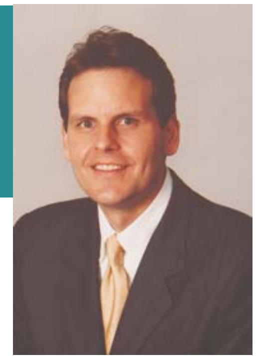
EDITORIAL COMMENT

Metals Technology: Solidifying Our Region's Wealth for a Third Century



Ronald E. Ashburn
Executive Director
Association for Iron & Steel Technology

> "By continuing to evolve metals technology, we in the profession pay homage to ... all those who toiled in the many furnaces that once lined our river banks."

Nanotechnology is nothing new for Western Pennsylvania. In fact, our region can boast about such infinitesimal technological pursuits — and the economic prosperity they attract — since the mid-1800s through our rich heritage in metals production. Each year, we continue to advance metals technology through the evolution of microscopic metallurgy and its complex combination of chemistry, temperature and force.

In this issue of *Pittsburgh Engineer,* we review with pride the historical perspective and influence of metals to the world around us. A truly versatile material that can be made into thousands of compositions and meet a spectrum of needs, metal truly is the infrastructure of our society.

Chief amongst the metals is steel — a combination of iron, carbon and numerous alloying elements. This ubiquitous material has surpassed 1 billion tons in global annual production for the first time last year. As a region, we take pride in knowing that the historical roots of steelmaking run deep in Western Pennsylvania. When Andrew Carnegie left the railroad industry in 1864 and relocated in this area to devote himself to the iron and steel industry, Pittsburgh soon became recognized as the center of the industrial world.

Though once infamously portrayed as "hell with the lid off," Pittsburgh's past must also be recognized for forging our region's reputation as the industry hub for metals technology. Lest we forget, there is a glimpse of this past contained within these pages from an excerpt of Charles Rumford Walker's "Steel — The Diary of a Furnace Worker," written in the summer of 1919.

Steelmaking has come a long way from Mr. Walker's era to the present day computer age that includes programmed control for delivering calculated amounts of hot metal, scrap, lance height and oxygen blowing rate. Computers make determinations on material weight, temperatures and other analysis that control production in every part of the mill to aid scheduling, orders and delivery.

By continuing to evolve metals technology, we in the profession pay homage to Mr. Walker and all those who toiled in the many furnaces that once lined our river banks. It is these generations of people that ultimately came to symbolize our region's resilience and fortitude to succeed.

From a technology perspective, giant leaps have been made in the steelmaking process in the past century. The replacement of the open hearths with basic oxygen furnaces starting in the 1950s boosted productivity more than any other development, cutting melt times from 10 hours to 45 minutes. Another important development was the introduction of continuous casting in the 1960s, which improved the liquid-to-solid yield from about 80 percent to more than 97 percent when compared to ingot casting. And the advent of thin-slab casting in 1989 has sped productivity from scrap to finished products to an amazing 3–4 hours. As we embark on the 21st century, we are advancing the industry toward a future of alternate iron sources, direct strip casting and synchronous operations in the mill.

Metals-related companies have always been and continue to be front-page news for the business section. At the start of the 20th century, consolidation and mergers were major issues for the steel industry, as further explored in the accompanying story about the history and evolution of United States Steel Corporation, the first billion-dollar corporation in the world when it was established in 1901. More than 100 years later, steelmakers still face the very same economic issues.

Another successful metals-oriented company calling Western Pennsylvania home is Alcoa, the world's leading producer of primary aluminum, fabricated aluminum and alumina. Also located here is Kennametal, a global leader in advanced tooling solutions for the manufacturing industry. The Kennametal story, as chronicled within this issue of *Pittsburgh Engineer,* represents how a metals company can continue to reinvent itself with the assertive development of new, improved products. This issue also features the history of Haynes International, depicting how a specialty alloy producer continues to evolve technology to remain a thriving company.

As guest editor for this Winter 2005 issue of *Pittsburgh Engineer,* I'm certain you'll find the accompanying stories informative and interesting, especially when we see history continue to repeat itself. Underscoring each of the articles is the ongoing relevance of metallurgical "nanotechnology," as we continue to defy the myth of being a mature industry with innovative research and product development. And from the global business perspective, we are currently experiencing a massive wave of corporate consolidation and the emergence of a giant industry force in the East, not unlike our domestic perspective from a century ago.

We sometimes hear that everything old is new again, and in the modern metals industry we are observing this phenomenon firsthand. With respect to technology development, market demand and employment opportunity, it truly is an exciting time to be in the metals industry. I suspect it may be the very same in another 100 years.

The American Iron and Steel Institute Historical Statistics

- **In 1880, the US produced approx. 20 million tons of steel and imported an additional 2 million tons.**
- **In 2005, the US produced approx. 105 million tons of steel and imported an additional 30 million tons.**

Man Hours per Ton as Estimated by AISI per Finished Steel Product:

1950	16.8
1960	14.2
1970	11.3
1980	10.4
1990	4.9
2004	2.2

STEEL: The Diary of a Furnace Worker

The Original 1922 Edition by Charles Rumford Walker

Homestead (PA) Works, Open Hearth Shop #5, Mar. 1949, United States Steel Corporation. Photo: Archives of Industrial Society, Wm. J. Gaughan Collection, University of Pittsburgh

Editor's note:

In the summer of 1919, a few weeks before the Great Steel Strike, Charles Rumford Walker bought some second-hand clothes and went to work on an open-hearth furnace near Pittsburgh to learn the steel business. He was a graduate of Yale and a few weeks before had resigned a commission as a first lieutenant in the regular army.

The following is an excerpt of what he saw, felt and thought as a steelworker during that time.

From Chapter V: (page 76) Working The Twenty-Four Hour Shift

We were about to tap. I went after my flat manganese shovel, but it was gone from the locker. Some dog-gone helper has nailed it. I took out an ordinary flat shovel.

In back of the furnace Nick was already busy with a "picker," prodding away the stopping from the tap. He burned his hands once, swore, gave it up, went halfway along the platform away from the tap, returned, and went at it again. Finally, the steel escaped with its usual roar of flame and its usual splunch as it fell into the ladle.

I stepped back and nearly into Shorty, who had come to help shovel manganese. "Where you get shovel?" he said, with his eyes blazing, pointing to mine.

"Out of my locker," I said.

He started toward it, and I held it away from him.

"I tell you that goddam shovel mine —" he began; but Dick, from the other side of the spout, shouted at us how many piles to shovel, and Shorty shut up. We were to get in the first big pile and the next little one.

The ladle was beginning to fill. "Heow!" yelled Dick.

Shorty and I went forward and put in the manganese. It was hot, but I took too much interest in shoveling faster than Shorty to care. Then came the second ladle, during which Shorty's handkerchief caught on fire and made him sputter a lot, and rid himself of some profanity in Anglo-Italian.

I went to that trough by Eight afterward to wash off the soot and cinder and put my head under water, straight down. I knew back-wall was coming, and sat down a minute, wondering, rather vaguely, how I was going to feel at six or seven the next morning.

"If it's not done quickly, you'll get a burn; you're an arm's length from molten steel, and no door between."

Back-wall came. I had bad luck with it, trying too hard. It was too hot for one thing. There are times when a back-wall will be so cool and you can hesitate for a long second as you fling your shovelful, and make sure of your aim; at others, your face scorches when you first swing back, and you let the stuff off any fashion to get out of the heat. There's a third-helper on Five, I'm glad to say, who is worse than I. They put him out of the line this time; he was just throwing into the bottom of the furnace.

