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Señores

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO

DIVISIÓN DE NUEVAS CREACIONES

E. S. D.

ASUNTO Solicitud Patente Invención No. **10-080.132**
Solicitante **UNITED STATES GYPSUM COMPANY**
Oficio **4767**

DANILO ROMERO RAAD, identificado como aparece al pie de mi firma, con domicilio en la Calle 70A No. 4-80, Bogotá D.C., obrando como apoderado de **UNITED STATES GYPSUM COMPANY** domiciliado en Estados Unidos, solicitantes de la patente en cuestión, en respuesta al oficio No. 4767 notificado por fijación en lista el 12 de marzo de 2013, me permito manifestar:

1. Modificaciones a la solicitud

En primer lugar, considerando las disposiciones del artículo 34 de la Decisión 486 para que el solicitante pueda modificar la solicitud de patente en cualquier momento del trámite, me permito adjuntar a este memorial nuevo capítulo reivindicatorio que consta de diez (10) reivindicaciones, en el cual se realizaron las siguientes modificaciones:

- Como primera medida, se modificó todo el capítulo reivindicatorio con el fin de reemplazar los términos que pueden ser considerados como ambiguos o indefinidos por los rangos específicos.
- Del mismo modo, se eliminaron las antiguas reivindicaciones 2, 3, 7, 10, 14, 15, 16, 17, 18, 19.
- Adicionalmente, se incluyó la nueva reivindicación independiente 10, la cual define un método para mejorar las propiedades de expansión de humedad del tablero de fibra-yeso.
- Finalmente, se modificó la reivindicación independiente 1 con el fin de mencionar que la fibra de celulosa no se calcinada con yeso y definiendo la cantidad de fibra-yeso final añadida al reactor para calcinación del yeso.

Con relación a las modificaciones anteriormente mencionadas, el solicitante manifiesta que las mismas no amplían de ninguna manera la materia objeto de la solicitud en estudio y se realizaron con el fin de superar las objeciones de claridad y novedad, planteadas por el examinador en el oficio para el cual se está presentando respuesta.

2. Cumplimiento de los requisitos de patentabilidad

a. Claridad de las reivindicaciones

Con relación a la claridad de la solicitud definida en el artículo 30 de la Decisión 486, es deseo del solicitante manifestar que gracias a las modificaciones enunciadas en el punto 1 del presente memorial, quedan subsanadas todas las objeciones relacionadas con este requisito.

Adicionalmente, el solicitante manifiesta que la reivindicación independiente 1 ha sido modificada para retirar las objeciones a la indicación de los resultados en el método mencionado. Igualmente, las reivindicaciones 3, 7 y 13 a 19 han sido canceladas en vista de las objeciones a las limitaciones de producto mencionadas en el método de la reivindicación 1.

De otra parte, nos permitimos informar a ese despacho que se ha adicionado la nueva reivindicación independiente 10, la cual incluye toda la limitación de la reivindicación independiente 1, donde el soporte para dicha modificación se encuentra en la mencionada reivindicación 1.

En consecuencia, el solicitante establece que las nuevas reivindicaciones 1 a 10 cumplen con el requisito de claridad tal como se encuentra definido en el artículo 30 de la Decisión 486.

b. Novedad

Con relación al cumplimiento del requisito de novedad, el examinador indicó en el oficio 4767 que la antigua reivindicación independiente 1 de la presente solicitud carece de novedad a la luz del documento D1 (US 5320677), donde dicha anterioridad enseña "*materiales y procesos para formar tableros de*

material que contiene celulosa-yeso".

De este modo, me permito indicar que el artículo 16 de la Decisión 486 establece que *"Una invención se considerará nueva cuando no está comprendida en el estado de la técnica"*.

Así, aplicando lo establecido en el artículo 16 a la presente solicitud, para que las razones indicadas por el examinador para desvirtuar la novedad fuesen ciertas, sería obligatorio que se demuestre que la presente invención está comprendida en el estado de la técnica de forma **total y completa**, lo que no se presenta con la materia definida en las nuevas reivindicaciones 1 a 10, como se demostrará a continuación.

