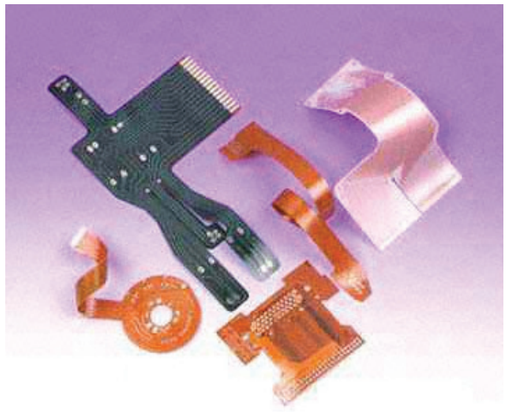
Cu Newsbriefs

Flex Copper Circuits:
Clean and Conductive



Flexible copper circuits come in many sizes and shapes (courtesy deplimitied)

Electronic equipment can now be made less expensively as a result of a new copper technology. Recently, an innovative way of printing flexible circuits, used in computers, calculators, cell phones and other electronic equipment, has been developed to deliver very thin lines of copper exactly where it's needed on flexible circuits. It involves electroless inkjet plating.

Currently, a sheet of copper is laminated to a flexible film, and then much of the copper is etched away, resulting in thin lines of solid copper that carry current. The new method uses inkjet technology to deposit only thin copper lines onto the circuit, eliminating waste and making circuits less expensive to produce. The electroless plating method results in much better electrical conductivity in the circuit than is possible with silk-screen technology. Very small thicknesses of copper, between 0.05 microns and 5 microns, are made possible by this new method. This makes it ideal for RFID (radio frequency identification) tags and heater circuitry, according to Tom Woznicki, president of Flex Circuit Design Co.

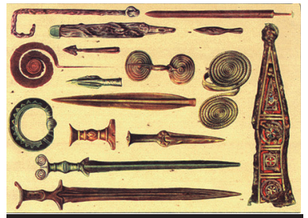
The new method was developed by a partnership between Conductive Inkjet Technology of Cambridge, England, and Preco, Inc. of Lenaxa, Kansas, and has not yet been widely used. *Cu*

"From Copper to Bronze to Conquest" Continued

Bronze arrow from the 7th BC in modern-day Pakistan

Bronze played a key role in the rise and fall of civilizations. In 2350 B.C., the warrior king Sargon I and his bronze-equipped armies conquered the city-states of Sumeria and united them into a vast kingdom with the fabled city of Babylon as its center. Around 1500 B.C., the Troy of Homer's Iliad, located in the southwest corner of modern-day Turkey, was an epicenter of bronze activity due to its proximity to copper and tin deposits, as well as its strategic location astride key land and sea trade routes. During that era, the ocean-faring war machine of the Phoenicians relied on copper cladding and bronze for its ships and weaponry. When they conquered the city of Byblos in modern-day Spain, the confluence of cultures resulted in one of mankind's greatest contributions, the creation of the alphabet.

The Bronze Age lasted for more than 1,500 years, from 2500 B.C. to 1000 B.C., and although it centered on the region stretching from the Mediterranean to the Middle East, the influence and effects of bronze were not limited to this area. Records and artifacts also show extensive copper and bronze usage throughout Asia as far back as 2600 B.C. The copper and bronze trade extended north along the Danube River and opened a gateway into central Europe and beyond.



Bronze age weapons from Eastern Europe

Advancements in metalworking eventually led to the discovery of iron and the dawn of the Iron Age. And though copper and brass were no longer the dominant metals of the era, their impact on the world continues today. Computers, automobiles, airplanes, motors and other modern devices that power our lives wouldn't be possible without the contributions of copper and brass. *Cu*

RESOURCES:

This edition of Discover Copper is also available online at www.copper.org and at www.homeplanningnews.com. For more information on the topics mentioned in this newsletter go to:

American Wind Energy Association
http://www.awea.org/

Copper Motor Rotor Project
http://www.copper-motor-rotor.org/

Heat Sink Technologies
http://www.embedded.com/

The History of Copper & Brass
http://copper.org/education/homepage.html

Flex Circuit Design Company
http://www.flexdude.com/

SUMMER 2006

Incorporating Copper Topics

Discover COPPER

Copper Connects Life.™

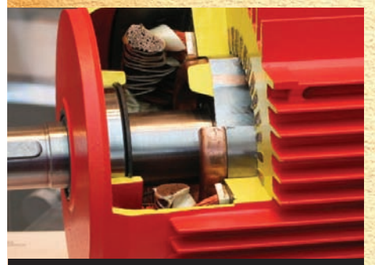
Edition #10

Motor Rotors

Whether we realize they are there, whirring quietly in the background, electric motors power our daily lives. Washing machines, automobiles, refrigerators, computers, vacuum cleaners, power tools, microwave ovens, clocks, air conditioners — all depend on small motors to convert raw electricity to motive power. And that's just a short list of items found around a home. Industry depends on countless electric motors to keep its wheels turning and factories producing.

