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Cold Facts

Cold-forming taps shrink tapping cycle times.

Today's highly competitive manufacturing environment requires companies to continually scrutinize their operations, seeking ways to increase productivity and lower operating costs. The tapping process is no exception.

End users must reduce their tapping cycle times. One way to speed tapping operations is by adopting high-speed-machining methods like those applied to milling and turning.

It is also essential to minimize tap breakage. Tapping usually occurs late in the machining process. This magnifies the negative effects of a broken tool: excess costs, time and frustration.

Choosing the correct tap is critical when high-speed tapping (HST). Inexpensive HSS taps, for example, were not designed to withstand the extreme operating conditions that arise in HST.

Solid-carbide cutting taps have the necessary strength, rigidity and wear resistance to withstand the heat generated during HST, but they fail in ferrous materials such as steel.

The drawbacks of solid-carbide fluted cutting taps are material brittleness and a wedge angle that creates a sharp cutting-edge corner.

A solution to the HST tool problem is the new generation of solid-carbide cold-forming taps. They can thread a variety of materials, including ferrous ones, while minimizing tool breakage.

Cold-Forming Basics

There are two main ways to produce a thread with a tap: by cutting it, a process that produces chips, and by the chipless cold-forming process.

The cutting tap is more popular than the cold-forming style. This is despite the limitation of a cutting tap's flute geometry, which requires space for chip formation and ejection. A special flute design is needed to prevent chip clogging and improve chip flow. This design element, however, reduces the tap's flute cross-section. That, in turn, makes tool breakage more likely as torque increases.

Cold-forming, or forming, taps are fluteless, polygonal tools. The thread form of the tap is pressed into the workpiece, stressing the material beyond its yield point. This action, known as swaging, causes the workpiece to deform plastically and permanently (Figure 1).

Forming taps are recommended for materials that possess good plastic-flow properties—at least 8 percent elongation (Table 1). Their maximum tensile strength should not exceed 240,000 psi. Their hardness should be lower than 35 to 40 HRC, which includes all ductile materials. Cast iron and hard brass alloys are not good candidates for forming-tap applications.

Forming Advantages

Cold-forming taps benefit users the following ways:

■ Thread flanks have higher surface-tensile, yield and shear strength. This is due to the threads being formed by the swaging process.

■ Achieve surface finishes finer than 32µin., minimizing thread corrosion and improving abrasion resistance (Figure 2).

■ Cutting speeds must be increased during form tapping to allow the workpiece material to flow. This dramatically reduces the cycle time.

■ Because no chips are cut, thread depth is not limited. Also, cleaning up and disposing of chips is eliminated.

■ Forming taps are suitable for both blind-holes and through-holes.

■ With forming taps, there is high precision uniformity of the tap thread limit, no pitch deviation and no miscut threads. Clean, true-to-gage threads are produced.

■ Because they lack cutting flutes, forming taps have a larger cross-section. This enhances rigidity and strength, thereby minimizing tap breakage. The larger cross-section allows microfine threads to be tapped to precision uniformity without tool breakage.

■ Forming taps require a larger hole than cutting taps, which reduces torque while machining. During the first revolution of the tap-reversal phase of the operation, a cutting tap experiences 2.5 times more torque than a forming tap. This is a result of the cutting tap clearing shear-zone chips.

■ Cold-forming taps are suitable for threads interrupted by longitudinal slots or cross-holes. This capability eliminates the need for special taps.

■ User tests have shown that cobalt-HSS forming taps, compared to cutting taps made of the same material, last 100 to 350 percent longer. And carbide forming taps outlast carbide cutting taps by 500 to 1,500 percent.

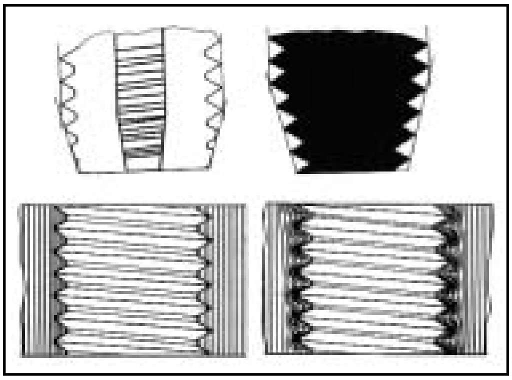

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Figure 1: A cold-forming tap plastically deforms the workpiece material when producing a thread. No material is cut during form tapping, making it a chipless operation. Shown clockwise from upper left: Cutting tap; cold-forming tap; formed thread; cut thread.

