



Greenleaf[®]
Excellerating Solutions[™]

It's About Productivity—
Your Productivity!

Increasing Your Productivity
with Ceramic Tooling

Breakthrough Carbide Grades
Will Boost Productivity

Custom Tooling Saves
Time and Money

Beyond Cutting Tools

Meeting Your Needs

Powermill™ sinusoidal inserts deliver serious milling productivity with less horsepower consumption.

It's About Your Productivity— Productivity— Productivity!

At Greenleaf Corporation, we want to offer a dramatic improvement in performance each time we bring a new product to market. When we offer you a new cutting tool technology or technical ceramic, you can expect that product to have a substantial impact on your production capability.

Productivity is a key word for all of us these days. In the following pages, we will explain how our ceramic tooling, new carbide tooling, and specially designed tools can help you become more productive. And we will also discuss the use of our proprietary ceramics technology in industrial applications other than cutting tools.

We understand your need for high performance because we compete in a market that demands innovation and superior products. At Greenleaf, we don't view today's environment of unrelenting hypercompetition as something to fear. Instead, competition inspires us to develop new skills and products, and deliver them to the market. Determination, customer service, and technical innovation are requirements for any company that intends to succeed in the cutting tool field. These characteristics have been a part of our company's DNA since we opened for business 60 years ago.

Determination, customer service, and technical innovation are part of our company's DNA.

We want to partner with you in a relationship that can help your company succeed. Our toolbox includes process design assistance, advanced carbide tools, and our unequaled expertise in ceramic cutting tools and ceramic components.



When you work with us, you'll find that we are much more than a supplier of specialized tooling. Greenleaf can become a source for solutions to your manufacturing problems that will enhance the productivity, and hence the profitability, of your shop floor.

Increasing Your Productivity with Ceramic Tooling

Today's ceramic inserts offer spectacular increases in performance and productivity when compared to first-generation ceramic and carbide inserts. The improvements they will make in your machining capabilities are equally dramatic. Whether you're using an old roll lathe or a state-of-the-art high-speed milling center, the latest generation of ceramic inserts can significantly reduce your cutting time, thereby reducing your costs and making your shop more productive.



A Greenleaf whisker-reinforced, ceramic insert turning hardened steel.

Ceramics are no longer limited to continuous-turning operations, and are being applied to many

applications once thought to be solely the domain of carbide. Modern ceramic inserts are tougher, more wear-resistant and more shock-resistant than the ceramics of years past. Ceramics like WG-300® continue to prove themselves outstanding cutting tools when used to mill or turn a variety of materials, from tool steels to cast iron.



Hard Milling 55 Rc steel with Greenleaf's WG-300® whisker-reinforced ceramic inserts.

But *why* are ceramic inserts so successful? And can they make a difference in your shop?

It depends upon the application. For instance, ceramic inserts are generally more successful at machining hard materials than carbide inserts due to their capability to resist extreme temperatures.

The faster you can turn or mill metal at a given depth of cut, the greater your metal removal rate. However, the faster your cutting speeds, the more heat is created. Heat can weaken a carbide insert and eventually cause it to fail, so you must limit the cutting speed to keep the heat within the operating range of carbide.

Ceramics, on the other hand, are not affected nearly as much by heat. In fact, ceramic inserts

use the heat generated ahead of the tool to plasticize the metal, making it much easier to remove. So for ceramic inserts to perform at their best, you need to increase the cutting speeds. In some operations, the order of magnitude is 10X faster.

Whisker-reinforced ceramic inserts are a great choice for cutting heat-resistant alloys.

It wasn't long ago that many machines couldn't achieve the high speeds necessary for successful ceramic machining. Now, however, manufacturers are producing low-horsepower machines that deliver spindle rpms and linear-axis movement rates that are extremely high when compared to those of machines available as recently as five years ago. Ceramic technology is being used in applications that exploit the high-speed potential of these machines.

"But even older machines are able to take advantage of today's ceramic inserts," says sales and service engineer Dick Chobot. "Thanks to the improvements we've made to our ceramic grades and our use of high-tech coatings, we now have much greater flexibility with the application of our ceramic inserts."

