(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
08 October 2020 (08.10.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/204865 A1

(51) International Patent Classification:
C04B 28/26 (2006.01) *C04B 111/28* (2006.01)

(21) International Application Number: PCT/TR2020/050262

(22) International Filing Date: 02 April 2020 (02.04.2020)

(25) Filing Language: Turkish

(26) Publication Language: English

(30) Priority Data:
2019/05135 05 April 2019 (05.04.2019) TR

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title:** THERMAL INSULATION MATERIAL AND METHOD OF APPLICATION THEREOF

(57) **Abstract:** The present invention relates to a thermal insulation material, a process for producing the thermal insulation material and also an application process of the material on surfaces. The thermal insulation material comprises 30 - 90 wt % aluminium silicate source and 1 - 30 wt % inorganic hollow material particles. The aluminium silicate source comprises fly ash and/or clay based material.

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THERMAL INSULATION MATERIAL AND METHOD OF APPLICATION THEREOF

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a thermal insulation material comprising ceramic based inorganic aluminium silicate source such as; fly ash, clay based material, and/or inorganic additives. The present invention relates to the process for producing the thermal insulation material and the application thereof.

BACKGROUND OF THE INVENTION

Increasing energy efficiency or energy conservation is one of the most important subjects all around the world and there has been many subjects working on it. In the world, the local energy sources about to exhaust and the conservation of energy is becoming more important.

There are many motivations to increase energy efficiency. The most promising starting point is that, reducing energy use reduces energy costs and can lead to financial cost savings for consumers and industrial processes. Energy saving can reduce the world's energy need and helps to protect the environment besides cost saving.

Industry is one of the most energy needed area in the world. Increasing energy efficiency in industrial processes can reduce the energy need in subsequent processes, helps cost saving and also gives less damage to the environment.

Thermal insulation is very important to save energy in industrial application and equipments.

Thermal insulation is a great solution to reduce energy consumption by preventing heat loss through the industrial equipment used mainly in energy sector. When thinking about efficiency of used industrial equipments and processes, the first strategy to apply should be saving energy. Heat or thermal insulation helps reduction of unwanted temperature changes and decreases the energy demand of heating and cooling systems.

In industry, especially in refineries, traditional insulation materials such as glass or rock wool are generally used to prevent heat losses as thermal insulation material. Such materials can only be applied to flat surfaces due to their thick and inelastic structure. For this reason, it is not possible to provide thermal insulation of equipment with recessed surfaces. There are many equipments having recessed surfaces in refineries such as; connection equipment, heat exchanger heads, flange, valve, cover or manifold need to be opened and closed for continuous maintenance or control. However, some of the conventional materials are not suitable for being used at high temperatures in refineries.

As another option, organic based materials, such as; polyurethane foam, polystyrene board, phenolic foam and so on, were used to be as thermal insulation materials but, the disadvantages of their organic nature, such as flammability or lability, increased the need of inorganic type materials.

Inorganic thermal insulation materials generally include glass wool, rock wool, expansion perlite, micro nano insulation board and so on. These inorganic materials have some advantages compared to organic ones such as; excellent fire resistance, high strength, durability.

US2018/0148376A1 patent application discloses a thermally insulating material formed of ceramic oxide and inorganic binding agent. The insulating material is treated up to 1000°C in the production process. There is a very long list of application area of the invention but the application of the material is suitable especially for buildings and construction materials. Moreover, it does not show any specific examples of application on metal surfaces.

Accordingly, there is a need for heat/thermal insulation material applicable for surface coating of industrial system equipment in energy industry, especially in refineries wherein the material is efficient to apply different surfaces and have decreased thermal conductivity.

OBJECT OF THE INVENTION

The present invention overcomes the problems mentioned above and provides an inexpensive and easy to use form of thermal insulation material having porous structured ceramic formulation.

The present invention provides also the production of the insulation material, application of that material and use thereof.

