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INSULATING MATERIAL AND METHOD OF MAKING SAME

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The present invention relates to an improved form of insulating material and the method of making it.

Primarily, the material consists of a fibrous material such as asbestos, finely pulverized slag, a siliceous material such as, for example, diatomaceous earth, lime, and, if desired, a small amount of sodium hydroxide. Its weight ranges from about nine to twenty pounds per cubic foot, and it possesses high thermal insulating value, being particularly useful for boiler lagging when temperatures up to 1000° F. are encountered.

One of the objects of the present invention is the production of such an insulating material by a process which involves the conversion of the fibrous material into thick, rather viscous, suspension while in admixture with pulverized slag, diatomaceous earth, and lime, and the casting of the resulting mixture into water-tight molds in which it is subjected to curing under steam pressure, followed by drying of the shaped pieces thus obtained.

A further object is the material thus produced.

A further object concerns itself with the methods of mixing, for the purpose of producing a mixture which will not exhibit any marked tendency to settle from an aqueous suspension.

While it has already been proposed to bond diatomaceous earth into an insulating material by means of lime, with or without the incorporation of asbestos or similar inorganic fibrous material, the products thus obtained, although relatively light in weight, did not have the structural strength of the products made in accordance with the present invention. By using slag, particularly ground, water-quenched slag, not only is the product stronger, but it also costs less per cubic foot, and moreover has a better resistance against shrinkage and warping when subjected to temperatures near or at the maximum temperature for which it is intended.

The insulation made in accordance with the present invention is the product of a mixture made within the limits of the following formula:

	Per cent
Asbestos fiber	5–35
Finely pulverized blast-furnace slag	10–89
Diatomaceous earth	3–42.5
Lime	3–42.5
Alkali	0–10.0

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A mixture of this kind is incorporated in sufficient water to produce a pourable slurry, and this slurry is violently agitated so as to coat the asbestos fiber with the other ingredients. This can be accomplished in various ways, such, for example, as by the use of a turbo-mixer or, preferably, a Bauer mill. The main function of such mixing is to promote fiber-to-fiber friction by forcing the mixture rapidly through relatively narrow openings. A mixture thus produced will not settle out to any great extent when left quiescent. Satisfactory mixing may be defined as that which results in a mixture which will not show clear water for more than about 7.5% of the head after being allowed to settle for three hours. The amount of water required, for example, in connection with the preferred mixture above mentioned is about six parts by weight to yield a product having a dry density of substantially 12 pounds per cubic foot.

After the mixture has attained the required degree of non-settling properties, it may be drawn off into a storage vessel provided with stirrers which keep the mixture slowly agitated so as to keep it of uniform consistency. From this vessel (or directly from the original mixer) sufficient quantities of the mixture are drawn off into water-tight molds, which may be in the form of pans. These, after filling, are preferably bumped or vibrated so as to bring to the surface any bubbles of air, primarily to insure uniformity of structure.

The pans thus filled are then transferred to a suitable autoclave in which they are horizontally supported. The autoclave is then closed and steam is admitted thereto until a pressure of about 100 lbs. per square inch (gauge) is attained. The pressure, and hence the curing of the material in the molds, is continued for about 20 hours for slabs in which the maximum distance from a heated surface is three inches; i. e., a six-inch slab. As a guide to proper autoclaving procedure, it has been ascertained that for a pressure of 100 lbs. (gauge) saturated steam, the time required for any given thickness of slab can be calculated from the following formula:

$$T=4D+8$$

wherein T is the time in hours, and D is the maximum distance in inches, from a heated surface of the slab. Thus for a ten-inch slab, this

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would be (where D is, of course, one-half the thickness) 4×5+8=28 hours. It is believed that a reaction occurs between the slag and the diatomaceous earth on the one hand, and the alkaline materials (lime and alkali) on the other. The inorganic fibrous material, such as the asbestos, serves as a sort of skeleton to maintain the dimensions of the material, and becomes fixed in position by the formation of a rather tough solid which is the product of the reaction.

No evaporation of moisture takes place during the autoclaving. In fact, it is distinctly advantageous that a small head of water remain above the solids in the pans during this operation, as a better and stronger surface finish is thus obtained. At the end of the autoclaving period the admission of steam is stopped and the temperature is slowly allowed to fall. It is imperative that the pressure not be reduced at such a high rate that disruptive vaporization takes place at the center of the cast at any time during pressure release and cooling cycle. For casts six inches deep, the pressure release time is approximately three hours; and for casts twelve inches deep, the time is approximately five hours.