For example, there are shops whose market doesn't warrant the expensive investment required to obtain new CNCs. They continue using the equipment they have on hand because it works fine for their needs. But these shops can still make great advancements in productivity in certain applications by switching to ceramic inserts. The latest generation of ceramic inserts from Greenleaf

works very well on older equipment. Although you may not see as great a productivity increase as you would using a new high-speed machine, you will still benefit from greater productivity with ceramic inserts.

How much of a productivity increase can ceramic inserts provide in your shop? It really depends upon the application. "The first thing we do to answer that question is to take a good look at what is being manufactured," says North American Sales Manager David Rydbom. "The type and capability of the machines being used, workholding fixtures, chip containment, coolant flow and programming all are important factors when reaping the benefits of a high-performance ceramic tool from Greenleaf."



This high-performance, small-diameter milling system allows hard milling with ceramic inserts down to 3/8-inch diameter.

Here are just a few examples of the dramatic metal removal improvements you can expect from Greenleaf tools:

- Greenleaf silicon nitride ceramics such as G.S.N.™ and HSN are widely used on gray cast iron as well as nodular, ductile and malleable cast irons. For instance, in a gray iron milling

Ceramic Solutions to Machining Problems

New ceramic inserts with impressive properties have been developed by Greenleaf researchers. Here's a list and brief descriptions of their capabilities.

WG-300®

A patented, whisker-reinforced ceramic with excellent wear and shock resistance at high surface speeds, WG-300® is very effective when machining nickel and cobalt-based superalloys and other hard materials. It provides metal removal rates as much as 10 times higher than carbide.

WG-600™

This is the only commercially available second-generation, coated ceramic-composite cutting tool using whisker reinforcement. It excels at finishing high-strength alloy materials.

WG-900™

Our newest whisker-reinforced ceramic grade will be available in 2005.

HSN-100

This engineered silicon-nitride cutting tool from Greenleaf has superior toughness and high cutting-speed capability. It's well-suited for turning and milling all classes of cast iron. HSN-100 is a good choice for ductile, malleable, nodular, and other difficult-to-machine irons.

HSN-200

Our newest coated silicon-nitride-based cutting tool offers toughness, long tool life, and excellent surface finish at high cutting speeds. It's a good choice when turning and milling ductile, malleable, nodular, and other high-alloy cast irons.



G.S.N.™

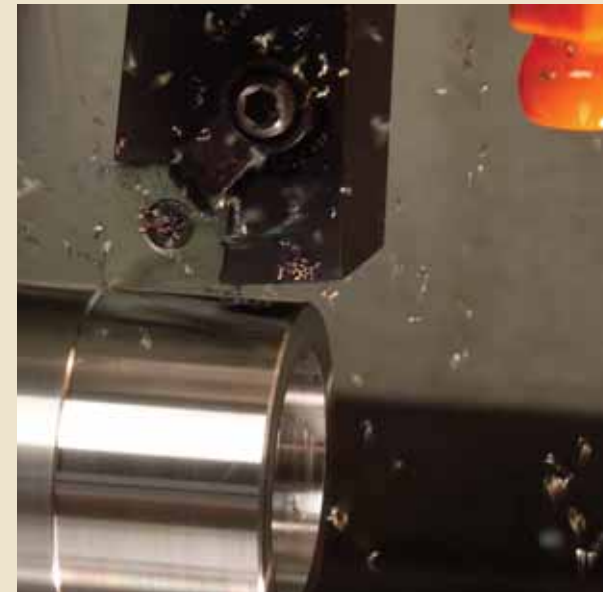
Made from hot-pressed, silicon nitride ceramic blended with toughening agents, G.S.N.™ offers superior wear characteristics in high-speed, cast-iron machining.

application, Greenleaf's GSN™ enabled the operator to double the feed rate of carbide and increased the cutting speed by a factor of 10, leaving a better surface finish than the carbide insert. That's a 1000% increase in productivity.

- In the steel-roll industry (steel rolls are used to flatten steel ingots, sheets, or bars), operators

turn 15 to 20-ton rolls that are roughly four feet in diameter and 15 feet long. When these rolls are removed from the production line for resurfacing, they present some tough metal removal challenges because of their work-hardened, cracked, and spalled surface. Furthermore, hardnesses are in the 60 Rc range, usually

requiring an expensive and time-consuming rough-grinding operation. Greenleaf's GEM 7 Ceramic has been used to machine these rolls for years. In fact, ceramic tooling is the most efficient means of resurfacing them because ceramic tooling eliminates the need for the rough-grinding operation and does the job four times faster. Carbide tooling cannot do the job as productively or cost effectively.



