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(54) **Title**: HIGH TEMPERATURE LIGHTWEIGHT THERMAL INSULATING CEMENT AND SILICA BASED MATERIALS

(57) **Abstract**: A high temperature lightweight thermal insulating material is formed from a mixture that includes cement or silica sand, water and a foaming agent. The foaming agent can be an aluminum powder or a surfactant. The insulating material has a maximum use temperature greater than about 600 degrees Celsius.

HIGH TEMPERATURE LIGHTWEIGHT THERMAL INSULATING CEMENT AND SILICA BASED MATERIALS

Field of Invention

The present invention relates generally to the field of composite materials and, more particularly, to high temperature lightweight thermal insulating cement and silica based materials.

Background Art

None.

Summary of the Invention

The present invention provides a high temperature lightweight thermal insulating cement or silica based material ("insulating material") formed from a mixture that includes cement or silica sand, water and a foaming agent. The foaming agent can be an aluminum powder or a surfactant. The insulating material has a maximum use temperature greater than about 600 degrees Celsius. The maximum use temperature can be up to about 900 degrees Celsius when Ordinary Portland cement (OPC) is used. The maximum use temperature can be up to about 1000 degrees Celsius when silica sand is used. The maximum use temperature can be up to about 1800 degrees Celsius when calcium aluminate cement (CAC) is used.

In addition, the present invention provides an insulating material formed from a mixture that includes cement or silica sand in an amount of about 25 to 90% of weight wet, water in an amount of about 10 to 70% of weight wet, and a foaming agent. The foaming agent can be an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or silica sand, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water. The insulating material has a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

Moreover, the present invention provides a method for manufacturing an insulating material by mixing cement or silica sand with water, foaming the mixture using a foaming agent, pouring the foamed mixture into a mold and allowing the foamed mixture to rise to form the insulating material, and removing the insulating material from the mold.

The insulating material can be cured or heat treated. The insulating material has a maximum use temperature greater than about 600 degrees Celsius.

Furthermore, the present invention provides a method for manufacturing an insulating material by mixing cement or silica sand in an amount of about 25 to 90% of weight wet with water in an amount of about 10 to 70% of weight wet, foaming the mixture using a foaming agent (an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or silica sand, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water), pouring the foamed mixture into a mold and allowing the foamed mixture to rise to form the insulating material, and removing the insulating material from the mold. The insulating material can be cured or heat treated. The insulating material has a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

The present invention is described in detail below with reference to the accompanying drawings.

Brief Description of the Drawings

Further benefits and advantages of the present invention will become more apparent from the following description of various embodiments that are given by way of example with reference to the accompanying drawings:

None.

Description of the Invention

While the making and using of various embodiments of the present invention are discussed in detail below, it should be appreciated that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments discussed herein are merely illustrative of specific ways to make and use the invention and do not delimit the scope of the invention.

To facilitate the understanding of this invention, a number of terms are defined below. Terms defined herein have meanings as commonly understood by a person of ordinary skill in the areas relevant to the present invention. Terms such as “a”, “an” and “the” are not intended to refer to only a singular entity, but include the general class of which a specific example may be used for illustration. The terminology herein is used to describe specific embodiments of the invention, but their usage does not delimit the invention, except as outlined in the claims.

Ordinary Portland cement (OPC) or calcium aluminate cement (CAC), in its wet state with water added before setting, can be foamed up with reacting aluminum powder or the use of a surfactant. The more the wet material is foamed by adding higher amounts of aluminum or surfactant, the lighter weight it will be and as a result the more insulating the set and dried material will be. Following setting and drying, when based on OPC, the insulating material will have a maximum use temperature up to approximately 900 Celsius, and when based on CAC, the insulating material will have a maximum use temperature up to approximately 1800 Celsius.

