

C³'s Patented Process Delivers Increased Productivity While Reducing Costs!

C³ gets good reviews from a major U.S. auto parts manufacturer

By Dr. Jacob Stiglich, Research Associate,
Department of Metallurgical and Materials
Engineering, Colorado School of Mines, April,
2003.

C³ infuses tool substrates with cubic zirconia— a cubic zircon (facsimile) is shown below



Hayes-Lemmerz Bristol, Indiana

Curt Pietrzak is a senior engineer at the Hayes Lemmerz Bristol, Indiana plant; he is part of the team that oversees the machining of over a million cast aluminum auto parts every year. Hayes Lemmerz International, Inc. is one of the world's leading global suppliers of automotive and commercial highway wheels, brakes, powertrain, suspension, structural and other light weight components. The Company has 44 plants, 3 joint venture facilities and 11,400 employees worldwide.

In 2001, Curt in an effort to raise the productivity of the process line, discovered that the face mill operation cutting the datum surface on the aluminum drive train knuckle was not running at the maximum recommended load and was an area that could be investigated for a performance increase. The speeds and feeds were set to provide a repeatable, quality part within the limitations of the fixtures. These settings were on the low end of the recommended performance for this type of operation.

The fixture modifications needed to improve the performance of the tool would be costly due to the amount of fixtures contained in the machine line,

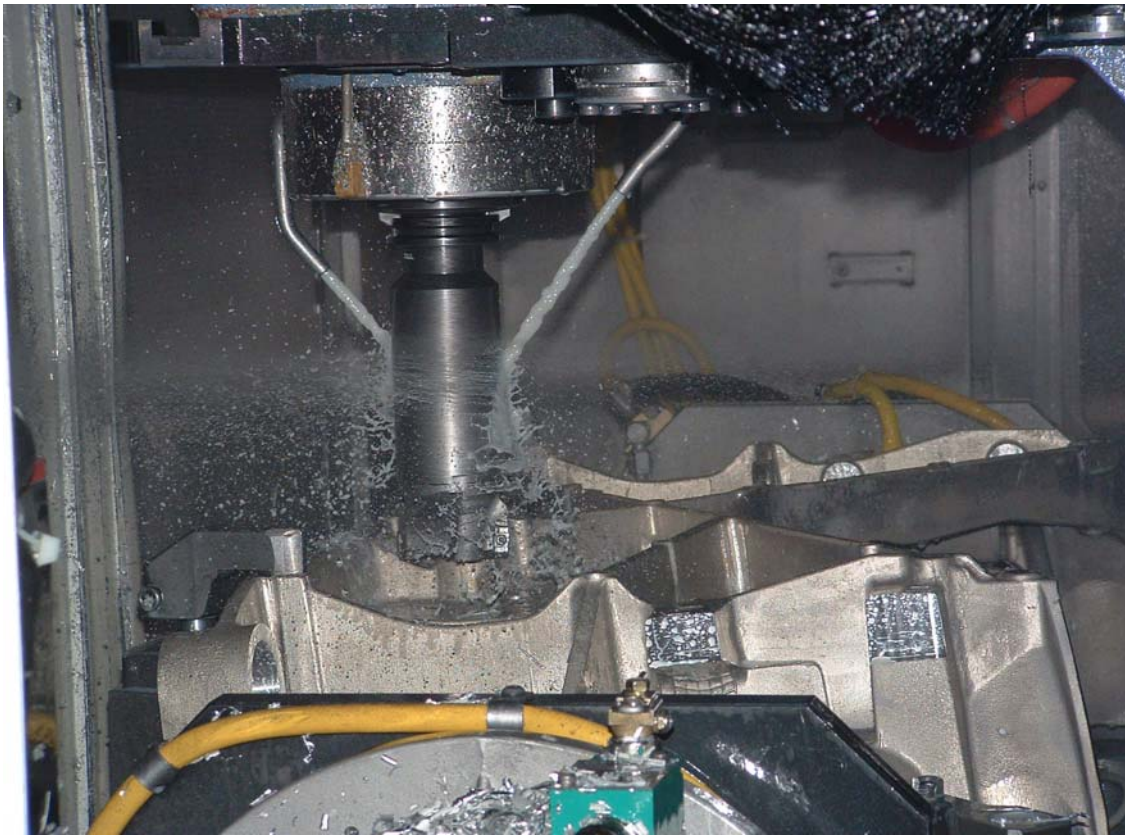
and require many weeks or months to implement due to production requirements. An alternative approach would be to raise the speed and feed proportionally thereby maintaining the same force on the fixture.



