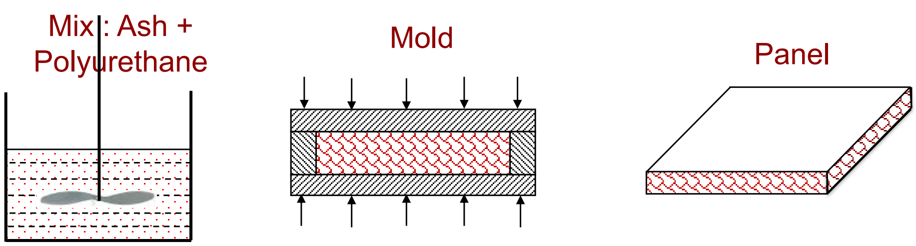
Coal Ash-Composites

What are Ash-Composites?

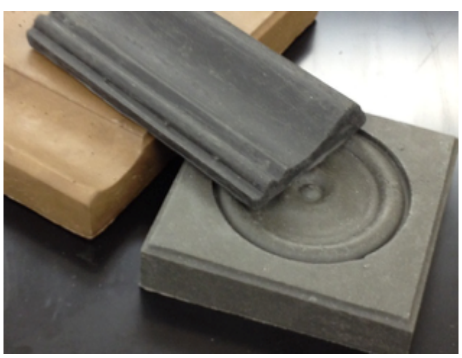
Materials that encapsulate the fine inorganic particles in coal ash with a polar polymer so that the minerals in the fine particles are safely prevented from being leaching out when in contact with water. Ash-Composites are also defined as materials that are made from majority of ash and a smaller percentage of polymer, and sometimes reinforcing fibers, with additives to aid high ash loading, and giving self and fast curing.

Processing

There are several ways the Ash-Composites can be produced; the common one used in the laboratory is mixing dry fly ash powder with liquid polymer ingredients and additives. The difficulty of incorporating a very high percent of ash was overcome by using selected 2-part liquid polyurethanes, surfactants, compatibilizers, water, and catalysts. The ash and polymer are mixed together in a high-speed mixer for minutes and poured in a controlled volume rubber mold. The mold can handle the high pressures of foaming, which is used to control the density of the composite part. When two-part polyurethane reacts, it generates its own heat and cures itself. The whole process takes about 30 minutes, depending on the type of curing agent used. Steps of the processes are shown in Figure below.



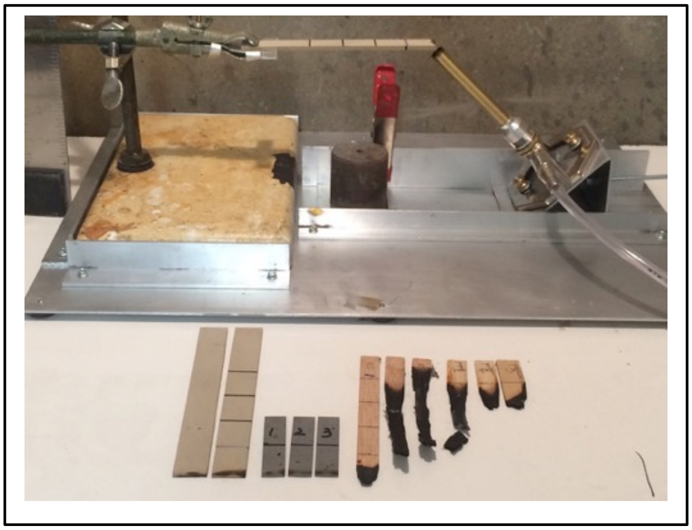
The rubber mold is designed to give a finished part, so that no trimming or machining is required. Grain, artistic 3D designs, cut-outs, and other features can be included in the mold. The figure below shows a panel (that could be used as moisture resistant wall board, lightweight ceiling panel and boards for a number of applications), decorative molding, and a solid block that can be used for many heavy weight applications.



The process is versatile and can be adapted into a broad range of products with relatively minor changes to the formulation, e.g. to produce very light weight parts, water is added to the formulation, and the water reacts and produces carbon dioxide, which foams the material, and can greatly reduce the density. Heavy parts like the ash-storage blocks, with 90 lb./cu ft density or flame-resistant lightweight foam, with 1 lb./cu ft density can be produced, both with high ash loadings. For increased toughness, strength and stiffness, chopped glass or other fibers can be added. Similarly, mass colorants and weathering stabilizers can be mixed in the formulation, or can be added after the part is made, using spray or roller-applied paint and coatings.

Physical and Mechanical Properties:

Variations of mechanical properties such as surface hardness, compression, impact and flexural properties can be measured. The density has a large influence on the properties, and can be varied from, e.g. 0.10 to 1.4 g/cc, corresponding to a Shore D hardness of 30 to 90, compression strength from 50 to 5,000 psi and the flexural strength from 100 to 3,500 psi. This shows that a large variation of density and mechanical properties can be achieved, and the density also has a large influence on material cost.