Turning hard materials with ceramics is a productive and cost-effective alternative to grinding.

- Whisker-reinforced ceramic inserts such as WG-300®, WG-600™, and WG-900™ are a great choice for cutting nickel and cobalt-based heat-resistant alloys like Inconel®, Hastelloy®, and Stellite. As an example of what the proper application of ceramic inserts on these materials can do, Greenleaf recently replaced a series of carbide groovers used in an abrasive Inconel application with a custom-engineered toolholder using a single whisker-reinforced ceramic insert. The use of the ceramic insert reduced the total cycle time

on this operation from 40 minutes with the carbide inserts to less than 30 seconds using a single ceramic insert. That's an 8000% increase in productivity! With productivity gains such as this, you can see why ceramic tools are becoming more and more popular in an ever-more-competitive marketplace.

Greenleaf is continuing to research and develop new, more productive grades of ceramic inserts. Furthermore, Greenleaf has been a pioneer in the use of coatings for ceramics. Our patented ceramic products WG-600™ and WG-900™ are the only commercially available second-generation, whisker-reinforced, coated-ceramic inserts. Chobot remarks that insert life is extended with coatings. "In the right applications, we're seeing a typical gain in tool life averaging two to three times over uncoated ceramic. It's dramatic when you start thinking about tripling tool life at the surface speeds that we're running."

Breakthrough Carbide Grades Will Boost Productivity

Our carbide-coating technology is expanding the range of our carbide grades. Greenleaf's advanced CVD (chemical vapor deposition) and PVD (physical vapor deposition) coatings are being applied to select carbide substrates, permitting those coated carbides to behave more like ceramic inserts, enabling higher cutting speeds and feeds.

Let's say ceramic tooling is not an option for you because your material is too soft or your machines cannot achieve the speeds and feeds required by ceramic tooling. This does not mean you have to endure extended machining times. Our new coated carbide grades offer a 20-30% increase in productivity at the spindle when compared to grades now being used.

High-performance Carbides Enhance Productivity

Greenleaf's commitment to resolving production challenges is demonstrated by its new coated carbide grades.

GA-5022

Designed for turning and milling cast iron at high speeds and moderate feed rates, this general-purpose CVD-coated grade can handle medium roughing to finishing operations. GA-5022 offers high wear-resistance characteristics and medium resistance to mechanical shock.

GA-5023

A high-speed grade for turning and milling cast iron, GA-5023 has an advanced MTCVD coating developed for abrasive-wear resistance. Applications range from roughing to finishing on most cast-iron materials, including gray iron, ductile, nodular, and other alloyed irons. The high wear-and-shock resistance of GA-5023 permits machining at high speeds and various feeds.

GA-5025

This high-speed, CVD-coated grade is intended for turning, light roughing, and finishing of carbon and alloy steels, as well as selected stainless steels.

GA-5026

Developed for turning nickel and cobalt-based superalloys, stainless steels and refractory metals, this high-speed grade has an MTCVD coating over a micrograin substrate to provide high wear resistance. GA-5026 provides exceptional resistance to the notching and deformation common when machining high-strength materials. GA-5026 should be used at high speeds and light feeds for turning and selected milling applications.

GA-5035

Developed for turning all types of steels and selected stainless steels, this high-performance CVD-coated grade can be used in rough, semifinish, and finish-turning situations that require resistance to heat deformation, thermal shock, and abrasion. GA-5035 should be applied at high speeds and can handle a range of feeds.



GA-5036

Providing high performance when milling steels at high speed, this CVD-coated grade should be used when milling forged and cast steels, and selected ductile irons. It has a combination of toughness and heat resistance that makes it suitable for heavy- and light-duty milling at high cutting speeds.

GA-5040

This CVD-coated grade for low-speed, high-feed milling of carbon and alloy steels and cast irons also can be used for milling and interrupted turning of stainless steel and selected high-temperature alloys. A multilayered CVD-coated grade, GA-5040 excels in severe machining applications that require resistance to mechanical shock.