Furnace workers crossed all ethnic and racial boundaries. Homestead (PA) Works, Open Hearth Shop #5, ca. 1954, United States Steel Corporation. Photo: Archives of Industrial Society, Wm. J. Gaughan Collection, University of Pittsburgh

Everyone develops an individual technique. Jimmy's is bending his knees and getting his shovel so low that it looks like scooping off the floor. Fred's is graceful, with a smart snap at the end.

Then front-wall. I start in search of a spoon and a hook. It's not easy to get one to suit the taste of my first-helper. There's one that looks twenty feet, — I haven't any technical figures on spoons, but it's too long, I know for Fred. There's a spoon three feet shorter, just right. Hell — with two inches melted off the end! I pick a short one in good repair, — he can use the thing or get his own, — and drag it to Seven, giving the scoop a ride on the railroad track, to ease the weight. Fred has put a hook over number one door; so I hurry, and lift the spoon handle with gloved hands to slip it on the hook. If it's not done quickly, you'll get a burn; you're an arm's length from molten steel, and no door between. I get it on, and pick up a shovel.

Front-wall can be very easy, — you can nearly enjoy it, like any of the jobs, — if the furnace is cool and there's a breeze blowing down the open spaces of the mill. And too, if the spoon hands right in the hook, and the first-helper turns it a little for you, then you can stand off, six feet from the flame, and toss your gravel straight into the spoon's scoop. You hardly go to the water fountain to cool your head when the stunt's over. On number one the hook hung wrong, the spoon wouldn't turn in it and you had to hug close, and pour, not toss. I tried a toss on my second shovel and half of it skated on the floor.

"Get it on the spoon, goddam you!" from Nick.

So I did.

After that, we sat around for twenty minutes. Fred looked at the furnace once or twice and changed the gas. Sever gathered in front of Seven — Jock, Dick, the melter, Fred and Nick.

"Do you know what my next job's going to be?" said Fred.

The others looked up.

"In a bank."

"Nine to five," said Dick. "Huh! Gentlemen's hours."

This excert was reprinted with permission from The Association for Iron & Steel Technology. The book "STEEL: The Diary of a Furnace Worker" is available for purchase through the AIST.

The Drivers Behind the Steel

By Tom Imerito,
President, Science Communications

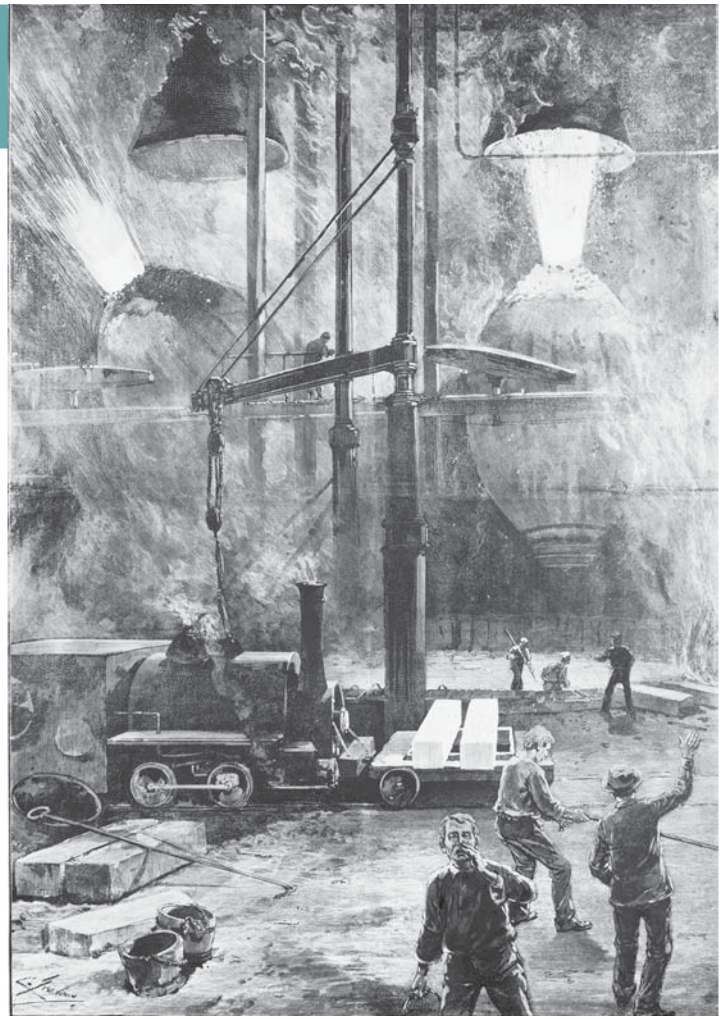
For millenniae the quest for better metals to make better lives has driven the development of cultures. Here are highlights of how steel technology has responded to socio-economic needs from the time of Andrew Carnegie to the present.

In 1848, in the midst of the Age of Manifest Destiny, a Scottish weaver named William Carnegie and his family immigrated to Pittsburgh from a village in Scotland where a disruptive technology called steam power had decimated the cottage weaving industry. It is ironic that steam power, the cause of William Carnegie's occupational misfortune would become the key to his son Andrew's fortune. Andrew Carnegie's uncanny knack for recognizing socio-economic needs and matching them with emerging technologies would become a way of doing business for the companies he founded and their successor, United States Steel, for more than a century.

In ancient times, the discovery that charcoal mixed with iron ore and burned in a pit with an air draft would yield a "puddle" of "sponge iron" opened the door to the Iron Age. Although nobody claims to know when iron first came into regular use, written evidence of the deliberate reduction of iron ore to produce metallic iron goes back two thousand years.

Early methods of iron production were not significantly different than those used today. In principle, heat from burning solid carbon liberates oxygen in iron oxides and promotes its association with gas phase carbon to form carbon dioxide and metallic iron. A flux, such as burned limestone, is used to catalyze the process. Until recently, the metal component was naturally occurring iron-bearing ore; today the same ore is ground and separated magnetically, mixed with a flux binder and formed into pellets. Until the nineteenth century, carbon was supplied in the form of charcoal — wood with the volatiles baked out. Since then carbon has been supplied in the form of coke — coal with the volatiles baked out.

> **"written evidence of the deliberate reduction of iron ore to produce metallic iron goes back two thousand years."**



Bessemer method of steel production

Open hearth steelmaking furnace

Through the centuries iron technology improved gradually through empirical practice as open puddles gave way to closed pits, closed pits morphed into open hearths, hearths became shafts, shafts became stacks, stacks were optimized for induction and pressure control; while blow pipes became wind tunnels, wind tunnels became air bellows, air bellows became steam driven blowing engines, steam driven blowing engines became stove preheated air delivered by large volume steam-driven turbo blowers; while sponge iron evolved into bloom iron, bloom iron to cast iron, cast iron to wrought iron, which evolved in turn into liquid iron pouring from the tapped base of today's giant blast furnaces.

At the time of the Carnegie family's arrival in the United States, cast iron and wrought iron were the ferrous metals of the day. Iron furnaces yielded iron castings and pig iron for re-melting and refining into wrought iron. Wrought iron was made by recasting pig iron into bars and annealing them in contact with charcoal for weeks. Steel was produced in small quantities by re-melting and recasting broken wrought iron bars and hand beating carbon into them over a charcoal fire. Arduous production methods and limited output resulted in high prices for all ferrous metal products. Then, in 1856, the renowned English industrialist/inventor, Henry Bessemer, proved his method for making cheap steel by decarburizing molten pig iron in a semi-rotating crucible by forcing air into the melt.

In 1864, after having risen meteorically as an employee of the in the Pennsylvania Railroad, Andrew Carnegie quit the railroad to devote himself wholeheartedly to the iron industry. Earlier, in 1862, he and other mangers from the railroad had formed the Keystone Bridge Company. Through acquisitions, mergers and buyouts the company prospered from contracts with the railroads to replace wooden bridges with iron ones. As a result of his experience with railroad bridges Carnegie saw that long lasting steel rails would eventually and inevitably supplant the wear-prone cast iron and ironclad wooden rails in use at that time. In 1873, he met Henry Bessemer and became convinced that his cost-efficient process for producing large quantities of liquid phase steel was the answer to the rail wear problem.

