Fastening Challenge In Auto Industry's Use of Magnesium Die Cast Parts

Larry Pickett, product manager
Textron Fastening System
Rockford, IL

The use of die cast magnesium parts in U.S. automobiles has more than doubled during the past decade, and is expected to increase another 50 percent by the end of the decade. The typical new vehicle has 7.5 pounds of die cast magnesium parts, versus only three pounds in 1990, with some having as much as 55 pounds. Industry projections call for magnesium content to exceed ten pounds by 2007.

Current die cast magnesium installations include instrument panel assemblies, seat structures, transfer cases, brake and clutch pedals, anti-lock brake mounting brackets, steering wheel armatures, headlight retainers, valve and cam covers, bumper support beams, and cruise control and horn mountings.

Automakers are embracing magnesium because of its lighter weight and toughness. At one quarter the mass of steel and two-thirds the mass of aluminum, it has the best strength-to-weight ratio of any commonly used structural metal. Good ductility and elongation properties improve dent and impact resistance.

Magnesium die casting methods are faster than steel and aluminum, producing light, thin walled components with good fatigue strength, dimensional stability, and sound and vibration dampening qualities. Fully integrated, one-part components produced through these processes eliminate welding requirements and reduce customer costs. Assuming sound engineering practices, virtually no post-production machining is necessary due to the net shape capabilities of magnesium.

Problems With Fastening

Magnesium brings problems to automotive assembly, however. Its low deformability does not mate well with traditional fastening methods, resulting in slivering, layer eruption, and cracking and chipping of formed threads. Fastener removals and reinsertions in repair and service can destroy formed threads and create chips and debris, causing contamination.

Conventional joining methods do not work:

- Bolt and nut hole preparation can be costly, requiring added joint thickness and flange width, which result in frequent loose fits.
- Thread cutting screws add fastener length, and require deeper pilot holes for cut thread chips. Asymmetrical points cause problems with starting and reuse, resulting in chipping.
- Machine screws require costly drilling and tapping, and loose fits cause clamp load problems.

One solution is the new type of fastener designed specifically for magnesium applications. Textron Fastening Systems solved the problem with Camcar® brand Mag-Form® thread forming fasteners, which compress threads into magnesium.

The key to this process lies in larger thread angles. Lobe-shaped steel threads with a wide pitch and a broad, 105° flank angle compress rather than roll form threads. This creates a strong, metal-to-metal bond in the low ductility magnesium that eliminates thread fractures while reducing shear stresses, increasing compression, and delivering consistent torque values. The larger thread angle also allows multiple removal and reinsertions without debris formation.

Application successes at DaimlerChrysler and Lunt Manufacturing demonstrate the efficacy of using a fastener designed specifically for magnesium joining processes.

DaimlerChrysler Solution

Machine screws and Textron Fastening Systems Taptite® thread forming fasteners did not perform well on joining lower mounting brackets to magnesium steering columns at the DaimlerChrysler Toledo Machining Plant. Steering columns produced at the facility are installed on Town & Country, Chrysler Voyager, Dodge Caravan, and Grand Caravan models. The tilt head and the main body of the steering column are made from die cast aluminum.

Machine screws were a burden on process efficiency, requiring time and expense in drilling and tapping processes, and causing problems with loose fits and clamp loads.

Fig. 1 – *Textron Fastening Systems Mag-Form Thread Forming Fasteners (right) replaced the longer Taptite roll forming fasteners (left) at the DaimlerChrysler Toledo Machining Plant.*

