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PROCESS FOR COATING OPEN-TOP POROUS CONTAINERS

Richard J. Pratt, Flossmoor, Donald E. Safford, Park Forest, and William S. Hooch, Flossmoor, Ill., assignors to Sinclair Research, Inc., New York, N.Y., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An open-top, porous container made of light weight aggregate and a binder such as sodium silicate or Portland cement is dipped in an aqueous medium containing sodium silicate and finely divided silica filler. The dipping operation is conducted to wet and coat the exterior but not the interior surfaces of the container and after heat curing of the coated container the exterior surfaces are effectively sealed while the interior surfaces remain porous. Such porous surfaces can exert a wicking action when a hydrocarbon fuel, e.g., wax, in the container is burned to supply heat, for instance, to orchards or other crops in combating frost.

This invention relates to the coating of the exterior surfaces of an open, porous block container. Particularly, this invention is concerned with the coating of porous fuel block heaters to prevent leakage of hot hydrocarbon fuel contained therein during long periods of firing.

Fuel block heaters can be used, for example, as a means for supplying heat to citrus groves, fruit orchards, and vegetable farms to protect the crop against damage caused by frost or freezing. Usually, the fuel block heater is comprised of a container having a solid or liquid fuel therein. In operation, a large number of the block heaters are positioned throughout the area to be heated and the fuel ignited. The addition of heat in this manner is based upon the principle of temperature inversion. On a clear, calm night there is a relatively thin layer of cold air near the ground and a gradual increase in air temperature up to a height of 300 to 800 feet. Hot gases from the burning fuel mix rapidly with the surrounding cold air to give a slightly increased ambient air temperature which rises slightly and acts as a roof over the area to be heated to retain the subsequently heated air.

A particularly useful fuel block heater comprises a normally solid hydrocarbon wax as the fuel component encased in an open top container. The container can be composed of a light weight, porous, predominantly inorganic aggregate material such as perlite or expanded vermiculite and a suitable binder, e.g., Portland cement. The porous interior of the container functions as a wick to burn the melted fuel therein.

In use, the fuel blocks may be fired for several hours, for instance, a period of up to about 12 hours or more.

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During such periods of sustained firing the liquid or molten fuel may penetrate the porous container walls causing leakage and subsequent loss of fuel. It is therefore desirable to coat the exterior of the fuel blocks to prevent such leakage.

To be effective, a fuel block coating must remain stable during long periods of firing of the fuel block. Coatings which crack or disintegrate from the heat generated during sustained firing periods not only permit fuel loss, but also prohibit reuse of the container. Ideally, the coating should possess an affinity for the aggregate container, be composed of materials low in cost and of ready availability and be easy to handle and apply.

Of significant importance is the manner in which the coating is applied to the fuel block heaters. A desirable method is one that applies a coating which is nearest the minimum, effective amount, that is, the least amount sufficient to prevent substantial loss of fuel upon firing, yet leaves the interior of the block porous to effect a wicking action when the block is fired. A block to which has been applied a heavy amount of coating may be leak-free, yet inoperative if the interior is not left porous. Similarly, a coated block possessing a porous interior and an insufficient amount of coating is of no use. A desirable coating method further should produce coated blocks at a commercially-acceptable speed.

We have now found a coating for the exterior of open, porous containers such as fuel block heaters which possesses the above desirable characteristics. In making the containers we apply to the exterior surfaces, but not the interior surfaces, of the container an aqueous composition of a water-soluble sodium silicate binder and an inert, finely-divided silica filler. The container which is preferably as dry as practical, can be dipped, open end up, up to approximately or just below the rim of the open end, in the aqueous composition for a time sufficient to effectively coat the exterior of the container, that is, for a time sufficient to provide an exterior coating which, after subsequent heat curing, gives the desired leak-protection, yet leaves the interior of the container substantially porous to effect wicking action. Usually the block is dipped for at least about 5 seconds up to about 1 minute or longer. A vacuum, for example, of up to about 15, preferably about 0.5 to 2, inches of mercury, can be applied to the cavity or interior of the block to hasten the dip coating operation. With a vacuum applied, the dipping time usually need not exceed about 30 seconds. The viscosity of the aqueous composition is often about 1000 to 1600, preferably from about 1200 to 1300, centipoises at 75° F. during the dipping operation. After removal of excess coating, by, for example, draining, brushing or wiping with a "doctor" blade, etc., the container is subjected to a heat treatment, e.g., at a temperature of about 250 to 700° F. to cure the coating. A suitable curing time is in the range of about 0.25 to 2.5 hours or more. Preferably, the coated block is subjected initially to a heat treatment at a temperature of about 250 to 350° F. for about 0.25 to 0.75 hour to set the coating and

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then heated at a higher temperature, say about 500 to 600° F. for about 0.75 to 1.75 hours, to cure the coating. The container can be filled with a solid or liquid fuel providing a fuel block heater having a cured coating which only partially penetrates the exterior of the walls of the heater which coating will not leak when the heater is fired.