Silica sand in a mixture with water and calcium oxide can be foamed with reacting aluminum powder or by the use of a surfactant. The more the wet material is foamed by adding higher amounts of aluminum or surfactant, the lighter weight it will be and as a result the more insulating, the set and dried material will be. Following gelation, foaming, setting, autoclaving and drying, the insulating material will have a maximum use temperature up to approximately 1000 Celsius.

The cement or silica sand binder can be used in combination with a multitude of additive materials such as sand, gypsum, silica fume, fumed silica, plaster of Paris, fly ash, slag, rock, fiber (e.g., glass fibers, cellulose fibers polyvinyl alcohol fibers, polypropylene fibers, or a combination thereof), etc. Note that the silica sand is initially ground as a wet slurry in a ball mill to a fineness less than 100 microns.

To make the foamed cement or silica water mixture, the water to solids ratio by weight is typically in the range of 0.2 to 2.0. When foaming mixtures with lower water to solids ratios in the range of 0.2 to 1.0, these mixtures can be made more fluid by adding a conventional high range water reducer (HRWR) in an amount of 0.25-4.0% of the cement or silica sand weight.

In one embodiment, the foamed mixture (cement-water or silica-water) is sometimes stabilized by the addition of a rheology modifying agent. The rheology modifying agent will typically be added in an amount of 0.1 to 5% of the cement or silica sand weight.

The rheology-modifying agents fall into the following categories: (1) polysaccharides and derivatives thereof, (2) proteins and derivatives thereof, and (3) synthetic organic materials. Polysaccharide rheology-modifying agents can be further subdivided into (a) cellulose-based materials and derivatives thereof, (b) starch based materials and derivatives thereof, and (c) other polysaccharides.

Suitable cellulose-based rheology-modifying agents include, for example, methylhydroxyethylcellulose (MHEC), hydroxymethylethylcellulose (HMEC), carboxymethylcellulose (CMC), methylcellulose (MC), ethylcellulose (EC), hydroxyethylcellulose (HEC), hydroxyethylpropylcellulose (HEPC) and hydroxypropoylmethylcelluose (HPMC), etc.

Suitable starch based materials include, for example, wheat starch, pre-gelled wheat starch, potato starch, pre-gelled potato starch, amylopectin, amylose, seagel, starch acetates, starch hydroxyethyl ethers, ionic starches, long-chain alkylstarches, dextrins, amine starches, phosphate starches, and dialdehyde starches.

The currently preferred rheology-modifying agent is hydroxypropylmethylcellulose, examples of which are Methocel 240 and Methocel 240S.

When using aluminum as a foaming agent, the aluminum is typically in a particle size below 100 microns. The aluminum can be added as a dry powder, or as a paste in a mixture with water or diethyleneglycol and for some applications can also be used in a retarded version. The preferred aluminum is purchased from the company Eckart (a German company). Typically, the aluminum is added in an amount of 0.05-3% by weight of the cement or silica sand weight.

When foaming OPC cement based mixes, the water and cement are typically mixed first for 1-5 minutes where after the aluminum is added and mixed for 5 seconds to 1 minute. When foaming CAC cement based mixes, the water, cement and rheology modifying agent are typically mixed first for 1-5 minutes, where after calcium oxide, calcium hydroxide, sodium hydroxide or similar pH increasing material is added in an amount of 0.5 to 10% of the water weight and mixed for 5 seconds to 1 minute, and finally the aluminum is added and mixed for 5 seconds to 1 minute. When foaming the silica sand based mixes, the water, sand and rheology modifying agent (when used) are typically mixed first for 1-5 minutes where after the calcium oxide, calcium hydroxide, sodium hydroxide or similar pH increasing material is added in an amount of 0.5 to 40% of the water weight and mixed for 1-5 minutes, and finally the aluminum is added and mixed for 5 seconds to 1 minute.

Following mixing, the mixture is poured into the mold system, which can be in the shape of a pipe, half-pipe or block and is allowed to rise (due to the formation of hydrogen bubbles as the aluminum reacts with the hydroxyl ions) and fill the mold over the next 0.5 to 2 hours.

