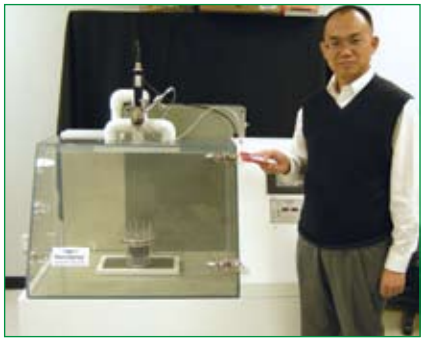
Ask the Expert

Why have coatings become such a critical factor in the performance of cutting tools?

These days, cutting tool suppliers are devoting increasing amounts of R&D resources into the coatings that go on cutting tools, and for good reason. Coatings and coating processes are getting the credit for recent improvements in metal removal rates in many of the difficult-to-machine materials such as hardened steels and Inconels used in the aerospace industry and other sectors.

Canadian Metalworking recently had an opportunity to speak with Dr. Wenping Jiang, director of product development at Duralor LLC, Fayetteville, AR, about the history of coatings on cutting tools and the challenges that coatings developers are trying to overcome today. Duralor recently patented cubic boron nitride (cBN) composite coatings for metal cutting tools and is now marketing those coatings as TuffTek to metal cutting manufacturers and cutting tool companies. Jiang explained how the different coatings and coating processes impart various properties to the cutting tool depending on the requirements of the application.



Dr Wenping Jiang, director of product development for Duralor.

Q. What is the history of the use of coatings for metal cutting tools?

Early tools for removing metals were primarily made of carbon steels and high speed steels. The increased demand for materials of high strength for functional requirements and high manufacturing productivity posed significant challenges to the early tools. The application of hard and wear resistant coatings on cutting tools began in the middle 1960s to provide improved surface hardness, chemical stability, and wear resistance that are essential for a typical cutting tool. Since then, both PVD and CVD coatings and processes have experienced significant development, with effort geared toward superhard and supersoft coatings for various applications. Superhard coatings offer significantly improved properties such as hardness and wear resistance as compared to many conventional hard coatings like TiN coating. These properties make the coatings suitable for many ferrous- and non-ferrous related applications. The development of supersoft coating is driven by the increasing interest in dry machining, which could help to reduce environmental pollution and disposal cost related to cutting fluids. In combination with hard coatings such as TiN, supersoft coatings have demonstrated promising results in high-speed machining of aluminum alloys. If it is fully developed, it can be a substitute for coolants, and has potential for round tools (drill bits, end mills, etc.) in machining and forming.

Q. What are the advantages and disadvantages of coated cutting tools?

The properties of coated cutting tools include high hardness, fracture toughness, and abrasive wear resistance that are typically difficult to obtain in uncoated tool material. Therefore, if it is properly selected for the application, coating on a tool helps to extend tool life and increase material removal rate, and thus productivity rates. Cycle times for cutting inserts vary depending upon the coating chemistry and thickness.

The common problems that can occur in applying a coating to uncoated inserts include degraded coating chemistry, substrate, and mismatch of

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Duralor: TuffTek Coating

Duralor has developed a new cubic boron nitrde (cBN) composite coating for metal cutting tools called TuffTek. The successful application of cBN as a coating had not been realized despite several previous development efforts by cutting tool companies. With the release of the TuffTek product line, users can now gain the performance and longevity advantages of cBN at vastly lower cost, says the company.

In side-by-side comparison for the machining of hardened steel, TuffTek-coated tools outperformed traditional coatings by 300 per cent or more, claims Duralor.

www.duralor.com

Ingersoll: TT8125 Turning Grade

Ingersoll's new CVD coated grade TT8125 has been developed for general machining on steels such as mild steel, carbon steel, alloy steel, bearing steel and tool steel. According to the company, the grade is built on a tough substrate with a cutting edge that provides excellent wear characteristics and crater resistance. TT8125 is

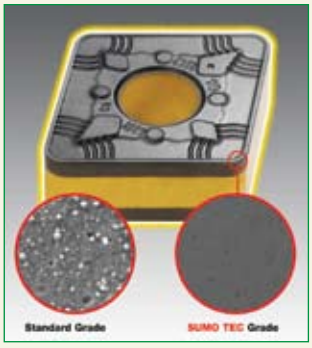
designed to deliver exceptional performance in both interrupted and continuous cutting. The cutting edges of this grade stand up very well to forged steel or parts with surface scale. Grade TT8125 minimizes edge build-up when machining low carbon steels and increases tool life by minimizing the friction between chips and the upper surface of the insert.

www.ingersoll-imc.com

Iscar: Sumo Tec

Iscar's Sumo Tec line now includes CVD and PVD coated carbide grades for turning. In identical tests in a variety of turning applications, the inserts outlasted their nearest competitors by 26 to 288 per cent, claims the

company. Iscar says the key to the longer life is the Sumo Tec special treatment that smoothes the coated surface and reduces surface tension stresses in insert coatings. These lead to cooler running, better chipping resistance, reduced built-up edge and reliably longer edge life in all workpiece materials. During the alumina coating process, internal tension stresses sometimes cause cracks. The new Sumo Tec treatment induces compression stresses, which help to seal those cracks.