Conventional Tapping vs. HST

HST is similar to conventional tapping. The system components are the same, and HST accommodates the use of either self-reversing tapping heads or the rigid tapping technique.

The main difference between conventional tapping and HST is that the latter is performed at a higher spindle speed. (In tapping, 120 sfm and above is considered "high speed.") The feed is adjusted accordingly.

The cutting speed attainable depends on the workpiece material's characteris-

Differences between HST and HSM

With respect to the high-speed-tapping and high-speed-machining processes, it is easier to perform HST than HSM with endmills.

Below are examples of how the processes differ:

Cutting speeds higher than 400 sfm are considered "high" when endmilling. When tapping, speeds of 120 sfm and above are considered high.

An endmill applied in an HSM operation makes multiple passes. Depths of cut are light and spindle speeds, and table feeds are high. Generally, the same endmill is used for roughing and finishing. With HST, the tap should produce the specified thread in one pass.

Users can expect to obtain good results with HSM heat-treated tool steels from 50 to 65 HRC. Maximum material hardness with HST is about 40 HRC.

With HSM, spindle speed usually exceeds 8,000 rpm. This requires the spindle, holder and tool to be balanced. When tapping, generally, the speeds are lower than 8,000 rpm and balancing is unnecessary.

When high-speed endmilling, particularly 3-D machining and cutting sculptured surfaces, special software and programming are required. No special software is required for HST. The only requirement is to increase the spindle speed and the feed.

— *A. Dov*

MATERIALS	TYPES
Steels	Plain carbon, free cutting, mild steels, magnetic soft, case carburizing
Stainless steels	Free machining, austenitic
Titanium	Unalloyed titanium
Nickel	Unalloyed nickel
Aluminum	Unalloyed aluminum and magnesium, aluminum alloys (Si < 0.5%)
Copper, bronze	Unalloyed copper, long chipping
Brass	Soft brass
Zinc, zinc alloys	Molded, die-cast, drawn, rolled

Table 1: Materials that are good candidates for cold-form tapping. Application tips: 1. Pay attention to springy materials, such as stainless steels. They may shrink after tapping, causing undersized pitch diameter. Choose a higher limit tolerance. 2. Since the tap forms the thread by a swaging process, upward burrs can form. Prevent this by chamfering the drilled hole before tapping. 3. Avoid threading near the workpiece's edge.

tics. In general, carbide cold-forming taps can be operated at cutting speeds four to 12 times higher than HSS-Co taps.

Taps for HST are available with a wide variety of coatings, including titanium nitride, titanium carbonitride and aluminum titanium nitride.

The high heat resistance of coated carbide forming taps minimizes the amount of lubrication needed when HST. Technically, the operation is "dry" because of the small amount of fluid applied. It is not recommended to dry-tap low-carbon steels, stainless steels, titanium alloys, aluminum or other sticky materials.

HST is well suited for production applications performed in virtually every industry.

Adopting HST

The benefits of utilizing high-speed machining methods when milling and turning has encouraged a growing number of end users to apply the same concepts to tapping.

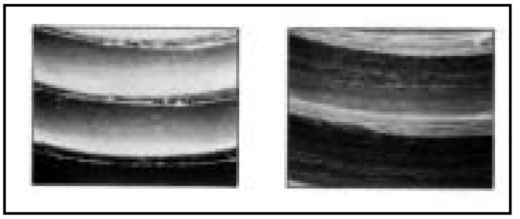

Figure 2: A forming tap produces threads with a finer finish (left) than a cutting tap does.

Management appraisal of whether to adopt HST processes must be considered in terms of the bottom line. Would HST profit the company by reducing cycle time and scrap while improving quality and productivity? If the answer is no, there would be no justification for adopting the process.

Management also must consider the available manufacturing equipment at its facility. If new equipment were purchased, how quickly would the company get a return on its investment?

Asking these types of questions is not only prudent but essential for financial survival.

Whether or not a company chooses to try HST depends on many factors. The first task should be to assess how well its current tapping operations are being performed. A manufacturing facility should not adopt HST unless it is already producing accurate threads consistently.

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