When using a surfactant as the foaming agent, the surfactant is specially chosen to have a high degree of foam stability and to generate the right bubble size. One such air entraining agent is sold by the company Sika. The surfactant is typically added in an amount of 0.05 to 2.0% of the weight of water. When foaming OPC or CAC cement based mixtures, the water, cement, surfactant and rheology modifying agent are typically mixed for 1 to 10 minutes to foam up the mixture. When foaming the silica sand based mixtures with a surfactant, the water, sand and rheology modifying agent are typically mixed first for 1-5 minutes, where after calcium oxide, calcium hydroxide, sodium hydroxide or similar pH increasing material is added in an amount of 0.5 to 40% of the water weight and mixed for 1-5 minutes, and finally the surfactant is added and mixed for 1 to 10 minutes to foam up the mixture. Following mixing, the foamed mixture is poured into the mold system.

Following hardening of the cement based mixtures, the wet material will be de-molded and can be cut to size, trimmed, sanded or routed into a specified shape (e.g., pipe, half-pipe, block, panel, etc.). Following gelation and development of sufficient green strength of the silica based mixtures in the mold system (2 to 10 hours), the wet material is de-molded and can be cut to size, trimmed, sanded or routed into a specified shape (e.g., pipe, half-pipe, block, panel, etc.).

To develop the final 28 days strength of products made from OPC cement, the product is either allowed to sit around for 28 days in a humid environment, or the strength development can be accelerated within 24-48 hours by heating either by its own internal heat development or by steam curing such as is conventional in the State-of-the-Art.

Products made from CAC cement will achieve its final strength in 24 hours and does not require additional curing.

Products made from silica sand are placed in an autoclave for 15-48 hours at a temperature of 150-200 Celsius and a pressure of 10-20 Bars to develop final strength. This treatment converts the gelled silica into the cementitious reaction products Tobermorite and Xonotlite that provides strength.

After achieving the final strength development, the product is dried to generate the finished lightweight insulating composite material. The hardened composite material can be cut to size, trimmed, sanded or routed into a specified shape (e.g., pipe, half-pipe, block, panel, etc.).

In one embodiment, the finished product can be made water repellent by spraying the product with water or solvent based silane. Such product is typically sold by BASF.

The finished lightweight cement or silica based insulating composite will have a density in the range of 0.1-1.0 g/cm^3, a compressive strength in the range of 30-3000 PSI (2.068 to 206.8 Bar) and a heat conductance in the range of 0.05-0.3 W/(m·K).

Material	
Component	Wt. % Range of Wet
Cement (OPC or CAC) or Silica Sand (finely ground)	25 to 90
Water	10 to 70
Secondary Material (optional): Sand, rock, fly ash, slag, silica fume, calcium carbonate, gypsum, etc.	0 to 50
Reinforcement Fiber (optional)	0 to 20
Rheology-Modifying Agent of Cement (optional)	0 to 4.0
Foaming Agent: Aluminum Powder of Cement, or Surfactant of Water	 0.5 to 3.0 0.05 to 2.0
CaO, $CaOH_2$, NaOH or Similar of Water (optional)	0.5 to 10

The cement or silica sand can be 25%, 26%, 27%, 28%, 29%, 30%, 31%, 32%, 33%, 34%, 35%, 36%, 37%, 38%, 39%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49%, 50%, 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89% or 90% by weight or other incremental percentage between.

The water can be 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23%, 24%, 25%, 26%, 27%, 28%, 29%, 30%, 31%, 32%, 33%, 34%, 35%, 36%, 37%, 38%, 39%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49%, 50%, 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, or 70% by weight or other incremental percentage between.

The secondary material can be 0%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23%, 24%, 25%, 26%, 27%, 28%, 29%, 30%, 31%, 32%, 33%, 34%, 35%, 36%, 37%, 38%, 39%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49% or 50% by weight or other incremental percentage between.

The reinforcement fiber can be 0%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19% or 20% by weight or other incremental percentage between.