These grades demonstrate the commitment Greenleaf has made to producing high-performance carbide cutting tools. For example, GA-

5026 is a high-speed grade for turning and milling difficult-to-machine materials like heat-resistant superalloys, refractory metals, and

stainless steels. It has shown the ability to extend its application range in all areas of machining, from roughing feeds and speeds to a final finish pass on aircraft engine parts where the wall thickness can be as thin as 0.045 inch. Only a well-developed carbide grade and engineered chip form will allow the machining of a thin-wall part without part deflection. In conjunction with the proper insert geometry, GA-5026 produces an excellent surface finish and can hold tight tolerances.

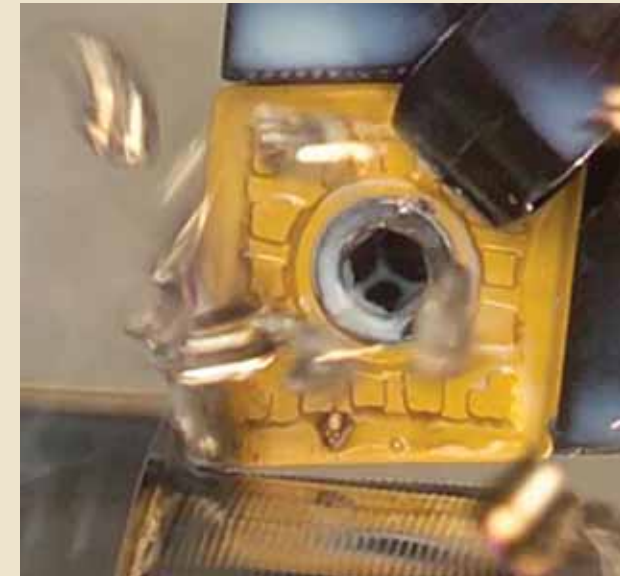
Our new coated carbide grades offer a 20–30% increase in productivity at the spindle.

- Greenleaf successfully applied GA-5026 to a turning application on a turbine engine case, increasing the SFM by 74% and tool life by 100% beyond what a competitive grade of carbide was able to accomplish.
- We developed our latest milling grade, GA-5036, as a premium milling grade for milling all forged and cast steels, as well as selected ductile irons. Case in point: GA-5036 is used in a 300-HP milling application with a depth of cut (DOC) of 0.750 inch at 380 SFM, and up to 0.020 inch feed per tooth in P-20 tool steel, at 35 Rc in scale condition. The same grade is used to mill tough manganese-enriched steel at more than 500 SFM at high feed rates, and is also employed in light-duty machining centers where various steels are milled at high speed with smaller cutters. The versatility of GA-5036 also makes it suitable for turn-

ing operations when you're dealing with heavy feed rates or interrupted cutting.

- Greenleaf successfully applied GA-5036 to a heavy duty milling operation using a 10-inch cutter on a forged steel application. The use of GA-5036 increased the speed, feed, and DOC to achieve a 73% increase in cubic inches of metal removed per minute.

GA-5026 and GA-5036 are only two of the new high-performance coated carbide grades Greenleaf has developed over the last 24 months to address the need for higher production rates in all materials and applications.



Rough turning steel with GA-5035.

“To be a well-rounded cutting-tool company, we need to offer our customers the best carbide-product technology that can be developed,” says Jim Greenleaf, president of Greenleaf Corporation. Our carbide tooling is very successful and respected. We offer a complete line of PVD-coated, CVD-coated, and uncoated carbide for just about every application in turning and milling.”



Greenleaf's Hushcut® II milling system is designed to reduce HP consumption and noise while boosting productivity.

Carbide cutting tools from Greenleaf can solve many production problems. If carbide offers the best means of dealing with your machining tasks, Greenleaf can provide high-performance carbide cutting tools to meet your needs.

Custom Tooling Saves Time and Money

Our expertise isn't limited to providing standard inserts and tools for our customers. Many manufacturing jobs place unique demands upon tools, and our engineered tooling teams can develop productive solutions to the problems you face.

Greenleaf designed a custom-engineered tool for a bearing liner that reduced machining time from three hours to seventeen seconds.

"Increasing productivity is our specialty," says David Rydbom, Greenleaf Corporation's North American Sales Manager. "Given our 60 years of

experience and our production of thousands of engineered tools, we have the experience to quickly tell if an operation could benefit from a custom tool."

