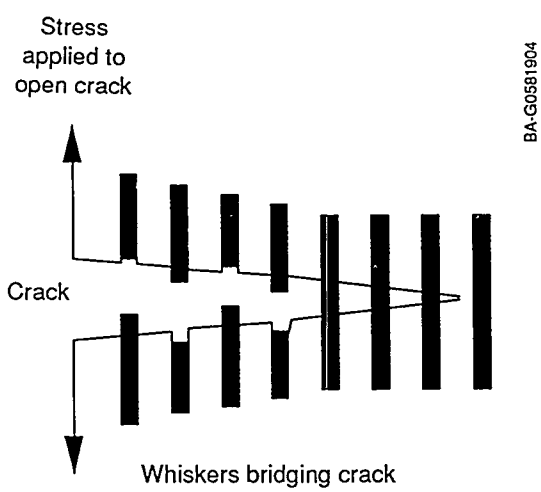
mass production; Armada Research Corporation, for heating elements in electric appliances and industrial furnaces; Metallamics, for tool and die components; and Valley-Todeco, for aircraft fasteners.

Separation of Impurities from Molten Metals

The manufacture and fabrication of steel and other metallic materials is often complicated by the presence of nonmetallic particulates in the solidified metals. In the steel industry, the movement toward thinner castings requires more stringent control of the particulate content of the metal. Earlier casting techniques that used large ingot molds and, later, continuous casting, required hot-rolling reductions followed by cold rolling to produce sheet material. This large amount of energy-intensive mechanical working was sufficient to break up and disperse the particulates and make them relatively harmless. In contrast, newer near-net-shape casting technologies that are less energy intensive do not require such substantial reductions; therefore, the particulates remain as originally formed, with possible deleterious effects to the metals' properties.

To alleviate the problems associated with particulate contaminants in metals, DOE developed a magnetohydrodynamic separator for use with liquid metals. Early work confirmed the value of using the molten metal as a current-carrying conductor passing through a magnetic field. The resulting force on the metal causes it to act as if it had a higher density. This makes the nonconducting particulates flow quickly to a region where they can be skimmed or separated from the metal.

Successful experiments were performed using molten aluminum and either alumina or silicon carbide as the impurity particles. Two patent applications for the process were filed, and industrial interest in the process is growing. Further technology development is being undertaken by the DOE Steel Initiative.



Whisker-reinforced ceramic composites increase resistance to fracture at elevated temperatures.

High-Purity Silicon Powder Process

Traditionally, the production of ceramics has relied on comminution to reduce materials to a uniform particle size. This is done through grinding and crushing operations that are typically less than 1% energy efficient.

Now a high-purity, low-cost silicon powder process, developed by the Oak Ridge National Laboratory and Advanced Refractory Technologies, eliminates most of the comminution required in producing ceramics. In the new process, powder is produced using a rotary kiln technique. Quantities of sample powder have been distributed to major ceramic component producers for manufacturing evaluation and properties testing. Projected material costs for this pure silicon carbide powder are estimated at one-third to one-fourth of current costs, making high-temperature ceramic recuperators much more economical and providing a higher-quality product.

Whisker-toughened Ceramic Composites

Ceramics such as alumina have excellent wear resistance and high-temperature strength, but are too brittle for wide commercial use. DOE researchers have developed a novel approach using "designed microstructures" in brittle ceramics that provides major gains in fracture resistance. The technique produces a ceramic composite reinforced with silicon carbide whiskers, disproving the conventional wisdom that only long fibers would work. To date, this new technology has yielded nine licensing agreements with the private sector.

Based on the results of research conducted with alumina composites, further DOE-supported efforts have produced a new, high-strength structural material based on reinforced molybdenum disilicide. This