The rheology modifying agent can be 0%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, 2.0%, 2.1%, 2.2%, 2.3%, 2.4%, 2.5%, 2.6%, 2.7%, 2.8%, 2.9%, 3.0%, 3.1%, 3.2%, 3.3%, 3.4%, 3.5%, 3.6%, 3.7%, 3.8%, 3.9% or 4.0% by weight or other incremental percentage between.

The aluminum powder can be 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, 2.0%, 2.1%, 2.2%, 2.3%, 2.4%, 2.5%, 2.6%, 2.7%, 2.8%, 2.9% or 3.0% by weight or other incremental percentage between.

The surfactant can be 0.05%, 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9% or 2.0% by weight or other incremental percentage between.

The pH increasing agent can be 0.5%, 0.6%, 0.7%, 0.8%, 0.9%, 1.0%, 1.1%, 1.2%, 1.3%, 1.4%, 1.5%, 1.6%, 1.7%, 1.8%, 1.9%, 2.0%, 2.1%, 2.2%, 2.3%, 2.4%, 2.5%, 2.6%, 2.7%, 2.8%, 2.9%, 3.0%, 3.1%, 3.2%, 3.3%, 3.4%, 3.5%, 3.6%, 3.7%, 3.8%, 3.9%, 4.0%, 4.1%, 4.2%, 4.3%, 4.4%, 4.5%, 4.6%, 4.7%, 4.8%, 4.9%, 5.0%, 5.1%, 5.2%, 5.3%, 5.4%, 5.5%, 5.6%, 5.7%, 5.8%, 5.9%, 6.0%, 6.1%, 6.2%, 6.3%, 6.4%, 6.5%, 6.6%, 6.7%, 6.8%, 6.9%, 7.0%, 7.1%, 7.2%, 7.3%, 7.4%, 7.5%, 7.6%, 7.7%, 7.8%, 7.9%, 8.0%, 8.1%, 8.2%, 8.3%, 8.4%, 8.5%, 8.6%, 8.7%, 8.8%, 8.9%, 9.0%, 9.1%, 9.2%, 9.3%, 9.4%, 9.5%, 9.6%, 9.7%, 9.8%, 9.9% or 10.0% by weight or other incremental percentage between.

As a result, the present invention provides a high temperature lightweight thermal insulating cement or silica based material ("insulating material") formed from a mixture that includes cement or silica sand, water and a foaming agent. The foaming agent can be an aluminum powder or a surfactant. The insulating material has a maximum use temperature greater than about 600 degrees Celsius. The maximum use temperature can be up to about 900 degrees Celsius when Ordinary Portland cement (OPC) is used. The maximum use temperature can be up to about 1000 degrees Celsius when silica sand is used. The maximum use temperature can be up to about 1800 degrees Celsius when calcium aluminate cement (CAC) is used.

In addition, the present invention provides an insulating material formed from a mixture that includes cement or silica in an amount of about 25 to 90% of weight wet, water in an amount of about 10 to 70% of weight wet, and a foaming agent. The foaming agent can be an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or silica sand, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water. The insulating material has a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

Moreover, the present invention provides a method for manufacturing an insulating material by mixing cement or silica sand with water, foaming the mixture using a foaming agent, pouring the foamed mixture into a mold and allowing the foamed mixture to rise to form the insulating material, and removing the insulating material from the mold. The insulating material can be cured or heat treated. The insulating material has a maximum use temperature greater than about 600 degrees Celsius.

Furthermore, the present invention provides a method for manufacturing an insulating material by mixing cement or silica sand in an amount of about 25 to 90% of weight wet with water in an amount of about 10 to 70% of weight wet, foaming the mixture using a foaming agent (an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or silica sand, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water), pouring the foamed mixture into a mold and allowing the foamed mixture to rise to form the insulating material, and removing the insulating material from the mold. The insulating material can be cured or heat treated. The insulating material has a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification, but only by the claims.

