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METHOD OF MAKING DECORATED WALLBOARD

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ABSTRACT OF THE DISCLOSURE

A process of making decorated wallboard in which an aqueous coating is applied to a paper cover of a wet gypsum board, the wet coated sheet is rendered porous by removal of moisture from the coating, and when the coating contains sand by pressing the sand particles into the coated cover sheet, and drying the coated board in a kiln.

This invention relates to a method of manufacturing wallboard having a protective decorative surface coating on a paper cover sheet over a set cementitious core. It relates particularly to a method of forming board with a wet set-gypsum core, applying a wet decorative coating of low permeability to the board, rapidly increasing the permeability of the coated cover sheet and then quickly drying the board.

In the customary practice of making wallboard, a face cover sheet is passed face down over a work surface, an aqueous slurry of calcined gypsum is deposited upon the paper, a back sheet is added over the slurry, the edges of the face sheet are folded up and secured to the back sheet and the board formed to desired dimensions. The board is supported until the core sets; it is then cut to size and passed through a kiln to drive the excess moisture from the core.

To enable the moisture vapor to escape from the core, the paper cover sheets are manufactured with a carefully controlled porosity which may be determined by methods such as TAPPI T460 m–49, or ASTM D726–58. The test method determines the number of seconds required to pass 100 ml. of air through 1 sq. inch of the paper; thus a high value indicates a "tight" paper having few and/or small pores as compared with a "loose" or highly permeable paper. Paper for board-making operations usually will pass 100 ml. of air in 250 seconds but paper requiring somewhat longer time, about 500 seconds, can be used in special circumstances or with additional caution to prevent "blows."

Gypsum board obviously is not a homogeneous material and the problems of producing it are unique to this product. For example, after the board is formed but while it is still wet, the bond between the paper cover and the set gypsum core may be extremely weak so that even at normal rates of drying, an irregularity in core formation may deteriorate an already weak bond so that during the drying step, the moisture driven from the core can "blow" the cover sheets free of the core. Following this type of accident in the drier, a "jam" may occur and the loose paper cover sheets, separated from the core, sometimes catch fire and further disrupt the drying operation.

A process for manufacturing a decorated wallboard had long been sought but it had previously been thought that the application of a wet decorative coating to only one side of the wet board would produce a warping tendency and accompanying "kiln jams" during the drying operation. To avoid such problems, a previously decorated sheet has been laminated to the paper cover of

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a dried board as a separate operation. This is an expensive procedure because of the extra labor involved in handling the board for the extra process step.

Attempts also have been made to produce decorated gypsum board by applying the decorative surface directly to the paper cover sheet before it was formed into board. This approach suffered the disadvantage of additional handling of the paper and placed some limitations upon the board-making process. If the board were made according to the conventional procedure and the decorative surface was placed face down upon the forming belt, the finished surface was exposed to damage or soil from the belt. On the other hand, if the board were made face up to protect the decorated surface, special edge-finishing techniques were required to produce a marketable product.

Thus there is a continuing need for a method to manufacture decorated gypsum board having a wear-resistant and esthetically attractive finish in which a coating is applied at a station on a conventional gypsum board machine at a speed comparable to that customarily used for gypsum board production and in a manner not disruptive to normal board-making operatioins.

It is an object of this invention, therefore, to provide a process for the manufacture of decorated gypsum wallboard in which an aqueous decorative coating is applied to the wet board and the coated boards dried in a kiln.

It is a further object of this invention to provide a process in which the coating and the board are dried at a temperature substantially above room temperature and preferably above the boiling point of water.

It is a further object of this invention to provide a process in which the coated wet board is dried in the kiln at ordinary manufacturing speed and without "blows."

It is a still further object of this invention to provide a gypsum board with a kiln dried finish which is highly washable, abrasion resistant and may be either textured or smooth.

