FIGURE 1 *Over the years engineers have developed myriad types and variations of self-clinching fasteners.*

The material world of self-clinching fasteners

The fastener and host material must be compatible

By Ron Dise

Self-clinching fasteners provide permanent and reusable load-bearing threads in thin metal sheets. Historically, fabricators have specified self-clinching fasteners for thin sheet metal that would be difficult or impossible to join by other methods. Upon installation they become integral parts of an assembly, will not loosen or fall out—not even when the mating thread is removed—and never have to be restrained from rotation with a tool.

For successful installation and optimal reliability in service, however, the fastener material must be compatible with the host metal sheet in all respects. For example, stainless into stainless can become problematic if the fastener is not hard enough, and stainless into aluminum poses the potential for galvanic corrosion.

The overriding requirements revolve around the relative hardness of the fastener and host material and the specified minimum sheet thickness. These will determine how well the fastener installs and subsequently performs.

Fastener Basics

Over the years engineers have developed myriad types and variations of self-clinching fasteners. They include nut products with threads that are free-running, self-locking, floating, or closed-end. Self-clinching studs come in a variety of head styles. Product families include threaded and through-hole, spacers and standoffs, captive screw assemblies, cable tie mounts and hooks, and face-to-face panel mounting hardware (see **Figure 1**). Newly introduced micro-sized self-clinching fasteners have expanded application possibilities, especially in the consumer electronics market, offering smaller thread sizes and thinner sheet capability than legacy product.

Self-clinching hardware typically is made from steel, several different grades of stainless steel, or aluminum. Fabricators install them permanently in thin ductile metal sheets by pressing them into place in a properly sized mounting hole and applying sufficient squeezing force. This forces a serrated clinching ring, knurl, ribs, or hex head into the panel surface, displacing the sheet material into a specially designed annular recess in the shank or pilot of the fastener known as an *undercut*. The metal forced into the undercut secures the fastener against axial movement, while a nonround displacer secures the fastener against rotation. No secondary operations are necessary (see **Figure 2**).

Fasteners can be installed manually in small quantities with a tool as simple as an arbor press. For high-volume jobs, fasteners can be fed automatically using dedicated installation presses or in-die equipment. Regardless of the method, sheet materials must meet three basic requirements to hold fasteners:

1. *They must have adequate ductility* to allow the displaced sheet material to cold-flow into the undercut without fracturing.

2. *They must be sufficiently softer than the fastener* so that the fastener itself does not significantly deform during the installation process.

3. *Sheets must meet the minimum thickness required by the particular fastener.* Most legacy self-clinching fastener product families can be installed into sheets as thin as 0.030 inch, with several families going down to 0.020 in. However, because of an industry trend toward thinner sheets, new product families have been released for sheets as thin as 0.016 in., and designs for even thinner sheets are being developed. Typically, fasteners have no specified maximum sheet thickness requirement.

Aluminum Panels

For non-heat-treatable aluminum-alloy panels such as 5052, aluminum fasteners (always made from a heat-treatable aluminum alloy) can be used. This eliminates concerns about galvanic corrosion of dissimilar metals and permits the entire assembly to be anodized or given a conversion coating.

Regarding fastener material, fabricators should always verify that the aluminum fastener is strong enough for the application. When working with internally threaded fasteners (such as the nut and standoff fasteners in Figure 2), a longer thread engagement (nut height) can increase holding power and so compensate for lower fastener material strength. Externally threaded fasteners do not offer this option because the tensile stress area for a given external thread size is fixed; other than increasing thread size of such fasteners, there is no way to make dimensional accommodation for the lower material strength.

Panels made from heat-treatable aluminum alloys in the hardened condition typically are too hard for aluminum fasteners, which have a maximum panel hardness limit of 50 Rockwell hardness B (HRB) scale. Therefore, 300 series stainless fasteners are often specified. This option can work in sheets up to HRB 70, which covers almost all heat-treated aluminum alloys. When this is done, the assembly cannot be anodized, but can be given a conversion coating. Experience shows that the conversion coating process may need to be adjusted slightly to prevent the stainless fasteners from darkening.

Because of concerns with aluminum fastener strength, 300 series stainless steel fasteners sometimes are specified for either non-heat-treatable or heat-treated aluminum panels. Because passive 300 series stainless and aluminum are far apart in a galvanic series, there is potential for galvanic corrosion if an electrolyte is present.

While technical staff usually decides whether passive 300 series stainless steel in aluminum sheets is acceptable before a job reaches the shop floor, fabricators should be aware of options should they be confronted with the issue.

One option is to substitute the passive 300 series hardware with an aluminum self-clinching fastener whenever possible, based on panel hardness and required fastener strength.

Another option is to substitute the passive 300 series stainless fasteners with 300 series parts having cadmium plating. This can eliminate galvanic corrosion concerns because cadmium and aluminum are very close on the galvanic series. These parts, however, usually are uniquely created to produce the required thread size allowance to accommodate the cadmium plating.

A third option (only if cadmium is deemed unacceptable) is for the fastener manufacturer to apply zinc plating to special stainless steel parts. This approach works if it can be determined that zinc is close enough to the panel's aluminum alloy in the appropriate galvanic series.

