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Test results show a new HSS drill can provide cost-effective performance when machining hardened plate material.

Built from Speed

All photographs: Erasteel

BY JAN TIBERG

Frederic Taylor invented the first high-speed steel a little more than 100 years ago and presented it in 1900 at the World Technical and Trade Fair in Paris. Today, research and development in HSS and the introduction of new grades continues.

An example is Erasteel's ASP 2060, which is a rapid-solidification, powder-metal HSS that is being used to make hobs, endmills, gear cutters and drills. It contains 2.30 percent carbide, 4.20 percent chromium, 6.50 percent tungsten, 6.50 percent vanadium, 7.00 percent molybdenum and 10.50 percent cobalt. Drills made of this material that are PVD-coated with multiple layers of titanium aluminum nitride can drill most materials, including hardened steel. And unlike carbide tools, these drills can be used in less-rigid machines, such as radial and column drilling machines.

The Stiffness Dilemma

The need for a HSS drill for difficult machining applications has become more pronounced in the last few years. High-strength plate materials, such as Hardox 600, call for extremely tough—and hard—drills. The quenched and weldable wear steel has a hardness of 600 HB, and often is used to make mining and earth-moving equipment.

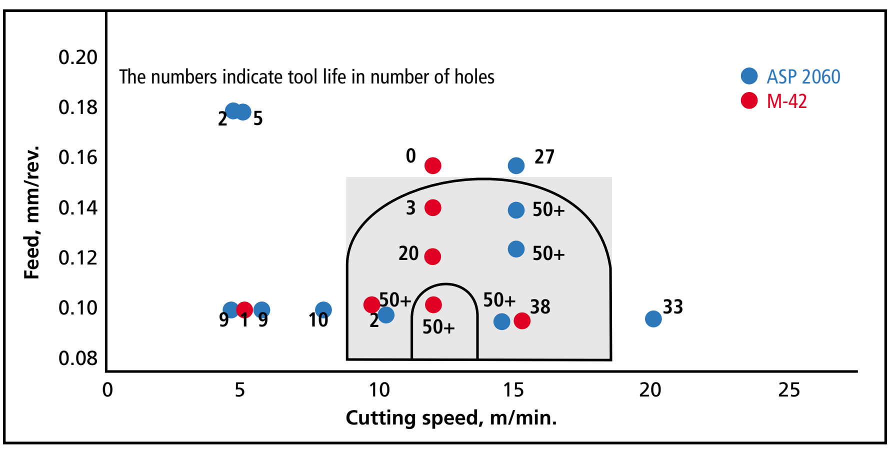

Figure 1. ASP 2060 drills can produce 50 or more holes in hard plate material over a wider range of cutting parameters than M-42 drills.

Work material	Hole size (mm)		Cutting data		Tool life (# of holes)		
	diameter	depth	m/min.	mm/rev.	M-42	K-945	ASP 2060
Hardox 500 (HB 500)	18	25	7	0.11	9		24
Hardox 500 (HB 500)	18	25	4	0.17	50		60
Kymmenite (HB300)	18	36	20	0.35	7		41
Cast iron	6.8	20	80	0.25		10	260
Tool steel (HRC 48)	5/6*	9	20	0.15		20	300

* The K-945 drills measured 5mm in diameter and the ASP 2060 drills measured 6mm in diameter.

Table 1. The test results from drilling different work materials with TiAlN-coated tools made of M-42, K-945 and ASP 2060.

Drill type	Indexable carbide	Solid carbide	ASP 2060 HSS
Cutting speed	30 to 40m/min.	20 to 30m/min.	10 to 18m/min.
Feed rate	0.05 to 0.1mm/rev.	0.06 to 0.1mm/rev.	0.10 to 0.14mm/rev.
Productivity index	1.5 to 4.0	1.2 to 3.0	1.0 to 2.5

Table 2. Recommended cutting parameters for drilling Hardox 600 in rigid machine tools and the corresponding productivity index for each cutting tool material.

Although carbide drills can do the job, they require very stable machine tools, which can cost 50 to 100 times more than a column drilling machine. A solid-carbide drill used on one of these less costly machines would immediately break into pieces because of the vibration generated during drilling.

In an attempt to combat this problem, TiAlN-coated ASP 2060 drills, with a thick web and a high helix angle, were produced. The drills have a hardness of 980 HV (69 HRC). Carbide drills have a hardness range of 1,400 to 2,000 HV.

The same type of drills also were made of M-42, which is considered to be one of the best HSS grades for through-hole drilling. M-42 contains 1.20 percent vanadium, 1.27 percent carbide, 1.50 percent tungsten, 3.80 percent chromium, 8.00 percent cobalt and 9.40 percent molybdenum.

To determine the effectiveness of the two tool materials, through-holes measuring 18mm in diameter were drilled in a 25mm Hardox 600 plate and the results were documented. When drilling with HSS drills, a fairly low cutting speed and a high feed is usually recommended, because these tools have the ability to withstand the high shear and tensile stresses found at higher feed rates. But those cutting parameters did not work when drilling the hard plate material. However, the tool life increased dramatically when the cutting speed was increased from 5m/min. to more than 15m/min. From about 10m/min. to 15m/min., a "window" was found where the drills could produce 50 holes or more (Figure 1).

Clearly, the cutting-parameter range where the ASP 2060 drills produced 50 holes is much larger than the one for the M-42 drills. A direct comparison between the two drill materials at a cutting speed of 10m/min. and a feed of 0.1mm/rev. shows the M-42 drill could only create two holes, whereas the ASP 2060 drill still had useful life after 50 holes.

P/M HSS drills coated with multilayers of TiAlN.

Unstable Conditions

While the first test was conducted with a rigid machine, additional tests also were performed with less-stable column and radial drilling machines at a feed of 0.11mm/rev. and a speed of 14m/min. The results showed that the tool life for the ASP 2060 drills was reduced to about 35 holes. This is still better than carbide drills, which would fracture immediately. Carbide tools usually have a universal tensile strength (UTS) of about 1,000 MPa, whereas the UTS is 3,000 MPa for conventional HSS cutters and 5,000 MPa for P/M HSS tools.

Drilling tests also were conducted in four other work materials: Hardox 500 (500 HB), hardened ductile iron called Kymmenite 9007, standard cast iron and 48 HRC tool steel. The Kymmenite was hardened to 300 HB, producing an austenite-ferrite microstructure, which workhardens and, therefore, is difficult to drill.

In addition to ASP 2060, drills made of two types of conventional HSS were tested: M-42 and K-945. The K-945 contained 0.91 percent carbide, 1.20 percent vanadium, 1.80 percent tungsten, 2.50 percent cobalt, 3.70 percent chromium and 5.00 percent molybdenum. The ASP 2060 drills outperformed the conventional HSS drills in all cases (Table 1). The improvements were particularly pronounced at higher cutting speeds.

Substituting Carbide

The test results for the ASP 2060 drills were then compared with the cutting parameters generally recommended for indexable-insert and TiN-coated, solid-carbide drills when drilling plate material with a hardness of 600 HB (Table 2). The table's productivity index was determined by multiplying the cutting speed by the feed and shows a similar range for all three types of drills. A major advantage of a HSS drill, though, is it costs considerably less. A carbide drill can cost twice as much as a P/M HSS drill.

About the Author

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