These and other objects are achieved through the provision of a process in which an aqueous coating is applied to a porous paper cover sheet of a wet gypsum board as it proceeds along the board machine. The coating, which is preferably applied to the upper surface of the board and may contain sand grains to assist the development of a textured surface, initially renders the coated cover sheet substantially non-porous. Removal of moisture from the coating by wicking into the underlying paper sheet or by evaporation, desirably at a temperature about 250° F. and preferably about 450° F. and when using sanded textured coatings, by pressing the sand particles into the surface of the paper, quickly develops permeability in the coated sheet not substantially less than that of the uncoated sheet and sufficient to permit the escape of moisture driven from the core during the kiln drying operation.

In a preferred embodiment of the process, the coating comprises a polyvinyl acetate emulsion as the binder ingredient and may use an acrylic emulsion to achieve a higher viscosity where such is indicated as for a textured finish.

The amount of material applied may be as low as 5 lbs. of solids per thousand square feet of board although coverage may be marginal at this low rate. Smooth coatings in excess of about ten pounds per thousand square feet tend to have low permeability, but textured coatings may employ about 75 lbs. or more per thousand square feet to achieve the desired surface effect and yet develop adequate permeability.

Formulas for coatings suitable for use in the process of the invention are shown in Table I:

TABLE I.—COATING FORMULAS, PARTS BY WEIGHT

Ingredient	Formula A	Formula B
Water	450	400
Phenyl mercuric acetate	1	1
Triethanolamine		10
Wetting and Dispersing Agent		2
Defoamer		4
Clay	375	335
Pigment TiO_2	85	125
Polyvinyl acetate emulsion, 55% solids	240	240
Ethylene Glycol		5
Premix:		
Acrylic thickener		20
Water		50
Hexylene glycol		10
Sand	350	350

A suitable polyvinyl acetate is a homopolymer emulsion with a large particle size (0.5–3 microns) such as that sold by Borden Chemical Company under the designation Polyco 117–H.

The clay was a water washed white clay with a particle size larger than about 0.7 micron and preferably with a size of about 4.8 microns. The clay with larger particles tended to produce a more porous coating.

Formula A is simpler but its viscosity was somewhat sentitive to pH changes. The acrylic emulsion thickener of Formula B provided more stability. A suitable acrylic thickner, was Acrysol ASE 60, an acid-containing, cross linked acrylic emulsion copolymer manufactured by Rohm and Haas. The viscosity of the coating material was adjusted by neutralizing the batch with the 10 parts of triethanolamine which gave a viscosity of 220 to 250 Brabender units (measured with the 5⁄16" paddle) or 120 to 124 ku.

Viscosity of the coating desirably is from 190 to 260 Brabender but for a sharper texture it may be adjusted to more than 400. Cellulosic thickners, such as methyl cellulose, were unsuitable.

A suitable wetting and dispersing agent was an anionic polymer type dispersing agent, the sodium salt of a polymeric carboxylic acid sold by Rohm and Haas under the mark Tamol 731.

A suitable defoamer was Nopco NDW, a nonionic liquid product sold by Nopco Chemical Co.

The sand was a white silica sand with the following approximate particles size as measured by U.S. Standard Sieves.

	Percent by weight
On 30 mesh	0
Through 40 mesh and on 50 mesh	50
Through 100 mesh	0

In the manufacture of a decorated gypsum board according to the process of this invention, a paper face sheet about three inches wider than the width of the finished board was first placed on a moving belt. Conventional aqueous slurry of calcined gypsum or "stucco" containing about 50% by weight of water was deposited on this face sheet after which the back sheet having a porosity of 150–180 seconds was added. The edges of the face sheet, it being wider, were folded up and bonded to the back sheet and the board shaped to one half inch thickness and about four foot width. This process was performed at a lineal speed of from 60 feet per minute to more than 100 feet per minute. As the continuous board moved down the production line on the belt the calcined gypsum hydrated and set so that after about eight minutes the board was quite firm. A coating prepared according to Formula B was applied to the back (upper) paper with a coating roll at a rate of 45–50 pounds of solids per 1000 square feet of board. By the time the board was cut to length the coating had lost its gloss but was still soft.

