Fibre Containing Compositions

Fig. 1:
- Fibrous Material
  - Carding (Web Forming)
  - Particulate Material Introduction
  - Needle Punching (Web Consolidation)
  - Composite Material

Fig. 2:
- Web Forming
- Web Consolidation
- Particulate Material
- Binding Medium (Optional)
- Fibrous Material

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ABSTRACT OF THE DISCLOSURE

A method for the production of a composite material comprising both fibrous and particulate ingredients includes the steps of forming a web of fibrous material, introducing particulate material onto or into the web, and consolidating the web containing the particulate material. The material so obtained has wide uses, for example as a hot top lining material or a sound insulation material.

This invention relates to heat and acoustic insulating fibre containing materials and particularly to heat insulating material consisting of fibrous material and particulate refractory material and to methods of producing the same.

There are many applications in industry where such materials are needed. For example, in the building industry, there is a demand for fibrous panels, tiles and sheets for building and acoustic insulation. A particular area of use of heat insulating materials of high refractoriness is that of the metallurgical industry, in such diverse applications as linings for molten metal containers, hot tops for ingot and casting moulds, protective covers for steel handling machinery, anti-piping covers, and, in the case of refractory cloths, protective clothing.

Previously, most of the non-flexible refractory materials, e.g., bricks, tiles, slabs, sleeves, have been produced by forming a mouldable mixture of the ingredients, usually with water, moulding it to the required shape and curing or allowing it to harden or set. Generally, it is necessary to remove water or other liquid medium from the material by a drying or firing step. Although the necessity for this step is disadvantageous, these methods are nevertheless widely employed.

It is possible to form a wholly fibrous refractory material without using any liquid by conventional textile techniques—e.g., the weaving of asbestos cloth.

It is an object of this invention to provide a wide range of novel materials comprising both fibrous material and particulate material and methods for their production.

According to a first feature of the present invention, there is provided a method for the production of a composite material comprising both fibrous and particulate ingredients, which includes the following steps:

I. forming a web of fibrous material

II. Introducing particulate material onto or into the web, and

III. Consolidating the web containing the particulate material.

Other features of the present invention will be evident upon reading the following detailed description while referring to the accompanying drawings, in which:

FIG. 1 is a schematic flow diagram of a process for forming a composite material in accordance with the present invention; and

FIG. 2 is a schematic flow diagram of an alternate process for forming a composite material in accordance with the present invention.

In a preferred form of the invention, from the standpoint of the utility of the products for use in metallurgical processes, the particulate material is a particulate refractory material and the following description will be directed more particularly to that case.

In this specification the following terms have the following meanings assigned to them:

Web includes any material of which two dimensions are large compared with the third. It thus includes all strip and sheet materials, and includes woven and non-woven cloths, felts, fleeces and mats, consisting of one or more layers.

Consolidation means the process of rendering the material which undergoes the process self-supporting.

Needle punching is any method of consolidation which includes the steps of passing a plurality of elongated rods (needles) of any desired shape into the material being processed and subsequently removing them therefrom. Needle punching is a common process in textile processing.

For ease of explanation it is convenient to consider in turn the three steps of the method of the invention set out above.

Referring to FIG. 1, the step of forming a web of fibrous material 1 may be carried out by any suitable known method. A preferred method is to feed a suitable fibrous material into a carding machine. The material issues from the machine as a loose web of orientated fibres (e.g. as a carded fleece), which web can be of thickness up to 35 mm. or more. Alternatively the fibrous material may be processed into woven or non-woven or knitted cloths. The web formed may consist either of a single layer (FIG. 1) or of a plurality of layers (FIG. 2). Formed either by a number of web-forming units working in parallel, or by folding. When a number of layers are used, they may be laid down with parallel plies or with cross plies.

The step of introducing particulate refractory material 2 into the web may be carried out in a number of ways. If the web is made up from a number of layers, then layers of particulate refractory material may be interposed therebetween. Alternatively, if the web is a single layer, the particulate refractory material may be spread or sprayed onto the web and then caused by any suitable method, e.g. vibration, air suction, mechanical pressure, to penetrate into the body of the fibrous web. This penetration may be combined in some cases with the step of consolidation 3 of the web (described hereafter), as, for example, in needle punching (FIG. 1).

Introduction of the particulate material into the web may also be effected by shooting the particles at the web into which they penetrate.

The consolidation of the web may be effected in a wide variety of ways. In some cases, e.g. in the case of a woven or knitted fibrous material, the consolidation will be necessary only to secure the particulate material in the web, and not to consolidate the web itself. In other cases, however, particularly when rigid products are desired, consolidation processes are needed after addition of the particulate refractory material to the fibrous web.

As noted above, one method of consolidation is needle punching the material (FIG. 1). This can serve also to distribute the particulate filler therein. This method is particularly valuable where the fibrous web is produced by simple carding and the particulate refractory material is spread on top of that web prior to needle punching. If used in relation to materials made up from a number of layers, needle punching not only consolidates each layer but also aids in bonding the layers together to a coherent whole.