CLAIMS

1. An insulating material formed from a mixture comprising:

a cement or silica sand;

water;

a foaming agent comprising an aluminum powder or a surfactant; and

the insulating material having a maximum use temperature greater than about 600 degrees Celsius.

2. The insulating material as recited in claim 1, the insulating material having a density in a range of about 0.1 to 1.0 g/cm^3.

3. The insulating material as recited in claim 1, the insulating material having a thermal conductivity in a range of about 0.05 to 0.30 W/(m·K).

4. The insulating material as recited in claim 1, the insulating material having a compressive strength in a range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

5. The insulating material as recited in claim 1, the insulating material having:

a density in a range of about 0.1 to 1.0 g/cm^3;

a thermal conductivity in a range of about 0.05 to 0.30 W/(m·K); and

a compressive strength in a range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

6. The insulating material as recited in claim 1, the cement comprising ordinary Portland cement and the maximum use temperature is in a range of about 650 to 900 degrees Celsius.

7. The insulating material as recited in claim 1, the cement comprising calcium aluminate cement and the maximum use temperature is in a range of about 900 to 1800 degrees Celsius.

8. The insulating material as recited in claim 1, the silica sand is used and the maximum use temperature is in a range of about 650 to 1000 degrees Celsius.

9. The insulating material as recited in claim 1, the mixture having a water to cement or silica sand ratio by weight in the range of about 0.2 to 2.0.

10. The insulating material as recited in claim 1, the mixture having a water to cement or silica sand ratio by weight in the range of about 1.0.

11. The insulating material as recited in claim 1, further comprising a high range water reducer (HRWR) in an amount of about 0.25 to 4.0% of a weight of the cement or silica sand.

12. The insulating material as recited in claim 1, wherein the cement is selected from the group consisting essentially of ordinary Portland cement, calcium aluminate cement, high-alumina cement, slag cement, silicate cement, phosphate cement and magnesium oxychloride cement.

13. The insulating material as recited in claim 1, the aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or silica sand.

14. The insulating material as recited in claim 1, the surfactant in an amount of about 0.05 to 2.0% by weight of the water.

15. The insulating material as recited in claim 1, the mixture further comprising an additive material selected from the group consisting essentially of cement (when silica sand is used), sand (when cement is used), gypsum, silica fume, fumed silica, plaster of Paris, fly ash, slag, rock and fiber.

16. The insulating material as recited in claim 15, the fibers comprising glass fibers, cellulose fibers polyvinyl alcohol fibers, polypropylene fibers, or a combination thereof.

17. The insulating material as recited in claim 1, the mixture further comprising a rheology-modifying agent in an amount of about 0.1 to 5.0% of a weight of the cement or silica sand.

18. The insulating material as recited in claim 17, the rheology-modifying agent comprising hydroxypropoylmethylcelluose.

19. The insulating material as recited in claim 17, the rheology-modifying agent selected from the group consisting essentially of polysaccharides, polysaccharide derivatives, proteins, protein derivatives thereof and synthetic organic materials.

20. The insulating material as recited in claim 19, the polysaccharides selected from the group consisting essentially of cellulose-based materials, derivatives of cellulose-based materials, starch-based materials, and derivatives of starch-based materials.

21. The insulating material as recited in claim 20, the cellulose-based materials selected from the group consisting essentially of methylhydroxyethylcellulose (MHEC), hydroxymethylethylcellulose (HMEC), carboxymethylcellulose (CMC), methylcellulose (MC), ethylcellulose (EC), hydroxyethylcellulose (HEC), hydroxyethylpropylcellulose (HEPC) and hydroxypropoylmethylcelluose (HPMC).

22. The insulating material as recited in claim 20, the starch-based materials selected from the group consisting essentially of wheat starch, pre-gelled wheat starch, potato starch, pre-gelled potato starch, amylopectin, amylose, seagel, starch acetates, starch hydroxyethyl ethers, ionic starches, long-chain alkylstarches, dextrins, amine starches, phosphate starches and dialdehyde starches.