The coated board was then passed into a dryer which had three zones. In the entrance zone which occupied about one quarter of the total length the air temperature was about 485° F., in the middle zone (about one half the drier length) it was 480–500° F. and in the outlet zone it was 255–260° F. Drying took about 45 minutes for this board but thicker board may take up to 90 minutes. In some instances it was desirable to pin perforate the uncoated paper sheet with a "porcupine" roll to aid drying.

In this drying step all of the moisture which was expelled from the core must pass as vapor through the paper cover sheets and for this reason the porosity of the coated cover sheet was very important. Two samples of the coated paper were removed from the dried board and were determined to have a porosity of 422 and 437 seconds respectively.

The dried coating was so water and abrasion resistant that it withstood a standard washability test of over 500 strokes on a Gardner Heavy Duty Wear Tester with an estimated removal of less than 1% of the coating material in the scrubbed area.

The invention can be further understood from reference to the following examples in which board paper was coated and its porosity determined without making the sheets into board.

EXAMPLE 1

Samples of coating materials according to Formulas A and B (for some tests the sand was omitted) were prepared and applied to board paper with a wire wound Meyer coating rod. All of the coatings applied without sand produced a smooth flat white finish on the paper. Two base paper materials were used, one each for samples 1 and 2, and 21 to 26. Each sample of coated paper was cut into halves, one of which was dried in an oven at 300° F. for 15 minutes while the other was dried in a room maintained at 70° F. and 50% relative humidity. The dried coated papers were weighed to determine the weight of dry solids applied. The porosity of the dried samples was measured using a soft rubber gasket to insure an adequate seal between the sample and the apparatus. Results are shown in Table II. The slight differences in porosity between the air-dried and oven-dried samples are not significant when determinations are performed on so few samples because of the low sensitivity of the test method.

The effect of sand on the permeability of a coated paper is illustrated by sample 1 in which instance the coating was prepared according to Formula A, and by sample 25 coated with material according to Formula B. Note that for sample 25 a weight of coating material was applied which was nearly ten times as great as that applied to sample 22 with but a moderate, if any, increase in resistance to air passage.

That the sanded coatings, samples 1 and 25, were so permeable was rather surprising, particularly in view of the relatively great weight of these coatings and their very substantial thickness. However, microscopic examination of the coated board disclosed that the grains of sand often were nearly completely embedded in the paper substrate by the pressure of the coating roll thus at least partially perforated the paper and easing the passage of gas through it.

TABLE II.—POROSITY OF COATED PAPERS

Sample No.	Coating formula	Solids applied, lbs./MSF	Porosity seconds
1	A	75	180 oven dry.
2		None	50.
21	B*	5.6	400 oven dry.
22	B*	6.7	440 air dry, 340 oven dry.
23	B*	14.5	1,200 air dry, 1,300 oven dry.
24	B*	19.4	1,920 air dry, 1,920 oven dry.
25	B	64	600 air dry, 440 oven dry.
26		None	148 air dry, 120 oven dry.

*Without sand.

Referring now to samples 21 to 24, it will be observed that as the weight of the sand-free coating increased, the porosity, that is the time to pass a given quantity of air, also increased.

Thickness of the dried coating was determined microscopically on samples 21 and 25. To prepare the samples the coated paper was in one instance cut with a shears, which undoubtedly produced some compression; a second specimen was sliced transversely with a knife, which possibly produced a small amount of expansion. These samples were then mounted on edge on a microscope stage and the film thickness determined optically. Results are shown in Table III. The value shown for sample 25 is the coating thickness generally between sand particles. Where the coating included sand particles, the total thickness was 800 to 1200 microns.

TABLE III.—THICKNESS OF APPLIED COATING

Sample No.	Solids applied, lbs./MSF	Coating thickness, microns	
		Sheared specimen	Sliced specimen
21	5.6	20–50	40–80
25	64	100–150	150–250

The porosities shown in Table II for the air-dried and the oven-dried sheets are not immediately available to pass moisture vapor as the coating when initially applied had very low permeability because of its water content. Until at least a portion of this water was removed to render this sheet more permeable satisfactory drying of the core cannot be achieved.

