Abrasives

Besides more usual applications, abrasives have been used to grind animal-gut sutures and guitar strings to a uniform thickness, saw frozen fish into fish sticks, and round off toothpicks.

Since the beginnings of civilization, abrasive materials have been used to grind, cut, polish, or smooth surfaces. Abrasives are harder than the materials they abrade and work by a fracturing or shearing action to erode the softer substance. As early as 25,000 to 15,000 B.C., weapons and utensils were shaped and polished by rubbing them with sand or against harder stone. Iron Age workers fashioned iron or bronze implements by rubbing stone against them. Ancient Egyptian tomb drawings show vases and jewelry being polished with powdered abrasives. Natural abrasive stones (such as sandstone) were later shaped into wheels for grindstones and millwheels, and into smaller blocks for sharpening knives, axes, scythes, and woodworking tools.

Abrasives were also often crushed into a powder and mixed with a liquid or a paste, then pressed into wheels or blocks, or glued to paper, cloth, or other soft material. A 13th century document from China describes the use of natural gums to glue bits of crushed seashell to parchment for an early form of sandpaper. In about the 15th century, the Swiss began to coat paper with crushed glass for the same purpose.

Many natural abrasives have been used throughout history. Flint, a form of quartz (SiO_2), is the abrasive most commonly used for sandpaper. Uncrushed sand with a high quartz content is frequently used in sandblasting processes and in sawing and polishing soft stone, such as marble. Pumice, hardened lava foam, is another common natural abrasive and is widely used in metal polishes and scouring powders.

Diamonds, vastly superior to stone or sand because of their hardness, were first mined around 1700 B.C. in India. (See last month's Historical Note on diamonds.) Near the start of World War II, diamond grinding wheels were bonded with ceramic, resins, or powdered metal. This innovation contributed to a great increase in industrial output.

Emery, a natural form of aluminum oxide mixed with magnetite (the black magnetic iron oxide, Fe_3O_4), is known to have been used as an abrasive beginning around 100 B.C. The Bible mentions a stone called *shamir*, which was probably emery. The highest grade emery is found at Cape Emeri on the island of Naxos in Greece, and in Turkey. Another deposit was found in Peekskill, New York, though this emery is of poorer quality.

In 1873 a worker from the Norton and Hancock Pottery Company in Worcester, Massachusetts, won a jug of beer by betting that he could create a grinding wheel by mixing emery with potter's clay and firing it in a kiln. It took him three tries, but he succeeded, establishing the process of making vitrified grinding wheels, which proved far superior to the glue-bonded products previously available.

In modern emery wheels or emery boards, much of the actual "emery" is now a synthetic abrasive. Currently, natural emery is most commonly used as a nonskid component in floors, stair treads, and pavements.

In 1825 another form of natural aluminum oxide—corundum—was discovered in India. Corundum is the *natural* abrasive closest to diamond in hardness. India was the first to use an artificially bonded grinding wheel—corundum bonded with gum resin.

Natural abrasives, though, have limited versatility in advanced processes, lacking the fracture strength, wear resistance, and hardness to mass-produce spindles, bearings, and other machine tool elements. Development of the electric furnace, though, allowed materials to be easily heated to the higher than 2000°C (3600°F) temperatures required for forming many synthetic abrasive materials.

In 1891 in Monongahela City, Pennsylvania, Edward Goodrich Acheson was the first to use the electric furnace to produce crystals of silicon carbide. Acheson heated silica and coke in an electric furnace. He found that the resulting intergrown mass of greenish black crystals could scratch glass. He named the new material "carborundum." It was first commercially used for polishing gemstones.

Synthetically produced carborundum crystals are superior to natural corundum and emery in hardness, toughness, and fracture strength. Carborundum remains the hardest common *manmade* abrasive, second only to diamond.

The introduction of general-purpose grinding wheels made with carborundum greatly improved manufacturing operations. Though relatively friable, carborundum is widely used in grinding cast iron, nonferrous metals, and nonmetallic substances like ceramics, rubber, and leather.

In 1897 at the Ampere Electro-Chemical Company in Ampere, New Jersey, Charles Jacobs manufactured fused aluminum oxide using a new tempering technique and rock bauxite. Hard enough and strong enough to be used as an industrial abrasive, the fused aluminum oxide was first sold on a commercial scale in 1901. It is so uniform and efficient that it has replaced carborundum in many applications.

Manmade diamonds—with all the desirable properties of natural diamonds—became widely available in 1955 through a high-pressure, high-temperature process developed by the General Electric Co. Synthetic diamonds are now extensively bonded in thin layers to metal or resinoid wheels as abrasive grains. Though still expensive, synthetic diamonds are among the most widely used abrasives.

Other abrasive materials include glass pellets and steel in several forms. Steel wool is good for removing corrosion from metal surfaces and smoothing them. Steel shot and glass pellets are used for peening or work hardening a surface. Steel grit is used for blasting and as a roughing abrasive for finishing granite and other stone.

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FOR FURTHER READING: *Abrasive Grains and Their Uses* by Heywood Johnson, Cleveland, OH, 1943; and *A Handbook on Abrasives and Grinding Wheels* by The Norton Company, Worcester, MA, 1954.

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