FIELD OF THE INVENTION

The present invention provides a thermal insulation material comprising a solid phase which comprises 30 – 90 wt % aluminium silicate source (Al and/or Si source), based on the total weight of the thermal insulation material; a liquid phase which comprises an alkaline solution; and 1 – 30 wt % (preferably 1 – 20 wt %) hollow inorganic material particles, based on the total weight of the thermal insulation material. The present invention preferably comprises additives.

The present invention also relates to the production process of the thermal insulation material and the application process of the material on surfaces.

The obtained thermal insulation material has very low heat conductivity, such as lower than 0.1 W/m.K. The material has high resistance to corrosion and other environmental side effects, as well. The material can be classified in A class non inflammable materials as having fireproof property. Moreover, the present invention provides a thermal insulating material applicable at temperatures $T< 900°C$, more preferably $T<500°C$ with a low thermal conductivity.

In addition to all these technical advantages, the material has a feature that can easily applied to all kinds of surfaces and no cracks occur on the surface during the drying phase after application.

In the present invention, ceramic based, slurry and/or powder formed thermal insulation material is obtained. More preferably, powder formed thermal insulation material is formed. The production process is based on the geopolymerization reaction of a solid phase which comprises inorganic aluminium silicate source (Al and/or Si source) and a liquid phase which comprises an alkaline solution followed by addition of hollow inorganic compounds and other suitable additives to the reaction medium.

Geopolymers are fully inorganic class of alumino-silicate-based ceramics balanced by group I oxides. Geopolymers are composed of a polymeric Si-O-Al framework similar to zeolites. The main difference of geopolymers is being in amorphous phase. These are hard gels, which then can be converted into crystal or glass-ceramic materials. Geopolymer's structure contains small aluminosilicate clusters with pores dispersed in a highly porous network. The main advantages of the geoploymerization reaction for the present invention are being as amorphous phase and having porous network to be filled and/or covered by hollow inorganic compounds.

Geopolymers are usually obtained by chemical activation of industrial solid wastes and/or natural minerals such as; fly ash or slag, clay based material or kaoline or vermiculite.

In the present invention, geopolymerization reaction is used because the polymer structure has highly porous structure and contains small aluminosilicate clusters with pores dispersed in a highly porous network. It is very important to obtain the maximum air foam in the geopolymerization reaction of the present invention because the pores formed are suitable for using inorganic hollow materials to fill the pores.

In the present invention, the geopolymer reaction comprises; fly ash, slag, kaoline, vermiculite and/or clay and a liquid phase which comprises an alkaline solution.

In one embodiment of the invention, the fly ash, slag, kaoline, vermiculite and/or clay based material is used as Al and/or Si source of the thermal insulating material. Ceramic oxide based thermal insulation materials have been used for years.

In the present invention, ceramic is chosen as the raw material due to its lightweight, stability at high temperatures, resistance to thermal shock and broad range of thermal capabilities and physical characteristics to be used in equipment in heat transfer applications in industry, especially in refineries.

In one embodiment, the solid phase comprised in the thermal insulating material comprises fly ash obtained from industrial solid wastes.

In one embodiment of the present invention, the fly ash is obtained from Thermal Power Plant wastes in Turkey, and is sieved from a sieve having from 25 to 74 micrometres (μm) size to remove the impurities and classify the particle size of the fly ash.

In one embodiment, the thermal insulating material comprises 5 - 63 wt. % fly ash having mean particle size of preferably less than 63 μm.

In one embodiment of the present invention, the thermal insulating material may comprise preferably 18 to about 48 wt % fly ash based on the total weight of the thermal insulation material.

In one embodiment of the invention, the thermal insulating material further comprises clay based material that is commercially available.

In one embodiment, the thermal insulating material comprises 1-50 wt. % (preferably 1 to 40 wt. %) clay based material based on the total weight of the thermal insulation material.