En este sentido, nos permitimos informarle al examinador que la nueva reivindicación independiente 1 define *"Un método para hacer un panel de tablero de fibra-yeso que comprende: proporcionar una suspensión acuosa que comprende yeso y una primera porción de fibras de celulosa a un reactor, hacer reaccionar el yeso y una primera porción de fibra de celulosa en un reactor para producir una suspensión de fibra de celulosa y yeso cristalina calcinada, reforzar uniformemente la suspensión de fibra de celulosa y yeso calcinada con una segunda porción de fibra de celulosa la cual no ha sido calcinada con yeso después de la etapa de reactor para formar una segunda suspensión, depositar la segunda suspensión para formar una placa, extraer el agua de la placa, rehidratar la placa formada para obtener una placa de fibra de celulosa-yeso y luego secar, cortar y acabar la placa formada para obtener un panel de tablero de fibra-yeso final, en donde no más de la mitad del total de fibra de celulosa en el panel de tablero de fibra-yeso final es añadido en la*

primera porción al reactor para calcinación del yeso", la cual incluye una serie de características novedosas que limitan el alcance de la invención definida inicialmente y que permiten que el método reclamado se diferencie del estado del arte, especialmente del documento D1, hecho que es claro para una persona versada en la materia a partir de la lectura de la nueva reivindicación 1, donde se puede ver claramente que las partes resaltadas corresponden a las consideradas como novedosas y que no se encuentran divulgadas en ningún documento en el estado del arte y se encuentran en la parte caracterizadora de dicha cláusula independiente.

De este modo, el solicitante desea establecer que con relación a la objeción planteada por el examinador para las antiguas reivindicaciones 1, 4 a 6 y 8 a 13 por carecer de novedad/nivel inventivo en relación con el documento D1, la misma no se encuentra respaldada en las enseñanzas de D1 en la cual no se sugiere que 50% en peso o más de la celulosa utilizada para reforzar el panel de yeso reforzado con fibra de celulosa es una fibra de celulosa sin reaccionar (esto es, no calcinada).

Así, cabe resaltar el hecho que D1 revela un proceso para reforzar un tablero de fibra-yeso por medio de los pasos de calcinar el yeso con toda la fibra de celulosa en un reactor antes de deshidratar y luego formar una placa la cual es rehidratada para formar el tablero de fibra-yeso. Contrario a la caracterización de las enseñanzas de D1, dicha anterioridad no revela ni sugiere la adición de "*partículas huésped de material de celulosa*" al estuco calcinado, y mucho menos sugiere que 50% o más del total de la fibra de celulosa utilizada para reforzar sea adicionado como una celulosa que no ha sido calcinada con yeso, tal como se encuentra definido en la nueva reivindicación independiente 1. De

este modo, no existe ninguna enseñanza o sugerencia para una persona versada en la materia que la lleve a modificar el proceso de D1 contrario a su enseñanza de que la celulosa debe ser primero calcinada antes de que se forme la suspensión en paneles.

Adicionalmente, el solicitante ha encontrado de manera inesperada que por medio de la adición de no más de la mitad de la fibra de celulosa al yeso en el proceso de calcinación y luego la adición de una solución de fibra de celulosa al yeso y la fibra calcinados, el proceso no sólo produce un producto de baja densidad con las mismas propiedades deseadas del tablero de fibra-yeso de D1, sino que además reduce la energía y la potencia necesaria para producir el tablero de fibra-yeso final. Así, adjunto al presente memorial nos permitimos adjuntar una copia de la declaración del inventor en la solicitud de los Estados Unidos, la cual resalta los resultados inesperados superiores obtenidos por medio del proceso reivindicado en comparación con el proceso del documento D1.

En este sentido, consideramos importante resaltar una vez más el hecho que D1 no enseña ni siquiera sugiere que no más de la mitad del total de fibra de celulosa en el tablero de fibra-yeso final sea añadido en la primera porción al reactor para calcinación con el yeso antes de la adición del resto de la fibra de celulosa al producto calcinado del reactor, junto con las otras limitaciones incluidas en las nuevas reivindicaciones 1 y 10.

Así mismo, nos permitimos informar a ese Despacho que la adición de celulosa después de las calcinaciones producirá un producto que es reconocido en la técnica como químicamente distinto del producto de D1, ya que las

calcinaciones cambian la identidad química de la celulosa, hecho que es claro y evidente para una persona versada en la materia.

Ahora bien, volvemos sobre el particular con relación a las reivindicaciones 1 y 16 a 19, donde el examinador en su concepto técnico establece que el documento D1 revela el método general para producir un tablero de fibra-yeso por medio de mezclar yeso no calcinado, fibra de madera y agua para formar una suspensión diluida en donde el yeso y las fibras son mezclados en una proporción de 0.5 a 30% en peso. La suspensión es alimentada en un recipiente de presión inyectada de vapor y calcinada a un estado semi-hidratado y es luego deshidratada, rehidratada, secada, enfriada y finalizada. Sin embargo, la acción oficial indica que D1 difiere del proceso reivindicado en la adición de una segunda porción de la fibra de celulosa para reforzar uniformemente la suspensión de fibra de celulosa y yeso calcinada después del paso de calcinación en el reactor.