We have found that a single or double dip in the coating composition with a short interval between dips for removal of excess coating or for briefly drying with warm air provides excellent results. Further, dip coating from tanks provides for high speed coating of the blocks and minimizes material loss.

The amounts of sodium silicate, silica filler and water employed in the coating composition may vary depending upon the porosity and moisture content of the blocks coated. In general, the coating composition applied to the blocks contains about 5 to 40, preferably about 9 to 30, wt. percent of sodium silicate, about 15 to 60, preferably about 30 to 50, wt. percent of silica filler of defined particle size and about 25 to 50, preferably about 30 to 45, wt. percent of water. The composition may further contain, for instance, about 2 to 5 weight percent of an inorganic pigment, for example, colored iron oxides, etc., if desired. The amount of solids in the aqueous composition, however, is preferably such that the viscosity of the composition is in the range given above during the dipping operation. Generally, a solids system of about 45 to 70 wt. percent can be employed. The higher solids systems of about 55 to 65%, are preferred for very porous or moist blocks (15-30% moisture) while lower solids systems of say about 45 to 55% solids content are preferred for blocks of lower porosity and lower moisture content.

Suitable sodium silicates include water-soluble, sodium silicates of about 20 to 45°, preferably of about 35 to 41° Baumé. The silica filler is finely divided and has a particle size predominantly in the range of about 150 to 350 mesh, preferably about 250 to 350 mesh. The silica filler is relatively non-porous as compared with materials such as diatomaceous earth. Moreover, the aqueous coating composition can contain a minor amount, for instance, about 1 to 25 or more wt. percent of other fillers such as talc, diatomaceous earth, asbestos, bentonite, silica of larger particle size than about 150 mesh. On a cured basis the coating contains about 1 to 8, preferably about 1 to 6, parts by weight of sodium silicate, about 3 to 12, preferably about 6 to 10 parts by weight of the silica filler of about 150 to 350 mesh size, and, if desired, a minor amount, e.g., about 0.2 to 5 parts by weight of other filler.

The materials used for making the containers coated in the present invention are light weight predominantly inorganic aggregates with a density, for instance, up to about 90 lbs./ft.³, preferably no greater than about 70 lbs./ft.³. The light weight of the aggregates can be achieved by screening out the fines to reduce the weight and using aggregates with a high porosity. The aggregate preferably passes an 8 size screen (Tyler). The porosity is contributed both by the pores of the aggregate and the space between aggregate particles. Hence, porosity may be varied by aggregate choice and by screen size selection. The aggregates include such light weight materials as perlite, pumice, scoria tuff, cinders, expanded shale, expanded slag, expanded clay, expanded slate, exfoliated vermiculite and mixtures thereof, with expanded shale or exfoliated vermiculite being particularly advantageous. Exfoliated or expanded vermiculite is produced when sheets of mined vermiculite are exposed to temperatures of about 2000° F. which removes a substantial amount of moisture causing the sheets to separate and move apart. At the same time the granules of vermiculite expand 12-15 times their original size forming thousands of tiny cells of dead air. There are several advantages of containers made from light weight aggregates as compared with those composed of metal and other materials

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previously suggested in the prior art. These light weight aggregates are inexpensive and therefor can be discarded after burning the fuel or in some instances may be crushed and used as a soil conditioner. The containers are also non-combustible, highly resistant to extreme temperature conditions, and as an essential features possess a low bulk density, permanently porous structure which acts as a wick in cooperating with the solid fuel to assure relatively constant heat from ignition until the flame is extinguished. The fuel block containers can be formed by compression and thus their porosity may depend to a considerable extent on formation pressures. The closed side walls and bottom of the container may frequently have thicknesses of about ¼ to 2 inches, preferably ½ to 1 inch. Frequently the container is an open top square or rectangular box with essentially solid walls and a bottom but other shapes can be employed.

