The Economics of Drill Screws

by Thomas Doppke

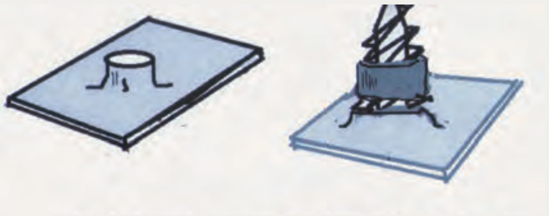
The origin and justification for a particular product is often lost or obscured over time. The drilling screw is one of these. Why was it invented, why is it used and what economic rules direct its use and proliferation? These are all questions that few can answer. With almost 60 years in the fastener trade I think that I can answer some of these.

Tapping screws are used to secure small items to sheet metal or other components. Rather than haphazardly installing them to any space available, the engineers must carefully plot where they will go. Then a pilot hole is located. In metal the hole is either punched during the stamping process (cheapest way), done with a post-stamping punch, or drilled (more expensive method). The most expensive method is an 'in-line drill at assembly' operation. This involves a lot of time and often the operator cannot reach the location due to interference with other attached components. The cost of 'in die' punching may be prohibitive or not even possible if the hole is located in a hard reach place. For example, in die work, all the forming, holes and cutouts included, are formed in one direction as the press halves come together. A hole that is in another direction will require the stamping to be punched in an 'off-line' operation.

One problem was what to do about an engineering option that was not always required? Rather than the 'old days' when things were hand built, one of-a-kind, today the holes in the sheet metal are punched for all options. If the option is not required, for example, control boxes for fig lights or cruise modules which might be ordered or not, the holes were left empty. Safety rules require that there be no opening into the car body (intrusion of gases, fluids, etc. are a "no-no"). The presence of screw pilot holes when the option is not ordered had to be addressed. Some assembly lines installed a screw into the hole just to plug it. A variety of other solutions were used at times, all of which added labor and cost to the assembly process. The obvious solution was to invent a screw that would drill its own hole and then tap in to the metal. Then the screw (and its hole) will be 'on demand, as required'. Also the expense of making that hole is saved (often a costly item).

If the sheet metal is thin enough, a sharp pointed screw can be 'shoved' through the metal with enough force. Screws installed this way rarely hold well. Part of the problem is that thin metal is not well adapted for tapping screw installations. When the metal was thicker (pre-1970's) the thickness allowed the screw to form most of a thread or greater. However, it also made driving the sharp point through the metal almost impossible. Often it would not penetrate and/or would get so hot, frictionally, that the screw would blacken and soften. For the screw to hold even moderately well a one pitch thread thickness is needed. As the illustration shows, a typical 8-18 (4.2 x 1.41mm) tapping screw needs 1.41mm metal thickness. Many gauges today are in the 0.71mm (0.028") range.

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



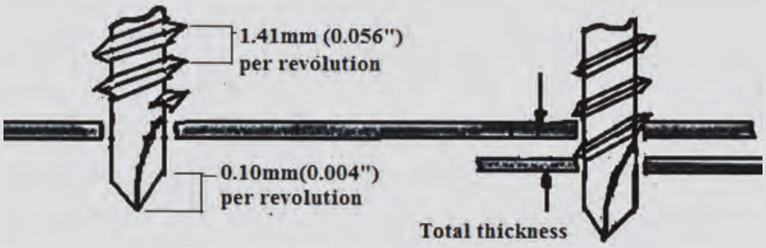
Standard extrusions are cut off with standard tapping screws leaving less than 1/2 pitch engagement

Other solutions to the tapping screw into thin metal involved using a 'spud' punch. A spud punch is very similar to a nail. Driven into thin metal it forms a hole with a cone like extrusion. It was thought that a cone-like protrusion would increase the total thickness that the screw would be driven into and the increase in total metal would solve the one pitch problem. However, this extrusion is often split down to the base; rendering the hole thus formed worse than if no hole had been made at all. This was a cheaper way of making an extrusion than using a costly punch. A proper punch made extrusion has a nice cone shape, increasing the metal thickness to allow a greater amount of thread formation. Unfortunately the extrusion, made in the thin metal, is often so thin walled that a tapping screw cuts it off, leaving a thinner section than before. It seems that a drill screw was the best way to attach components to thin metal despite that fact that a drill screw costs about double the price of a standard tapping screw.

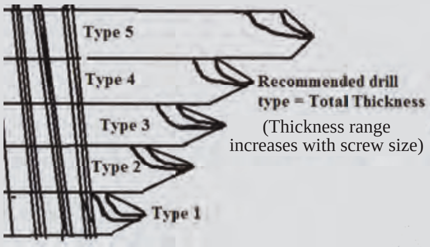
The drill screw is a combination of drill point fastened to the end of a tapping screw threaded fastener. The screw drills its own hole and taps into the metal in one operation. It can be located wherever the operator wishes. To accurately locate the part sometimes an indented depression is placed in the metal. This locator also acts as a starter point to prevent slippage and chatter which may mislocate the fastener.