Así las cosas, la acción oficial hace referencia a la discusión de los procesos del estado de la técnica en D1 en los cuales las fibras de celulosa eran añadidos a la suspensión de yeso ya calcinada y concluye que sería obvio modificar a D1 para *"combinar la cantidad total de madera o fibras de celulosa ya sea en el proceso de calcinación, después del proceso de calcinación (tal como se revela en los procesos del estado de la técnica) o en una combinación de ambos, ya que ambos darían como resultado la incorporación de madera o fibras de celulosa en el producto final"*.

Así mismo, con relación a las reivindicaciones 2, 3, 11 y 14, la acción oficial indica que debido a que el proceso modificado de D1 tiene los mismos pasos,

sería de esperarse que la cantidad de hemihidratos no hidratados también se reduciría en la misma cantidad o en el 50% reivindicado dando como resultado un producto final que contiene 0.0 a 3.0% en peso de hemihidratos no hidratados.

Al revisar la discusión sobre los procesos del estado de la técnica en la columna 2, línea 7 a la columna 3, línea 6, y las pruebas comparativas de los tableros hechos por medio de estos procesos anteriores del estado de la técnica al proceso de D1 en la Tabla II en la columna 10, el tablero "B" del proceso de D1 suministra Módulos de Ruptura comparables en una densidad de panel mucho menor que los paneles de yeso reforzado de fibra de madera del proceso del estado de la técnica I a K y aun así suministra buenas calificaciones de fuego.

En este sentido, el solicitante manifiesta que no existe ninguna razón revelada en dicha anterioridad D1 o de otra manera sugerida en la técnica relevante para una persona versada en la materia para modificar el proceso de D1, contrario a la enseñanza de dicho documento, para no utilizar yeso y fibra co-calcinados para toda la suspensión de yeso reforzada con fibra y añadir cantidades significativas de fibra que no haya sido co-calcinada, tal como se propone en la acción oficial. Por el contrario, la enseñanza del proceso mejorado en D1 sugeriría a una persona versada en la materia que este tipo de modificación no sería deseable porque reduciría la resistencia del panel debido a la reducción de la estructura de yeso cristalizado y fibra obtenida por medio de la co-calcinación. Con base en la enseñanza en el estado de la técnica, una persona versada en la materia esperaría que el proceso reivindicado actualmente suministre un producto menos satisfactorio con una

resistencia reducida.

Así, cabe resaltar una vez más el hecho que el solicitante ha encontrado de manera inesperada que por medio de la reducción de la cantidad de fibra co-calcinada con el yeso en el proceso de Baig y por medio de la adición de una suspensión de fibra al yeso y los cristales de fibra ya co-calcinados, el panel de fibra-yeso resultante ha mantenido la resistencia del panel en D1 por medio de la reducción significativa de la cantidad de hemihidrato no hidratado (UHH) en el panel. El solicitante ha encontrado que el UHH no contribuye a la resistencia del panel y se ha encontrado que aumenta las propiedades de expansión de humedad adversas que hacen que el panel divulgado en D1 sea inaceptable en una variedad de aplicaciones de construcción, tales como tableros para cubrir techos, en las cuales el panel es expuesto a la humedad durante periodos extendidos de tiempo y a temperaturas elevadas. En particular, mientras que el nivel de UHH en el presente proceso es controlado para que sea menos de 6% y, preferiblemente en niveles de aproximadamente 0.1 a 0.3% en peso, por la formación de cristales más finos y más delgados de hemihidrato los cuales son más rápidos de fijarse antes del secado, en comparación con el nivel de UHH obtenido en el proceso de D1 el cual usualmente tiene un promedio de 10% en peso de UHH.

De este modo, los resultados de las pruebas comparativas experimentales en la Declaración de Skinner, la cual también se anexa a este escrito, confirman la reducción en la cantidad promedio de UHH en los paneles hechos con el proceso actual LFC en comparación con la cantidad de UHH en los paneles comerciales hechos de acuerdo con el proceso de D1 sin una reducción en la resistencia del panel de tablero de fibra-yeso (ver las pruebas en las Tablas en

las Figuras V a VIII de la Declaración de Skinner para el tablero de fibra-yeso probado como placa de base con un método de Probador de Piso Tipo Robinson de la Asociación Nacional de Baldosas). Estos resultados de las pruebas fueron discutidos en los párrafos 5 a 11 de la Declaración de Skinner en la cual se discuten las pruebas reportadas en las figuras V a VII.