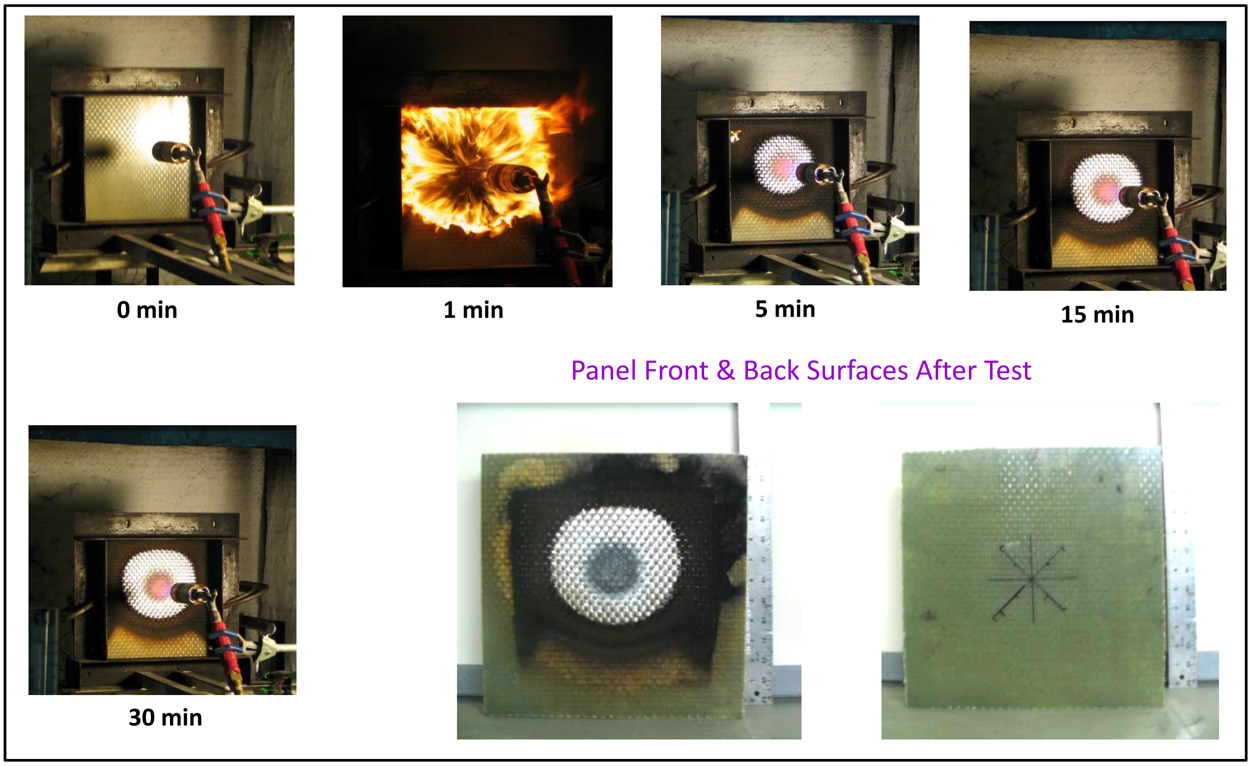


ASTM D635 Fire Test

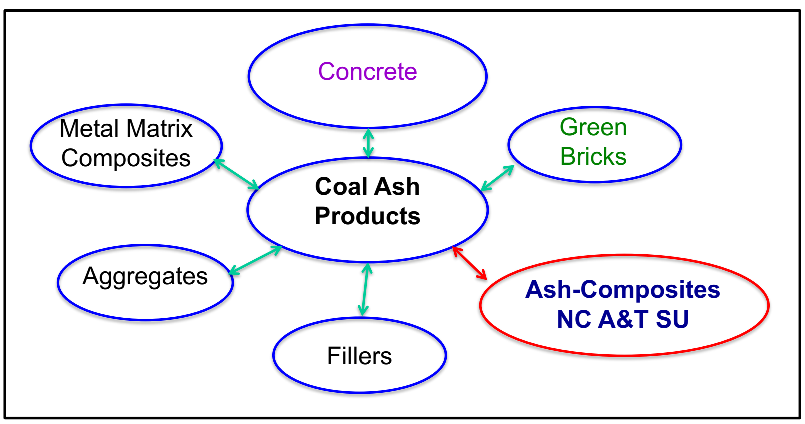
The fire apparatus Figure shows the ASTM D635 test conducted on some Ash-Composites, wood and plywood test samples. The wood samples completely burned, ply-wood samples partially burned, and some Ash-Composite samples did not ignite, same ignited and extinguished once the flame was removed. This demonstrates Ash-Composites high resistance to fire.

David Taylor Naval Lab Burn-Through Test (MIL 2031): This test is designed to demonstrate the fire containment in glass/vinyl ester sandwich panels for ship structures that U.S. Navy uses. The figure below demonstrates the burn-through test of a sandwich panel made of Ash-Composite. The panel was a 12x12x2 inch and the face sheet was 4-ply-thick open roving glass fabric and vinyl ester matrix over an Ash-Composite core. The test was conducted according to MIL standard 2031 protocol. The burner was held at a distance of 6 inches from the panel with a heat flux of 170 kW/m^2 for 30 minutes.

The images of the panel at 0, 1, 5, 15 and 30 minutes after the burner was ignited are shown. The glass/vinyl ester composite face sheet on the front side of the panel burned very quickly (1 minute) and ignited like an inferno. By the end of 5 minutes all the vinyl ester resin was burned away and only glass fabric and some vinyl ester char remained at the edges – the Ash-Composite core still remained. For the next 30 minutes, the flame impinges directly on the surface of the Ash-Composite core. The picture of front and back surfaces shows that the back surface had no impact on what happened on the front, i.e. the Ash-Composite core did not allow burn-through.



Additional Beneficial Use of Coal Ash:



With introduction of Ash-Composite, we extended the use of coal ash to polymer-based particulate composites (see accompanying Chart).This composite is self-curing using the internal chemical energy, the foaming of the polymer helps to control the density and mechanical properties, the high percentage of ceramic particles makes the composite fire- and insect-resistant, and can be as hard as cement/concrete or rubbery, has low electrical and thermal conductivity, which offer applications in insulation.

Products:

The application products we are envisioning are for buildings, power utilities, and infrastructure products. Some product development is currently underway with commercial clients.