Sometimes specially engineered tooling can perform multiple operations at once, saving perhaps five seconds per part. This kind of time savings doesn't sound like much, but when you start doing the calculations on five seconds saved per part over 100,000 parts each month, that special

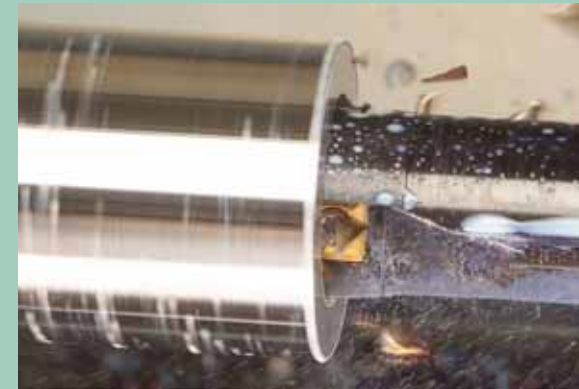
tool suddenly becomes very valuable. "On any given day, the Greenleaf engineered-tool design staff is working on special tools to improve applications," says Rydbom. "We're constantly doing research to improve a customer's process, or working on new inquiries we've received."

Here are a few examples of work recently done by our engineered tooling group:

- "Greenleaf designed a custom-engineered tool for a bearing liner that reduced machining time from three hours to seventeen seconds, while eliminating a grinding operation," says Dick Chobot. "This success allowed the completion of an APU gearbox in eight hours, a time savings of 152 hours over the entire project."
- As an example of our work on custom tooling, Greenleaf engineers designed and built some special boring bars used to machine actuator pumps. The application required spot face, chamfer, counter-bore, and circular interpolation operations. Previously, four different tools were being used in this application. Using a Greenleaf custom-engineered tool, the customer machines these features with just one boring bar. This tool has saved a considerable amount of time previously

A Short History of Greenleaf

Walter Greenleaf, Sr., was an independent cutting tool representative who sold tungsten carbide and designed special tooling throughout the 1930s and 40s. At the end of World War II, he



The innovative geometry of the HoleMill offers reduced cutting forces.

decided to go into business for himself, and in 1945 he founded Greenleaf Corporation. Developing new ideas and products was Walter's goal. An innovator and entrepreneur, he produced a motor-oil additive containing graphite, as well as graphite-based cutting fluids.

- consumed by machining the part, tool service, setup, and maintenance. Also, it reduces the number of tools the company must inventory and track.
- In another successful application of special tooling, Greenleaf recently helped a customer extend the capabilities of six new machines it purchased. The company bought the machines without taking into consideration the extended reach necessary for an OD (outside diameter) groove operation. "They turned to us because they knew about our capabilities with

When the 1960s rolled around, Greenleaf had already pioneered a new tooling concept, toolholders with mechanical clamps, leaving brazed tooling in the dust. Greenleaf's customers were now able to continue using the same toolholder, and only replace the inserts. In fact, Walter Greenleaf is unofficially credited with being the inventor of indexable-insert tooling.

Greenleaf was the first cutting-tool manufacturer to offer coated carbide inserts to US industry, and the company started producing ceramic cutting tools in the early 1970s. Greenleaf then formed a company, GSL, to make technical ceramics for general industrial usage, as well as for the electronics and cutting-tool industries that already employed the company's products.

In 1985, Greenleaf introduced the world's first reinforced ceramic composite, WG-300®, and in 1986 WG-300® received the IR100 Award from R & D magazine as one of the 100 most significant technical innovations of that year.

Today, Greenleaf continues its legacy of cutting-tool innovation by introducing the only commercially available, second-generation, whisker-reinforced ceramics, WG-600™ and WG-900™, along with coated ceramics and new advanced carbide grades.

engineered tooling. We built special tooling adapters to 0.0005-inch tolerances to fit on the machine, and they were able to overcome their miscalculation," adds Rydbom.

Communication with our customers is imperative. The more ideas we discuss the more help we can give to one another. We have the latest solid modeling and CAD/CAM software packages, which allow us to completely design custom tools without actually machining them. These files can be exchanged with the customer through fax or email for their input and approval before production begins.



We will also work with sketches or drawings on the backs of business cards—because this is often where engineered-tooling ideas originate. When we develop a special tool, our customers feel pride in its performance, because they are an integral part of the tool development process. We're always working with customers to continuously improve their operations, not only to come up with newly engineered tools, but to improve their existing processes.

Beyond Cutting Tools

Developing ceramic inserts capable of handling the extreme environment faced by metal-cutting tools has given Greenleaf engineers a deep understanding of the characteristics and special strengths of ceramics.