En este sentido, el desempeño superior de expansión de humedad de los paneles hechos con niveles menores de UHH es aproximadamente 7% en peso en comparación con los paneles de tablero de fibra-yeso con contenidos de UHH de 11% a 20%, que se reporta para la expansión de humedad tanto para temperaturas mayores a 120°F (gráfica de barras en la Figura I) como para tiempos mayores de inmersión de hasta 72 horas a 70°F (gráfica de barras en la Figura I Ia a I Id y la Figura III). Ver la discusión de estos resultados en los párrafos 13 a 19 de la Declaración de Skinner. Así, estos resultados ilustran el beneficio inesperado de hacer un tablero de fibra-yeso con una resistencia comparable con los paneles más pesados y más densos hechos con el proceso de D1. El proceso LFC produce de manera inesperada un tablero de fibra-yeso que puede ser utilizado en aplicaciones, tales como cubiertas de techos, las cuales requieren de una exposición a la humedad a temperaturas elevadas con el problema de pandeo encontrado en el tablero de fibra-yeso comercial hecho por medio del proceso descrito en el documento D1 y usados para estos usos de alta humedad y temperatura (ver la fotografía en la Figura VII de la Declaración de Skinner).

Así, cabe resaltar que D1 no reconoce los problemas de producción de un tablero de fibra-yeso con altos niveles de hemihidrato no hidratado, el cual añade peso al panel sin contribuir a la resistencia del panel y mucho menos

reconoce los medios para reducir la expansión de humedad inaceptable de los paneles por medio de la reducción de los altos niveles de UHH de más de 10% en los paneles producidos por medio del proceso de calcinación completo de la fibra de D1. Es más, no hay nada en la anterioridad D1 que sugiera el beneficio del proceso reivindicado en (1) reducir los hemihidratos no hidratados en el producto final mientras que se mantiene la resistencia del tablero de fibra-yeso completamente co-calcinado de D1 y se permite el uso de los paneles en aplicaciones que requieren de una exposición prolongada a la humedad a temperaturas elevadas, o (2) la reducción significativa en tiempo y energía requeridos para extraer el agua de la suspensión de fibra-yeso en el presente proceso LFC y producir un tablero de resistencia comparable a aquel de D1 mientras que no se utiliza la calcinación completa de la fibra y el yeso enseñada por D1 para producir la resistencia requerida del tablero de fibra.

Así las cosas, el solicitante indica que por las razones establecidas anteriormente, una persona versada en la materia no esperaría que el proceso de reducción significativa de la cantidad de fibra y yeso definido en las nuevas reivindicaciones 1 a 10 utilizados en el proceso de D1 permitiera que se mantenga la resistencia del tablero de fibra en un peso reducido con energía y tiempo de procesamiento reducidos, mucho menos las propiedades de expansión de humedad significativamente mejoradas del panel producido por el presente proceso LFC en el control de la cantidad de contenido de UHH del panel final por medio de incrementar la cantidad de rehidratación del hemihidrato a dihidrato en el proceso en comparación con el proceso de D1.

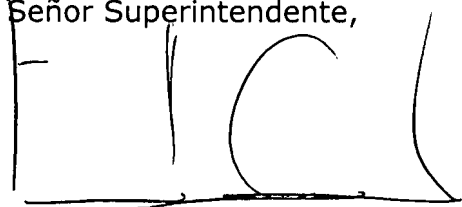
Por lo tanto, las nuevas reivindicaciones 1 a 10 de la presente solicitud cumplen con el requisito de novedad, tal como se encuentra definido en el

artículo 16 de la Decisión 486 y de acuerdo con los lineamientos definidos en el Manual Andino de Patentes y la Guía para Examinadores de esa Superintendencia, al tiempo que también cumple con el requisito de nivel inventivo definido en el artículo 18 de la misma Decisión.

En conclusión, me permito establecer que debido a las modificaciones realizadas y los argumentos expuestos anteriormente, la presente solicitud cumple cabalmente con los requisitos de claridad y novedad respecto al método expuesto en las nuevas reivindicaciones 1 a 10.

Por lo tanto, solicito a ese despacho reconocer estos requisitos y conceder el privilegio de patente de invención a la solicitud de mi mandante.

Señor Superintendente,



DANILO ROMERO RAAD

C.C. 79.547.687 - Bogotá

TP : 79.289 C.S.J.

Anexos:

- Capitulo Reivindicatorio
- Declaración del Inventor en la solicitud de EE.UU., la cual resalta los resultados inesperados superiores obtenidos por medio del proceso reivindicado en comparación con el proceso de D1.
- Declaración Skinner
- Solicitud de Patente No. US 7, 918.950 de Estados Unidos.