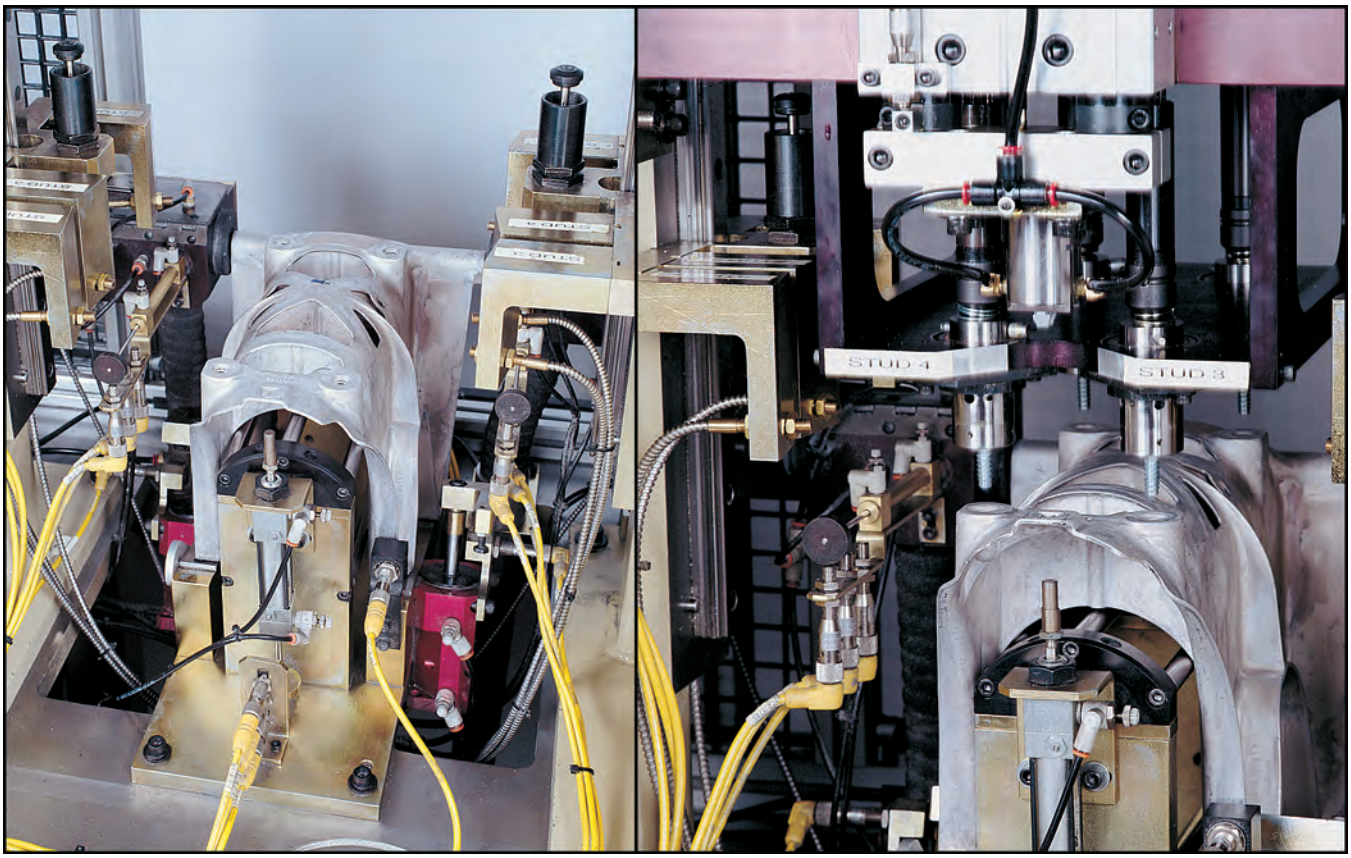

Fig. 2 – *A magnesium shift tower for a new line of SUVs from General Motors is shown at an assembly station where Mag-Form fasteners compress threads into four cored holes.*