23. The insulating material as recited in claim 1, the mixture further comprising a pH increasing material in an amount of about 0.5 to 10% by weight of the water.

24. The insulating material as recited in claim 23, the pH increasing material selected from the group consisting essentially of calcium oxide, calcium hydroxide and sodium hydroxide.

25. An insulating material formed from a mixture comprising:
a cement in an amount of about 25 to 90% of weight wet;
water in an amount of about 10 to 70% of weight wet;

a foaming agent comprising an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water; and

the insulating material having a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

26. An insulating material formed from a mixture comprising:

a silica sand in an amount of about 25 to 90% of weight wet;

water in an amount of about 10 to 70% of weight wet;

a foaming agent comprising an aluminum powder in an amount of about 0.5 to 3.0% by weight of the silica sand, or a surfactant in an amount of about 0.05 to 2.0% by weight of the water; and

the insulating material having a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

27. A method for manufacturing an insulating material comprising the steps of:

mixing a cement with water;

foaming the cement-water mixture using a foaming agent;

pouring the foamed cement-water mixture into a mold and allowing the foamed cement-water mixture to rise to form the insulating material;

curing the insulating material;

removing the insulating material from the mold; and

the insulating material having a maximum use temperature greater than about 600 degrees Celsius.

28. The method as recited in claim 27, wherein the mixing step is performed for about 1 to 5 minutes.

29. The method as recited in claim 27, wherein the foaming step is performed for about 5 seconds to 1 minute.

30. The method as recited in claim 27, wherein the foamed cement-water mixture is allowed to rise for about 0.5 to 2.0 hours.

31. The method as recited in claim 27, the curing step comprises the step of allowing the insulating material to sit for about 28 days in a humid environment.

32. The method as recited in claim 27, the curing step comprises the step of heating the insulating material.

33. The method as recited in claim 27, the curing step comprises the step of steam curing the insulating material.

34. The method as recited in claim 27, further comprising the step of drying the insulating material.

35. The method as recited in claim 27, further comprising the step of cutting, trimming, sanding or routing the insulating material into a specified shape.

36. The method as recited in claim 27, wherein the specified shape comprises a pipe, a half-pipe, a block or a panel.

37. The method as recited in claim 27, further comprising the step of spraying the insulating material with a water repellent.

38. The method as recited in claim 27, the insulating material having a density in the range of about 0.1 to 1.0 g/cm^3.

39. The method as recited in claim 27, the insulating material having a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K).

40. The method as recited in claim 27, the insulating material having a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

41. The method as recited in claim 27, the insulating material having:

a density in the range of about 0.1 to 1.0 g/cm^3;

a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K); and

a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

42. The method as recited in claim 27, the cement comprising ordinary Portland cement and the maximum use temperature is in the range of about 650 to 900 degrees Celsius.

43. The method as recited in claim 27, the cement comprising calcium aluminate cement and the maximum use temperature is in the range of about 900 to 1800 degrees Celsius.

44. The method as recited in claim 27, the cementitious mixture having a water to cement ratio by weight in the range of about 0.2 to 2.0.

45. The method as recited in claim 27, the cementitious mixture having a water to cement ratio by weight in the range of about 1.0.

46. The method as recited in claim 27, further comprising a high range water reducer (HRWR) in an amount of about 0.25 to 4.0% of a weight of the cement.

47. The method as recited in claim 27, wherein the cement is selected from the group consisting essentially of ordinary Portland cement, calcium aluminate cement, high-alumina cement, slag cement, silicate cement, phosphate cement and magnesium oxychloride cement.

48. The method as recited in claim 27, the aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement.

49. The method as recited in claim 27, the surfactant in an amount of about 0.05 to 2.0% by weight of the water.

50. The method as recited in claim 27, the cementitious mixture further comprising an additive material selected from the group consisting essentially of sand, gypsum, silica fume, fumed silica, plaster of Paris, fly ash, slag, rock and fiber.