REIVINDICACIONES

1. Un método para hacer un panel de tablero de fibra-yeso, caracterizado porque comprende:

proporcionar una suspensión acuosa que comprende yeso y una primera porción de fibras de celulosa a un reactor,

hacer reaccionar el yeso y una primera porción de fibra de celulosa en un reactor para producir una suspensión de fibra de celulosa y yeso cristalina calcinada,

reforzar uniformemente la suspensión de fibra de celulosa y yeso calcinada con una segunda porción de fibra de celulosa la cual no ha sido calcinada con yeso después de la etapa de reactor para formar una segunda suspensión,

depositar la segunda suspensión para formar una placa, extraer el agua de la placa,

rehidratar la placa formada para obtener una placa de fibra de celulosa-yeso y luego secar, cortar y acabar la placa formada para obtener un panel de tablero de fibra-yeso final,

en donde no más de la mitad del total de fibra de celulosa en el panel de tablero de fibra-yeso final es añadido en la primera porción al reactor para calcinación del yeso.

2. El método de la reivindicación 1, en donde el yeso suministrado al reactor está en forma de una suspensión acuosa y la primera porción de fibra de celulosa que se agrega al reactor también está en forma de una suspensión acuosa y las dos suspensiones se combinan entre sí antes de ingresar al reactor.

3. El método de la reivindicación 2, en donde la segunda porción de fibra de celulosa también se agrega a la suspensión de fibra de celulosa y yeso calcinada en la forma de una suspensión acuosa.

4. El método de la reivindicación 1, en donde la primera

porción de fibra de celulosa es 3,0% en peso a 4,5% en peso de la suspensión acuosa en base seca antes de la etapa de reacción.

5. El método de la reivindicación 1, en donde la consistencia de la suspensión de fibra de celulosa y yeso en el reactor es de 25% a 30% en peso.

6. El método de la reivindicación 1, en donde 50% en peso a 70% en peso del total de fibra de celulosa se agrega como la segunda porción a la suspensión de fibra de celulosa y yeso calcinada después de que la suspensión sale del reactor.

7. El método de la reivindicación 1, en donde la placa formada fragua dentro de 15-25 minutos después de la formación y rehidratación.

8. El método de la reivindicación 1, en donde el tiempo para calcinar el yeso y la primera porción de fibra de celulosa es de 15 a 25 minutos.

9. El método de la reivindicación 7, en donde el tiempo necesario para calcinar el yeso y la primera porción de fibra de celulosa es de 18 a 22 minutos.

10. Un método para mejorar las propiedades de expansión de humedad del tablero de fibra-yeso que comprende:

proporcionar una suspensión acuosa que comprende yeso y una primera porción de fibras de celulosa a un reactor,

hacer reaccionar el yeso y una primera porción de fibra de celulosa en un reactor para producir una suspensión de fibra de celulosa y yeso cristalina calcinada,

reforzar uniformemente la suspensión de fibra de celulosa y yeso calcinada con una segunda porción de fibra de celulosa después de la etapa de reactor para formar una segunda suspensión,

depositar la segunda suspensión para formar una placa,

extraer el agua de la placa,

rehidratar la placa formada para obtener una placa de fibra de celulosa-yeso y luego secar, cortar y acabar la placa formada para obtener un panel de tablero de fibra-yeso final, en donde no más de la mitad del total de fibra de celulosa en el panel de tablero de fibra-yeso final es añadido en la primera porción al reactor.

DETAILED ARGUMENTS FROM US APPLICATION REGARDING LACK OF
INVENTIVENESS OVER BAIG US PATENT 5,320,677.

Claims 1-19 have been rejected under 35 U.S.C. §103 (a) as being unpatentable over Baig US Patent 5,320,677 (hereinafter "Baig").

Regarding claims 1 and 16-19, Baig is cited as disclosing the general method of producing a fiber gypsum board by mixing uncalcined gypsum, wood fiber and water to form dilute slurry wherein the gypsum and fibers are mixed in a ratio of about 0.5 to 30% by weight. The slurry is fed into a steam injected pressure vessel and calcined to the hemihydrate state and is then dewatered, rehydrated, dried, cooled and finished.

The Office action notes Baig differs from the claimed process in adding a second portion of the cellulose fiber to uniformly reinforce the calcined gypsum and cellulose fiber slurry after the calcinations step in the reactor.

The Office action refers to the discussion of the prior art processes in Baig in which cellulose fibers were added to already calcined gypsum slurry and concludes it would be obvious to modify Baig to "combined total amount of wood or cellulose fibers either in the calcinations process, after the calcinations process (as taught in the prior art processes) or a combination of both, as both would result in the incorporation of wood or cellulose fibers in the final product"

Regarding claims 2, 3, 11, and 14, the Office action asserts since the modified process of Baig has the same steps, it would be expected the amount of unhydrated hemihydrates would also be reduced by the same amount or by the claimed 50% resulting in a final product containing 0.0 to 3.0 weight % unhydrated hemihydrates.

In reviewing the discussion of the prior art processes in Column 2, lines 7 through column 3, line 6, and the comparison tests of boards made by these prior art processes compared to the process of Baig in Table II in column 10, the board "B" of the Baig process provides comparable Modulus of Rupture at much lower panel density than the wood fiber reinforced gypsum panels of the prior art process I through K and yet provides good fire ratings.