Industrialist Andrew Carnegie

USS Clairton Plant Today

Although the Bessemer process efficiently removed silicon and carbon from the steel, it did not remove phosphorous, which makes steel brittle. Consequently, low phosphorus iron ore was needed to make the Bessemer process work. Large deposits of such ore were to be found in the Upper Michigan Peninsula and had just recently become available by means of large-scale transport to the lower states.

As a consequence of the convergence of Carnegie's association with the Pennsylvania Railroad and the Keystone Bridge Company, the availability of the Bessemer converter to make cheap steel rail, Pittsburgh's renowned supply of high quality coal for coking, the availability of low phosphorus iron ore and efficient means of transporting it to Pittsburgh, in 1872 Carnegie resolved to construct a steel mill dedicated to the manufacture of steel rails. The new rail mill would be named after the president of the Pennsylvania Railroad. Located in Braddock, Pennsylvania, it was called then, as it is now, the Edgar Thompson Works.

Once in operation, the designated mastermind behind the new mill was Captain William R. Jones, an expert in the Bessemer process, hard driving manager and fiercely competitive businessman. Jones was responsible for many process improvements at the plant, one of the most significant being the Jones Mixer, which stored up to 100 tons of molten pig iron in a vessel that dispensed 10 ton charges into the Bessemer converters as needed, thereby making the process continuous.

> **"Although the steel industry had made tremendous progress over a period of about fifty years, a seemingly intractable problem lingered... Iron rusts."**

In addition to the original two Bessemer converters, the Edgar Thompson Works was equipped with two open hearth furnaces. Although primitive open hearths had been used centuries earlier, in the 1880's in Europe, the ancient process was resurrected, redesigned, scaled up and transformed by the addition of a low roof, furnace doors and a logistics system that enabled the efficient movement of materials through the steelmaking process. In the open hearth process, cold scrap followed by molten iron, several hours later, went from the charging floor through the furnace doors into the hearth where it was heated from above and, eight hours later, flowed as molten steel through a tapping spout into a ladle on the pouring floor on the other side. The ladle was hoisted to the nearby mold yard, where molten steel flowed from a nozzle in the ladle bottom into ingot molds. While Bessemer converters had been capable of ten-ton charges, open hearth furnaces were capable of charges as high as 350 tons. In addition, open hearths tolerated wide variations in the ratio of cold scrap to molten iron in the charge. The ability to add alloying materials and to take samples for laboratory testing at any time during the process enabled the production of finely tuned steels. As a consequence of tremendous increases in production output and process improvements, in the first decade of the twentieth century, open hearths supplanted Bessemer converters as the technology of choice among steelmakers around the world.

In the early decades of the twentieth century the emerging automotive industry needed sheet steel for automobile bodies. At that time however, sheet steel was still produced by primitive, arduous methods of manual rolling, turning and re-rolling ingots that were, as a matter of necessity, cast sufficiently light in weight for several men to carry. Output was limited and costs were high until the development of the continuous hot strip mill by the American Rolling Mill Company (Armco), in the early 1920s, With the advent of continuous milling, massive slabs of high quality steel could be rolled while hot through a progression of rollers, each flattening the metal to a thinner gauge, while elongating the slab into a strip and, finally, rolling it into a coil.

By the 1930s, cold rolling of previously manufactured hot rolled steel coils came on to the scene. Using the same machine principles as hot rolling, cold rolling enabled the further reduction in thickness below hot roll's physical limit of about .050 inches, as well as the enhancement of the steel's surface finish.

Although the steel industry had made tremendous progress over a period of about fifty years, a seemingly intractable problem lingered. In the words of U.S. Steel's current Director of Product Technology, Joseph Defilippi, the problem can be summed up in two words: "Iron rusts." In response to that lingering problem, in 1938 U.S. Steel opened its first experimental tinplating line for the production of tin cans for the food processing industry. Tin cans had come into popular use after World War I as a consequence of returning doughboys having grown accustomed to them while overseas. The result of the company's experimental electrolytic tinplating line was the patented and globally licensed U. S. Steel Electrolytic Tinplating process which employs a sulphonic acid electrolyte to carry the stannous tin before it is reduced to a zero-valence state and electrodeposited onto the steel substrate.

The thirties also saw the early development of vitreous enamel coatings for the appliance industry and both electrolytic and hot-dip zinc galvanizing processes.

World War II brought the steel-hulled Victory Ships, which experience proved, tended to crack in cold, rough seas. Following the war, the United States government authorized a unified steel industry effort to find the cause of the problem and come up with solutions. Between 1945 and 1965, this industry-wide effort led to tremendous advances in the understanding of steel microstructures with the resultant development of techniques to control the opposing characteristics of brittleness and ductility. Principal among those techniques were the fine control of grain size and the elimination of embrittling nitrogen from the steel, which was entrained from the air used to oxidize the molten mix during manufacture.

In the mid 1950s, the Basic Oxygen Process (BOP) came to the rescue when Union Carbide developed an inexpensive process for producing oxygen. Today, having replaced the open hearth process, the Basic Oxygen Process employs a removable lance to blow pure oxygen, rather than air, into the molten iron in a large refractory lined vessel, called a BOP furnace, before tapping into a portable covered ladle in which the deoxidized, reduced nitrogen, tuned and alloyed molten steel is stored before transport to the continuous caster. At the caster, the steel is dispensed into a tundish, which acts as a reservoir for the continuous process, and then into caster molds for solidification into long continuous slabs, which are subsequently torch cut to size in-line before delivery to the slab yard.

The construction of oil and gas pipelines during the 1950s and 60s required steel pipe with high fracture toughness, especially in Artic and desert environments. With earlier steel pipe, a small fracture in a pressurized line could expand along grain boundaries in the steel microstructure, resulting in a mile long crack. Researchers at U.S. Steel found that the addition of nanoscale niobium and titanium particles to the steel formula promoted both nucleation and controlled inhibition of crystal growth during cooling. The result was small grain size which greatly increased fracture toughness.

Steel slab manufactured at the Gary Works facility

Beginning in the 1970s, with the demise of the practice of planned obsolescence, demand for corrosion resistant sheet steel for the automotive industry took an upswing. The impetus from that trend led to increases in research and development as well as investments in production capacity for both electrolytic and hot dip galvanizing facilities for U.S. Steel, worldwide.