In some embodiments of the present invention, the clay based material may be a kaolinite, vermiculite, perlit, halloysite, illite, smectite, muscovite, bentonite and attapulgite or any combination thereof. The clay based material may be a commercially available kaolinite clay, stoneware or fire clay.

In one embodiment of the present invention kaolin can be preferred as clay based material.

In another embodiment of the present invention, kaoline can be converted to metakaolen under 700-800 ° C prior to use. Metakaolen can be chosen as Al/Si source, wherein the Al ratio is higher than Si ratio which should be used as Al^{3+} cation source, which is required for the geopolymerization reaction.

In some embodiments, the clay based material may be treated prior to use. The clay based material may be treated by heating to about 900°C, or about 800°C, or about 700°C prior to use to remove the excess water in the clay based material. By the way, the water has been removed before crystallization. It is very important to keep the clay based material in amorphous form to be solved in slurry mixture of the reaction medium.

In one embodiment of the present invention, the thermal insulation material further comprises ceramic oxide. In accordance with the application field and desired characteristics, inorganic hollow materials can be used as ceramic oxide comprising; ceramic, glass microspheres, aluminate and/or silicate, and preferably, glass hollow microsphere particles can be used.

In one embodiment, the thermal insulating material comprises 1 - 30 wt % hollow inorganic material based on the total weight of the thermal insulating material, preferably 1- 20 wt % hollow inorganic material.

In one embodiment of the present invention, the hollow inorganic material may have a mean particle size of less than 120 micrometer (μm). The mean particle size may vary from 5 to 120 μm.

The particle size of the hollow inorganic materials are suitable for application of the thermal insulation material with spray coating on any kind of surfaces, preferably hot surfaces.

The ceramic oxide based hollow inorganic material used in the reaction medium decreases thermal conductivity up to values lower than 0.1 W/m.K, that is crucial for the invention.

In some embodiments, the liquid phase of the thermal insulating material further comprises a binding agent. In one embodiment of the present invention, potassium silicate and/or sodium silicate can be used as a liquid phase of the thermal insulation material.

In one embodiment of the present invention, sodium silicate solution in water ($Na2O:SiO2$) is used preferably as an alkaline solvent having a pH of higher than 10. It has been chosen for having superior features such as; increasing the reaction rate and also increasing the rate of binding of the hollow inorganic materials in the reaction medium.

In some embodiments, the liquid phase of the thermal insulation material further comprises further additives to be used in the reaction medium such as; water, NaOH and/or KOH. These additives are used to control pH and reaction rate and also used as a solvent in the reaction medium.

In some embodiments, the thermal insulating material further comprises other additives. The additives may be selected from the group consisting of a colorant, fibers, dispersants, surfactants, stearate lubricants or any combination thereof.

In second aspect of the present invention, there is a process provided for producing a thermally insulating product comprising preparing two different composition parts to be combined prior to use. One part of the composition is the solid phase comprising fly ash and clay based material and the other part of the composition is the liquid phase comprising sodium and/or potassium silicate, NaOH, KOH and/or water. In one embodiment of the present invention, the composition further comprises inorganic hollow materials.

In one embodiment of the present invention, the solid phase of the composition comprises 5 – 63 wt. % fly ash, 1 – 50 wt. % metakaolen based on the total weight of the thermal insulating material. Preferably, the solid phase of the composition is prepared by mixing fly ash and metakaolen as a first mixture. The hollow particles are added into the reaction medium at last, after combining solid and liquid phases. In one embodiment of the present invention, the composition further comprises 1 – 30 wt. % inorganic material.

In one embodiment of the present invention, the liquid phase of the composition comprises 6 – 56 wt. % sodium silicate, 1 – 20 wt. % NaOH, 5 – 55 wt. % H_2O. The liquid phase of the composition is prepared by dissolving NaOH in water and admixed with sodium silicate solution as the second mixture.

After combining first and second mixture, the hollow particles are added into the reaction medium to avoid damaging of the hollow inorganic materials.