Applicants submit there is no reason disclosed in Baig or otherwise suggested in the relevant art to one skilled in the art to modify the Baig process, contrary to the teaching in Baig, to not use co-calcined gypsum and fiber for all of the fiber reinforced gypsum slurry and to add significant amounts of fiber which has not been co-calcined, as proposed in the Office action. The teaching of the improved process in Baig would suggest to one skilled in the art this type of modification would be not be desired because it would reduce the strength of the panel due to the reduction of the crystallized gypsum and fiber structure obtained by the co-calcination. Based upon the teaching in the art, one skilled in the art would expect the present claimed process would provide a less satisfactory product with reduced strength.

Applicants have unexpectedly found by reducing the amount of fiber co-calcined with the gypsum in the process of Baig and adding fiber slurry to the already co-calcined gypsum and fiber crystals, the resulting gypsum fiber panel has retained the strength of the panel in Baig by significantly reducing the amount of unhydrated hemihydrate (UHH) in the panel. Applicants have found UHH does not contribute to strength of the panel and it has been found to increase adverse moisture expansion properties which makes the panel of Baig unacceptable in a number of building applications such as roofing cover boards, in which the panel is exposed to moisture for extended periods of time and at elevated temperatures. In particular, while the level of UHH in the present process is controlled to be less than 6 % and, preferably at levels of about 0 to 0.3% by weight, by the formation of finer and thinner crystals of hemihydrate which are quicker to set before drying, compared to the UHH level obtained in the Baig process, which usually averages about 10% by weight UHH (see the discussion in paragraphs 19 through 21 of the accompanying Declaration of Ms. Marsha S. Skinner of September 23, 2010 (hereinafter the "Skinner Declaration"). The results of production of gypsum fiberboard made using the low fiber calcination ("LFC") process of the present invention in commercial production compared to commercial production of panels using the Baig process are discussed in paragraphs 12 and 20 of the Skinner Declaration.

The experimental comparative test results reported in the Skinner Declaration, confirms the reduction in the average amount of UHH in the panels made from the present LFC process compared to the amount of UHH in the commercial panels made in accordance with the Baig process without reduction in strength of the gypsum fiberboard panel. (see the tests in the Tables in Figures V through VII of the Skinner Declaration for gypsum fiberboard tested as a backerboard with a conventional Robinson Tile Tester method of the National Tile Association). The results of the tests are discussed in paragraphs 5 through 11 of the Skinner Declaration which discusses the tests reported in Figures V through VII.

The superior moisture expansion performance of panels made with lower levels of UHH of about 7 wt % compared to gypsum fiberboard panels with UHH contents of 11 % and 20%, are reported for moisture expansion at both higher temperatures of 120F (bar graph in Figure I) and for longer soak times of up to 72 hours at 70F (the bar graphs of Figures IIa through II d and Figure III. See the discussion of these results in paragraphs 13 through 19 of the Skinner Declaration. These results illustrate the unexpected benefit of making gypsum fiberboard with reduced UHH content using the present LFC process for producing boards with strength comparable to the heavier and more dense panels made with the Baig process. The LFC process unexpectedly produces gypsum fiberboard which can be used in applications, such as roofing, which require exposure to moisture at elevated temperatures without the problem of warping found with commercial gypsum fiberboard made by the Baig process are used for these high moisture and temperature uses (see photograph in Figure VIII of the Skinner Declaration).

Baig does not recognize the problems of production of a gypsum fiberboard with higher levels of unhydrated hemihydrate, which adds weight to the panel without contributing to the strength of the panel, much less recognize means for reducing unacceptable moisture expansion of panels by reducing higher levels of UHH of over 10% in the panels produced by the complete fiber calcination process of Baig. Moreover, there is nothing in Baig to suggest the benefit of the claimed process in (1) reducing unhydrated hemihydrates in the final product while

retaining strength of the complete co-calcined gypsum fiberboard of Baig, and allowing use of the panels in applications requiring extended exposure to moisture at elevated temperatures, or (2) the significant reduction in time and energy required to dewater the gypsum-fiber slurry in the present LFC process and produce a comparable strength board compared to Baig, while not using the complete calcination of fiber and gypsum taught by Baig for producing the required strength of the fiberboard.

Applicant submit, for the reasons set forth above, one skilled in the art would not expect the present process of significantly reducing the amount of calcined fiber and gypsum used in the process of Baig would allow retention of the strength of fiberboard at reduced weight with reduced energy and processing time, much less the significantly improved moisture expansion properties of the panel produced by the present LFC process in controlling the amount of UHH content of the final panel by increasing the amount of rehydration of the hemihydrate to the dihydrate in the process compared to the Baig process.