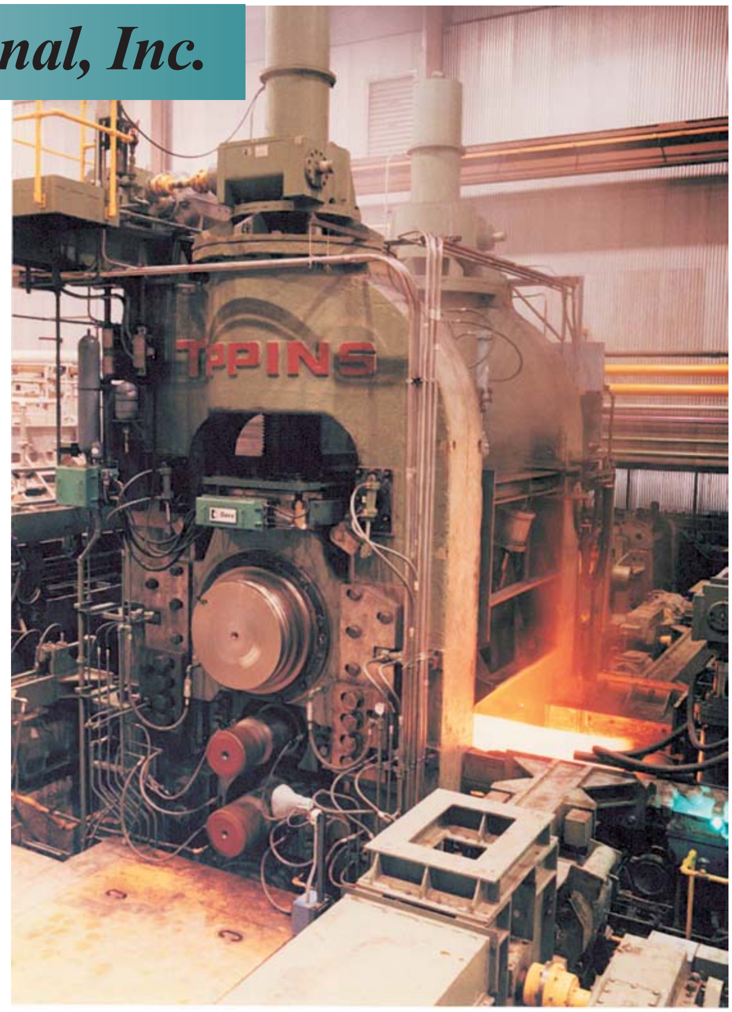
Today, researchers at U.S. Steel manipulate steel formulations at nanoscale levels both within the mass and on the surface of steel products to produce heretofore unavailable performance and aesthetic characteristics including: corrosion and dent resistance, surface integrated color and reflective coatings, bake hardenability, superior strength, impact resistance, easy formability and light weight.

Of the forty some grades of steel that U.S. Steel produces today for hot-dip automotive galvanizing, thirty were not available ten years ago. Twelve new automotive grades are under development. Over 950 total steel grades are produced at U. S. Steel Gary Works for all sheet and tin products.

Back in 1927, U.S. Steel's board of directors declared that henceforth, the company would engage in the formal practice of research and development. Through the years that declaration would prove to be prophetic. True to the board's vision and in keeping with Andrew Carnegie's aptitude for recognizing opportunity and matching it with technology, today United States Steel employs analytical science in conjunction with advanced technology to meet the needs of customers around the world. Lighter, stronger, more formable, more beautiful steels are the holy grails of the company today. Mr. Carnegie would be proud.

History of Haynes International, Inc.

By Charlie Sponaugle
Haynes International, Inc.



The story of Haynes International spans almost a century. Intertwined with the 94 years of Haynes' continuous operation is the history of many nickel — and cobalt-based superalloys. Tracing the evolution of these unique materials, we will follow their applications in aerospace, rockets to Mars, world wars, the chemical industry, and medical prosthetics.

The company was formed in December, 1912 by Elwood Haynes in Kokomo, Indiana. Elwood Haynes was an inventor, teacher, experimenter, businessman, and philanthropist. He was born in Portland, Indiana in 1857 and received his education at Wooster Polytechnic Institute and John Hopkins University. His post graduate work at John Hopkins provided the basis for his successful metallurgical work that followed.

After a short early career as a teacher, Haynes entered the oil and gas industry. It was during this time that Haynes ideas for a "horseless carriage" were developed. Haynes moved to Kokomo in December of 1892 and found time to work on his "horseless carriage". His first automobile, the "Pioneer", was successfully tested July 4, 1894. While there is some dispute as to who the honor of the first automobile in the United States goes to, (J. Frank Duryea tested a horseless carriage in September, 1893), the success of the "Pioneer" led Haynes to form an automobile company producing high-end automobiles through the mid 1920s.

It was during 1887 that Haynes began experimenting with metals in search of a material that would resist tarnishing and be suitable for cutlery. After a number of years of unsuccessful experiments, he began working with nickel-chromium and cobalt-chromium alloys. After much additional experimentation he was successful, and was awarded two patents in 1907, one for the nickel-chromium alloy and one for the cobalt-chromium alloy. Subsequent work produced other cobalt-based alloys with additions of molybdenum and tungsten. Patents on these new alloys were granted in late 1912 and Haynes began to set up a manufacturing site. Haynes called these alloys "Stellite". This name came from the Latin word "stella" for star because of their star-like luster. (Stellite is a registered trademark of Deloro Stellite, Inc., Belleville, ON, Canada.)

While Haynes was targeting usage in cutlery, dental instruments, and edged tools, their real value was found in lathe tools. Cutting tools made from "Stellite" would outlast other products, and most importantly would allow cutting speeds three times as fast as the best available high speed steel tools.

The first name of the company was Haynes Stellite Works. In the early years of the company, Haynes continued experimentation with cobalt-based alloys. He was granted a patent for a cobalt-chromium-molybdenum-tungsten-carbon alloy in 1913, now known as Haynes® alloy 6B, that has been in continuous production since its discovery. Patents were granted for other cobalt alloys as well.

The business was incorporated in October, 1915 as Haynes Stellite Company. Over the course of the next year revenues for "Stellite" alloy exceeded $1,000,000. The company began to expand rapidly and had 20-25 employees in 1916. By 1918 sales were about $3,600,000. The reason for the growth was the First World War and the demand for lathe cutting tools. By 1920 employment was up to about 125 people.

The business was sold to Union Carbide in April, 1920 and this marked the start of the second chapter of the company's history.

The first few years of Union Carbide & Carbon (UCC) ownership were difficult for all parties. Being owned by a "group of eastern capitalists" was a challenge in small-town Kokomo.

The Union Carbide Era

Union Carbide's interest in Haynes was a result of Haynes being a customer of various ferroalloys provided by UCC. After the First World War ended sales had fallen and profitability was restored by 1925. Research continued on the cobalt alloys, expanding into hard-facing products. New alloys included trade names such as J-Metal, Star-J, and Haynes Stellite 98M2. There was considerable competition in the hard-facing market with the Stoody Company during this time.

In the early 1920s research was also being conducted on nickel-molybdenum alloys for corrosion resistance. This research was carried out at Union Carbide's R&D facilities at Niagara Falls and marked the beginning of the nickel-based superalloy industry. A patent was obtained on a nickel-molybdenum alloy composition range in 1921. From this came Hastelloy® A alloy and two years later, Hastelloy B alloy. The unique composition of Hastelloy B is still being manufactured today. About 1926 work was beginning on nickel-molybdenum-chromium alloys for improved corrosion resistance in oxidizing environments. From this research Hastelloy C was born. Today the fifth generation of this alloy (Hastelloy C-2000®) is being supplied to the chemical process industry by Haynes International. Hastelloy D, a nickel-silicon-copper alloy was also invented during the 1920s.

The company weathered the depression years selling its hard-facing alloys in industrial and agricultural applications and the new Hastelloy alloys in the growing chemical process industry. During this time new melting technology was moved to Kokomo from Union Carbide's facility in Niagara Falls, NY. It was about 1940 that the first wrought versions of the Hastelloy alloys were being developed and rolled at Ingersoll Steel and Disc Company in New Castle, Indiana.

The 1940s were the beginning of a new era for the company. The second world war would alter the company's future much as the first world war had done. One of the growing applications for Stellite was investment cast turbine blades (or buckets). These blades were used in the superchargers for military piston engines on a number of planes. Over 25 million buckets were produced for the war effort. Haynes Stellite alloys 21 and 31, both cobalt-based, were used in this application about 1941. Haynes Stellite was the premier investment casting house in the US at this time and supplied about 70% of the turbine buckets used.