Curt called his Walter Wakuesha Cutting Tools representative to inquire about a standard, off the shelf, face mill utilizing the polished up sharp insert that had proven effective at other operations within the department. The Walter Wakuesha face mill was installed and tested with a slight improvement over the existing face mill but the gain was not large enough to cost effectively make the change. The freer cutting inserts allowed slightly more aggressive feeds but the speed could not be increased substantially without the decline of the cutting edge resulting in poor surface quality and burring. The Walter representative anxious to beat the competition offered up a box of inserts with a shiny black treatment that looked similar to CVD diamond film. The cutter was retested with the black inserts. The resulting gain was more than had been expected. The inserts were rotated and retested to confirm the previous outcome. Once again the inserts performed with exceptional performance.

Curt experimented with TiCN, TiN, and various other standard PVD treatments and Poly-Crystalline Diamond throughout 2001, but not until December, when his Walter representative sent him a box of TC inserts that had been treated by C³ International, LLC (C³), did he find what he was looking for. “I hesitate to jump into PCD tools until a process is completely stable. One misfortune and a \$400 diamond load is lost vs. a \$47 C³ load. C³ provides near diamond performance at a fraction of the cost. This would be beneficial on start ups where casualties are sure to happen.”

C³, then a start-up “treatment” company, was looking for manufacturers willing to test their newly patented Metal Infusion Surface Treatment (MIST) on TC inserts. C³ had received these laser-sharpened inserts from Walter after the 2000 IMTS in Chicago, “treated” them, and returned them to Walter in January 2001.

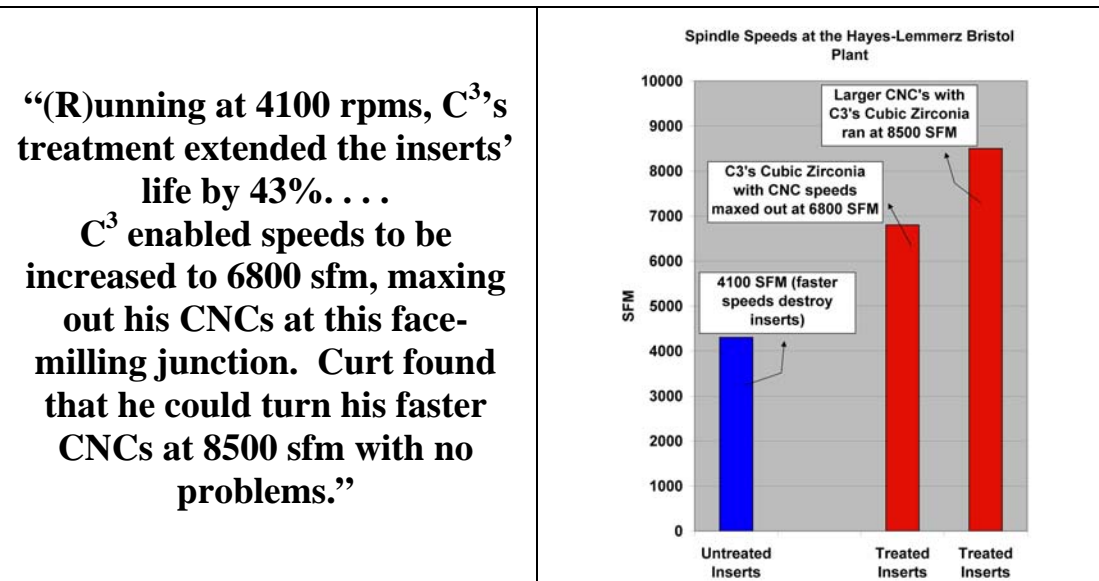


Although the standard PVD treatments marginally increased the life of the TC inserts, C³'s Metal Infusion Surface Treatment (MIST) outperformed them all by a significant margin. In fact, running at 4100rpm, C³'s surface treatment extended the inserts' life by 43%.