The product in the pans is then in the form of a coherent, but still thoroughly wet, solid. The shape thereof is substantially that of the molds with but very litle shrinkage, about 0.7% lineal being the maximum for a product having a density of about 13 lbs. per cubic foot. The shaped pieces may then be removed from the molds, or dried therein. In any event, all of the water contained in the shaped pieces is removed by drying. This is not a critical operation, and temperatures as high as 450° F. may be used in the dryers, which, for example, may be directly heated by gas. Finally, the dried blocks are cooled down and milled or sawed, or otherwise trimmed, to the desired dimensions.

The density of the products may vary between nine and twenty pounds per cubic foot. The strength of the insulation thus obtained is quite high; and on the average, the ratio of the modulus of rupture, expressed in pounds per square inch, to the density, in pounds per cubic foot, is at least 4.5.

The raw materials used for the production of the insulation produced as above described are all readily available. The slag preferred is water-quenched blast-furnace slag which has been pulverized, as for example in a ball mill. The lime is high-calcium, dry, hydrated lime, although quicklime, suitably hydrated before use, may be used. The asbestos is preferably the 5K grade or better. The diatomaceous earth is the commercial form of this material, also known as kieselguhr, etc. The alkali, such as the sodium or potassium hydroxide, may be omitted, but then a longer autoclaving period will be required. It is believed that the alkali performs the function of a catalyst, but it is quite important from the standpoint of successful commercial exploitation of the invention.

The insulation made as hereinabove described may safely be used up to temperatures of about 1000° F. without significant deterioration, and the lineal shrinkage, even under the severest conditions, does not exceed about 2%. On a basis of not exceeding a density of about 20 lbs. per cubic foot, the main ingredients of the composition may vary within the following limits: asbestos or similar fiber, 5% to 35%; reaction products resulting from the autoclaving of the slag, diatomaceous earth and lime, about 65% to 95%. In the latter, but based in percentage on the total composition, the lime and diatomaceous earth are used in about equal proportions, but not less than about 3% of each and not more than about 42.5% of each; the slag, in any case, accounting for the remainder of the composition, except for such alkali as may be used as a catalyst.

The amount of water mixed with the ingredients prior to agitating and molding is at least three times the weight of the non-aqueous ingredients. The steam pressure used for autoclaving may be higher or lower than 100 lbs., but should not be much below about 50 lbs.

As an indication of proper autoclaving, it may be mentioned that the product when first removed from the autoclave should have a dark green color. If it is gray, it is an indication that there was not enough water present during the autoclaving operation; that is, there has been a partial dry-out, probably resulting from steam pressure fluctuations. The product is marketed in the form of bricks, blocks, or slabs; for instance, 36 inches by 6 inches, with a thickness of from 1 inch to 4 inches. Other special shapes can of course be made.

The importance of the mixing operation is to be kept in mind, as this contributes to a considerable extent to the properties of the slurry from which the shapes are cast, and serves to keep the ingredients of the mixture from settling out. It is again emphasized that the mixture is not filtered, but placed in its entirety into the molds. As the reaction proceeds during the autoclaving operation, the mass assumes structural rigidity, the fibrous materials, which are distributed in all three spatial directions, becoming cemented together at their points of contact. The material contains a great deal of empty space which is occupied by the water during the process, but which when eliminated by the drying operation consequently leaves corresponding space filled with air, for which reason the material has its excellent insulating properties. It also has a high abrasion resistance and low shrinkage loss.

The invention is to be liberally construed so far as mechanical and chemical equivalents are concerned, and accordingly what is novel and inventive therein is claimed as:

1. Process of producing a heat-insulating material having high strength and low density, capable of use at temperatures up to about 1000° F., having a density of not more than about 20 pounds per cubic foot and a modulus of rupture, in pounds per square inch, of at least 4½ times its density in pounds per cubic foot, and a lineal shrinkage of not more than about 2% when heated to 1000° F., which comprises the steps of mixing asbestos fibers, finely pulverized quenched blast-furnace slag, diatomaceous earth, lime, and an alkali, in the proportions of said materials chosen from within the ranges of the following formula:

	Percent by weight
Asbestos fibers	5–35
Slag (as defined)	10–89
Diatomaceous earth	3–42.5
Lime	3–42.5
Alkali	0–10.0

with an amount of water, by weight, of from about three times to about six times the weight

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of the dry constituents of the resultant mixture, thereby producing a freely flowable suspension; violently agitating said suspension by means which cause it to traverse a narrow confining space under conditions of great turbulence so as to cause the suspension to become thickened and substantially non-settling; then filling said now substantially non-settling suspension into imperforate molds and curing it therein under a steam pressure of at least about 50 pounds per square inch (gauge), but without vaporization of any substantial amount of its constituent water until, as a result of the reaction between the components of the mixture, the material in the molds becomes hard and set, and then reducing the steam pressure slowly enough to prevent disruption of the hardened material, followed by final drying thereof, whereby it is left highly porous by the disappearance of the water from the interstices therein.

2. An insulating material produced in accordance with the process claimed in claim 1.

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