Another application using both the Stellite alloys and the new Hastelloy alloys was search light reflectors for the US Navy. These metallic reflectors were shatterproof and maintained a high luster even in saltwater environments. These reflectors were made from plate rolled by outside conversion sources using billet melted in Kokomo. Another factor in the growth of the company during the 1940s was the large amount of Hastelloy alloy used by the Manhattan Project and the Chemical Warfare Service.

Production during the war years was at an all time high, with employment reaching over 2,000 during the second world war and 3,000 by the end of the Korean war.

A major milestone occurred in the late 1940s with the establishment of the wrought alloy plant in Kokomo. Prior to this, wrought products were finished by outside rolling mills. The new wrought alloy plant was situated on about 100 acres of land south of the main plant location. This new facility included rolling equipment for the production of plate and sheet products.

New high temperature wrought alloys were also being added. MULTIMET® (a nickel-cobalt-chromium-molybdenum-tungsten alloy) appeared in 1949 and in 1950 the cobalt alloy L-605 (now called Haynes alloy 25) was first manufactured. These alloys found increasing usage in aircraft superchargers and in the newly invented jet engine.

The invention of a new nickel-based alloy, Hastelloy X, in 1953 marks the beginning of the next chapter in the company's history.

The Expansion Era

In many respects the 1950s marks the beginning of significant change for the company. New alloys, led by Hastelloy X, were being invented, and new applications were being found. In the case of Hastelloy X, it was the right alloy at the right time. Just as the alloy was being introduced, Pratt & Whitney was looking for a replacement material for a failed combustor can in their new JT-3 jet engine. Hastelloy X was tested and performed very well. It was chosen for the JT-3 and the later JT-8D engines, which powered the first Boeing 727 aircraft. Fifty years later, Hastelloy X remains the largest volume nickel-based sheet alloy for gas turbine hot section components.

1957 saw the installation of 6 new vacuum furnaces in Kokomo. This melting technology allowed the company to manufacture more sophisticated alloys, particularly alloys with additions of aluminum and titanium.

> **"Even though the nickel and cobalt metallurgy field has been thoroughly researched over the last 100 years, there are still innovations to be found."**

The 1960s were characterized by advances in superalloy metallurgy, particularly the introduction of Argon Oxygen Decarburization (AOD) and Electro Slag Remelting (ESR). AOD processing allows for the manufacturing of alloys with very low levels of carbon. This process is similar to decarburizing steel with an oxygen lance. The ESR process is a second melting operation that refines the cast structure and removes impurities. These improvements allowed the development of a new class of superalloys for both high temperature and corrosive applications. The most notable were Hastelloy C-276 and Haynes® 188 alloys. Hastelloy C-276 is now an industry standard alloy for use in the chemical and petrochemical processing. Haynes 188 remains the alloy of choice for jet engine afterburner components in engines like the Pratt and Whitney F-100. The invention of Haynes 188 allowed jet engine designers to increase the temperature in the engine by 300 degrees F, resulting in substantially greater thrust and performance.

Along with advances in melting technology and the subsequent refinement in superalloy capabilities, the 1960s brought a new cold strip mill to the company. This mill gave the company greatly expanded capabilities and capacity in the production of sheet, coil, and strip products. The growing aerospace market was a big user of sheet material and the new strip mill was the right capital expansion at the right time. As in past wars, the Vietnam conflict used substantial amounts of products produced in Kokomo, Indiana. Ironically, one of the major applications was for helicopter rotor shields made from Haynes alloy 6B, which was invented by Elwood Haynes *before* the first world war.

The Modern Era

In January, 1970 Union Carbide sold the company to Cabot corporation, ending fifty years of ownership by UCC. Following this transaction, alloy development work continued vigorously and took advantage of the advanced capabilities of the new melting and rolling technologies. New low carbon double melted alloys were being introduced into both aerospace and chemical industry applications. New markets, such as Flue Gas Desulfurization, were beginning to use superalloys such as Hastelloy C-276 in many critical applications.

Hastelloy B-2, the second generation of Hastelloy B alloy, was introduced. Hastelloy C-4, designed for the European chemical industry was also brought out.

Changes in the commercial organization were occurring as well. More and more applications in the Chemical Process Industries and the Aerospace market were opening up in Europe. The company opened a service center in Corby, England in 1974 and one in Lille, France in 1978. Nickel Contor, a service center in Zurich, Switzerland, was purchased in 1977.

The Arcadia tubular manufacturing facility in Arcadia, Louisiana was started in 1977.

By 1980 it was clear that the company had to improve its sheet and coil manufacturing. New applications required better quality control and lower costs, and higher capacities were needed for growth. It was for these reasons that the company embarked on its most ambitious capital expansion project.

Installation of the "4-High"

In 1980 work began on the installation of a new 4-High combination plate/hot band Stekel mill. This facility would have the ability to hot roll superalloy plate product up to 2 inches thick and 72 inches wide and produce continuous 10,000 pound hot bands at widths up to 48 inches with a thickness of 0.250" or less. When installation was finished in 1982, Haynes had a state-of-the-art hot mill that is still the largest, most powerful 4-High Stekel mill in the world devoted to the rolling of nickel- and cobalt-based superalloys. This mill was designed and installed by George Tippins of Pittsburgh, PA and features a 12 million pound separating force. The two mill housings weigh 300,000 pounds each and were cast in Germany.

Alloy development was also moving at a fast pace. The early 1980s saw the introduction of several major alloys including Hastelloy C-22®, Hastelloy G-30®, Haynes 214®, Haynes 242®, Haynes HR-120®, Haynes HR-160®, and Haynes 230®. All of these superalloys are still in production and have become standard engineering materials in many applications.

The 4-High allowed the company to produce large continuous hotbands to feed the cold strip mill. Prior to the 4-High, hot bands were built up by welding long, narrow 0.250" plates together end-to-end to form a coil. This method of building up a hotband is still used for some small volume hard-to-make alloys where their metallurgical properties prevent 4-High hotband rolling.

Uses for superalloys continued to expand in the 1980s. Millions of pounds were specified for flue gas desulfurization units at coal-fired power plants. Removing sulfur compounds from the exhaust gases of coal burning boilers can be very corrosive and nickel-based superalloys are used in the "scrubbers", breeching ducts, and even chimney liners of power plants. Hastelloy C-276, C-22® and C-2000® alloys are standard engineering materials in these systems. Another interesting application involved the Abrams M-1 Main Battle Tank. This tank has a 1500 horsepower gas turbine engine and uses an air-to-air heat exchanger, often referred to as the recuperator, to heat intake air with the exhaust gases from the turbine. The recuperator is a plate type unit and uses several hundred pounds of superalloy for each engine. Haynes supplied millions of pounds for this application.

Today

Today Haynes International is a thriving developer and manufacturer of superalloys with 8 company-owned service centers around the world. The combination of primary manufacturing facilities with multiple service center locations is unique in the superalloy industry. The research and development commitment is also quite unique in today's highly competitive environment. The most recent inventions include a new nickel-chromium-molybdenum alloy, Hastelloy G-35®, designed for phosphoric acid service. Also just being introduced is a new high temperature alloy, Haynes 282™ which is an age-hardenable superalloy designed for hot section components in military and commercial gas turbines. This alloy appears to be a significant improvement over existing hot section alloys and will likely develop into a high volume aerospace alloy.

Often research and development can take several years to go from an idea to a viable alloy product. Even though the nickel and cobalt metallurgy field has been thoroughly researched over the last 100 years, there are still innovations to be found. R&D remains an important part of Haynes' business and new alloys will continue to be invented in Kokomo.

As the company approaches its 100th anniversary, Haynes International is a company that lives up to its slogan "A History of Innovation Spanning a Century".

This article was written with the help of many people. Many of the facts cited and many of the quotations come directly from the book STELLITE — A History of the Haynes Stellite Company 1912-1972, by Ralph D. Gray. Dr. F. Galen Hodge, associate director of the Materials Technology Institute, greatly assisted in the editing of the article and in the chronology of events. Numerous others also helped with the years after 1972, when Ralph Gray's book ends. Many thanks to all who helped.

