

HOT

FORGING PROCESS

► **A new class of materials has been patented for use in the hot forging of ceramic compositions.**

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Synthetic Hybrid Rock Composition, Method, and Article Formed by the Method” (U.S. Pat 8,216,955) is a composition patent that was issued to Ceramext LLC on July 10. The patent includes: “a composition comprising clasts fused together by a glass phase, wherein the glass phase is solid and directly bonds to the clasts, wherein the glass phase comprises a crystallite, wherein at least a portion of the composition has plasticity such that the composition is plastically deformable in a certain temperature range.”

In the U.S. alone, hundreds of millions of tons of usable waste are disposed of every year in landfills. Ceramext® technology can transform even low-cost waste materials such as mine tailings and coal fly ash into multiple ceramic compositions, including high-quality floor, wall and roof tile; building cladding; and brick and pavers.

Ceramext has developed hot-forging methods and advanced ceramic compositions for which some patents have been granted and others are pending. Ceramic products made with

this technology can contain up to 100% recycled content and provide an opportunity for highly sustainable manufacturing.

Hot-Forging Ceramics

This patent-pending method of ceramic production relies on the plastic nature of certain materials that have been heated to about 1000°C, partially melted, and then pressed with about 1000-2000 psi (see Figure 1). The raw materials for these ceramics can originate from most mine tailings, quarry fines, coal fly ash or other waste materials. No binders are required, and up to 100% of the waste material can be used. In addition, the expensive spray drying step is eliminated. New ceramic compositions using this hot-forging technology have also been patented.

Pilot production to date has produced quality porcelain-grade tile that exceeds the strength of typical commercial Italian porcelain tile. With minor modifications, conventional green ceramic presses and electric or gas roller kilns can be used for hot forging. As shown in Figure 2, a heated green tile is placed

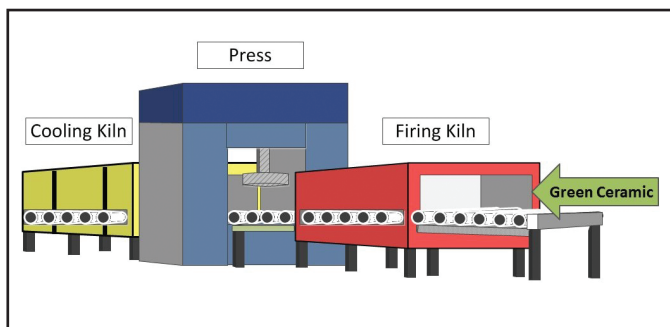


Figure 1. The hot-forging process.

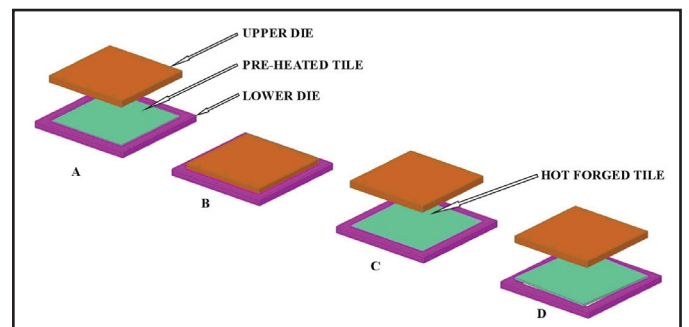


Figure 2. Hot forging within the cavity.

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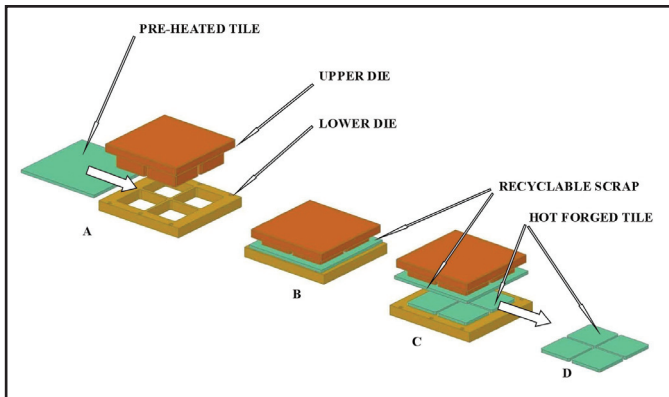


Figure 3. Multiple tiles can be punched out from a larger ceramic sheet.

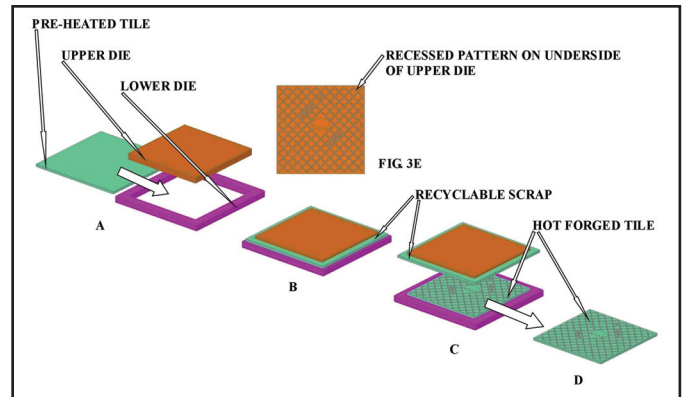


Figure 4. A raised pattern can be created on the hot-forged tile.

within the cavity of a die, pressed, and then ejected. (Generally, a cold steel die is used.) As the die slightly expands from the heat of the ceramic, it facilitates the ejection of the hot-forged tile.