In a third aspect, there is provided a thermally insulating product produced by the process of the second aspect.

Any example below is solely for providing a context for the present invention and understanding the invention clearly; not for limiting the scope just with the examples.

The composition of the thermal insulation material and also the production process of the material are disclosed in examples with further details below.

EXAMPLES

Example 1: A Composition of the Thermal Insulation Material

In accordance with the first aspect of the present invention; the thermal insulation material comprises;

Solid Phase Content	% by weight
Fly ash	43-48
Metakaolen	8-12
Liquid Phase Content	
Sodium Silicate	29-33
NaOH	5-10
Water	5-10
Total	100

In the present example, there are no hollow particles used in the thermal insulation material composition, which can be used as a reference example.

Example 2: A Composition of the Thermal Insulation Material

In accordance with the first aspect of the present invention; the thermal insulation material comprises;

Solid Phase Content	% by weight
Fly ash	18-23
Metakaolen	8-12
Hollow Inorganic Particles	9-12
Liquid Phase Content	
Sodium Silicate	42-46
NaOH	2-5
Water	10-15
Total	100

In the present example, hollow inorganic material has been used about 10 wt. %

Example 3: A Composition of the Thermal Insulation Material

In accordance with the first aspect of the present invention; the thermal insulation material comprises;

Solid Phase Content	% by weight
Fly ash	26-32
Metakaolen	5-8
Hollow Inorganic Particles	18-20
Liquid Phase Content	
Sodium Silicate	24-26
NaOH	5-8
Water	12-15
Total	100

Example 4: A Composition of the Thermal Insulation Material

In accordance with the first aspect of the present invention; the thermal insulation material comprises;

Solid Phase Content	% by weight
Fly ash	32-36
Metakaolen	8-12
Hollow Inorganic Particles	18-20
Liquid Phase Content	
Sodium Silicate	9-16
Water	35-40
Total	100

<u>Example 5: A Composition of the Thermal Insulation Material;</u>

In accordance with the first aspect of the present invention; the thermal insulation material comprises;

Solid Phase Content	% by weight
Fly ash	20
Metakaolen	9
glass microspheres	10
Liquid Phase Content	
Sodium Silicate	44
NaOH	2
Water	15
Total	100

Table 1. Test Results of Examples

	Example 1	**Example 2**	**Example 3**	**Example 4**	**Example 5**
Thermal Conductivity (W/mK)	0.90	0.05	0.04	0.06	0.05

Adhesion on Metal Surface	Very good	Very good	poor	good	Very good

Results and Evaluation of Thermal Conductivity and Surface Adhesion Capacity

According to the examples given below and thermal conductivity results; it is seen that Example 2, 3, 4 and 5 has very low thermal conductivity which is below 0.1 W/mK. Example 1 is given as a reference material composition without hollow inorganic material. It is clear from the examples and the results shown in Table 1 that using hollow inorganic particles significantly decreases the thermal conductivity of the material.

Additionally, in Example 1 wherein the hollow inorganic material is not added into the composition, adhesion on metal surface is very good but the thermal conductivity is very high, which is nearly 1 W/mK, thereby making the composition useless according to present invention. Comparing the other Examples 2, 3 and 4 with each other and also with Example 1; by adding hollow inorganic material to the composition, it is seen that the thermal conductivity has decreased significantly, but in Example 3 and 4, the adhesion to the metal surface has deteriorated. The improvement of the adhesion to provide k <0.1 W / mK is achieved by increasing the alkali solvent sodium silicate in the composition.

It is seen that a high amount of hollow particles has a negative effect on the material adhesion properties. The fact that the surfaces of the hollow particles added to the composition cannot be completely covered is thought to have a negative effect on the mechanical properties of the material due to both the breaking of the particles and the lack of the binding phase. Hence, the amount of hollow particles within the composition should be optimal, such as between 9 – 12 % wt, as can be seen from Example 2.