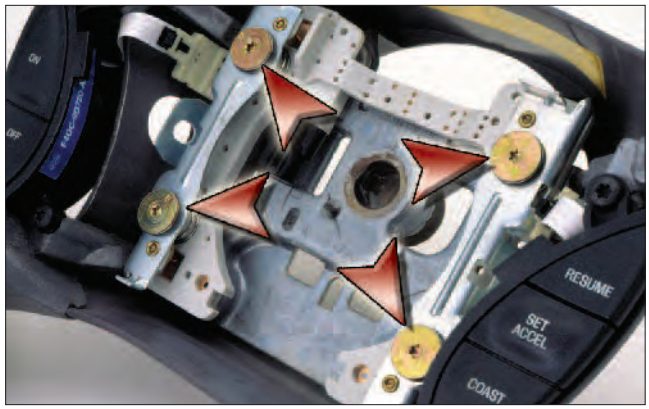

Fig. 3 – *Four fasteners are used for the steering wheel horn on a Ford Motor Company's line of small and medium-sized cars.*

These were replaced by Taptite® roll forming fasteners, which work well with aluminum and steel, but have narrow thread spaces and 60° flank angles that are too strong for the low-ductile magnesium.

The thinking was that the 30 mm length and finer thread pitch of the fastener would ensure better engagement, but the opposite proved true. Debris and powder build-up from magnesium chips caused screws to reach torque before they were seated, resulting in loose parts that required rework.

Engineers at Toledo Machining decided to take a look at Mag-Form®. After a full year of evaluation and validation, with special emphasis on vibration and shaking tests, it became the sole fastener for joining the lower mounting bracket to the magnesium steering columns. A specially designed version was produced for existing assembly equipment in which two fasteners form threads as they are torque driven into cored magnesium holes.

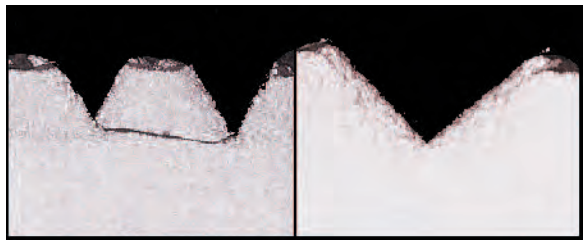

Fig. 4 – *The 60-degree flank angle on the standard fastener exceeds the ductility limit of the material, damaging formed threads and creating debris. (L) Mag-Form fasteners compress rather than roll form threads, eliminating thread fractures and debris accumulation. (R)*

Since going on line, more than 1.5 million of the new thread forming fasteners have been installed on steering columns without any of the problems experienced with machine screws or other fasteners.

The switch also reduced assembly times markedly. The previous fastener installations took 3.7 seconds per screw, making that station the bottleneck on the line. The new fasteners take 2.2 seconds per installation, a 40 percent reduction. The combination of shorter length and fewer threads allowed the decrease in process times, saving hundreds of hours and thousands of hours annually.

GM Shift Tower Application

The Lunt Manufacturing plant in Hampshire, IL, is one of the largest facilities in the world devoted entirely to production of magnesium castings for the automotive industry. The 152,000-square-foot facility employs cold chamber processes that transform magnesium ingots into complex and intricate components in less than 90 seconds.

The one-piece castings include instrument panel housings, roof structures, intake manifolds, steering wheels, steering column lock housings and jackets, and dozens of other custom-designed components for OEM and Tier One customers. Lunt has more than doubled the size of the plant in recent years to keep pace with the growing demand for magnesium castings in the automotive industry.

When Lunt was selected to produce a magnesium floor-mounted shift tower for a new line of SUVs for General Motors, company engineers faced design, engineering and assembly decisions for the four fastening points on the component. Set during casting, these would be the only holes in the part, and their formation and the fastening system employed in them had to be flawless. They represented the mating points where the shift tower would be installed in the steel floor of the vehicle's body-in-white frame.

Lunt had no experience with Mag-Form® fasteners, and this was to be the first magnesium shift tower ever installed in a production vehicle. A three-year collaboration ensued, involving design, testing, and validation among Lunt, Textron Fastening Systems, and General Motors.

The result was a specially designed fastener that fit the specifications for the shift tower holes and any follow-up removals and reinstallations during warranty and service procedures over the life of the vehicle. Today, Lunt is producing 7,600 magnesium shift towers monthly for the new SUV with no quality problems in assembly or service procedures.