This is the season for preparing our vehicles for winter weather. This means installing snow tires for some of us, or just rotating the tires for the warmer climates. Either way, the wheels are removed and replaced with the common expectation that they will faithfully remain firmly attached. Unfortunately, this is not always the case.

Throughout the year, there are many instances where motorists experience a wheel detachment. Most go unreported. Those that are considered news worthy have caused major damages by flying across freeway lanes and striking oncoming vehicles. Many of these involve truck tires but there are many more of these incidents involving passenger vehicles.

Because of the litigious society in which we live, if any failure occurs it is always the last person who mounted the wheel, along with the manufacturer who made the wheel hardware and the company who sold the parts who are blamed.

After reviewing literally hundreds of wheel incidents over the years, I find that almost all of the vehicles had over 100,000 miles (161,000 km) on the odometer. As the mileage increased, the wheel failures were more likely to occur, especially over 150,000 miles (241,400 km). Vehicle manufacturers have limited warranties which all expire after 100,000 miles. Simply put, parts normally wear out with use, wheel hardware is no exception.

Vehicles used to be lucky to last over 75,000 miles (120,700 km). Now, with better assembly techniques and quality control, vehicles will go beyond 150,000 miles. However, parts like water pumps, timing belts, struts, generators, etc. are wearing out and need replacement, whereas before, the vehicles were traded long before the parts needed to be replaced.

Why Automobile Wheels Fail

by Guy Avellon

Distributors of automotive hardware will carry a variety of wheel nut styles. This would include a short nut, medium length nut and a longer wheel nut (Fig. 1). In addition, some wheel nuts will have a washer attached for use with some alloy wheels (Fig. 2). The other variety of wheel nuts will have a round or conical end which is designed to fit into the concave seat, or piloting hole, of the wheel to firmly engage the wheel to clamp it both axially and radially.

Wheel nuts are naturally meant to mate with wheel studs. The studs have a flanged bearing head with a ribbed neck body (Fig. 3). The ribs provide an interference fit with the wheel hub or disc brake and must therefore be installed by a hydraulic press. Many new disc brake kits will already have the wheel studs press-fit into them. However, none of the kits are supplied with new wheel nuts. Currently, all wheel studs are made to meet either SAE Grade 8 or ISO 10.9 strength standards.

Fig. 1 Short and long nuts carried by distributors

Fig. 2 Nut with thrust washer

Fig. 3 Typical Wheel Stud with a ribbed neck

New wheel nuts are not supplied because of the variety of wheels and nut configurations used by each auto manufacturer and for each model of vehicle: it is impossible to know what vehicle is being repaired. The fact that new wheel nuts are not supplied with new brakes is the beginning of problems with keeping the wheels on because the mechanics servicing the vehicle must reuse the wheel nuts that were just removed.

Vehicle mileage is only a statistical marker representing the number of times that a vehicle's wheel would be commonly removed and remounted for tire rotations, new tires, changing from winter / summer tires, brake inspections, brake replacements, new rotors, new shocks or struts, CV joints, etc. Each time the wheel nuts are reused they are normally installed with an unregulated air impact wrench. The internal threads of the wheel nuts become damaged, lose their strength over time and will not allow proper clamp load to be achieved.

When wheel nuts are tightened, all internally threaded products must give plastically to absorb the thread pitch change of the externally threaded fasteners, whose threads expand like coils of a stretched spring under tension. Materials that undergo tension will regain their original length and thread dimensions when the tension load is released, provided they were not stretched into yield. However, all nuts plastically deform permanently under compression and the threads will create an interference fit with the threads of the wheel stud under the pressure of tightening.

This pressure and interference fit generate an increase in tightening friction which inhibits proper tightening and will cause lower clamp loads. Every time the nut is retightened, the threads will deform a little more, causing a further increase in thread friction and a further loss of clamp load. The clamp load will continue to decrease upon every reuse of the nut. Every time any nut is removed and retightened, under normal conditions, it will never produce the same clamp load as the moment before it was loosened, even if the same torque was applied.

The common hex nut loses 90% of it's assembly power to thread friction and rotation contact friction as it is tightened against the clamped surface. Therefore, only 10% of torque energy is used to cause the externally threaded fastener to stretch and create clamp load. The wheel nut is different. Because of its conical seat, it has more contact surface area than a regular nut and will lose between 92-93% friction. Therefore, the 8-7% assembly power left to tighten the wheel stud becomes very critical.

Wheels will lose clamp load in service caused from a variety of reasons: over-tightening the wheel studs, which will weaken the stud and warp the brake rotor; by embedment of the lug nut or wheel stud bolt into the wheel; from excessive rust; from the threads of the wheel lug nut being damaged from too many removals and re-applications; from tightening by a common unregulated air impact wrench; from not using a criss-cross tightening pattern; from wheel alignment problems which increases the prying stresses on the wheel; ABS, 4WD and Traction Control systems and even from not retightening the wheel after driving the vehicle for at least 25 miles (40 km).

Fig. 4 Abused wheel nut having markings

Fig. 5 Thread damage on the nut

Fig. 6 Wheel Stud Bolts primarily found on European cars

The wheel nut pictured below (Fig. 4) has been abused with many removal and remounting applications. The markings indicate where the impact wrench socket hammered into the sides of the wheel nut leaving impressions on both the 'on' and 'off' direction. Many times, thread damage is not visible because the damage creates thread interference and friction when the parts are mated together. Other times it is very visible as in Fig. 5.

When you have parts that look like these, failure was not due to inferior material or any other quality issue with the product. Fault lies with the vehicle owner and whoever mounted the wheels last, or even the previous person that mounted the wheels.

Another piece of wheel hardware not mentioned yet is the wheel stud bolt. These bolt the wheel directly onto the wheel hub by threading either into the hub or brake rotor. These wheel fasteners are primarily found on many European vehicles; BMW, SAAB, Volvo, Volkswagen, etc (Fig. 6). Their tendency to fail is much less than that of a wheel nut, but its proper mounting is very critical.

I will continue the topic in another issue when I explain the different mechanisms for failure and how they affect the wheel and safety of the vehicle. In the meanwhile, here are a few points to ponder:

- Wheel studs will be more prone to metal fatigue failure on the right side of the vehicle than the left.
- Wheel nuts on the left side of the vehicle are more prone to loosen.
- Replacing wheel nuts on a vehicle with well over 100k miles won't do any good unless the wheel studs are also replaced.
- If a mechanic is ratcheting the wheel nuts on for more than three (3) seconds with his air impact gun, something will be destroyed and it won't be his air gun.
- After driving in winter slush and deicing chemicals, wash the underside of the vehicle, specifically the wheels and suspension. ■