Cold-rolled Steel Panels

Low-carbon cold-rolled steel panels are very common in high-volume applications. Typically, this material is too hard for aluminum fasteners, which have

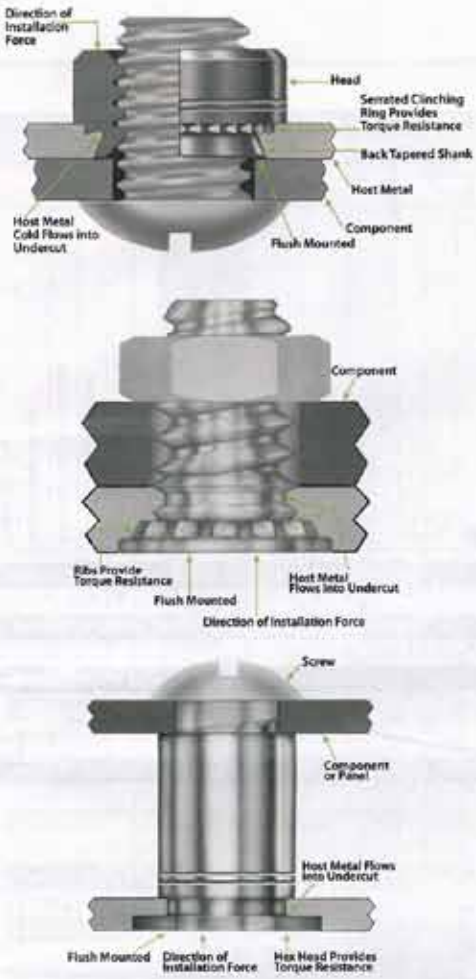

FIGURE 2 *In the nut (top), stud (middle), and standoff (bottom) fasteners shown, the metal forced into the undercut secures the fastener against axial movement while a knurled, ribbed, or hex-shaped displacer secures the fastener against rotation. While the stud fastener has external threads, the nut and standoff fasteners have internal threads.*

a maximum panel hardness limit of HRB 50, but either steel or stainless steel fasteners will clinch successfully. Plated steel fasteners are common, though not in applications where repeated assembly and disassembly of the mated hardware may generate plating debris. If this is the case, stainless steel fasteners are specified.

Low-carbon cold-rolled steel panels are often zinc-plated, and this frequently raises the question of whether the panel can be plated after the fasteners have been installed, mainly because of concerns about damaging the panel plating during fastener installation. Plating after fastener installation is not recommended because caustic solutions can become trapped in crevices between the fastener and the panel, causing "bleed out" later. In some cases, this also increases the risk of chemically damaging the fastener surface or embrittling the fastener.

The lowest-risk procedure is to plate the panel first and then install plated fasteners. The second-lowest-risk procedure is to purchase unplated steel fasteners, install them, and then plate the assembly. This eliminates the need to strip the zinc plating from the fasteners, which could damage the fastener surface. Case-hardened fasteners are particularly susceptible to this type of damage because of the high carbon content of their surface.

Fasteners made from 300 series stainless steel also can be used in low-carbon cold-rolled steel panels as long as the panel hardness is below HRB 70, which is typical. Stainless steel fasteners must be installed after the panel is plated, as plating processes for steel generally are incompatible with stainless steel.

High-strength Steel Panels

High-strength steels (HSS) help reduce weight in an assembly. Most standard steel fasteners are heat-treated adequately to clinch into panels with hardness up to HRB 80. For harder HHS panels, testing may show that a standard heat-treated steel fastener can be used. This is particularly true of highly formable HSS that have a lower work-hardening rate, because the hardness differential used in the design of the self-clinching fasteners assumes a significant work hardening of the panel during fastener installation.

For even harder HHS panels, fasteners designed for use in stainless steel panels can work well. Depending on the fastener type, maximum panel hardness for these fasteners is HRB 88 to 92. If fasteners designed for use in stainless steel panel are too costly for the application, a steel fastener's heat treatment may be able to be adjusted to achieve adequate hardness differential for clinching. Parts with this type of modified heat treatment may also require material with higher hardenability, and so are produced as specials.

Harder panels highlight the importance of proper heat treatment. Improper heat treatment can cause a fastener to fail during or after installation; improper tempering can result in fastener brittleness, which can cause the fastener to crack; and inadequate treatment can cause a fastener to be so soft that it literally is crushed during installation, especially when installed in HSS panels.

Stainless Steel Panels

An ever-increasing number of fastener attachment applications demand corrosion resistance and hardness, as well as thinner and lighter designs. Self-clinching fasteners manufactured expressly for use in stainless steel can meet these needs.

But fabricators should exercise caution when installing stainless self-clinching fasteners into stainless sheets. A prevalent misconception is that any stainless self-clinching fastener will perform without fail when installed in any stainless sheet. This is not true. In fact, standard stainless self-clinching fasteners made from 300 series cannot be expected to perform reliably in 300 series stainless sheets because of the relative hardness issue.

The proper stainless self-clinching fasteners for installation into 300 series stainless sheets include types manufactured from 400 series stainless. They offer the necessary relative material hardness. Types made from special alloy (precipitation-hardened) stainless will offer even higher corrosion resistance. Depending on the type, such fasteners can be used effectively in sheets with hardness ranges from HRB 88 to 92.

Fabricators also should be aware that work hardening could occur around the mounting hole during installation of stainless types. Every effort must be made to enable the displaced sheet material to flow as intended. Recommendations to achieve this include specifying annealed panel; installing self-clinching fasteners far enough away from bends or other highly cold-worked areas; keeping the punch sharp; keeping the hole size toward the lower end of the specified tolerance range; and installing into the punch side of the hole. In some cases, specialized tooling can aid in displacing panel material.

About Material

Self-clinching fasteners deliver opportunities for fabricators to reduce the number of parts for installation, eliminate secondary operations, and accelerate overall production. For some applications it should be noted that self-clinching hardware may not be the way to go. In these situations, other fastener options (such as weld nuts, blind fasteners for use where only one side of a workpiece is accessible for installation, or flaring fasteners, among other types) may be more appropriate.

In all cases, though, fabricators should recognize that the compatibility between fastener and host sheet will always be a material issue. **FAB**

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