The ratio of fly ash / metakaolen is found to be useful in Examples 2, 3, 4 and 5.

As a result of the observations, the example 5 is chosen to provide maximum benefit in terms of low cost and thermal conductivity which is below 0.1 W/mK and also provides maximum adhesion on metal surface.

It is seen that, if the amount of fly ash in the material is used above 50 % wt, the geopolymerization reaction is not fully occurred/completed in the expected range, although the Si / Al ratio required for the geopolymerization reaction is achieved. In this case, the insoluble crystalline phase in the heat insulation slurry will be more than the reaction product amorphous phase. As a result, the grains are not bonded to one another and the adhesion strength of the coating material is reduced.

Additionally, if the metakaolen is used by an amount over 50 % wt, the Si / Al ratio required for the geopolymerization reaction will decrease and the geopolymer reaction will not be fully occurred/completed. The Sialat structure formed in geopolymerization reactions will not occur and the binding phase will not be stable.

Moreover, Sodium silicate and NaOH used in geopolymer sludge provide the required alkaline medium for geopolymerization. The alkaline medium is one of the most important parameters for the realization of geopolymerization. Additionally, water forms the reaction medium for geopolymerization reactions and also affects the flow of the sludge. H2O produces suitable conditions for producing a homogeneously distributed pore connected to each other by producing O2 in the reaction medium.

Hollow inorganic particles are well distributed within the composition and the grain size is larger. It is thought that the surfaces of the glass spheres are not fully coated and the reason for this is the high sodium silicate and the liquid ratio of the alkali solvent phase in the composition.

In addition, the determination of the amount of NaOH used is also very important because the use of large amounts of NaOH leads to the dissolution of inorganic materials in solution.

In addition to its use as an alkaline solvent, Na_2SiO_3 provides a metal-to-thermal insulation material interface for the coating of metal with the desired temperature (300°C etc.), thus increasing the adhesion strength.

The production method of the thermal insulation material is disclosed in examples with further details below.

Example 5: Production and Application of the Thermal Insulation Material

In second aspect of the present invention, the thermal insulation material is prepared by a process that combines solid and liquid phases by following the steps below;

Solid phase is prepared as the first mixture;

Fly ash is sieved from 63 micrometres (µm) size sieve,

Fly ash and metakaolen are dry mixed for 30 minutes.

Liquid phase is prepared as the second mixture;

NaOH particles are dissolved in water completely,

Dissolved solution is added slowly into sodium silicate solution in water and alkaline solution having pH:10-12 is formed

Water is added into the prepared alkaline solution and mixed for 30 min.

Prepared solid mixture is added into the liquid mixture slowly and mixed for nearly 15 min. and a fluidal slurry mixture is obtained

Finally, the hollow inorganic particles are added into the slurry mixture and mixed for 15 min. further.

The prepared thermal insulation material is ready for spraying to hot and/or cold surfaces then it is followed by curing the thermal insulation material on surface.

In one aspect of the present invention, there is provided an application method for improving the heat resistance of an article comprising at least partially coating the article with the thermally insulating material according to the first aspect.

The thermal insulation material developed according to the invention is suitable for use as a material to be sprayed or moulded on the surface by applying the material by spraying method.

In one embodiment of the present invention, the thermal insulation material in powder form is mixed with water or other suitable solvents prior to use to form a slurry mixture to be applied with spraying.

In one embodiment of the present invention, the thermal insulation material in powder form is mixed with water or other suitable solvents and then shaped specifically by using moulds for particular end-uses.

In one embodiment of the present invention, the surfaces to be treated should be free of water and other contaminations before application of the thermal insulation material

In one aspect of the present invention, the thermal insulation material applied on the surfaces has a thickness between 1-20mm.

In one embodiment of the present invention, the thermal insulation material applied on the surfaces has a thickness preferably between 1-10mm.

In another embodiment of the present invention, the surface temperature is decreased much more if the coating thickness is between 1 to 10 mm.