Ceramic materials possess attributes such as extreme hardness, wear resistance, biological compatibility, heat and corrosion resistance, and a wide range of impressive electrical and dielectric properties. Taking advantage of these attributes by using custom-engineered technical ceramic components can solve unique design problems. Whether it's a pump, seal, medical implant, or a

device that must withstand intense heat and corrosion, Greenleaf brings its extensive knowledge of ceramics to bear on the challenges customers face when choosing a material for a product design.

Here are a few examples:

- Greenleaf technical ceramics can replace traditional materials, such as carbide, in wear applications like metalforming draw dies, dramatically extending die life.
- Ceramics can provide a mirror-like surface finish. If you make a product such as a seal that requires a perfect, hard-surface finish, ceramics can provide an exceptionally good design solution.

- Ceramics also provide an excellent thermal barrier. For instance, ceramics are a very good choice for lining materials in heat vessels or kilns.

Custom-engineered Technical Ceramic components can solve unique design problems.

- The use of ceramic inserts in valves gives them longer life and better resistance to corrosion or heat.



GA-5036 High-Performance Carbide Inserts

GA-5036 is a high-performance grade for milling of all classes of forged and cast steel as well as selected ductile irons.

Developed to handle light- to heavy-duty milling at high cutting speeds, GA-5036 delivers excellent resistance to mechanical and thermal shock. GA-5036 is also a good choice for turning operations where heavy feed rates or interrupted cutting is encountered.

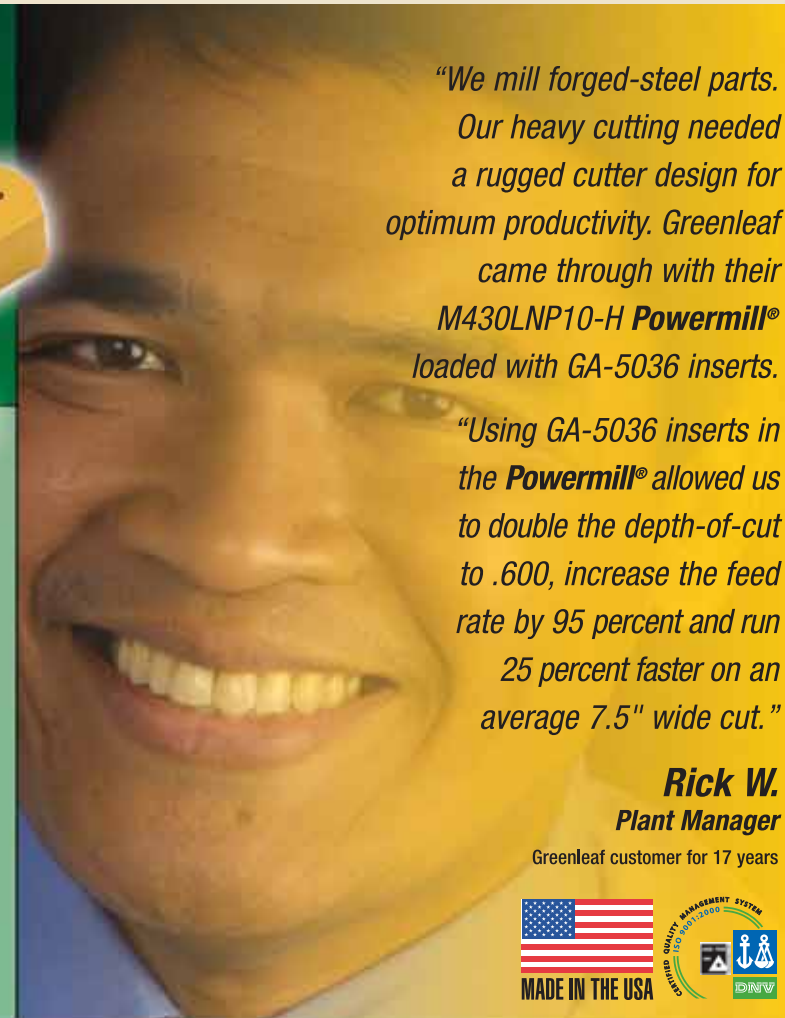
Using the latest CVD coating technology, GA-5036 provides excellent edge strength, resistance to high temperature cratering, deformation and edge build-up.