Since March 2002, Curt has worked closely with C³ to ensure consistency in life extension, at higher spindle speeds. C³ enabled speeds to be increased to

6800 sfm, maxing out his CNCs at this face-milling junction. Curt found that he could turn his faster CNCs at 8500 sfm with no problems. Increased rpm's combined with fewer change-outs for inserts has increased his throughput by up to 17%, 16,000 pieces per year, with the help of C³'s cubic zirconia.

“The process consisted of a combination of face milling, plunge milling, and circular interpolation utilizing one face mill on many features through out the part. I had been running 2,100 pieces before changing out inserts,” says Curt. “Now I can run 3,150 pieces on the same inserts....or, I can increase speed and feed and cut cycle time. If I can produce an additional 250 pieces per week and maintain approximately the same load cost we have accomplished something.” This increase of output helped solved Curt's bottleneck problem in face milling his crossmembers. The bar graphs below show his results with C³'s MIST-treated inserts.



Curt now is using C³'s MIST technology to treat Iscar inserts, with additional life-extension results. “We will extend MIST to other inserts used in other milling operations throughout the plant over the next several years,” says this engineer with a vision.

Broad-Based Technology

The year after its formation in 1999, C³ built its application lab. Since then, it has been using its technology to apply various rare earth metals, like zirconium, cerium, titanium, iridium, palladium, cobalt, chromium, and more than two dozen other elements in different combinations, to steels, carbides and ceramics, in order to achieve different results. For instance, it

successfully tested, and has patented, one of its formulations on ceramic insulators in spark plugs, to prevent carbon fouling in cold temperature regimes. C³ now is testing a related formulation on catalytic converters used in diesel engines to reduce carbon particulate emissions. Other applications are being tested by C³ in coordination with the Institute of Paper Science and Technology, and a Fortune 500 paper company, in an attempt to diminish corrosion on ceramics used in pulp mill operations.

Importantly, C³ discovered that a formulation similar to the zirconia treatment used on cutting tools has additional application on aluminum die-casting. Testing revealed that MIST, when applied to steel can prevent “liquid metal attack,” or aluminum soldering. Notably, C³’s MIST technology has given 800%+ life extension to the H-13 steel sheaths used to protect thermocouples when dipped into hot, liquid aluminum. It has extended aluminum die cast core pin use, prior to the pins needing to be repaired because of aluminum “soldering”, by 3000%. C³’s patented Infusion Surface Treatment is now undergoing field tests on aluminum die cast molds, as well as core pins, ladles, and other die casting accessories that are susceptible to liquid metal attack.



Pouring liquid Aluminum into die cast at Hayes Lemmerz Bristol plant

These tests, as well as the “dunker” tests performed at Case Western Reserve University (CWRU), demonstrate that this newest application of C³'s technology is commercially viable. In fact, Hayes Lemmerz Bristol joined C³ International, Oak Ridge National Laboratories (ORNL), Case Western Reserve University (CWRU), The North American Die Casters Association (NADCA), and a half-dozen other North American manufacturers on a \$3 million U.S. Department of Energy (DOE) grant project designed to extend C³'s process to aluminum die casting and other applications over the next three years.

Why Does C³ Zirconia Work in So Many Different Applications?

A heat treatment facility owned by John Abrahamse, Surface Metallurgical, Inc. (Stoney Creek, Canada), has been testing C³ treatments on punches, dies, and stamps since 2002 with encouraging results. His clients found that C³'s MIST technology greatly diminishes their need for lubricants. Specifically, TRW has found that MIST brings “added lubricity to the die components.” So much so that some clients are able to convert from oil-based lubricants to water-based liquids, enabling them to use a more environmentally “friendly” lubricant in smaller volumes. Mark Deininger, president of C³ International, and John Abrahamse were invited to speak to the PMA (Precision Metal-forming Association) conference in Rosemont, Illinois on March 24, 2003 to explain these phenomena. Deininger told the conference that:

“Aluminum, and to some extent steels and carbides, especially when exposed to aluminum at high temperatures, have a tendency to chemically bond with each other. This causes cutting tools to weld with the aluminum parts they are milling, appearing to wear a TC insert down; similarly hot liquid aluminum tends to weld to the steel sides of aluminum die cast molds, something that C³ appears able to prevent as well. In metal stamping, lubricants are needed to prevent micro-welds from occurring—when a steel stamp strikes, compression temperatures spike causing tiny micro-welds to occur between colliding steel parts. Welding or ‘scoring’ also occurs on punches because when punches are drawn back up through the hole, friction causes high temperatures which micro-weld the surface of the steel to the punch.