A portion of the water may be removed from the coating by wicking the moisture into the paper substrate if the paper has not been highly sized. Development of permeability of the coated paper by this mechanism is illustrated in Example 2.

EXAMPLE 2

A coating prepared according to Formula B (but without the sand) was applied with sufficient thickness to deposit from about 6 to 8 pounds of solid per thousand square feet over a regular manila board paper having a porosity of 154 seconds per 100 mls. of air. The paper with the wet coating was immediately placed in the porosity measuring apparatus and a determination of its porosity begun. The quantity of air passed through the sample was recorded at one minute intervals and the increment for each one minute period noted. In this procedure there was virtually no opportunity for water to evaporate from the coating.

Data in Table IV show that during the first minute a small amount of air passed through the coated paper but that during the second minute, when the water was wicking from the coating and into the paper, the coated paper was less permeable, possibly because the absorbed water swelled the fibers. As the water distributed itself further through the paper, the porosity value of the combination diminished (i.e. the paper became more permeable) until, after about six minutes, it was just about equal to twice the value of the uncoated paper (300 seconds to pass 100 ml. of air).

TABLE IV.—DEVELOPMENT OF POROSITY IN COATED PAPER, FORMULA B

Time, min.	Total air, cc.	Increment, cc.	Sec./cc. increment
1	7	7	8.5
2	10	3	20
3	15	5	12
4	25	10	6
5	37	12	5
6	57	20	3
7	77	20	3

When the paper was coated with about the same weight of a coating material containing methyl cellulose the seal on the paper was nearly complete during the first minute. After 7 minutes, the amount of air passed per second was only one tenth that passed by paper coated with material according to Formula B.

The amount of moisture which a paper sheet can absorb without reducing its permeability is quite limited. For example, the permeability of the face paper of sample 26 (see Table II) was sharply reduced when its moisture content was in excess of the air dry condition by more than 15 pounds per 1000 square feet. This paper had a basis weight of 70 pounds per 1000 square feet. When an attempt was made to remove moisture from a coating weighing 64 pounds per thousand square feet solely by absorption into the paper under the test conditions of Example 2, the moisture in the paper exceeded this amount and no air had passed through the sheet in a period of 45 minutes after which time the test was terminated. For coated paper containing a large amount of moisture, permeability was obtained by evaporative removal of the water. The effect of oven drying coated paper was shown in Table II.

It had been determined that the drying of board in a kiln raised the temperature of the paper cover sheets much more rapidly than that of the core so that moisture was removed from the covers before any substantial quantity was driven from the core.

This will be illustrated by Example 3.

EXAMPLE 3

A sample of ½ inch uncoated wet gypsum board was prepared and thermocouples mounted in the middle of the gypsum core, at the interface between the core and a paper cover sheet and against the outer paper surface. This board was inserted into a kiln in which drying gas at 500° F. was circulated over the surface of the board at a rate of 50 pounds per minute per square foot of board. The temperatures indicated by the thermocouples in response to this drying treatment are shown in Table V.

TABLE V.—KILN DRYING OF HALF INCH BOARD WITH AIR AT 500° F., THERMOCOUPLE LOCATION

Time, min.	Core center, (° F.)	Interface, (° F.)	Paper surface, (° F.)
0	78	78	78
2		168	
3	174	172	228
4	183	186	232
5	188	191	236
6	190	193	238
7	192	195	239

The above data indicate that when a board initially at room temperature was placed in the dryer under the conditions of this test, by the end of the third minute the indicated temperature of the surface of the board was already well above the boiling point of water while the center of the core was more than fifty degrees cooler.

When a coated board was dried, the temperature of its core rose still more slowly because the decorative coating reduced the heat transfer rate and unless heat is transferred to the board, its temperature will not rise. Thus the coated cover sheets were rendered permeable before any substantial quantity of moisture was driven from the core.