WHY EFFICIENCY MATTERS

According to the U.S. Department of Energy, electric motors use approximately 23 percent of all the electricity generated in the United States. Roughly 70 percent of all electricity used by U.S. industry is devoured by motor-driven sys-



SEW EFF1 motor with cast copper rotor

tems. At current electrical consumption rates, a one-percentage point increase in electrical motor energy efficiency could save over 20 billion kilowatt hours of electricity per year, equivalent to 3.5 million barrels of oil annually in the USA, alone.

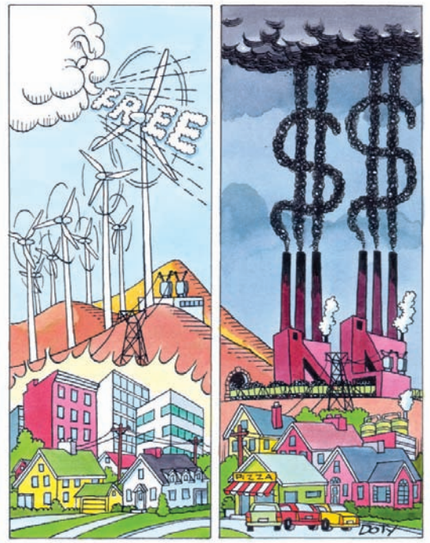
Copper has been a key component in motors since they were invented by Michael

Continued Inside

Wind Power:
A Positive Future

With consumers in "gas pump shock," environmental issues looming and the economy threatened by recent oil price hikes, wind power is increasingly being promoted as a viable source of alternative commercial energy.

The advantages of wind energy are numerous. Randall Swisher, executive director, American Wind Energy Association (AWEA), states, "Wind energy is a clean, safe, domestic, abundant and affordable energy source and one of the best options we have for new power generation."



According to AWEA, the production of wind-generated power this year will surpass that of 2005, which broke all existing records. Last year, wind turbines capable of producing 2,400 megawatts (MW) of power were installed in 22 states, bringing the total amount wind of wind generated power in the USA to 9,149 MW, enough to serve the equivalent of 2.3 million homes.

Mark Haller, president, Haller Wind Consulting, says, "The wind industry is in a very steep growth curve, and prospects for integrating wind power into the normal energy mix in America are very good. We're only seeing the beginning of a long-term growth industry."

THE PRICE IS RIGHT

Wind turbines are built by developers who own wind farms and sell power to utilities or who build wind farms for utilities that own them. Although California has the most installed wind energy infrastructure with 2,150 MW of power generation, Texas is about to overtake it.

"Land owners love wind farms because of the money they receive from leasing land to developers," says Mark Kapner, senior strategy planner, Austin Energy. The Texas utility is accelerating its use of wind energy and will have almost 200 turbines in place by the end of the year. Kapner expects more than 20 percent of Austin Energy's electricity to come from wind power by 2020.

Another benefit of wind energy is the price. According to Kapner, "The cost of our wind power contracts from 2003 to 2006 increased by almost 50 percent, but it's still economical compared to natural gas. So we use less fossil fuels and wind power is more economical."

Copper plays a crucial role in the delivery of wind energy, based on its high-conductivity, low electrical resistance, and resistance to corrosion. Some wind farms contain more than 300,000 feet of copper wire. Electricity generated through wind power flows through insulated copper cables to a copper-wound transformer. Underground copper cables collect the electricity from the base of each tower and deliver it to a substation that transmits it to the utility grid.

Even a modest wind farm uses a great deal of copper wiring. A 36-turbine project in Ainsworth, Nebraska, uses more than 14 miles of bare copper grounding as protection against lightning damage. Another 3 miles of copper wire comprise the ground rings encircling the

Continued Inside

Wind power reduces dependence on finite fossil fuels

foundations of each tower, and a similar length conducts electricity to the transformers at the base of each tower. Wind turbine manufacturers are steadily increasing the amount of energy that can be produced by wind towers, from 1.5 MW to 2 MW and beyond. GE currently has a 3.6 MW prototype.