In one embodiment of the present invention, the curing period after the thermal insulation material is applied to the surface varies according to the surface temperature and it takes between 1-24 hours on average, preferably 18-20 hours.

The invented insulation material can be applied to different metal surfaces regardless of whether the surface is smooth or not. The thermal insulation material applied metal surfaces will finally have high temperature resistance (T> 300°C) and low thermal conductivity coefficient (k <0.1 W / mK). In the field of the present invention, the surface temperature of a metal equipment is decreased from 250-300°C to 60-70°C.

In the present invention, the produced thermal (heat) insulation material can be used for fire and heat resistant coatings and adhesives, high temperature ceramics, new binders for fire-resistant fiber composites.

The powder based thermal insulation material of the present invention is preferably applied to metal surfaces such as furnaces, heaters, incinerator, hot pipes in industry and especially in refineries.

The thermal insulation material of the present invention is provided with a powder-based material form to provide thermal insulation for the equipment, preferably by coating with a spray method.

In one aspect of the present invention, the thermal insulation material is provided for use in especially refineries to prevent heat loss on the heat transfer surfaces of the refinery equipments.

CLAIMS

1. A thermal insulation material comprising;
   - a solid phase which comprises 30 – 90 wt % aluminium silicate source based on the total weight of the thermal insulation material;
   - a liquid phase which comprises an alkaline solution; and
   - 1 – 30 wt % hollow inorganic material particles based on the total weight of the thermal insulation material.

2. A thermal insulation material according to claim 1, further comprising additives.

3. A thermal insulation material according to claim 1, comprising 1-20% of hollow inorganic material particles based on the total weight of the thermal insulation material.

4. A thermal insulation material according to claim 1, wherein the hollow inorganic particles are coated with the aluminium silicate source in the reaction medium.

5. A thermal insulation material according to claim 1, wherein aluminium silicate source is selected from fly ash, slag, kaoline, vermiculite clay based material and/or combinations thereof.

6. A thermal insulation material according to claim 1, wherein aluminium silicate source is fly ash and/or clay based material.

7. A thermal insulation material according to claim 6, wherein the clay based material comprises kaoline.

8. A thermal insulation material according to claim 1, wherein the liquid phase further comprises potassium silicate, sodium silicate, NaOH, KOH and/or combinations thereof.

9. A thermal insulation material according to claim 1, wherein the liquid phase comprises sodium silicate and/or NaOH.

10. A thermal insulation material according to claim 1, wherein the hollow inorganic material comprises ceramic microspheres, glass microspheres and/or combinations thereof.

11. A thermal insulation material according to claim 1, wherein the hollow inorganic material comprises glass microspheres.

12. A thermal insulation material according to claim 1, wherein the thermal insulation material is in powder form or slurry form.

13. A thermal insulation material according to any of the preceding claims, the material comprising;

- 5– 63 wt. % fly ash,
- 1– 50 wt. % kaolene
- 1 – 30 wt. % hollow inorganic particles
- 6 – 56 wt. % sodium silicate
- 1 – 20 wt. % NaOH and
- 5 – 55 wt. % Water,

wherein the ratio is based on the total weight of the thermal insulation material.

14. A thermal insulation material according to any of the preceding claims, the material comprising;

- 18– 48 wt. % fly ash,
- 1– 40 wt. % kaolene
- 1 – 20 wt. % hollow inorganic particles
- 10 – 50 wt. % sodium silicate
- 1 – 20 wt. % NaOH and
- 5 – 40 wt. % Water,

wherein the ratio is based on the total weight of the thermal insulation material.

15. A thermal insulation material according to any of the preceding claims, the material comprising;

- 18– 23 wt. % fly ash,
- 8 – 12 wt. % metakaolen

- 9 – 12 wt. % hollow inorganic particles
- 42 – 46 wt. % sodium silicate
- 2 – 5 wt. % NaOH and
- 10 – 15 wt. % Water,

wherein the ratio is based on the total weight of the thermal insulation material.