Some of the trademarks used in the article, along with their owners, follows: Haynes, Hastelloy, Multimet, C-22, C-2000, G-30, 214, 230, G-35, 242, HR-120, HR-160, and 282 are trademarks of Haynes International, Inc. Stellite is a trademark of Deloro Stellite, Inc.

Event NEWS

Celebrating Innovation: The ESWP's 125th Anniversary

By Chriss Swaney
Freelance Writer

The century's smartest and most innovative leaders queued up Oct. 26, 2005 to spend an evening with famed historian David McCullough at the 125th anniversary of the Engineer's Society of Western Pennsylvania (ESWP).

More than 1,100 engineers, educators, lawyers, physicians, politicians, corporate leaders, journalists and students streamed into Pittsburgh's David L. Lawrence Convention Center to salute ESWP's long history of innovation and community involvement.

WQED Producer Rick Sebak, who created a special history video for the ESWP anniversary dinner, was the event "M.C."

"I'm both pleased and proud to be part of this history-making event where we are really celebrating our past, present and future," said Sebak. "Very few people understand what engineers really do, and how they impact our lives," he said.

David McCullough

Prior to the gala dinner, replete with military honor guard and a stirring rendition of the national anthem, McCullough spent time with a handful of ESWP guests during a VIP reception at the Senator John Heinz Pittsburgh Regional History Center in the city's colorful strip district.

At the reception, McCullough, autographed his latest book, "1776," and admonished attendees to get children interested in history.

"We are in danger of being a country of historical illiterates," McCullough warned. "We have amnesia about our history."

The two-time Pulitzer Prize winner prodded the crowd to learn more about learning. "I'm convinced that we learn by struggling to find the solution to a problem on our own, with some guidance, but getting in and getting our hands dirty and working it."

Reception attendees flocked to

> **"We are in danger of being a country of historical illiterates"**
>
> *— David McCullough*

have books signed and photos taken with Pittsburgh's favorite native son.

"I think this event is a great kickoff for our next phase of activities designed to entice tomorrow's youth to study more engineering and science," said Anthony M. DiGioia, Jr., co-chair of the ESWP 125th anniversary and head of DiGioia, Gray & Associates, LLC.

The ESWP, for example, is partnering with the Carnegie Science Center to produce a selection of programs that focus on middle and high school aged students designed to create interest in engineering, science and architectural careers.

In addition to beefing up interest in engineering careers, the ESWP is developing a special exhibit to be featured at the History

> **"this event is a great kickoff for our next phase of activities designed to entice tomorrow's youth to study more engineering and science."**

Center in 2008 and a new history book about the association's 125 years of public service.

"Engineering and innovation are two key elements that make Pittsburgh such a special place," said Andrew E. Masich, president and chief executive officer of the Senator John Heinz Pittsburgh Regional History Center. "This is a place where big ideas became reality."

McCullough was quick to point out that most of the steel used in World War II was forged in Pittsburgh. "We were aptly dubbed, 'the arsenal of democracy.' "

"Aviator Charles A. Lindbergh's plane propeller was made here, and the boat that launched the famous journey of Lewis and Clark also came from Pittsburgh," McCullough said.

In fact, many of the ESWP founding members were icons in the turn-of-the century where men lived in booming, anarchic times and thrived on them. Industrialist Andrew Carnegie, whose steel furnished the sinews of America's growing communities, played an important role in the development of ESWP.

Anthony M. DiGioia Jr., Ph.D., P.E.

And the Carnegie legacy continues. Carnegie Mellon University faculty members Jay Apt, .James H. Garrett, Jr., and Deborah A. Lange serve on the 125th anniversary planning committee.

"This is a very proud evening for engineers because the profession has played such an important part in the life of this region," said Jared L. Cohon, president of Carnegie Mellon University.

James Roddey, a principal of the Hawthorne Group and a member of the 125th ESWP anniversary planning committee, said that we often forget to credit the role engineers play in all we do. "The building of Pittsburgh took inspiration and guidance from engineers who labored long and hard to get it done." Roddey said.

But the engineering profession is changing. As globalization and competition for jobs intensifies, engineers are reinventing how they hone skills to tackle tomorrow's urban and environmental challenges.

"I guess you could call me the poster boy for this change," said Alex G. Sciulli of Mellon Financial Corp. and co-chair of the 125th ESWP anniversary committee.

"It's important for our country not to lose our technology edge when it comes to engineering and the sciences," he said. "Our anniversary celebration is really as big as it gets for engineers who are usually the folks doing all the work behind the scenes with scant recognition, '' said Sciulli.

Michael G. Bock of Schnader, Harrison, Segal and Lewis LLP and an ESWP board member, said the entire anniversary kick off is designed to get a broader audience excited about engineering.

That excitement culminated in a rousing welcome for McCullough as claps and cheers could be heard when the nation's best narrative historian stepped up to the convention center podium. His familiar face and easy manner immediately helped the audience settle into an hour's worth of wit and wisdom.

"If you learn anything tonight it's that the solution of the problem is often in the problem itself," McCullough said. "It's not just intelligence; it takes leaders."

Throughout his latest book, "1776," a cadre of important military and political figures crop up to challenge and augment McCullough's own bullish faith in America's timeless resilence.

"When I read in my research that the British army had landed 32,000 troops – and I had realized, not very long before, that Philadelphia only had 30,000 people in it – it practically lifted me out of my chair. They landed an army bigger than the entire population of the largest city in the country," McCullough said.

> "It's important for our country not to lose our technology edge when it comes to engineering and the sciences."

Alex G. Sciulli, P.E.

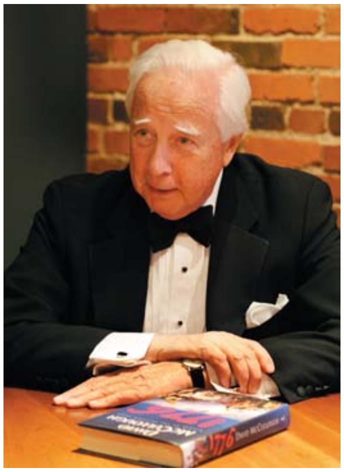
He compared the early struggles endured by America's patriots with all the challenges civil engineers made when they built both the Brooklyn Bridge and the Panama Canal.

"I salute all of you, and your ability to solve problems," McCullough said. "You can learn from these genuine American heroes. Because a handful of very brave people refused to see a bleak history, we are the beneficiaries. Without them, The Declaration of Independence would have been that only, a declaration, words on paper."

In a crowded and productive career, McCullough has been an editor, essayist, teacher, lecturer and familiar presence on public television. He was also the narrator's voice in the recent movie *Seabiscuit.*

Following his talk, McCullough autographed more books and joked with the crowd, who meandered between the book signing and a successful ESWP silent auction.

The ESWP event was made possible by a variety of generous corporate sponsorships and the hard work of ESWP staff led by David Teorsky, editor-in-chief of *Pittsburgh Engineer.*



A Golden Hour With America's Historian David McCullough

By Chriss Swaney, Freelance Writer

David McCullough arrived in Pittsburgh like a high-speed sunrise, a blur of brightness that quickly eased into chatting about how engineers helped furnish the building blocks of America's burgeoning towns, factories and bridges.

"Engineers are the symbols of U.S. enterprise and ingenuity, and Pittsburgh shares a lot of that history," said McCullough, as he reminisced about growing up amidst belching steel mills and tightly-knit ethnic neighborhoods.

Like most rapacious young boys, McCullough said he delighted in hearing all the foreign accents at streetcar stops on his way to spend a rainy Sunday afternoon at Carnegie Library.