THE FUTURE OF WIND POWER

One major factor affecting the development of wind power is the extension of federal production tax credits. Since 2000, tax credits that encourage development have periodically expired, only to be extended, creating uncertainty in the market. But in 2005, Congress extended eligibility before it expired, granting credits for production through 2007. New initiatives at the state level also have encouraged investment in wind power. "Many states now require utilities to generate more power through renewable energy," says Kathy Belyeu, AWEA. New York State's goal is to create 25 percent of its power through renewable sources by 2010. Because hydroelectric power already generates 17 percent of New York's energy, only 8 percent needs to be added.

Experts see a very bright future for wind power. "We are headed for a day where we have 20 percent of the nation's power coming from wind," concludes Brian Evans, senior vice president, Renewable Energy Systems America, Inc. "Fossil fuels won't last forever, and this is a clean way of generating power." *Cu*

Faraday in 1831. It's used for the wire windings in the stationary portion (stator) of the motor, due to its superior electrical conductivity. The more windings, the more efficient the motor.

Copper is extensively used also in large motors (500 hp and above) for bars in the rotating portion (rotor) of the motor to achieve maximum efficiency. However, its use in the rotors of smaller motors has not been practical due to die-casting limitations. For these smaller motors, aluminum, a less efficient conductor, has been used in the rotor assembly.

For many years, engineers have looked at ways to incorporate copper into the armatures, or rotors, of these smaller motors as a way to increase their efficiency and reap substantial energy savings. But, for a variety of reasons, these initiatives were met with limited success.

Now, thanks to some innovative, groundbreaking research by the Copper Development Association (CDA), the International Copper Association (ICA), and a number of corporate partners including Siemens Energy & Automation, FAVI S.A. and SEW Eurodrive, the die-cast copper rotor is playing a key role in revolutionizing electric motors.

According to John Caroff, Siemens' marketing manager, "We are excited by the potential for electric motors with copper rotors in the North American market. Years of research into copper die-casting technology has led to this breakthrough where we can offer electric motors with reduced weight, increased energy efficiency, and which can run cooler than their aluminum counterparts for extended service life." Siemens recently introduced several lines of ultra-efficient motors to the North American market, with other manufacturers expected to follow suit.

WHY COPPER?

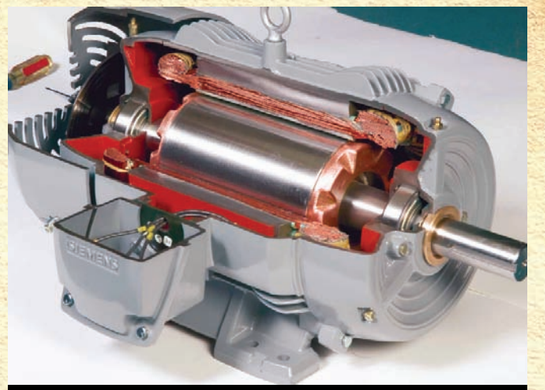
Most motor rotors in operation today are made from aluminum using a die-casting process where the molten metal is poured into a die, or mold, and cooled. In use since the 1930s, aluminum die-cast rotors are easily manufactured and widely used.

Copper rotors offer a number of advantages over their aluminum counterparts. Because less volume of copper than aluminum is required for a given motor, a smaller, lighter motor can be manufactured offering equivalent performance. This can lead to a significant reduction in long-term operating costs. Likewise, using the same volume of copper as aluminum in the rotor of a given motor can result in a motor of the same size but with greater performance.

Another advantage of copper is that high efficiency motors with copper rotors operate at lower temperatures then their aluminum counterparts. A general rule of thumb among motor designers is that motor life doubles with each 10°C reduction in operating temperature. This is critical, as increased motor maintenance and replacement costs are directly related to higher operating temperatures. Operating costs over the lifetime of the motor are reduced, while the motor itself lasts longer, further enhancing the investment in the copper technology.

ENDLESS POTENTIAL

As energy costs continue to spiral, everyone is looking for ways to conserve. Die-cast copper rotors can help boost motor efficiency by one to five percentage points. Even small increases in motor efficiency can lead to billions of dollars of savings and less dependence on fossil fuels. *Cu*



Cross-section of copper rotor in an electric motor

From Copper to Bronze to Conquest

The word copper comes from the Latin word cuprum, which was used to describe the unique bluish-green metal that dotted the landscape of the ancient world and greatly influenced the primary cultures of Mesopotamia, Egypt, Greece and Rome. Neolithic humans about 10,000 years ago first used native copper as a substitute for stone. A copper pendant discovered in what is now northern Iraq has been dated to about 8700 B.C. For nearly five millennia copper was the only metal known to man, and thus had all the metal applications.

