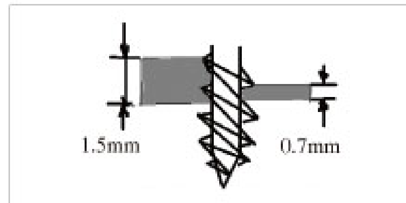
The Future of Fasteners in Emerging Markets

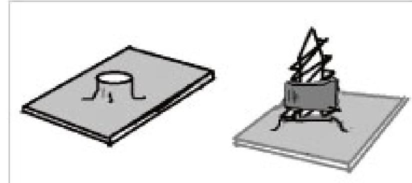
by Thomas Doppke

Emerging markets will change how fasteners look, function, and even if they will continue to exist. The future offers challenges to current fastener philosophy. These challenges are opening markets for innovative companies with new solutions. Materials, styling considerations, corrosion, environmental concerns and the ever present cost/deproliferation factors will affect what fasteners are and what they need to do to survive as a relevant technology. Let's review some of the challenges that fasteners will face in the coming future. Many of these are already begun to appear in current applications.



Standard and 0.7mm sheet.
1 pitch vs 1/2 pitch engagement

Fig. 1. Screw Thickness in Metal



Standard extrusions are cut off with standard tapping screws leaving less than 1/2 pitch engagement

Fig. 2. Extruded Hole Cut Off

Materials Matter!

One of the greatest challenges to the future of fastening will be in the area of **Materials.** As wood was replaced by sheet steel years ago, sheet steel is being replaced by aluminum in many applications never thought of as viable before. Magnesium is replacing aluminum where both strength and light weight are required. Limited amounts of titanium are being seen in applications other than the usual aerospace area. Plastics seem to be everywhere and its use is growing so fast that the use of metallic materials almost seems like last century's technology. Where steel is still dominant, weight considerations have thinned the gauges to little more than foil thicknesses in many areas other than structural members.

Tapping screws have been the staple of attachments into sheet steel since wagons were replaced with automotive bodies. But for a tapping screw to develop any strength at all, it needs at least one thread pitch engagement to hold adequately. For the standard #8 screw (M4.2 x 1.41), this means a thickness of 1.41mm is required. Many current gauges are as thin as 0.7mm or about ½ a thread pitch. **(Fig. 1)** Unless more material is present, the screws will not hold and be a viable attachment device.

Extruded holes (formed cones punched into the metal) have been suggested but with very thin metal the screw simply cuts the extrusion off. **(Fig. 2)** U-nuts and various styles of clipping have been used currently but at a great increase in cost and labor. Many times the clips just cannot fit into the design.

Some promise has been shown with the development of special form, thread rolling screws. Similar in concept to the larger diameter (M10 and larger) thread rolling types used in seat belt attachments and other areas, these small diameter parts roll a thread rather than cutting one in the base metal. The metal they extrude forms a cone with the thread rolled in rather than cutting off the walls like the illustration above. Costly now, the price may improve if they become a solution. The most recent types also have a 0.7mm pitch which allows for both a formed extrusion and a rolled thread of one pitch for maximum strength.

Many of the present day solutions to thin metal may not be useable if the use of thinner gauges is expanded into new areas. Various clinch fasteners, pre-assembled or on line, will all involve additional cost and labor, two items that are definitely scheduled for reduction in future markets because of cost and possible twist outs in thinner gauges.

Light Metals

Aluminum and magnesium offer weight savings which is directly translated into gas mileage increases. But both metals are very much softer than steel. More engagement for security of the attachment is required which means thicker sections of aluminum, negating the weight savings in part. Also with a lower strength base metal the attachment loads must be lower or strippage and loosening will occur. **While aluminum is an item on the future materials list there are still problems to be overcome; embedment of tightened parts due to its softness, corrosion from environmental conditions (i.e., road salts) and chemical attack from abutting finishes, thermal creep and creep under load.** Despite these aluminum is still a "GO".