Various binding agents or mediums may be included in the material being produced. These may be caused to
exert a binding action on the fibrous material and the incorporated particulate refractory material to consolidate the structure. For example, particulate or fibrous binders may be introduced which are caused to exert a binding action by, for example, heating or activation with a fluid (liquid or gaseous) catalyst. Alternatively, binders can be introduced from a liquid phase (e.g. by spraying or dipping) which may either self-cure or be caused to harden e.g. by heating or gassing.

Specific examples of the addition of binding agents per se include:

1. Incorporation of 10-15% by weight polypropylene fibre. On heating, the fibres soften and weld at crossing points to provide a consolidated structure on cooling.
2. Dipping in liquid alkali metal silicate and subsequent gassing with an acid gas e.g. CO₂.
3. Spraying with a solution of urea-formaldehyde resin and subsequently with phosphoric acid.

By suitable choice of binder system, products varying from rigid to very flexible ones may easily be obtained. If it is desired to impart additional strength or handleability to the products, especially in layered products, it is preferable to introduce between the layers, further webs for strengthening e.g. of woven muslin or wire gauze, sheet plastics, paper or metal foil (Fig. 2).

Such a further web also aids in manufacture by minimising loss of particulate refractory material from the product.

The products may contain fibrous materials of such properties that it cannot easily itself form a fibrous web, either distributed in the fibrous web itself, e.g. incorporated into the web during its formation, or introduced into the material in the same manner as the particulate refractory material. These materials include paper and wood pulp.

The actual materials used in the method of the present invention may vary widely.

The fibres used to form the web may be wholly organic (e.g. wool, cotton, rayon, nylon, acrylonitrile, cellulose fibres, polyethylene terephthalate fibres) or inorganic (asbestos, calcium silicate, aluminium silicate, often used in commercial forms of rock, slag and mineral wool). It is also possible to produce highly refractory carbonaceous fibres in organic material when used by incorporating carbonisable fibres such as rayon and acrylonitrile fibres. Metal fibres such as steel wool may also be employed, for example to make panels porviding acoustic but not thermal insulation.

The particulate refractory filler may be (for reasons of economy) sand or other silica, but other materials can be used, including grog, refractory silicates, chamotte, calcined rice husks, alumina, magnesium, olivine, zircon, chromite, sillimanite, silicon carbide, ball mill dust, coke dust. Lightweight fillers such as diatomaceous earth, perlite, vermiculite and bubble alumina may also be used.

The particle size of the refractory material may vary but typically is between 50 to 6 mm. The finer graded refractory materials generally tend to give denser and more impermeable final products.

Sawdust or coke granules may also be incorporated in the product of the invention, in the same manner as the particulate refractory materials.

If desired, for certain applications (e.g., hot topping ingot moulds) the products may contain exothermically reacting ingredients such as aluminium or calcium silicide and an oxidising agent, such as alkali metal or ammonium nitrates, chlorates, perchlorates, iron oxide, manganese dioxide.

In certain applications (e.g. hot topping) it may be desirable to apply surface coatings to the material, e.g. of silica sol, or other refractory dressing.

In the manufacture of layered products, economies may be made having regard to the orientation of the product in use. For example, in making hot top slabs of three layer construction, with a central layer of particulate refractory material sandwiched between layers of fibrous material, it is preferable to use a highly refractory fibre (e.g. aluminio-silicate fibre such as that manufactured by Morganite Ceramics Ltd., West, Wirral, Cheshire and sold under the trademark Triton, carbon fibres or a fibre which becomes carbonised in use) for the side which in used will contact molten metal, backed by a less refractory fibre, e.g. slag wool. In such a product, between the central layer of particulate refractory material and the slag wool, a layer of aluminium foil may be interposed to aid reflecting heat from the molten metal. If made by a method using needle-punching, the molten metal-contacting surface is preferably arranged to be adjacent the table of the needle-punching during manufacture.

The final products, however made, may be deformed and/or made more dense by passing through suitable rollers, heated if necessary.

The density of the final products may vary widely. A density range of 0.2-1.5 gm./cc. is easily obtained by varying the materials used and process conditions.

The following examples will serve to illustrate the invention:

**EXAMPLE 1**

A flexible hot topping material was made up having the following composition (by weight):

<table>
<thead>
<tr>
<th>Material</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcined rice husks</td>
<td>82</td>
</tr>
<tr>
<td>Crimped rayon fibre (3 denier Sarille, a cramped staple viscose rayon made by Courtaulds Ltd., Coventry, England)</td>
<td>15</td>
</tr>
<tr>
<td>Newspaper (as a coherent layer)</td>
<td>1.5</td>
</tr>
<tr>
<td>Cotton gauze</td>
<td>1.5</td>
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</tbody>
</table>

This was made up as follows:

The rayon fibre was passed through a carding machine and emerged onto a table as a web 50 cm. wide and 35 mm. thick. Half the web was covered with a strip (25 cm. wide) of a newspaper, and on this was spread a layer of calcined rice husks. The husks layer was then covered by a (25 cm. wide) strip of muslin, and the other half of the rayon web then folded over on top of the muslin, to give a rayon/newspaper/rice husks/muslin/rayon sandwich.