"I loved looking at old photographs," said McCullough, a Pulitzer Prize winning historian who now lives in West Tinsbury, Mass. "They made me wonder what it must have been like back then."

It was photography that led to his first book. Published in 1968, "The Johnstown Flood" brought him national attention and set him on a path to becoming the country's most popular historian.

McCullough said he never forgot the images of the 1889 flood he came across in the Library of Congress.

"They were these marvelously clear prints taken by a Pittsburgher who somehow got to Johnstown soon after the flood," he said. "I couldn't get over the violence they showed."

McCullough said he knew little about the flood despite his Pittsburgh childhood. "All I can remember as a kid was pouring gravy into mashed potatoes, then pushing the potatoes down to make the gravy flow out. 'Here comes the Johnstown flood,' I'd say. "

Working nights and weekends, McCullough finished the book in three years. But he couldn't think of a title for it. "Finally, I called my editor and said, 'Look, I've finished the book, but I don't have a title. ' "

The editor said, "How about 'The Johnstown Flood'?"

The title question was solved, but a bigger question faced the new author — what would he write about next?

McCullough, 72, said he remembered the words of Thornton Wilder, the playwright and novelist who was his adviser at Yale.

"Wilder said he got the idea for a book or play when he wanted to learn something. Then, he'd check to see if anybody had already done it, and if they hadn't, he'd do it. ' '

When a friend wondered about the history of the Brooklyn Bridge, a span McCullough had often walked across when he lived in Brooklyn in the 1950s, the idea for the next book was hatched.

"I knew about the Roebling family — that they were from near Pittsburgh — but that was it. The first thing I did was head for the New York Public Library. The card catalogue was on the third floor, and I took the steps two at a time," he recalled.

"I found more than 100 references to the bridge, but none was a history of it. I had my second book."

"The Great Bridge" appeared in 1972, but it was "The Path Between the Seas" that gained McCullough widespread attention. Published in 1977, the book arrived about the time the U.S. Senate debated the fate of the canal treaty that called for Panama to assume full control of it in 2000. He testified before a Senate committee and also discussed the canal with then President Jimmy Carter.

"I think my fascination for bridges and engineers really began at Linden Elementary School in Pittsburgh," McCullough said. "I'll never forget the matchstick model bridges we used to make in class to replicate many of the big, old bridges in Pittsburgh."

A tireless champion of Pittsburgh, McCullough remains active in his hometown, working with the Heinz History Center, where he was interviewed for this story, and donating money to the Pittsburgh Public Schools to transport students to Pittsburgh Symphony concerts.

"History teaches, reinforces what we believe in, what we stand for and what we ought to be willing to stand up for…" he said as his right hand never stopped moving. The pile of autographed copies grew higher.

"Because Pittsburgh was this big steel powerhouse of the world, I sometimes think of research material as the ore out of which the steel of the book will be made," McCullough said.

Since late summer, the Pittsburgh native has been in constant motion. His new book, 1776, tells the intensely human story of a tenacious band of patriots who marched with George Washington in the fateful year of the Declaration of Independence.

"To a large degree, the book is about character. In an immediate and very human way it's about staying power on the brink of disaster. The people who make the difference are those who won't give up. It's to them we owe so much. Most of all, I hope I conveyed that no one knew how things were going to turn out."

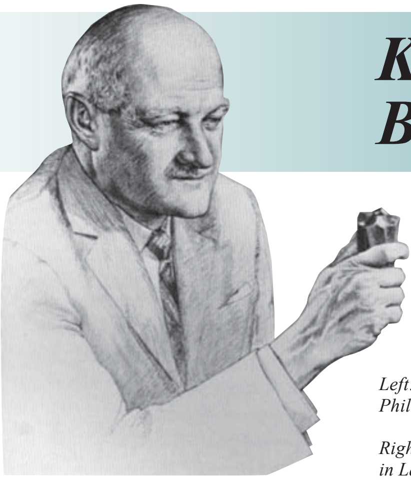
For McCullough, who credits his Scottish-Irish heritage for his storytelling prowess, history relies on memory, and memory on will.

"I like to wait for the dust to settle before starting to write, and I think that's why I'm so comfortable in the 18th Century," said McCullough, who cautiously avoids technology. He still uses a dull black Royal typewriter and refuses to own a cell phone.

When asked about his next book venture, he slowly pushes back in his chair and says he's still thinking about it.

"Or as my old Shady Side Academy athletic coach used to tell me: "Take the hurdles one at a time." "I'm not quite ready to go to the next hurdle."

Kennametal Inc. — Global Manufacturer Based in Southwest Pennsylvania



By Joy Chandler
Director, Corporate Relations
Kennametal Inc.

Left: Kennametal founder, Philip M. McKenna

Right: Kennametal Corporate Headquarters in Latrobe, Pennsylvania

Today, Kennametal Inc. is a $2.3 billion company with 14,000-plus employees working in 60 countries around the world. However, in 1938 this company, now a world leader in tooling, advanced materials and engineered components, was just a tiny start-up in the Southwestern Pennsylvania town of Latrobe. Nearly seven decades ago, company founder Philip M. McKenna started McKenna Metals with all of his personal savings, plus some breakthrough innovations in the science of tooling. That first year, the company had about a dozen employees and annual revenue of $30,000.

McKenna, a metallurgist, based his company on innovation. After years of research, he created a tungsten-titanium carbide alloy for cutting tools that provided a productivity breakthrough in the machining of steel. Referred to as "Kennametal," the material cut faster and lasted longer, and thereby facilitated metalworking in products from airliners to automobiles and road working machinery. The company was later renamed Kennametal.

The company continued to grow, and with the advent of World War II, American heavy industry shifted into high gear. Kennametal's annual sales approached $10 million and employment was nearly 900 as the company's tools were used extensively in the wartime economy. Foreseeing that this boom would be temporary, Kennametal sought new ways to exploit the toughness and wear resistance of tungsten carbide alloys. In the mid-1940s, the company pioneered the use of carbide tooling for mining, which led to the development of the continuous mining machine. Kennametal also found uses for tungsten carbide in demanding specialty applications where resistance to wear was vital, such as in valves, dies, drill bits and snowplow blades.

From the very beginning, Kennametal saw the importance of becoming a global supplier, and the company developed its international distribution early on by entering into joint ventures. Earliest partners were in Italy, the United Kingdom, Canada and Germany. However, Kennametal realized that in order to better serve customers that were becoming global and to position the company to grow with developing markets, Kennametal needed to add manufacturing facilities in key locations. By 1955, Kennametal had facilities in 19 countries and non-US sales accounted for 34 percent of annual revenue.

In 1993, Kennametal acquired Hertel AG, a tooling systems manufacturer headquartered in Fürth, Germany, with operations throughout Europe and worldwide. This enabled the corporation to compete more effectively in Western Europe, gain better access to emerging markets in Eastern Europe, and offer additional product lines in Asia Pacific. The Asia Pacific effort was further expanded to include manufacturing joint ventures for mining tools in China and a metalworking tool manufacturing plant in Shanghai. In 2002, Kennametal acquired Widia, a leading manufacturer and marketer of metalworking tools in Europe and India. Widia, with its strong brands and highly respected technology, enables Kennametal to expand its capabilities to better serve customers in Europe, India and around the world.

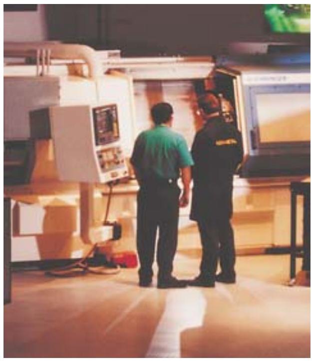
"In the mid-1940s, the company pioneered the use of carbide tooling for mining, which led to the development of the continuous mining machine."