This thermodynamic property, the propensity of metals to chemically bond with other metals at high temperatures, is a common problem in metal stamping, cutting, and die-casting. This problem is sometimes

called welding, or soldering, but often disguises itself as a wear or lubricity problem.

Zirconia acts as barrier, blocking the metals from attaching to the other metals they come into contact with at high temperatures. C³'s cubic zirconia tends to block the welding at high temperatures because cubic zirconia is very stable thermodynamically—it does not have a great propensity to bond to metals even at temperatures somewhat higher than 1500 degrees C (2748 degrees F).”

C³'s patent is based on C³'s ability to get the cubic zirconia to form at the surface accompanied by an infusion of Zr metal into the treated metal carbide at low temperatures. Notably, once the zirconia treatment is performed, the zirconia stays in place *even though the treated parts are used in much hotter industrial applications—up to 1000°C and even as high as 1500°C (2748°F)*.

C³ has conducted characterization studies at Oak Ridge National Laboratory's (ORNL's) High Temperature Materials Laboratories (HTML) since March 2002. Some of the results of those studies are disclosed in this magazine under studies done by Dr. Harry Meyer and Dr. Tom Watkins—see boxes below.

C³'s Infusion Surface Treatments can be distinguished from PVD, CVD and other coatings in two key respects. First, MIST is not a merely a coating, but is both a surface treatment and an infusion process whereby the zirconia actually penetrates the substrate of the treated steel or carbide several hundred angstroms deep. Second, this penetration serves as an “anchor,” securing the extremely thin zirconia film to the surface of the treated material. The thinness of the material, typically two-tenths of one micron in thickness, means that there are no real changes in the treated part's dimensions.

Another distinguishing MIST feature is that zirconia attaches directly to the material treated, without the need for intermediate “bond” layers. No contact-bonding agent is needed. Furthermore, scientists find it somewhat remarkable that a very stable and finely grained (3nm) cubic zirconia has formed at low treatment temperatures and continues to maintain the cubic zirconia structure even at room temperature. This low temperature treatment allows C³ to treat parts without deforming them or exposing them to high temperature structural changes that can impair their underlying material strength.

Finally, the C^3 treatment is applied merely by dipping the part into the patented solution and then placing it into a furnace or other heating apparatus. Presently, C^3 heats the treated part using infrared apparatus a standard industrial-grade furnace, or custom-built induction heating coils. In all cases, application is reliable, uniform, and nontoxic. In addition, there are no “line-of-sight” problems— C^3 solutions can get into every “nook and cranny” of the part being treated, in part because of the capillary action that occurs when the C^3 liquid touches the material’s surface.

As a Research Associate for the Department of Metallurgical and Materials Engineering at the Colorado School of Mines, this author has had the privilege of introducing C^3 ’s technology to Oak Ridge National Laboratories, as well as the opportunity to study C^3 ’s technology for the past three years. In my professional assessment, **I have never seen a simpler, more cost effective process that is as user friendly as the C^3 surface treatment. In my 30-plus years of working on surface treatments, I have never seen a technology with C^3 ’s wide range of imparted properties, and scope of potential applications that reach into so many industries.**

To date, *only* C^3 offers a commercially viable way to cause a finely grained cubic zirconia structure to reliably impregnate the substrate of various carbide and steel tools. Many of those tools are now being commercially used with success in various industrial settings.



Curt Pietrzak, left, and Mark Deininger, right, at Hayes Lemmerz Bristol plant

Specific Cutting Tool Applications for C³'s MIST

Beginning at IMTS 2000 in Chicago, C³ solicited potential clients, asking them to try out its new treatment on cutting tools. As the following table shows, the strongest results were in face milling 356 cast aluminum auto parts, with performance topping out with 1000% life extension of TC inserts. As discussed by Curt Pietrzak of Hayes Lemmerz, the biggest advantage (not shown below) is increased feed and speed, resulting in a doubling or tripling of his CNC output in some instances. Using MIST on steel and carbide tools when used to cut various types of plastics and synthetics (such as fiberglass and carpet material) predictably achieves life extension of between 100% and 300%. Results vary with respect to treating tools used to cut steels, but more often than not are about the same as commercial grade PVD treatments, such as TiAlN and TiN.