For cast iron, Iscar offers IC5005, with a hard substrate, MTCVD TiCN and thick Al2O3 coating, recommended mainly for nodular cast iron. It also handles other cast irons at medium to high cutting speeds at stable or slightly unstable conditions. This grade may be used in hard cast irons when exceptionally high wear resistance is required. IC5010, featuring a tough substrate, MTCVD TiCN and thick Al2O3 coating, targets grey cast iron. It is recommended for interrupted cuts and unstable turning conditions in other materials.

For steel, IC8150 consists of a very hard substrate with a cobalt enriched outer layer, MTCVD TiCN and a thick alpha Al2O3 CVD coating. This grade is recommended for high speed turning of steel under stable or slightly unstable conditions. It can also handle stainless steel and interrupted cuts in nodular cast iron, says Iscar. IC8250 has a tough substrate with the same outer layers. It features excellent thermal stability and resistance to plastic deformation and is recommended for general machining of alloyed and stainless steel in a wide range of conditions. IC8350 features a very tough substrate under the same outer layers. It delivers excellent shock resistance and good wear resistance on alloyed and stainless steel.

For alloys, stainless steel and hardened steel, the company offers IC807 with a tough submicron substrate under a TiAlN PVD coating. It is suitable for turning heat resistant alloys, austenitic stainless steel and hard steel at low to medium cutting speeds. In a test against its nearest competitor on all three materials, the improvement in tool life was up to 150, says the company.

www.iscar.ca

Kennametal: Screw-On Positive Insert Chip Breakers

Kennametal has expanded its Beyond line of turning products with the introduction of new screw-on positive insert chip breakers – FP (Finishing Positive), MP (Medium/Roughing Positive) and MW (Flat Top). The new chip breakers are showing up to 250 per cent longer tool life across a range of applications and materials and dimensional tolerances are tighter by 50 per cent, says Kennametal.

According to the company, FP (Finishing Positive) chip-breaker inserts have a proprietary chip groove that results in lower cutting forces and a nose design that avoids overcrowding of chips in the nose radius area. This optimizes chip control while at the same time permits higher metal removal rates at lower cutting forces. MP (Medium/Roughing Positive) chip breaker inserts are suitable for chamfering applications and spindle boring due to high-strength edges for increased depth of cut. The flat top MW Beyond insert provides positive cutting, but also shows consistent chip control in short-chipping materials like cast iron.

All these new screw-on inserts share the performance characteristics of the entire Beyond line – micro-polished edges to improve edge toughness, proprietary post-coat treatment to reduce depth-of-cut notching, and a fine-grained alumina layer to enhance coating integrity at higher cutting speeds.

www.kennametal.com

coating and substrates, depending on the specific coating process.

Q. Why would a manufacturer choose to use an uncoated tool rather than a coated one?

In some cases, tools made of high-speed steels and uncoated inserts are preferable for certain applications due to their flexibility and relatively low cost. For example, uncoated carbide inserts prove to be effective in turning and face milling titanium and titanium alloy because titanium and its alloys have high chemical reaction with most of the other tool materials, leading to rapid tool wear. Typically, coated tools work effectively for most ferrous materials, aluminum alloys, and thermal sprayed Ni and Co based materials due to the high material removal rate and good tool life offered by the coated tools.

Q. What is involved in the PVD coating process and the CVD coating process?

The major difference between a PVD coating and a CVD coating is its deposition temperature.

PVD coating is typically deposited at relatively low temperature (typically in the range of 250°C~450°C), and is therefore suitable for applications where sharp edges are required, such as threading and end milling, and applications that demand a tough cutting edge. PVD is a process in which materials in a vapour state are condensed to form a solid state. TiAlN coating is currently the most widely deposited PVD coating for cutting tools.

CVD coating is often deposited by chemical reactions of gaseous reactants on or near the vicinity of heated substrates, resulting in the decomposition of some of the gaseous reactants and formation of solid film or coating on the substrate. Thus, it is a relatively high temperature process (in the range of 450°C up to 1050°C, depending on the variant of CVD coating process or application). CVD is a non-line-of-sight process. This means that the CVD process can: coat substrates with complicated geometries such as undercuts; deposit dense and pure materials with good

adhesion; form a uniform coating with reasonable deposition rate; and control coating surface morphology and crystal structure by adjusting the process parameters. CVD is mainly used for depositing compound protective coating such as oxides (Al2O3, ZrO2), carbides (TiC, TaC, TiCN), nitrides (TiN, HfN, AlN), and etc.

