Under normal conditions, **every time any nut is removed and retightened, it will never produce the same clamp load as the moment before it was loosened, even if the same torque was applied.**

Most of all repair shops use unregulated impact wrenches/guns. The common ½" (40 mm) impact gun delivers an initial torque of 425 lb-ft of torque or greater. The standard sedan or minivan requires a low torque of 80 lb-ft to 110 lb-ft of torque. An impact wrench looks for friction to cause it to stall. If the operator can sense a slight hesitation, he will impact the nut harder and faster to 'overcome' any obstacles like thread nicks or burrs. It is this type of impacting that weakens the threads of the nut and initiates stresses in the thread roots of the wheel studs.

The use of unregulated air impacting guns will destroy the internal threads of a wheel nut with accumulated use, not to mention destroying the conical wheel boss surface of the wheel itself because the wheel nuts almost never go back onto the same wheel stud and mate with the same wheel boss depression. Improper tightening techniques, such as not using a criss-cross pattern, will also apply uneven loads on the wheel assembly.

Full torque should never be placed on one wheel nut, they should all be tightened at a low torque first to position and set the wheel. Then in a criss-cross manner, tighten all of the wheel nuts to the final torque. All auto and truck manufacturers specify using a torque stick or torque wrench to avoid damage to the brake rotors. They also specify that the wheel nuts should be retightened within 100 miles of driving to be sure residual joint relaxation is reset.

Once a wheel stud has weakened, the clamp load is reduced causing the wheel assembly to become loose. This will further exacerbate the looseness of the entire wheel to become very loose. If the wheel is on the left side of the vehicle and loose, it is much easier for the wheel nuts to become extremely loose due to the helix angle of the threads. Tightening a threaded nut is caused by rotating the nut in clockwise rotation. The loosening of a threaded nut is in the counter clockwise rotation, the same direction the wheel turns on the left side of the vehicle.

Engine torque and wheel spin control devices apply additional stresses to the wheel. Snow, ice and even when it rains, the surface oils allow the front tires to spin when starting from a stop. The spin control on most vehicles only allows the wheel to spin one quarter rotation or less before the automatic traction brake is applied in a harsh and sudden manner. This contributes to further wheel stress and loosening and will further exacerbate a fatigue crack that has already begun.

Any tightened joint will lose 10-15% of its clamp load from joint relaxation within 90 seconds of tightening. This is why a good tightening procedure will retorque the assembly a second time. Criss-cross patterns and torquing in increments will ensure evenly clamped joint materials. Then, **any dynamically loaded joint must be retorqued after applying service loads to that joint due to embedment, reseating of components and loss of clamp load.**

When new disc brakes **(Fig. 2)** are installed, the disc brake and brake hat go over the wheel hub which contain the wheel studs. New wheel nuts are never provided due to the many styles of wheel nuts for different vehicles. Therefore, the same wheel nuts are always reused. The wheel nuts are hardly ever placed on the same wheel stud or mate with the same conical wheel mounting hole when the wheel nuts are replaced and/or when the wheel is rotated. Therefore, the nut seating is different, which is why it is always important to retorque the wheel nuts after driving the vehicle a minimum of 25 miles so the components can reseat themselves, then be retorqued in their new secure position. This is also a recommended practice as stated in any vehicle Owner's Manual.

Fig. 2. Disc brake and wheel hub

The continual reuse of wheel mounting components will cause a loss of clamp load every time the wheels are removed and replaced for tire rotations, new tires, brake inspections and replacements, new rotors, new shocks or struts or the addition of winter / summer tires. Statistically, due to the average number of times a wheel is removed and remounted, wheel nut thread damage significantly increases after the 100,000 mile warranty and continues exponentially higher the closer the odometer approaches 150,000 miles and beyond.

Every threaded nut has a finite life. They need to be replaced after 100,000 miles. ■