Magnesium is extremely difficult to work (it cannot be stamped, bent or deformed without cracking. Most magnesium parts are cast and/or machined. However, new science is underway to improve working techniques (for example, hot forming under inert gas envelopes). Because of magnesium's tendency to flake and its brittleness under deformation loads (as in forming a thread), attachments have been a problem which has restricted increased usage. Magnesium's strength (many times that of aluminum and only slightly less than soft steel) makes it a definite item on the list of future materials. Special threads and threading methods are being developed with some limited success.

Titanium has few uses beyond aircraft and a select number of industries. Extremely difficult to work, expensive, subject to certain types of corrosion, it is still on the list for a second look in new areas.

While adhesives have had some developmental tests and tryouts and appear to offer solutions to thin metal and plastic fastening, real world usages leave much to be desired. Cleanliness, installation techniques and plant operating conditions affect correct attachment. Time to cure will affect line speed, and chemical attack and thermal variations (hot and cold, winter and summer) will be two other factors that will have to be addressed. Still, much time is being devoted to improving techniques and opening up new venues for adhesive fastening. A metallic multi-piece dashboard was scheduled to be adhesive bonded as were multi-piece body panels. There are several semi-structural assemblies currently being used today. Adhesives are messy, time consuming and may have environmental concerns attached with their usage. (Fig. 3)

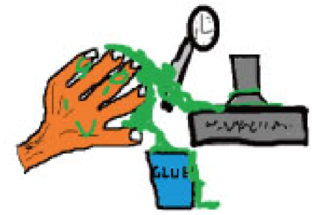


Fig. 3. Messy Glue

Composite Materials

Once composite materials were used exclusively in the field of aerospace but now are being seen everyday in the marketplace. Composites are materials that derive their strength from reinforcing fibers mixed in an epoxy material matrix. Fiberglass is one such material. Glass fibers, carbon fibers, and new variations and materials are on the drawing boards with little thought on how these will be attached. Offering weight savings with increased strength,

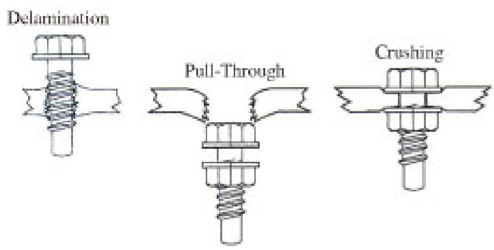


Fig. 4 Failures in Composites

they are the future of structural constructions like body panels, furniture, and many building components. Composites have been around for a while in fiberglass bodies (small watercraft, special panels, etc.) and other high end and limited production. The advantages of composite material have not been lost on designers. Fastening these materials opens up a whole new field for the innovative manufacturer. As the illustration shows, there are three major modes of failure in composites. (Fig. 4)

While offering tremendous savings in weight, strength and component formations (whole pickup boxes for trucks have been experimentally made), attachment philosophy has remained an opportunity for the future. Present ideas have involved adhesives; however **removal sections, panels, and serviceable areas will require a means of mechanical attachment fastening.** Bolts and nuts, as shown, do not address the problems.

Holes cut in the material are prone to delamination at the edges. Standard bolts and nuts placed in the direction of the loading show high shear out failures. Shear out failures generally appear like a tab shaped hole extending from the hole to the edge of the composite piece. Any bending present will cause the formation of cracks which will extend to the hole over time. Holes too close cause crushing due to the reduction of the length of fibers between the holes.

Since composites are not as strong as steel, the present attachments (bolts and nuts) are often over torqued as they may seem "not tight enough" to the operator.

In review, **composites today fail by crushing the material by over torque and/or insufficient bearing surface under the head to sustain the load, pull through of the fastener for the same reasons, and delamination caused the fastener rubbing against the hole edges.** This is another field open for new ideas from the fastener industry or that new inventor.