Increased Tool Life	Tool Composition	Materials Cut	Number of Tests
Inserts 35+/- %	Solid TC	Steels (all kinds)	80
PVD Inserts 25 +/- %	C ³ On TC treated by TiN	HS Steel	1
¼" Flute 200+%	TC	Plastic (polypropylene)	2
Saw blades	TC tipped	Plastic (polystyrene)	4
½" Stagger Bits 100+%	TC Tipped	Fiberglass (RV panels)	41
Tufting blades 135%	Steel	Synthetics (carpet)	100+
Inserts 100-1000%	TC	Aluminum (cast 356 Al)	500+
Various blades 10-25%	Steel	Hard Woods, Particle Board	5
Various blades 0-5%	Steel	Soft Wood, Pine, Plywood	3

Although C³ intends to continue treating inserts used to cut aluminum, it is considering licensing its technology to cutting tool manufacturers that want to use MIST on tools used to cut steels or plastics. Significantly, a 25+% life-extension when MIST is applied over TiN or TiAlN, which may

ordinarily get a 40% life extension, could yield an aggregate gain of 75% over untreated tools. Manufacturers who would like C³ to treat their inserts with one of its MIST formulations can contact Dwaine Stark at C³'s Corporate Office by phone at 678 624-0230, by fax at 678-624-0503, by e-mail at dwaine.stark@cccintl.com.

Clients, such as tool manufacturers, who would like to explore the possibility of treatment their tools with MIST technology at their plant site as a substitute for PVD or CVD treatments, can contact Mann Shoffner, VP of Licensing, at Corporate Office. Parenthetically, the cost of installing a C³ treatment process at a manufacturer's plant is a fraction of the cost of installing equipment capable of doing PVD or CVD treatments.

For more information, visit C³'s Web site at: www.cccintl.com. Mail inquiries to C³ International, LLC, 1370-F Union Hill Industrial Court, Alpharetta, GA 30004.



Mann Shoffner examining stamps and dies with John Eisenbarth, project engineer at the World Kitchen, Inc. plant in Massillon, Ohio

About the Author: Dr. Stiglich is an experienced and recognized expert on ceramic composite fabrication, CVD fluidized-bed powder treatment and materials for ordnance applications. He has worked for over thirty-five years in the ceramics and composite materials industries and has extensive experience in the development of CVD treatments and ceramic materials and fabrication processes to solve problems such as wear, corrosion and high temperature oxidation. Since establishing his Consultancy in 1985, Dr. Stiglich's clients have included commercial companies, governmental agencies and institutional clients with whom he has worked on a broad spectrum of projects. Publications include:

- Stiglich, J. J. and Tracy, M.J., et al: "*Consolidation Methods for Nanocrystalline Tungsten and Tungsten Treated Powders.*" Sintering Seminar. Pennsylvania State University.
- Stiglich, J. I., Raghunathan and T.S. Sudarshan: "*Jr-Re Duplex Treatments on Ta/LOW by Pulsed Electrode Surfacing.*" Symposium on High-Temperature Treatments, Rosemont, Illinois
- Stiglich, J. J. and Williams, B.E., et al: "*A Major Advance in Powder Metallurgy.*" Presented at the 2nd National Technology Transfer Conference: Technology 1999. San Jose, California.
- Stiglich, J. J., et al: "*CVD Treated Tungsten Powder Composites, Part II: Powder Fabrication & Properties.*" Proceedings of TMS Refractory Metals Symposium on Tungsten and Tungsten Alloys. Recent Advances, TMS Meeting, New Orleans, Louisiana.
- Stiglich, J. J. and R. Tuffias: "*High Temperature Aerospace Treatments.*" Proceedings of the 4th International Conference on Surface Modification Technologies, Paris, France.
- Stiglich, J. J., et al: Part I of two part review of cemented tungsten carbides. "*WC-Co Enjoys Proud History and Bright Future.*" *Journal for the Powder Metallurgy Industry*, "Metal Powder Report."
- Stiglich, J. J., et al: Part II of two part review of cemented tungsten carbides. "*Nanosized WC-Co Holds Promise for the Future.*" *Journal for the Powder Metallurgy Industry*, "Metal Powder Report."