The invention claimed is:

1. In the process of manufacturing decorated wallboard having a set gypsum core including the steps of depositing a foamed slurry of calcined gypsum in water between paper cover sheets of appreciable permeability and initiating the set of the core, the improvement comprising the steps of applying to the surface of a cover sheet an aqueous coating comprising sand particles larger than about 50 mesh and in a proportion sufficient to produce a textured surface, said coating being applied with sufficient pressure to cause at least some of the sand particles to penetrate the surface of the paper, the weight of the coating applied being from about 5 pounds to about 75 pounds of solids per thousand square feet of board area, removing moisture from the coating to render the coated sheet not substantially less permeable than the uncoated paper, and subsequently exposing the coated board to a gaseous atmosphere above the boiling point of water to drive moisture from the core and through the coated sheet.

2. The process of claim 1 wherein the moisture content of the core is maintained substantially unchanged while at least a portion of the moisture of the coating is removed therefrom.

3. The process of claim **1** wherein the permeability of the coated sheet is increased by absorbing a portion of the moisture from the coating and into the underlying paper cover sheet.

4. The process of claim **1** wherein the water is removed from the coating by raising the temperature of the coating above the core temperature.

5. The process of claim **1** wherein the temperature of the gaseous atmosphere is above 250° F.

6. The process of claim **1** wherein the temperature of the gaseous atmosphere is above 450° F.

7. The process of claim **1** wherein the moisture is removed from the coating by evaporation.

8. In the process of manufacturing decorated wallboard having a set gypsum core including the steps of depositing a foamed slurry of calcined gypsum in water between paper cover sheets of appreciable permeability and initiating the set of the core, the improvement comprising the steps of applying to the surface of a cover sheet an aqueous decorative coating in an amount sufficient to deposit from about 5 pounds to about 75 pounds of solids per thousand square feet of board area whereby the coated sheet initially becomes substantially less permeable, removing moisture from the coating to render the coated sheet not substantially less permeable than the uncoated paper, and subsequently exposing the coated board to a gaseous atmosphere above the boiling point of water to drive moisture for the core and through the coated sheet.

9. The process of claim **8** wherein there is deposited a smooth coating of less than about 10 pounds of solids per thousand square feet and the permeability of the coated sheet is increased by absorbing moisture from the coating into the underlying paper cover sheet.

10. The process of claim **8** wherein the water is removed from the coating by raising the temperature of the coating above the core temperature.

11. The process of claim **8** wherein the temperature of the gaseous atmosphere is above 250° F.

12. The process of claim **8** wherein the temperature of the gaseous atmosphere is above 450° F.

13. The process of claim **8** wherein the moisture is removed from the coating by operation.

14. The process of claim **8** wherein the moisture content of the core is maintained substantially unchanged while at least a portion of the moisture of the coating is removed therefrom.

15. In the process of manufacturing decorated wallboard having a set gypsum core including the steps of

depositing a foamed slurry of calcined gypsum in water between paper cover sheets of appreciable permeability and initiating the set of the core, the improvement comprising the steps of applying to the surface of a cover sheet an aqueous decorative textured coating in an amount sufficient to deposit from about 5 pounds to about 75 pounds of solids per thousand square feet of board area whereby the coated sheet becomes substantially less permeable, absorbing a portion of the moisture of the coating into the paper and evaporating moisture from the coating to render the coated sheet not substantially less permeable than the uncoated paper and subsequently passing the coated board into a gaseous atmosphere above the boiling point of water to drive moisture from the core and through the coated sheet.

16. In the manufacture of decorated gypsum wallboard wherein an aqueous foamed calcined gypsum slurry is deposited between the paper cover sheets of substantial permeability and permitted to set, the improvement which comprises the steps of rendering one of said sheets essentially impermeable to passage of gas by applying thereto an aqueous coating in an amount sufficient to provide from about five to about 75 pounds of solids thereof per thousand square feet of board area, restoring the permeability of said coated sheet to substantially its initial uncoated value by removal of water from said coating prior to any significant removal of water from said set gypsum, and thereafter removing excess water from said set gypsum by evaporation at elevated temperatures and causing said evaporated water to pass as vapor through said cover sheets.

17. The process of claim **16** wherein the uncoated paper cover sheet is provided with numerous minute perforations.

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