Plastics

Plastics have been touted as the material of the future. The amount of plastic used in manufacturing today is expected to triple within the next decade. Some forecasters say that plastic manufacturing will consume more petrochemical (oil) than will gasoline by 2040. Plastic attachment technology is a whole different world. Few steel joining ideas work or work well when attaching plastics. Plastic is soft, it cold flows (moves under time and pressure), becomes brittle at low temperatures, softens at high, and is not really considered a structural material. Currently it is a cosmetic material, designed for appearance items. Screws, especially those with wide spaced threads have been used for years but as plastics expand into all areas, threaded technology may not be as effective. Heat, cyclic loading and long term pressure will cause plastics to fail in several ways. Temperature is a major factor. Some plastic applications today expand and contract as much as 25mm during a hot day (plastic dashboards in a car can exceed 160°F [71°C]). Chemical attack from road salt, oils and other common encountered substances such as washer fluid, car wash soaps and so on cause crazing brittleness and failure of many types of plastics (nylon is sodium chloride sensitive, ABS plastics are oil crazed.) **(Fig. 5)**

Petro stress cracking on ABS plastic.
(Oil based finish in fastener)

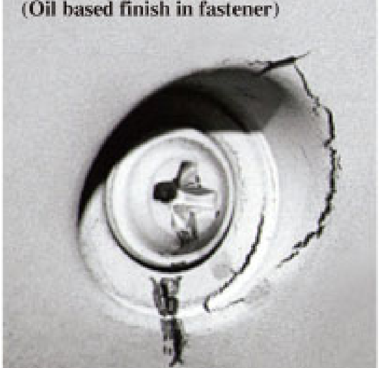


Fig. 5. Plastic Stress Cracking

Still plastics are growing in usage and formulation. Whereas steel is a single substance with a history of how to attach it, plastics are like cooking. There are hundreds of types and literally thousands of formulations. The Material Engineer can stir up a unique formulation to fit any desired property specification. This leaves the fastener designer wondering if yesterday's solution will work with Plastic X today. While, as mentioned, considered as mostly cosmetic (appearance) items today, plastics will expand into many areas once considered the property of steel. Today, alone, we have car fenders, hoods, side panels, interior trim (of cutes). Furniture, appliances, a thousand items can be made cheaper, in one piece and colored than metal. Zinc die cast (remember that material) is a rare sight today.

Better Appearance, Less Cost, Corrosion Resistant?

In addition to plastic fastening problems is added the fact that designers are looking for a better appearance in their designs. This will be stated as a request to "no visible fasteners". The conundrum is to attach but don't be seen attaching. Currently some of this philosophy is addressed by the use of hidden fasteners. These are of two main types. **Screws and such which are attached and then covered with a matching cover or cap.** The little round matching plastic spot of the windshield "A" pillar is a usual area as are some trim pieces. **The other main idea is the use of clips on the backsides which fit into slot in the structural members.** Interior trim utilizes many clips into slots. These are loose fitting, rattle prone and labor intensive ways to attach plastic. Another open market for new ideas. Required is a way to attach plastic which is not visible (or at the worst not visibly intrusive), easily installed (with hand only labor if possible), serviceable, and hold through a variety of impacts and jolts while maintaining their position with respect to adjacent surfaces. In addition, they should accommodate movement thermally (a large truck dashboard can expand and contract more than one inch [25mm] on a hot day) without wrinkling up the component.

Like everything else in the emerging future, cost will be a factor. Many companies today are pursuing programs to reduce the number and types of fasteners. While the cost was once thought of as minimal when the whole assembly was considered, today the smallest amount of money saved is viewed as significant. Deproliferation equates to less inventory, handling, storage, procurement, paperwork, less parts to mix on the line, etc. A study some time back showed for every 15 parts reduced one person would be saved in a large assembly operation (automotive). **Idea- make a part that has several functions.**

Corrosion has always been here and does not appear to be going away in the future. But with new materials emerging and customer expectations much greater than ever in the past, it will assume a higher standing in the list of complaints that manufacturers will face. Many times a rusty screw will be overlooked when the entire assembly was rusty. Now a red screw stands out on the flawless paint jobs of new coating technology. Plastics, as mentioned before, is subject to various types of destructive corrosion failures. Galvanic corrosion is common today if aluminum is placed against stainless steel. **(Hey! Ain't both of those corrosion resistant metals?)** ■