ANEXO 2 – ARGUMENTOS DETALLADOS DE LA SOLICITUD DE LOS ESTADOS UNIDOS EN RELACIÓN CON LA FALTA DE NIVEL INVENTIVO EN RELACIÓN CON LA PATENTE DE LOS ESTADOS UNIDOS 5.320.677 DE BAIG.

Las reivindicaciones 1 a 19 han sido rechazadas bajo 35 U.S.C §103 (a) por no ser patentable en relación con la patente de los Estados Unidos 5.320.677 de Baig (de ahora en adelante “Baig”).

En relación con las reivindicaciones 1 y 16 a 19, se dice que Baig revela el método general para producir un tablero de fibra-yeso por medio de mezclar yeso no calcinado, fibra de madera y agua para formar una suspensión diluida en donde el yeso y las fibras son mezclados en una proporción de 0.5 a 30% en peso. La suspensión es alimentada en un recipiente de presión inyectada de vapor y calcinada a un estado semi-hidratado y es luego deshidratada, rehidratada, secada, enfriada y finalizada.

La acción oficial anota que Baig difiere del proceso reivindicado en la adición de una segunda porción de la fibra de celulosa para reforzar uniformemente la suspensión de fibra de celulosa y yeso calcinada después del paso de calcinación en el reactor.

La acción oficial hacer referencia a la discusión de los procesos del estado de la técnica en Baig en los cuales las fibras de celulosa eran añadidos a la suspensión de yeso ya calcinada y concluye que sería obvio modificar a Baig para “combinar la cantidad total de madera o fibras de celulosa ya sea en el proceso de calcinación, después del proceso de calcinación (tal como se revela en los procesos del estado de la técnica) o en una combinación de ambos, ya que ambos darían como resultado la incorporación de madera o fibras de celulosa en el producto final”.

En relación con las reivindicaciones 2, 3, 11 y 14, la acción oficial indica que debido a que el proceso modificado de Baig tiene los mismos pasos, sería de esperarse que la cantidad de hemihidratos no hidratados también se reduciría en la misma cantidad o en el 50% reivindicado dando como resultado un producto final que contiene 0.0 a 3.0% en peso de hemihidratos no hidratados.

Al revisar la discusión sobre los procesos del estado de la técnica en la columna 2, línea 7 a la columna 3, línea 6, y las pruebas comparativas de los tableros hechos por medio de estos procesos anteriores del estado de la técnica al proceso de Baig en la Tabla II en la columna 10, el tablero “B” del proceso de Baig suministra Módulos de Ruptura comparables en una densidad de panel mucho menor que los paneles de yeso reforzado de fibra de madera del proceso del estado de la técnica I a K y aun así suministra buenas calificaciones de fuego.

Los solicitantes indican que no existe ninguna razón revelada en Baig o de otra manera sugerida en la técnica relevante para una persona versada en la materia para modificar el proceso de Baig, contrario a la enseñanza de Baig, para no utilizar yeso y fibra co-calcinados para toda la suspensión de yeso reforzada con fibra y añadir cantidades significativas de fibra que no haya sido co-calcinada, tal como se propone en la acción oficial. La enseñanza del proceso mejorado en Baig sugeriría a una persona versada en la materia que este tipo de modificación no sería deseable porque reduciría la resistencia del panel debido a la reducción de la estructura de yeso cristalizado y fibra obtenida por medio de la co-calcinación. Con base en la enseñanza en el estado de la técnica, una persona versada en la materia esperaría que el proceso reivindicado actualmente suministre un producto menos satisfactorio con una resistencia reducida.

Los solicitantes han encontrado de manera inesperada que por medio de reducir la cantidad de fibra co-calcinada con el yeso en el proceso de Baig y por medio de añadir una suspensión de fibra al yeso y los cristales de fibra ya co-calcinados, el panel de fibra-yeso resultante ha mantenido la resistencia del panel en Baig por medio de reducir de manera significativa la cantidad de hemihidrato no hidratado (UHH) en el panel. Los solicitantes han encontrado que el UHH no contribuye a la resistencia del panel y se ha encontrado que aumenta las propiedades de expansión de humedad adversas que hacen que el panel de Baig sea inaceptable en una variedad de aplicaciones de construcción, tales como tableros para cubrir techos, en las cuales el panel es expuesto a la humedad durante periodos extendidos de tiempo y a temperaturas elevadas. En particular, mientras que el nivel de UHH en el presente proceso es controlado para que sea menos de 6% y, preferiblemente en niveles de aproximadamente 0.1 a 0.3% en peso, por la formación de cristales más finos y más delgados de hemihidrato los cuales son más rápidos de fijarse antes del secado, en comparación con el nivel de UHH obtenido en el proceso de Baig el cual usualmente tiene un promedio de 10% en peso de UHH (ver la discusión en los párrafos 19 a 21 de la Declaración que se acompaña de la señorita Marsha S. Skinner de 23 de septiembre de 2010 (de ahora en adelante la "Declaración de Skinner"). Los resultados de la producción de tablero de fibra-yeso hecho utilizando el proceso de calcinación de baja fibra ("LFC") de la presente invención en la producción comercial comparada con la producción comercial de los paneles utilizando el proceso de Baig son discutidos en los párrafos 12 y 20 de la Declaración de Skinner.