Drill Screw Locator Dimples

With every solution it seems that another problem arises. A drill screw penetrates metal at a rate of 0.10mm (0.004") inches per revolution. When the tapping screw thread starts its installation, the thread penetrates at a rate of 1.41mm (0.056") per revolution (for a 4.2x 1.41 [8.18 screw]). If the metal is thick enough so that the drill portion has not cleared the metal when the tapping begins the screw will probably jam.



This additional problem was solved by the innovation of drill screws with longer drill sections (see illustration). Choosing a screw with a drill length suitable to the metal thickness being drilled was a necessary requirement for the designer. This problem led to the proliferation of parts as each was designed to fit a different gauge. Of course, the increased length increased the cost, required more backside room, and possibly interfered with other components, could cut wiring, and presented a hazard to human extremities.



Recommended Thickness per Drill Point Type (4.2 x 1.41[8-18]) Size Screw

Type	Thickness Range
1	←0.89mm (0.035")
2	0.89-2.54 (0.035-0.10)
3	2.54-3.56 (0.10-0.14)
4	3.56-6.35 (0.14-0.25)
5	Up to 12.7mm (0.50")

The stamping community and the cost analysis people were, for different reasons, against drill screws at first. The stamping people wanted their spuds, the cheapest hole producing method in the industry. The hole, akin to that produced by hammering a nail through the metal, was reasoned to by acceptable as the height of the extrusion 'doubled' the thickness that the screw would tap into. Unfortunately this is not so. The extrusion would be cut off, as mentioned above, by the screw threads cutting the cone off as the extrusion walls, produced by stretching the metal, were even thinner than the flat section. Also the cone produced by spudding was often cracked to the base so that a tapping screw would, instead of tapping, just open up the cone like a flower. Dimensionally the cone actually has less tapping thread contact as the cone opening is bell shaped. Measurements of the enlarged conical entrance area, the thinned down cone walls and the fact that the cone was formed with a spud instead of the more uniform forming punch, shows only about 1/3 of the original thickness is utilized.

Another solution, the ideas were band aide upon band aide, was to manufacture a drill screw with a fine thread in place of the standard tapping screw thread. A whole series of screws with a 0.7mm pitch were made and released. These allowed a full pitch engagement although driving effort was increased and stripping of the threads during high speed rundown occurred more often.

The use of screws in exposed areas required some sort of increased corrosion finish. This was usually a thick coating which meant that the drill flutes, coated with the thick plating, would not effectively drill. Much more end load was required to start the drilling .One company coated the ends with plastic and wax to mask off the coating during the plating process. The wax spun off, melted in the summer heat, and was a horrible mess as well as rusting quickly. One company designed a 'burr' on the drill flute edge which would break off during installation, presenting a clean sharp cutting edge The burr most often fell off before the screw was even finished being manufactured. The solutions to the everyday pile of problems continued. And the cost continued to go up!

The constant corrections to the basic idea of the drill screw increased the cost to the point where the expense could no longer be tolerated. Since the drillers cost about US$ 0.002 or more per part than the non-drilling kind (the average car uses approximately 200-250 tapping screws), the bottom line was an increase of as much as US$4.00-4.50 per car. While the advantages of the drilling screws made them 'must have' item, potential cost savings in other areas was explored.

One serious consideration was the flute design. Since the screws were manufactured with the drilling point (flute) milled in as a secondary operation, the thought that another way of making the flute would render a large cost savings.


MILLED POINT


FORGED/PINCH POINT


'IMPROVED' MILLED POINT


FORGED/MILLED POINT

Obviously forming the point during the heading operation was a logical solution. Drill screws with forged drill flutes, also known as 'pinch points', were made and sold as standard drill screws. This led to complaints that the new forged points did not drill as quick and required a larger end load to institute the drilling. A study was run to examine these ideas. While the study was in process of being formalized it was found that there were other variations of drill flute manufacture. The forged points were found to be available in both a pinched and a milled version. The milled version was first forged (formed in the heading operation) and then milled as secondary operation. It was explained that this reduced the milling operation and was somewhat more economical. An 'improved' milled point was also touted and was included in the study for evaluation.

The study used 8-18 (4.2 x 1.41) screws, run into a 1.62mm thick, cold rolled steel plate (hardness RHB 68-70) with state of the art laboratory equipment at a test laboratory. A test size of 25 pieces was selected. A review with users and manufacturers gave a list conditions which were deemed as possibly critical. These were; the effects of pre-cleaning of the parts, the effect of plating, and the effect of end load. Although there is no industry specification for drill time, many companies require a time of two seconds maximum. A series of summation tables follows below. For a non-mathematical type person, the data is roughly summarized after.

MILLED POINT DATA SUMMATION

Point Type	Plating	Pre-Condition	Load (Lbs)	Drill Time (Average)	Standard Deviation*	Average Hole Diameter(mm)
Milled	Unplated	As Rec'd	40	1.743	0.101	3.28
			45	1.764	0.190	3.25
			50	1.696	0.356	3.22
	Unplated	Chemical Clean	40	2.079	0.529	3.29
			45	1.889	0.216	3.28
			50	1.825	0.440	3.24
	Unplated	Wheel Abrader	40	2.122	0.270	3.26
			45	1.824	0.281	3.27
			50	1.646	0.242	3.21
	Plated#	Chemical	40	2.093	0.439	3.30
			45	1.770	0.327	3.31
			50	1.629	0.369	3.26
	Plated	Wheel Abr	40	2.418	0.354	3.27
			45	2.243	0.384	3.25
			50	1.950	0.609	3.25

Note: * Standard deviations are average and are included to determine if any wide variations in results skewed the averages.
Plating used was industry standard, exterior multi-coat metallic with organic top coat, designed for 5 year corrosion resistance.