Figure 3 (p. 14) illustrates multiple tiles being punched out from a larger ceramic sheet placed above the cavities of the lower dies. The un-pressed “picture frame” scrap can also be recycled in the ceramic manufacture circuit. Figure 4 (p. 14) shows an example of a raised pattern on the hot-forged tile. Curved parts such as shaped terracotta roof tiles can also be made by this process, even from flat stock. Finished parts with integrated assembly details—such as interlocking edges, holes for fasteners, or decorative textures—can be directly manufactured during the pressing operation.

The quality of the green tile prior to heating is not as important as it is with conventional ceramic manufacturing. Any cracks or breaks that may occur in the tile during preheating are completely healed in the hot-forging operation. Molten material in the tile flows and fills in cracks, welding together breaks in the tile during pressing and resulting in a strong, crack-free tile.

Ceramics from Mine and Quarry Tailings

Commercial ceramics can be manufactured with this technology from about 90% of the rocks within the earth’s crust, while the other 10% can be blended in as well. For example, pure limestone or serpentine do not include enough glass-forming materials at usable temperatures for plastically formable hot-forged ceramics; they must be blended in with other wastes. Mine tailings and quarry fines have the added value of generally being very fine particles (less than about 200 microns). This can help manufacturers avoid grinding, which can be an expensive procedure for standard ceramic feedstock preparation that cannot use such materials.

With the new technology, extensive studies have been made in successfully creating high-quality ceramic tile from mine tailings and development rock fines of the Idaho-Maryland gold mine in Grass Valley, Calif. In contrast, when using conventional methods on these waste materials, only non-commercial sub-standard tiles could be made, even with extensive feedstock pretreatment. The

crushed rock used in these pilot tests were combinations of meta-volcanic, meta-sedimentary, sulfide-bearing quartz veins, as well as serpentine.

Ceramext technology can make viable those mines that have no suitable land nearby for tailings disposal. Even when land is available for tailings disposal, advanced technology can save the cost of expensive tailings impoundments and transportation while preventing the potential problem of acid leaching from contaminants into nearby water systems. In addition, the mine tailings can represent a low-cost source of feedstock for tile manufacturers.

Several thousand square feet of high-quality tile were produced using the Ceramext process and quarry fines from crushed granitic rock from a quarry in central California. This quarry produces thousands of tons per day of waste fines from its aggregate crushing operations. The operation is running out of locations to store the otherwise unusable fines. In an operation in Nevada, fines from a facility producing kitty litter from volcanic rocks produced a unique commercial-grade tile using the Ceramext process.

Ceramics from Coal Fly Ash

High-quality, porcelain-grade ceramic products from coal fly ash can also be produced using the technology. A variety of fly ash has been successfully used for ceramic tile production, including ash not suitable for cement manufacturing. Because of the unique material compositions made with the process, the strength of this tile exceeds the strength of typical commercial Italian porcelain tile.

More than 40 types of power plant fly ash tested for suitability as feedstock have been successfully qualified, including anthracite, bituminous, lignite and biomass ash, each of which can make high-quality ceramic products generally using 100% ash (no binders are required). All ashes can be mixed with other ashes or with other fine particle wastes such as most mine tailings and quarry fines.

Class C fly ash can also be used for producing Ceramext products, as well as the Class F fly ash more commonly used for concrete. With Class C fly ash, the self-cementing properties are

often helpful in producing a stable green product prior to firing and pressing. The higher alkali contents often contribute to the necessary glass part of the composition at relatively lower temperatures.

Fly ash that does not qualify for concrete production because of excessive loss on ignition (LOI) or particle size can still be used with the technology. The unburned coal in the fly ash is oxidized at about 750°C for a few minutes prior to hot forging at higher temperatures. If mercury is present in the unburned coal, it volatilizes at firing temperatures and may have to be collected in conventional retorts or carbon filters; however, the amount of total gaseous emissions and temperatures will be much lower than during the initial firing of a coal power plant.

Particle size, which is critical for cement use, is not a problem for Ceramext technology, even for larger ash par-

ticles of 200 microns. Ash color is also not a problem and generally changes upon firing at production temperatures.

Pilot plant production to date using coal fly ash has primarily been with floor and roof tile and wall cladding. The green, unfired tile is generally heated to about 750°C to oxidize unburned coal. It is then raised to higher temperatures, hot forged with cold dies and then run through an annealing kiln. The product can then be polished, glazed, or left in its existing state, which is often preferred by many architects because of its visual qualities.

Future Potential

Actual production costs are still being evaluated. Preliminary estimates are that energy costs will be significantly lower than with conventional ceramic production. Favorable locations for new facilities using this technology

can be determined through a number of factors, including close proximity to waste product production and disposal sites, population and building product consumption areas, and power sources (generally electric or gas). A modern, fully automated ceramic factory using the Ceramext technology is expected to experience capital costs that are less than a conventional ceramic tile factory.

This technology minimizes negative environmental impacts; conserves energy and natural resources; and can be beneficial for job creation, communities and consumers. Waste materials like mine tailings and coal fly ash, which would otherwise be deposited in landfills, can be used to produce high-quality ceramic products. 🌐

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