51. The method as recited in claim 50, the fibers comprising glass fibers, cellulose fibers polyvinyl alcohol fibers, polypropylene fibers, or a combination thereof.

52. The method as recited in claim 27, the cementitious mixture further comprising a rheology-modifying agent in an amount of about 0.1 to 5.0% of a weight of the cement.

53. The method as recited in claim 52, the rheology-modifying agent comprising hydroxypropoylmethylcelluose.

54. The method as recited in claim 52, the rheology-modifying agent selected from the group consisting essentially of polysaccharides, polysaccharide derivatives, proteins, protein derivatives thereof and synthetic organic materials.

55. The method as recited in claim 54, the polysaccharides selected from the group consisting essentially of cellulose-based materials, derivatives of cellulose-based materials, starch-based materials, and derivatives of starch-based materials.

56. The method as recited in claim 55, the cellulose-based materials selected from the group consisting essentially of methylhydroxyethylcellulose (MHEC), hydroxymethylethylcellulose (HMEC), carboxymethylcellulose (CMC), methylcellulose (MC), ethylcellulose (EC), hydroxyethylcellulose (HEC), hydroxyethylpropylcellulose (HEPC) and hydroxypropoylmethylcelluose (HPMC).

57. The method as recited in claim 55, the starch-based materials selected from the group consisting essentially of wheat starch, pre-gelled wheat starch, potato starch, pre-gelled potato starch, amylopectin, amylose, seagel, starch acetates, starch hydroxyethyl ethers, ionic starches, long-chain alkylstarches, dextrins, amine starches, phosphate starches and dialdehyde starches.

58. The method as recited in claim 27, the cementitious mixture further comprising a pH increasing material in an amount of about 0.5 to 10% by weight of the water.

59. The method as recited in claim 58, the pH increasing material selected from the group consisting essentially of calcium oxide, calcium hydroxide and sodium hydroxide.

60. A method for manufacturing an insulating material comprising the steps of:

mixing a cement in an amount of about 25 to 90% of weight wet with water in an amount of about 10 to 70% of weight wet;

foaming the cement-water mixture using a foaming agent comprising an aluminum powder in an amount of about 0.5 to 3.0% by weight of the cement or a surfactant in an amount of about 0.05 to 2.0% by weight of the water;

pouring the foamed cement-water mixture into a mold and allowing the foamed cement-water mixture to rise to form the insulating material;

curing the insulating material;

removing the insulating material from the mold; and

the insulating material having a maximum use temperature greater than about 600 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

61. A method for manufacturing an insulating material comprising the steps of:

mixing a silica sand with water;

foaming the sand-water mixture using a foaming agent;

pouring the foamed sand-water mixture into a mold and allowing the foamed sand-water mixture to rise to form the insulating material;

removing the insulating material from the mold;

heat treating the insulating material; and

the insulating material having a maximum use temperature of about 1000 degrees Celsius.

62. The method as recited in claim 61, further comprising the step of grinding the silica sand using a ball mill.

63. The method as recited in claim 61, wherein the mixing step is performed for about 1 to 5 minutes.

64. The method as recited in claim 61, wherein the foaming step is performed for about 5 seconds to 1 minute.

65. The method as recited in claim 61, wherein the foamed sand-water mixture is allowed to rise for about 0.5 to 2.0 hours.

66. The method as recited in claim 61, the heat treating step comprises the step of autoclaving the insulating material for about 15-48 hours at a temperature of about 150 to 200 degrees Celsius and a pressure of about 10 to 20 Bars.

67. The method as recited in claim 61, further comprising the step of drying the insulating material.

68. The method as recited in claim 61, further comprising the step of cutting, trimming, sanding or routing the insulating material into a specified shape.

69. The method as recited in claim 68, wherein the specified shape comprises a pipe, a half-pipe, a block or a panel.

70. The method as recited in claim 61, further comprising the step of spraying the insulating material with a water repellent.