A binder material is added to the light weight aggregate of the present invention before the container is formed, and is especially useful in molding the containers. Suitable inorganic binders include sodium silicate and Portland cement. The preferred binder is Portland cement. While Portland cement has a cost advantage over the other binder, it may have a weight limitation. The use of sodium silicate as a binder gives a container having an appreciable weight advantage over one made with cement. This weight difference is exemplified by comparing the following two formulae:

Material required for 3-gallon container		Weight, pounds
No. 2 exfoliated vermiculite	-----	2.1
Sodium silicate	-----	5.8
		7.9
No. 2 exfoliated vermiculite	-----	2.1
Portland cement	-----	6.0
Water	-----	4.3
		12.4

Another mixture suitable for forming the container has about 40 weight parts of expanded shale, 15 weight parts of Portland cement and 11 weight parts of water.

In producing the present containers, a volume ratio of light weight aggregate to binder of about 2:1 to 14:1 can be used, often about 5 to 10:1. The containers of the present invention can be formed by compressing the container material mixed with the desired binder until a container of desired strength is obtained, often at least about 1000 p.s.i. The curing temperature may vary depending upon which binder is used. For example, if sodium silicate is selected as the binder, a curing temperature of about 600° C. for about thirty minutes gives a desired container which has a compressive strength of about 200 p.s.i. In using cement as the binder material for the container, it was found desirable to cure under high humidity conditions, for example, using a steam kiln for about 8-16 hours or longer at a temperature of about 140 to 190° F. to produce a strong container having a compressive strength of at least about 1000 p.s.i. The binder material selected for use with the light weight aggregate in forming the container of the present invention may depend on how the burner is to be used and the purpose for which it is used. For example, if a light container is desired, sodium silicate would serve as a better binder over portland cement.

The following example is included to further illustrate the present invention and is not intended to be limiting.

EXAMPLE

Several compositions listed in Table I were prepared and a number of concrete fuel block containers were coated using various methods to apply the coating. The coated blocks were dried at 350° F. for 30 minutes unless indicated otherwise. Table II describes the type of blocks coated as well as the methods of coating employed and the results obtained with each method.

TABLE I.—COATING FORMULATIONS

Formulation	40° sodium silicate			Silica 300		Calcined diatomaceous earth		Water added, lbs.	Water, wt. percent total	Other		Solids, wt. percent
	Weight, lbs.		Percent dry weight	Lbs.	Wt. percent	Lbs.	Wt. percent			Lbs.	Wt. percent	
	Wet	Dry										
A.....	12	4.5	10.4	20	46.1	4.0	9.2	7.3	34.3	None.....		65.7
B.....	12	4.5	9.3	20	41.4	4.0	8.3	12.3	41.0	do.....		59.0
C.....	12	4.5	9.5	20	42.1	4.0	8.4	11.5	40	do.....		60
D.....	14	5.2	10.3	10	19.8	4.0	7.9	12.5	42.2	Silica 80 + 10...	19.8	57.8
E.....	12	4.5	9.5	20	45.3	4.0	10.6	11.5	37.6	None.....		62.4
F.....	14	5.2	9.6	20	37.1	4.0	7.4	16.0	45.9	do.....		54.1
G.....	40	15	26.3	17	29.8	None	-----	None	43.8	do.....		56.2

¹ Silica 300 is 300 mesh silica.² Silica 80 is 80 mesh silica.

TABLE II.—RESULTS OF COATING BLOCK

Runs	Number of blocks	Type of block	Pretreatment ²	Coating mixture	Coating method ³	Weight ⁴ pickup (lbs.)	Filling ⁵	Firing ⁶
1.....	6	X-2 ¹	None.....	D	4 blocks vacuum dipped, 1 block single and 1 block double dipped with no vacuum.	0.8-0.9	Light (lt.) to very light (v. lt.) sweat.	No change.
2.....	6	T-block.....	do.....	E ⁷	4 blocks vacuum dipped.....	0.8-0.9	Moderate lt. and v. lt.	
					1 block single and 1 block double dipped with no vacuum.	0.8-0.9	Moderate light.	
3.....	3	do.....	do.....	F	Double dip, no vacuum.....	0.6-1.0	Very light	Do.
4.....	12	do.....	do.....	G ⁷	Vacuum during 20-30 seconds of dip.	2.7 ave.	No sweat.	Do.
5.....	5	X-2.....	Water dipped.....	A	Dipped 10 sec., vacuum 50 sec. (1 had cracked bottom, leaked on filling).	(¹⁰)	Very light sweat.	Do.
6.....	1	X-2.....	Surface brushed with water to increase (0.1-0.2 lb.) water.	B ⁷	Vacuum 10 sec.....	3.5	Light sweat, pitted....	Not fired.
7.....	4	X-2.....	None.....	C	Dipped 10 sec., vacuum 25 sec.	1.6-1.8	Light to very lt. sweat.	No change.