Contact your Greenleaf representative or call our customer service office for more information.



Greenleaf Sales • 1-800-458-1850
Phone: 814.763.2915 • Fax: 814.763.4423
sales@greenleafcorporation.com
www.greenleafcorporation.com



"We mill forged-steel parts. Our heavy cutting needed a rugged cutter design for optimum productivity. Greenleaf came through with their M430LNP10-H Powermill® loaded with GA-5036 inserts.

"Using GA-5036 inserts in the Powermill® allowed us to double the depth-of-cut to .600, increase the feed rate by 95 percent and run 25 percent faster on an average 7.5" wide cut."

Rick W.
Plant Manager

Greenleaf customer for 17 years





A sample of Greenleaf Technical Ceramics.

- For the aerospace and defense industries, Greenleaf manufactures a ceramic button that's inserted into a traveling-wave tube guide. These buttons are made from several kinds of ceramic materials. Precisely engineered to absorb microwaves, the buttons tune microwaves for radar systems.

Whatever the application, Greenleaf has the engineering and custom design experience to develop a ceramic component that solves the unique product design challenges our customers face.

Meeting Your Needs

It's our business to help your business succeed. Whether you require cutting tools, advice on a difficult application, or specialized knowledge in technical ceramics, Greenleaf Corporation wants to be your partner.

We've provided industry with high-quality cutting tools for 60 years, and over the past three decades we have won an enviable reputation as ceramic cutting-tool specialists. Our engineered tools have been the keys to success for many customers, and our expertise in technical ceramics is unsurpassed. In the very competitive environment we now face, manufacturers and manufacturing engineers must be open to innovation and new ways of solving problems.

It's our business to help your business succeed.

We're not selling commodity products, and we don't treat our customers as commodities. We're here to serve you, and we look forward to the opportunity, and the challenge, of meeting your needs. ●



James M. Greenleaf
President
Greenleaf Corp.
jgreenleaf@greenleafcorporation.com

We Want to Earn Your Business

At Greenleaf, we know that our prosperity depends upon giving our customers superior service and a superior product. We use our expertise in advanced materials technology to develop products of superior quality and performance, and we work with our customers to help them use those products in the most efficient manner. It's our technology, and our willingness to work closely with our customers, that makes us a world leader in cutting-tool technologies.

The truth is quite simple, and quite important. We have the best thing to offer to our customers—productivity. When Greenleaf helps our customers become more productive and prosperous, they will continue to use Greenleaf products.

In today's manufacturing economy, productivity separates winners from losers. Our goal is always to help our customers become more productive by solving their tooling problems. We do this in several ways: by developing a better tool design, by producing superior tool materials, or just by offering some good shop-floor advice. We're usually the company

that solves the toughest application problems. We've built a reputation on being able to find solutions to tooling challenges. While other cutting tool companies are selling commodities, we're selling technical ability, service, and excellent products.

To produce our high-quality products, we use advanced production equipment. Greenleaf operates a highly automated manufacturing facility, and many of our machines run lights-out, without intervention, over the weekends and on holidays. We have state-of-the-art engineering design experience, and steel manufacturing capability for toolholders and milling cutters, along with insert-manufacturing capabilities that use the latest technologies.

Greenleaf is a world leader, but we know how small companies struggle. Small businesses mean a lot to us, and we give them our personal attention. When customers visit us, we're glad to show them through the plant, because our customers are important. They are the people we serve and we never lose sight of that fact.

If you're facing a challenging metalcutting problem, consider us a resource you can tap. At Greenleaf, solving such problems is our business. We'd like to hear from you.

We invite you to contact the following members of the Greenleaf team:

For Machining Applications:
David Rydbom
North American Sales Manager
drydbom@greenleafcorporation.com

For Technical Ceramic Applications:
Chuck Dzedcik
Technical Ceramics Division
cdzedcik@greenleafcorporation.com



We take our commitments seriously.



Here's a proposal: Increase your productivity and profits with Greenleaf. For over five decades, our use of innovative technology and responsive, personal service has saved our customers time and money. From our WG-300 **ceramic inserts** to our improved line of high-performance coated **carbide inserts**, we provide cutting tools that make our customers **more productive**. So make the commitment to your company's success. Visit www.greenleafcorporation.com or call 800-458-1850 and get there faster with Greenleaf.