Evidence of copper's use throughout history can be found in artifacts from around the globe — from Asia and the Middle East to South America and even the present-day United States (over 7,000 years ago, Native Americans mined and used copper in what is now Michigan). As a result of copper, mankind's "oldest metal," the art and craft of metalworking spread into almost every facet of life, from currency to tools to ornaments and, especially, weaponry.

THE NEED FOR BRONZE

For ancient artisans, copper's malleability in its natural, pure state was a major attribute, but this quality had significant drawbacks when it came to producing armaments. Swords and spears made from copper could be easily sharpened, but they were unable to hold their edge for very long.

Bronze tools and weapons found in modern-day Turkey

This led to experimentation and, ultimately, to the creation of alloys that combined the best qualities of two or more metals. When early metalsmiths discovered more durable metal with performance attributes beyond anything they had ever known, the Bronze Age began. It is believed that bronze (an alloy of copper and tin) was first created over 5,300 years ago in Mesopotamia (modern-day Iran).

The discovery of bronze and brass (a fusion of copper and zinc) had a twofold effect on ancient societies — it fostered both trade and warfare. As a result, these immeasurably useful metals became basic requirements needed to protect, improve and expand ancient civilizations. The need for copper, tin, zinc and other metals inspired societies and led to a number of extraordinary events that forever changed the course of the world.

CPUs Reach Their Potential through Copper

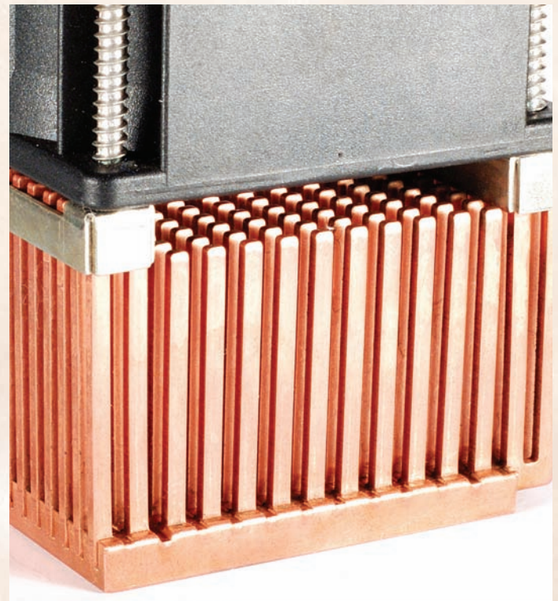
The Hottest Computers Depend on Copper

A transistor is a device that amplifies an electrical signal or opens and closes a circuit. The very first microprocessors in 1971 had 2,300 transistors. The most recent generation of processors boasts about 1,720,000,000 transistors, nearly a 750,000 times increase! In a few years, some 10 billion are expected to reside on a single chip.

Each transistor generates heat during operation. The more transistors integrated on a chip, the more heat that's generated. Most processors are mounted onto circuit boards made from cellulose, a synthetic plastic with a relatively low melting temperature. In many cases, enough heat is generated from the processor to potentially melt and destroy the circuit board. This poses a unique problem — how to remove this excessive heat and keep the processor operating at peak efficiency? The answer lies in copper heat sinks.

Heat sinks are used to conduct heat away from an object. They feature a flat surface with various tube and/or fin protrusions to help increase heat dissipation. Most personal computers in the past have used a combination of fans and aluminum heat sinks with good success; however, aluminum is a less efficient thermal conductor and cannot meet these new and increasing heat demands like copper.

Copper's thermal conductivity, or capacity to conduct heat, is about 60 percent greater than that of aluminum, so copper can remove much more heat more quickly. The more heat removed from the processor, the more efficiently it will operate, with less potential for damage to other critical components. Copper heat sinks also help offset the need for computers to integrate cooling fans, significantly reducing noise, as well as energy consumption. In addition, copper is being used instead of aluminum in the electrical pathways of the millions of transistors on a chip. Not only do these new-generation chips run cooler, they perform faster. *Cu*



Copper heat sink is used to remove heat away from internal computer components

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