¹ Rectangular shaped block 12½" x 7½" x 7½"=400 square inches, 1½" thick, weight, about 20 lbs., made from 6 parts by volume of expanded shale aggregate and 1 part by volume of Portland cement.² Blocks were conditioned outside under a tarpaulin. Before applying the coating the blocks were moved into a 75° F. room and left overnight. Blocks contained about 2-3 lbs. of moisture when coated.³ Vacuum (1 inch of mercury) when used was applied to block before and during dipping (1 minute).⁴ Weight pickup, weight increase due to wet coating.⁵ Appearance of coating after filling heated block with hot wax. Heavy sweat, all sides wet and some buildup of wax on lower half of block; moderate sweat, all sides wet but no buildup; light sweat, half of total

outside area wet with wax; very light sweat, less than one-fourth of total area wet with wax.

⁶ No change, no degradation of coating. Loss of wax less than ¼ lb. Block with large cracks or holes was not fired.⁷ The "B" treated blocks were dried in 300° F. oven overnight while the "G" treated blocks were dried at 300-600° F. for 1.25 hours.⁸ Square block, dimensions 9¼" x 9¼" x 7¼"=300 square inches, ¾" thick, weight about 14 lbs.⁹ About ½ lb. of water was added to bath after dipping each block to maintain original bath composition.¹⁰ Not measured.

It is claimed:

1. A method of coating an open-top, porous container comprising a light weight aggregate with a density up to about 90 pounds per cubic foot and a binder material selected from the group consisting of sodium silicate and portland cement in an aggregate to binder volume ratio of about 2:1 to 14:1, said method comprising dipping said container to wet the exterior surfaces but not the interior surfaces of said container into an aqueous medium, said medium having a viscosity of about 1000 to 1600 centipoises at 75° F., comprising about 5 to 40 weight percent sodium silicate, about 15 to 60 weight percent silica filler of about 150 to 350 mesh size and about 25 to 50 wt. percent water and having about 45 to 70 weight percent solids, and heat curing the coated container, the dipping of said container into said medium being for a time which is sufficient to effectively seal the exterior of said container yet leave the interior of said container substantially porous.

2. The method of claim 1 in which the amount of said silica filler is about 30 to 50 weight percent.

3. The method of claim 2 wherein the container is dipped for about 5 to 60 seconds.

4. The method of claim 3 wherein said container is dipped a second time into said medium after removal of excess medium from the first dipping.

5. The method of claim 3 wherein a vacuum of up to about 15 inches of mercury is applied to the interior of the container during the dipping operation.

6. The method of claim 3 wherein the container is dipped without vacuum being applied to the interior of the container.

7. A method of coating an open-top, porous container comprising a light weight aggregate with a density up to about 70 pounds per cubic foot and a binder material selected from the group consisting of sodium silicate and portland cement in an aggregate to binder volume ratio of about 5:1 to 10:1, said method comprising dipping said container up to just below its open top for about 5 to 60 seconds into an aqueous medium having a viscosity of about 1200 to 1300 centipoises at 75° F., said medium comprising about 9 to 30 weight percent of sodium silicate, about 30 to 50 weight percent of silica filler of about 250 to 350 mesh size, and about 30 to 45 weight percent of water, and having about 45 to 70 weight percent solids to effectively seal the exterior but not the interior of said container, removing excess medium from the exterior of said container, and heat curing the container at a temperature of about 250 to 700° F.

8. The method of claim 7 wherein a vacuum of about 0.5 to 2 inches of mercury is applied to the interior of said container during the dipping operation.

9. The method of claim 7 wherein the container is dipped without vacuum being applied to the interior of the container.

10. The method of claim 9 wherein the binder material is portland cement.

11. The method of claim 10 wherein said heating is conducted at a temperature of about 250 to 350° F. for about 0.25 to 0.75 hour and then at a temperature of about 500 to 600° F. for about 0.75 to 1.75 hours.

12. The method of claim 2 wherein the aqueous medium contains a minor amount of diatomaceous earth.

13. The method of claim 7 wherein the aqueous medium contains a minor amount of diatomaceous earth.

ALFRED L. LEAVITT, Primary Examiner
W. E. BALL, Assistant Examiner

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