This sandwich was then passed through a needle puncher which punched the total thickness of the material down to about 10 mm. Lengths of this 10 mm. thick 25 cm. wide strips were cut off and were formed into strong, very flexible hot top slabs. The rayon/newspaper side turned to contact the molten metal in use. This side was coated with colloidal silica sol by spraying (Monsanto's Syton 2X) and the hot top used to line a test cavity. The linings could be applied by any of the usual methods (nailing, sticking, stapling), and if a thicker lining were required, two layers of product could be sewn, stapled, or cemented together to form a laminate about 20 mm. thick. On testing using steel at 1650°C, the hot tops performed satisfactorily.

**EXAMPLE 2**

A rayon fibre/silica flour/rayon fibre sandwich containing 95% by weight silica flour was made up by the process of Example 1 (omitting the newspaper and muslin liners). The silica flour was all — 200 BSS mesh. This material was used to line the heads of test ingot moulds, the folded edge of the fibre web lowermost. Steel ingots cast from molten steel at 1650°C, showed adequate feeding characteristics and surface finish of the head portion of the ingot was very satisfactory. No steel penetration or slagging was observed.

The present invention includes, as specific features, hot tops and linings for metal casting moulds which are formed of a material produced by the method defined above, and anti-piping covers, which may be of predominantly heat insulating or exothermic nature, or consist of two layers, one heat insulating and one exothermic, which covers are produced by the method defined above.
We claim as our invention:

1. A method for the production of a composite heat insulating material including both fibrous and particulate refractory ingredients and suitable for use as a lining for molten metal containers which comprises:
   (a) dry forming a web of fibrous material,
   (b) introducing particulate refractory material to the fibrous web in an amount sufficient to allow the composite material to withstand the penetration of molten metal therethrough and
   (c) consolidating the web and particulate refractory material to form a composite material having a density of from about 0.2 to 1.5 gm./cc.

2. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material, said consolidating including a needle punching operation.

3. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web oriented fibres on a carding machine
   (b) introducing in organic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material.

4. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate material into the web, said particulate material being refractory and first disposed on the surface of the web of fibrous material and thereafter caused to penetrate into the body of the web, and
   (c) mechanically consolidating the web containing the particulate refractory material.

5. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web consisting of at least two layers of fibrous material
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material.

6. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material, said method being further characterized by the introduction of a binding agent to bind the composite material to a coherent whole.

7. A method according to claim 6 wherein the binding agent used is a thermoplastic fibrous material, and this is caused to bond the material to a coherent whole by heating the fibres to weld them together at their crossing points.

8. A method according to claim 6 wherein the binding agent used is an alkali metal silicate, and this is caused to harden by means of gassing with an acid gas.

9. A method according to claim 6 wherein the binding agent used is a heat-settable resin and heat is applied thereby to consolidate the composite material.

10. A method according to claim 6 wherein the binding agent used is a chemically settable resin and a chemical capable of setting the resin is applied thereto to consolidate the composite material.

11. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material, said method being further characterized by the introduction of at least one strengthening layer into said composite material.

12. A method according to claim 11 wherein the strengthening layer is formed from a material selected from the group consisting of woven cloth, wire gauze, sheet plastics, paper and metal foil.

13. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material, said method being further characterized by the introduction of at least one strengthening layer into said composite material.

14. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material, said web including at least one fibre selected from the group consisting of wool, cotton, rayon, nylon, acrylonitrile, cellulose and polyethylene terephthalate fibres,
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material.

15. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material, said web comprising at least one inorganic fibre selected from the class consisting of asbestos, calcium silicate, aluminium silicate, and metal fibres,
   (b) introducing inorganic particulate refractory material into the web, and
   (c) mechanically consolidating the web containing the particulate refractory material.

16. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing inorganic particulate refractory material into the web, said particulate refractory material including at least one material selected from the class consisting of sand, grog, silica flour, refractory silicates, chamotte, calcined rice husks, alumina, magnesia, olivine, zircon, chromite, sillimanite, silicon carbide, ball mill dust and coke dust, and
   (c) mechanically consolidating the web containing the particulate refractory material.

17. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
   (b) introducing in organic particulate refractory material into the web, said particulate refractory material including at least one material selected from the class consisting of perlite, vermiculite, diatomaceous earth and bubble alumina, and
   (c) mechanically consolidating the web containing the particulate refractory material.

18. A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which comprises:
   (a) forming a web of fibrous material
(b) introducing inorganic particulate refractory material into the web, and
(c) mechanically consolidating the web containing the particulate refractory material, said method being further characterized by the incorporation into said composite material of an exothermically reactive ingredient, consisting substantially of a material selected from the class consisting of easily oxidizable metals and alloys, and an oxidizing agent therefor.

A method for the production of a composite heat insulating material including both fibrous and particulate ingredients which consists of a wholly dry process comprising:

(a) forming a web of fibrous material,
(b) introducing inorganic particulate refractory material into the web, and
(c) mechanically consolidating the web containing the particulate refractory material.

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