Kennametal is now in the process of constructing a second manufacturing plant in China. Demand for Kennametal products and services is so high in this rapidly developing economy that all products from this 170,000 square-foot facility will be absorbed locally for the foreseeable future.

Even with all this global growth, Kennametal's world headquarters remains in Southwestern Pennsylvania, where the company's growth strategy led to the 2005 acquisition of Extrude Hone, located in Irwin, Pennsylvania. The acquisition of this global company furthers Kennametal's strategy to significantly grow its advanced materials and engineered components business.

Kennametal was founded on the strength of a technological breakthrough, and a list of highlights demonstrates that it has continued to lead its industry in innovation. In 1946, the company introduced the Kendex line of mechanically held, indexable insert systems that accelerated tool changing and increased machining precision. Kennametal's unique, patented thermit process for producing impact-resistant macrocrystalline tungsten carbide today remains the best way to produce extremely tough tool materials for demanding applications such as mining. In 1964, Kennametal introduced tungsten-carbide-tipped Kengrip tire studs. Although studs clearly contributed to safe winter travel, they became controversial amid speculation about their role in road deterioration. After legislation limited the use of carbide studs, Kennametal left the business in 1977.

The list of pioneering products never stops growing. Kennametal led development of silicon-nitride "sialon" ceramics for the machining of exotic aerospace materials. Kennametal was the first to develop cobalt-enriched substrates for coated inserts, was first to introduce commercial physical-vapor-deposition (PVD) coatings for carbides and created the first commercially viable diamond-coated carbide inserts. Kennametal also drove the development of quick-change tooling sys-



> **"Kennametal finished its fiscal year 2005 with 45 percent of sales from new products"**

tems that today lead the world in versatility, speed and accuracy.

The company's track record of 'game changing' technology advancements keeps Kennametal customers on the cutting edge of productivity and performance. Just five years ago, 17 percent of the company's revenue was generated by the sale of new products — these are products that are less than 5 years old and that also deliver at least a 30 percent productivity gain to the customer. Although the 17 percent might have been acceptable in the industry, Kennametal decided to move to the next level and set an aggressive target of 40 percent of sales revenue from new products. Through talented employees and a disciplined, gated new product development process called ACE, Kennametal finished its fiscal year 2005 with 45 percent of sales from new products, and this level of performance is sustainable.

Kennametal maintains its technological leadership through, of course, its talented workforce and its $30-million Technology Center at its Latrobe headquarters, complemented by facilities in Rogers, Arkansas; Beford, Pennsylvania; Evans, Georgia; Fürth and Essen, Germany; and Bangalore, India. The facilities are dedicated to rapid development of products engineered to meet specific customer requirements.

The customer has, from the beginning, been the driving force behind the innovation for which Kennametal has become known around the world. Quick, thorough response to customer needs has been a key component of Kennametal's success. The application experts who make up the company's field sales force work directly on the customer shop floor, at the mine face or on the construction site to solve problems and increase productivity. Kennametal's real-time, on-line customer service system provides instantaneous information on global product availability, order status and application solutions. The customer acquisition process is our systematic, repeatable method for increasing sales to existing customers and winning new customers.

Kennametal goes to market through a wide variety of sales channels. Kennametal's subsidiary, J&L Industrial Supply, markets and distributes a broad line of consumable metalcutting tools and other industrial supplies. In November 1997, Kennametal acquired Greenfield Industries, Inc., the leading North American manufacturer of drilling and other rotary high-speed steel consumable metalcutting tools. Kennametal recently acquired Conforma Clad Inc. in March 2004 and Extrude Hone Corporation, as mentioned above, in March 2005. Conforma Clad Inc. is a leading provider of engineered components that deliver premium wear solutions and Extrude Hone Corporation is a supplier of market leading engineered component process technology. Kennametal continuously explores opportunities for profitable growth through partnerships with customers, distributors and suppliers, as well as through selected strategic acquisitions.

From its modest beginnings, Kennametal Inc., still based in Latrobe, Pennsylvania, has grown into a leading global supplier of tooling, engineered components and advanced materials consumed in production processes. Traded on the New York Stock Exchange, the company improves customers' competitiveness by providing superior economic returns through the delivery of application knowledge and advanced technology to master the toughest of materials application demands. Companies producing everything from airframes to coal, from medical implants to oil wells and from turbochargers to motorcycle parts recognize Kennametal for extraordinary contributions to their value chains.

Is America Falling Behind?

By Chriss Swaney
Feelance Writer

Above: Panelists Pradepp Khosla, Bob Black, Bill Holstein, Alex Sciulli, and Peter Faletra

Left: Panelist Peter Faletra (U.S. Department of Energy)

A panel of experts led by Carnegie Mellon University Engineering Dean Pradeep Khosla recently shared ideas on how the United States can prepare itself to compete in the ever-changing global economy.

"We must train engineers who will be managing, creating and deploying innovation," said Khosla during a discussion titled: *"Is America Falling Behind."*

Moderated by William J. Holstein, editor-in-chief of CEO Magazine, other panel members included Bob Black, deputy executive director of the American Society for Engineering Education; Peter Faletra, assistant director of the office of science for workforce development for teachers and scientists for the U.S. Department of Energy and Alex G. Sciulli, a senior vice president at Mellon Financial Corp. and first vice president at the Engineering Society of Western Pennsylvania (ESWP).

More than 60 engineers, academics, researchers and business leaders jammed a second floor ESWP meeting room Dec. 2, 2005 to discuss ways to stem the brain drain.

Despite recent studies by the American Society for Engineering Education and the National Academy of Engineering reporting that fewer than 5 percent of undergraduate degrees awarded in 2004 were in engineering, America can remain "at the top of the food chain" if it trains its engineers in management, finance, policy and entrepreneurship, according to Khosla.

"We need to change the perception of engineering," said Sciulli. "One of our greatest challenges is to prep engineers in topics that are considered "soft" by some — public speaking, leadership and writing," he said.

Panel members said it's not enough anymore to be a technical genius, you have to be able to develop a business plan and execute it, too.

> **"fewer than 5 percent of undergraduate degrees awarded in 2004 were in engineering"**

"It's a new world out there and we need to understand how important engineers and scientists are," Faletra said. "Scientists and engineers make up less than 5 percent of the population but create up to 50 percent of our gross domestic product."

But in the disciplines underpinning our high-tech economy — engineering, math, and science — America is steadily losing its global edge. China will likely produce six times the number of engineers next year than we will graduate, according to the American Society for Engineering Education.

There are many more unnerving developments, and they add up to this: As other countries create the learning centers and jobs to hang on to their best and brightest, the United States is losing a dependable pipeline of talent.

Ten years ago, for example, American companies and engineers were granted 10,000 more U.S. patents than foreign companies. Now, that margin is down to 4,000, and six of the top ten companies are foreign.

Still, Khosla argues that all is not lost in the United States quest to remain a global superpower.

"We still lead the world in research and development," Khosla said. "We can make the changes necessary to be competitive."

Sciulli said that you don't have to be an engineer and work in technology. "You can take leadership roles in other areas."

That leadership goal is a big part of the ESWP's mantra as the 125-year-old organization holds quarterly educational panel discussions about key engineering issues, and supports speakers interested in giving talks at area high schools about careers in engineering.

Above: Panel moderator Bill Holstein, (CEO Magazine)

Below: Panelists Pradepp Khosla (CMU) and Bob Black, (American Society for Engineering Education)

Above: Alex Sciulli replies to a question for the audience while moderator Bill Holstein listens.

Below: the media listens as the discussion continues after the program

Dean Pradepp Khosla discusses the issue with colleagues following the presentation

Photography by Larry Rippel