16. A thermal insulation material according to any of the preceding claims, the material comprising;

- 20 wt. % fly ash,
- 9 wt. % metakaolen
- 10 wt. % glass microspheres,
- 44 wt. % sodium silicate
- 2 wt. % NaOH and
- 15 wt. % Water,

wherein the ratio is based on the total weight of the thermal insulation material.

17. A process for obtaining the thermal insulation material according to claim 1, comprising the steps of;

- Forming the solid phase composition, comprising steps of sieving fly ash from sieve, and dry mixing the fly ash and kaolene,

and;

- Forming the liquid phase composition, comprising steps of dissolving NaOH particles in water completely, adding dissolved NaOH solution slowly into sodium silicate solution in water to obtain an alkaline solution, adding water into the prepared alkaline solution and mixing the liquid alkaline solution;

and

- Adding the prepared solid phase into the liquid mixture slowly and,
- Adding hollow inorganic particles into the slurry mixture prior to use.

18. A process according to claim 17, comprising the steps of;

- Sieving 18 – 23 wt.% fly ash from sieve having 63 micrometres (μm) size sieve,
- Dry mixing the fly ash and 8 – 12 wt. % kaolene for 30 min,
- Dissolving 2 - 5 wt % NaOH particles in water completely and separately to form the dry mixture,

- Adding dissolved NaOH solution slowly into 42 – 46 wt.% sodium silicate solution in water and obtaining an alkaline solution having pH: 10 - 12,
- Adding 10 – 15 wt. % water into the prepared alkaline solution and mixing the liquid alkaline solution,
- Adding prepared solid mixture into the liquid mixture slowly and mixing for 30 min., and
- Adding 9 – 12 wt % hollow inorganic particles into the slurry mixture and mixing for 15 min. prior to use.

19. A process according to claim 17, comprising the steps of;

- Sieving 20 wt.% fly ash from 63 micrometres (µm) size sieve,
- Dry mixing the fly ash and 9 wt. % kaolene for 30 min,
- Dissolving 2 % NaOH particles in water completely and separately to form the dry mixture,
- Adding dissolved NaOH solution slowly into 44 wt.% sodium silicate solution in water and obtaining an alkaline solution having pH: 10 - 12,
- Adding 15 wt. % water into the prepared alkaline solution and mixing the liquid alkaline solution,
- Adding prepared solid mixture into the liquid mixture slowly and mixing for 30 min and
- Adding 10 wt % hollow inorganic particles into the slurry mixture and mixing for 15 min. prior to use.

20. A thermal insulation material obtained by a process according to claim 17 or claim 18 or claim 19.

21. A thermal insulation material obtained by a process according to preceding claims, wherein the thermal insulation material has a thermal conductivity (k) lower than 1 W/mK, preferably lower than 0.07 W/mK.

22. A method of applying the thermal insulation material according to claim 12 on a surface, wherein the material is applied by spraying.

23. Use of a thermal insulation material according claims 1 to 16 for coating the industrial equipment in applying to metal surfaces such as furnaces, heaters, incinerator, hot pipes in industry and especially in refineries.

INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2020/050262

A. CLASSIFICATION OF SUBJECT MATTER
INV. C04B28/26 C04B111/28
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 2017/174560 A1 (CONSTRUCTION RESEARCH & TECHNOLOGY GMBH [DE]) 12 October 2017 (2017-10-12) page 1, line 3 - line 7 page 18; table 1 -----	1-16 17-23
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 July 2020	18/08/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kolb, Ulrike

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INTERNATIONAL SEARCH REPORT

International application No
PCT/TR2020/050262

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 2018/148376 A1 (BEN-NISSAN BESIM [AU]) 31 May 2018 (2018-05-31) cited in the application paragraph [0079] paragraphs [0106], [0109] paragraph [0185] - paragraph [0187]; examples B,D claims 1,11,16,21 -----	1
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