71. The method as recited in claim 61, the insulating material having a density in the range of about 0.1 to 1.0 g/cm^3.

72. The method as recited in claim 61, the insulating material having a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K).

73. The method as recited in claim 61, the insulating material having a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

74. The method as recited in claim 61, the insulating material having:
a density in the range of about 0.1 to 1.0 g/cm^3;
a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K); and
a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).

75. The method as recited in claim 61, the mixture having a water to sand ratio by weight in the range of about 0.2 to 2.0.

76. The method as recited in claim 61, the mixture having a water to sand ratio by weight in the range of about 1.0.

77. The method as recited in claim 61, further comprising a dispersion agent in an amount of about 0.25 to 4.0% of a weight of the sand.

78. The method as recited in claim 61, the aluminum powder in an amount of about 0.5 to 3.0% by weight of the sand.

79. The method as recited in claim 61, the surfactant in an amount of about 0.05 to 2.0% by weight of the water.

80. The method as recited in claim 61, the mixture further comprising an additive material selected from the group consisting essentially of cement, gypsum, silica fume, fumed silica, plaster of Paris, fly ash, slag, rock and fiber.

81. The method as recited in claim 80, the fibers comprising glass fibers, cellulose fibers polyvinyl alcohol fibers, polypropylene fibers, or a combination thereof.

82. The method as recited in claim 61, the mixture further comprising a rheology-modifying agent in an amount of about 0.1 to 5.0% of a weight of the sand.

83. The method as recited in claim 82, the rheology-modifying agent comprising hydroxypropoylmethylcelluose.

84. The method as recited in claim 82, the rheology-modifying agent selected from the group consisting essentially of polysaccharides, polysaccharide derivatives, proteins, protein derivatives thereof and synthetic organic materials.

85. The method as recited in claim 84, the polysaccharides selected from the group consisting essentially of cellulose-based materials, derivatives of cellulose-based materials, starch-based materials, and derivatives of starch-based materials.

86. The method as recited in claim 85, the cellulose-based materials selected from the group consisting essentially of methylhydroxyethylcellulose (MHEC), hydroxymethylethylcellulose (HMEC), carboxymethylcellulose (CMC), methylcellulose (MC), ethylcellulose (EC), hydroxyethylcellulose (HEC), hydroxyethylpropylcellulose (HEPC) and hydroxypropoylmethylcelluose (HPMC).

87. The method as recited in claim 85, the starch-based materials selected from the group consisting essentially of wheat starch, pre-gelled wheat starch, potato starch, pre-gelled potato starch, amylopectin, amylose, seagel, starch acetates, starch hydroxyethyl ethers, ionic starches, long-chain alkylstarches, dextrins, amine starches, phosphate starches and dialdehyde starches.

88. The method as recited in claim 61, the mixture further comprising a pH increasing material in an amount of about 0.5 to 40% by weight of the water.

89. The method as recited in claim 88, the pH increasing material selected from the group consisting essentially of calcium oxide, calcium hydroxide and sodium hydroxide.

90. A method for manufacturing an insulating material comprising the steps of:

mixing a silica sand in an amount of about 25 to 90% of weight wet with water in an amount of about 10 to 70% of weight wet;

foaming the sand-water mixture using a foaming agent comprising an aluminum powder in an amount of about 0.5 to 3.0% by weight of the sand or a surfactant in an amount of about 0.05 to 2.0% by weight of the water;

pouring the foamed sand-water mixture into a mold and allowing the foamed sand-water mixture to rise to form the insulating material;

removing the insulating material from the mold;

heat treating the insulating material; and

the insulating material having a maximum use temperature of about 1000 degrees Celsius, a density in the range of about 0.1 to 1.0 g/cm^3, a thermal conductivity in the range of about 0.05 to 0.30 W/(m·K), and a compressive strength in the range of about 30 to 3000 PSI (2.068 to 206.8 Bar).