FORGED/PINCH POINT DATA SUMMATION

Point Type	Plating	Pre-Condition	Load (Lbs)	Drill Time (Average)	Standard Deviation	Average Hole Diameter(mm)
Forged/ Pinch	Unplated	As Rec'd	40	1.936	0.761	3.05
			45	1.420	0.581	3.04
			50	1.290	0.761	3.05
	Unplated	Chemical Clean	40	1.886	0.920	3.05
			45	1.346	0.403	3.04
			50	1.251	0.466	3.04
	Unplated	Wheel Abrader	40	2.004	0.744	3.05
			45	1.405	0.537	3.05
			50	1.260	0.537	3.04
	Plated	Chemical	40	2.802	0.909	3.06
			45	1.902	0.946	3.06
			50	1.424	0.598	3.05
	Plated	Wheel Abr.	40	2.686	1.215	3/05
			45	1.816	0.593	3.06
			50	1.425	0.461	3.05

FORGED/MILLED POINT DATA SUMMATION

Point Type	Plating	Pre-Condition	Load (Lbs)	Drill Time (Average)	Standard Deviation	Average Hole Diameter(mm)
Forged/ Milled	Unplated	As Rec'd	40	1.710	0.406	3.22
			45	1.532	0.232	3.20
			50	1.508	0.495	3.17
	Unplated	Chemical Clean	40	1.716	0.212	3.24
			45	1.888	0.425	3.20
			50	1.750	0.528	3.18
	Unplated	Wheel Abrader	40	1.702	0.299	3.20
			45	1.417	0.287	3.21
			50	1.574	0.392	3.17
	Plated	Chemical	40	1.726	0.249	3.22
			45	1.458	1.190	3.23
			50	1.167	0.151	3.18
	Plated	Wheel Abr	40	1.893	0.499	3,20
			45	1.547	0.230	3.22
			50	1.296	0.193	3.18

IMPROVED MILLED POINT*

Point Type	Plating	Pre-Condition	Load (Lbs)	Drill Time (Average)	Standard Deviation	Average Hole Diameter(mm)
Improved	Unplated	As Rec'd	40	2.207	0.590	3.22
			45	1.671	0.358	3.21
			50	1.707	0.613	3.23
	Unplated	Chemical Clean	40	2.107	0.489	3.23
			45	1.779	0.388	3.21
			50	1.947	0.908	3.24
	Unplated	Wheel Abrader	40	1.958	0.365	3.23
			45	1.691	0.508	3.22
			50	1.785	0.767	3.24
	Plated	Chemical	40	2.166	0.573	3.24
			45	1.695	0.614	3.23
			50	1.565	0.453	3.24
	Plated	Wheel Abr	40	2.049	0.514	3.24
			45	1.836	0.387	3.23
			50	1.656	0.325	3.25

Note: * The improved point has been marketed as a Type BSSD

What does this all mean? No great variation was discovered although some trends are noted. These are just observations of a general nature: 1-the higher the end load the faster the drill times, 2-plated parts increased the thread diameter and showed slightly longer drill times, 3-Wheel abrader cleaning appears to roughen the drill flute surfaces enough to drag the times downward slightly, 4-drill wobble (a common drill factor) produces a slightly larger hole, hence the narrower pinch point produces a smaller diameter hole. It shows a slightly faster drill time also (due to smaller diameter?), and 5- the improved drill type is not much better than the others except for a reported price increase. In total, there is not much truth in the stories of pinch points being worse. Ergonomics may be involved because of the end load required by the operator to push on the tool to start the drilling but other than that any other imagined fault was not validated. The use of the wheel abrader cleaning method was the only factor that might have an impact but that was relatively minor.

What are the economics of using drill screws vs. standard tapping screws? Drill screws do not require a pilot hole, saving cost over the location placement of a hole, the labor and time to do so, and the need to plug unneeded holes. The drill screw is more costly but when the cost of the other operations required to install a tapping screw into a piloted hole are considered, the balance is about equal. The tapping screw is easier to start and is readily available. It installs exactly where required while the drilling screw may wander unless some sort of template is used (for example, the component to be mounted or a preformed dimple in metal as shown above). The drilling screw needs a bit more backside clearance than a standard tapping screw and the drill portion must be clear of the metal (as mentioned above). Its sharp point is more of a hazard to hands intruding into its area than a regular screw. And finally, while a standard tapping screw can be installed often with just the weight of the tool pushing it into the hole, the drill screw needs at least a 40 pound (18.8 Kg) 'push'. This is a point to consider with today's ergonomic requirements, operator fatigue, and potential for screw wandering. ■