Wheel Technology **by Tim Gibson**

Why new wheels?

Without a doubt, one of the greatest influences on the appearance of a car is its wheels. And we're all for great looking wheels. But aside from just appearance, on the street or at the track, wheels are a huge factor in the way a car performs. While stock wheel construction has progressed over the years, any car's design team has serious constraints placed on them to achieve all kinds of compromises that are required by all kinds of drivers. Stock wheels have to meet requirements that may have nothing to do with the kind of driving that you do. Add in a possibly severe OEM cost factor and it's extremely doubtful that even high performance cars have the exact wheels a design team would have wished for. Even highly advertised, well known aftermarket wheels are usually more style and cost driven than truly high performance. If that's difficult to believe, weigh one.

Certainly light weight wheels would be at the top of any designer or engineer's wish list. Light weight wheels significantly increase a car's performance through lower rotational moment of inertia, which improves acceleration and braking, and through decreased unsprung weight, which improves traction and handling. In addition, wheels can allow the fitment of better and/or larger tires, which also can dramatically improve traction for acceleration, braking, and cornering.

Why 3-piece wheels?

1) The easy obvious reason is ease of repair. If a one-piece wheel rim is damaged, the whole wheel must be replaced. If a 3-piece wheel is damaged, the damaged rim section can be replaced without replacing the whole wheel.

2) The 3-piece design allows us the use of a billet 2024-T351 center. The 2024-T351 material is classic aircraft wing spar material. In the T351 temper, it has approximately 50% higher fatigue strength than other wheels. This means the wheel can be lighter and stronger than a wheel made from forged 6061. The 6 series alloys are usually used for aircraft trim, not airframe components. Our centers are CNC machined from Alcoa 2024-T351 aircraft grade aluminum alloy 3" or 4" thick plate. Therefore, a 3-piece wheel made of billet 2024-T351 can be lighter, stronger, and have lower rotational inertia than other wheels.

3) Excellent machine tooling is critical to producing a round, true, low run-out wheel. Most wheels are machined using a standard axial compression jaw type chuck and a center hold down fixture, which due to their compressive and bending forces, can easily cause distortion during manufacturing. Our custom made tooling is designed to maintain precise concentricity and have no compressive or bending forces acting on the wheel at any time. Also, we incorporate an additional step in manufacturing. After all machine work has been done, the wheel is mounted in the CNC lathe exactly as it is mounted on

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the car, and a final truing operation is done. This step removes any run-out caused by residual stress, metal removal, induced stress, or whatever.

4) Using a billet CNC machined center allows much greater flexibility in wheel design. Since all of our wheels are designed "in-house" and are billet (made from plate), we can accommodate most requirements. Offsets (or backspace), brake caliper position, or most other requirements present little or no problem. Our web site contains a dimension sketch. Very good wheel/tire/car fitment can be achieved with these dimensions.

Any good 3-piece wheel requires special rims. Rims require a combination of old world craftsmanship and modern CAD/CAM technology. We use computer designed, custom built to print, proprietary, rotary forged, CNC precision machined, 6061-T6 rims. Forming and strength are the dominant concern for rims. The 6061 material, heat treated to T6 condition, is a good choice due to the extensive amount of forming involved in making a rim. While not as strong as the 2000 series, 6061 has a good combination of formability and heat treatability, as long as certain precautions are taken.

Aluminum alloys “work-harden” when they are formed. During rotary forging, or forming, aluminum must be kept in a semi-soft condition so forming can continue. If this is not done correctly, cracking will occur. Even though the aluminum rim parent material starts the rim process in a soft, or annealed, condition, at stages during the forming process the 6061 rims work-harden and have to be softened by annealing before further forming can continue. Then they are heat treated to T6 condition and finished. Although somewhat complicated, this process produces a very lightweight, precision, high strength rim.

In an attempt to circumvent the annealing and heat treating requirements of 6061, some rims are made out of 5000 series aluminum. 5 series cannot be heat treated. It gains strength through mechanical working, or forming. However, forming of a rim is not consistent throughout the rim. Only the outer periphery is formed, but not the bolt flange area. This means the strength of a 5 series rim is not consistent throughout. So even if the rim outer periphery, due to forming, has properties approaching heat treated 6000 series, the bolt flange area remains unformed parent material and therefore in a soft condition. This could cause critical areas of 5000 series rims to be weak and in order to compensate the rims have to be thick and heavy.

Fasteners are a critical factor with 3-piece wheels. We normally use 30 bolts, although this can vary. All bolt holes are precision drilled, reamed, counter bored and bottom radiused. Our fastener/wheel combination is designed to create the proper balance between the clamp load provided by each bolt, the total clamp force required to hold the wheel together, and the bearing area required by each bolt. 30 bolts is an optimum number of bolts for 17 to 20 inch wheels as long as bolt size, preload (or clamp load), and load bearing area is correct. Fasteners made for different applications and materials have different load bearing areas. Our fasteners and mating areas are designed to be an optimum package.

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Some wheels use less than 30 bolts, 24 bolts used to be a common number. That may have been OK when a performance wheel was 15 or 16 inches in diameter. Now, with wheel diameters at 17 to 20 inches or more, and performance tires generating more traction than ever, less than 30 bolts may not be enough. The lower the number of bolts, the more clamp load each bolt has to provide. This could place too much stress on the bolt and its ability to maintain clamp load. Also higher clamp load requires a larger load bearing area, which many fasteners do not have. High clamp load with insufficient bearing area may yield the rim material.

Some wheels use 40 bolts. This might be done in order to use smaller bolts, or bolts which have less preload and/or load bearing area. Using too many bolts does not necessarily make the wheel better. More than an optimum number of fasteners make the wheel unnecessarily heavy. And with bolts the weight is concentrated along the outer periphery of the wheel, significantly increasing the wheel's rotational moment of inertia. The point is, the number, size, and configuration of fasteners is a somewhat complicated trade-off. The number of fasteners used in a modular wheel depends on the size of the wheel, the specification and dimension of the fasteners, and the strength of the rim material.

We are a California engineering corporation: Gibson Engineering, Inc. Gibson Engineering was started in 1992. We have extensive experience with aerodynamics, wind tunnel research, light weight structures, fabrication, and machine work. We make absolutely the finest wheels commercially available. Our wheels are tested extensively to SFI and SAE specs. Depending on the details, the wheels start at approximately $1000 with steel bolts. We have access to lightweight, high strength, mil-spec 6Al-4V Titanium bolts, but they add approximately $200 to the price.

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