PVD and CVD are the two primary techniques used in the cutting tool industry. However, hybrid coating processes are in development to overcome the limitations of PVD and CVD, respectively. Examples of such hybrid processes include: electrostatic spray coating of micro/nanosized cBN particles followed by chemical vapour infiltration of binder phases to form thick cBN based coating; magnetron sputtering-assisted pulsed laser deposition; and combined cathodic arc and unbalanced magnetron sputtering.

Q. Where is coating technology going in the future?

Coating technology is moving toward developing superhard, supersoft, and the combination of hard and soft phases to form 3D nanocomposite coatings. These coatings have tremendous potential for significant improvements in the performance of coated tools because of their excellent properties.

www.duralor.com

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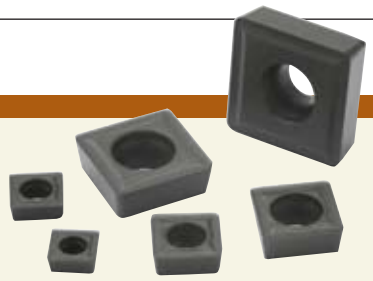


Seco: DP2000

Seco Tools Canada has applied its Duratomic coating process technology to its drilling products. The new DP2000 grade is designed for steel and cast iron applications where high cutting speeds can be used. According to Seco, in field tests, DP2000 has consistently shown a 30 per cent increase in productivity in combination with up to 100 per cent longer tool life in certain applications.

The DP2000 drilling insert grade is being launched with the -P2 geometry.

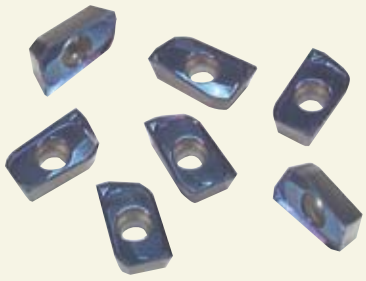
The key to the DP2000 grade lies in the Duratomic process where the aluminum oxide is arranged at the atomic level to adjust the coating to fit specific applications and workpieces. Grades produced with this process have consistently shown major improvement in coating toughness as well as wear-resistance, claims the company.

www.secotools.com

Sumitomo: Diamond Like Coating

Sumitomo Electric Industries, Ltd. have developed a Diamond-Like Carbon Coating (DLC) for the dry machining of aluminum alloys and non-ferrous applications. Previously, in the first stages of harsh-environment cutting, coatings would peel and lose their beneficial properties. Now, with the new DLC, cutting tools effectively maintain their properties that include high hardness, excellent lubrication, very low friction coefficient, very smooth surface, corrosive resistance and longer tool life, claims Sumitomo.

The DLC coating promotes good chip control and has a low friction coefficient of μ=0.05 - 0.2 - even without lubricants. According to the company, aluminum alloy adhesion on the edge is suppressed even in dry machining, thereby decreasing cutting resistance. Furthermore, generation of built-up edge is suppressed, thereby maintaining the sharpness of the edge

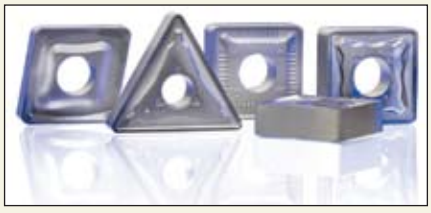


and improving the quality of the cutting material. Chips are removed effectively, preventing the cutting material from being scratched by chips and preventing deterioration of the machined surface caused by re-adhesion to the cutting material. The advanced DLC coating can be found on Sumitomo carbide grades, drills, and endmills.

www.sumicarbide.com

Valenite: VP5635, V490 & V560

Valenite is introducing a number of new insert products this spring. The company completes its 5600 Series of turning grades with the introduction of the VP5635 tough grade for roughing steels, stainless steels and cast irons. The new grade can increase production cost savings an average of 35 per cent and reduce production time by 40 per cent over comparable steel turning grades, claims the company. VP5635 offers the potential to use a single grade where two may have been required in the past. The new grade features an aluminum oxide coating that is twice the thickness of prior levels, and the coated surface is polished smooth in a patented post-coating process. The process results in a smoother surface and increased edge strength by relieving inherent stresses in the coating, says Valenite.



The company has also introduced the V490 multi-application face mill, available in square, round or octagonal inserts. The octagonal inserts is suitable for low cutting force milling with eight indexes, the square is designed for 90° shoulder milling with a depth of cut up to .500 in. (12 mm), and the round insert performs well in rough face milling and shallow profile machining, claims the company.

Valenite has also expanded its Penta family of milling cutters with an inch version of the V560 heavy roughing milling cutter. The new V560 is suitable for full depth-of-cut machining conditions (10 mm depth-of-cut capability) in forgings and beneath-casting scale.

www.valenite.com