Los resultados de las pruebas comparativas experimentales en la Declaración de Skinner confirman la reducción en la cantidad promedio de UHH en los paneles hechos con el proceso actual LFC en comparación con la cantidad de UHH en los paneles comerciales hechos de acuerdo con el proceso de Baig sin una reducción en la resistencia del panel de tablero de fibra-yeso (ver las pruebas en las Tablas

en las Figuras V a VIII de la Declaración de Skinner para el tablero de fibra-yeso probado como placa de base con un método de Probador de Piso Tipo Robinson de la Asociación Nacional de Baldosas). Los resultados de las pruebas fueron discutidos en los párrafos 5 a 11 de la Declaración de Skinner en la cual se discuten las pruebas reportadas en las figuras V a VII.

El desempeño superior de expansión de humedad de los paneles hechos con niveles menores de UHH es aproximadamente 7% en peso en comparación con los paneles de tablero de fibra-yeso con contenidos de UHH de 11% a 20%, se reporta para la expansión humedad tanto para temperaturas más altas de 120°F (gráfica de barras en la Figura I) como para tiempos mayores de inmersión de hasta 72 horas a 70°F (gráfica de barras en la Figura I la a I Id y la Figura III). Ver la discusión de estos resultados en los párrafos 13 a 19 de la Declaración de Skinner. Estos resultados ilustran el beneficio inesperado de hacer tablero de fibra-yeso con una resistencia comparable con los paneles más pesados y más densos hechos con el proceso de Baig. El proceso LFC produce de manera inesperada tablero de fibra-yeso que puede ser utilizado en aplicaciones, tales como cubiertas de techos, las cuales requieren de una exposición a la humedad a temperaturas elevadas son el problema de pandeo encontrado en el tablero de fibra-yeso comercial hecho por medio del proceso de Baig usados para estos usos de alta humedad y temperatura (ver la fotografía en la Figura VII de la Declaración de Skinner).

Baig no reconoce los problemas de producción de un tablero de fibra-yeso con altos niveles de hemihidrato no hidratado, el cual añade peso al panel sin contribuir a la resistencia del panel y mucho menos reconoce medios para reducir la expansión de humedad inaceptable de los paneles por medio de reducir los altos niveles de UHH de más de 10% en los paneles producidos por medio del proceso de calcinación completo de la fibra de Baig. Es más, no hay nada en Baig que sugiera el beneficio del proceso reivindicado en (1) reducir los hemihidratos no hidratados en el producto final mientras que se mantiene la resistencia del tablero de fibra-yeso completamente co-calcinado de Baig y se permite el uso de los paneles en aplicaciones que requieren de una exposición prolongada a la humedad a temperaturas elevadas, o (2) la reducción significativa en tiempo y energía requeridos para extraer el agua de la suspensión de fibra-yeso en el presente proceso LFC y producir un tablero de resistencia comparable a aquel de Baig mientras que no se utiliza la calcinación completa de la fibra y el yeso enseñada por Baig para producir la resistencia requerida del tablero de fibra.

El solicitante indica, por las razones establecidas con anterioridad, que una persona versada en la materia no esperaría que el presente proceso de reducción significativa de la cantidad de fibra y yeso utilizados en el proceso de Baig permitiera el mantenimiento de la resistencia del tablero de fibra en un peso

reducido con energía y tiempo de procesamiento reducidos, mucho menos las propiedades de expansión de humedad significativamente mejoradas del panel producido por el presente proceso LFC en el control de la cantidad de contenido de UHH del panel final por medio de incrementar la cantidad de rehidratación del hemihidrato a dihidrato en el proceso en comparación con el proceso de Baig.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Marsha S. SKINNER et al

EXAMINER: Daniel H. LEE

Application No.: 11/962,031

Group Art Unit: 1791

Filed: December 20, 2007

For: LOW FIBER CALCINATION PROCESS FOR MAKING GYPSUM
FIBERBOARDMail Stop Amendment

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

Marsha S. SKINNER RULE 132 DECLARATION

I, Marsha S. Skinner, declare and state:

1. I have been employed by U.S. Gypsum Company from 1979 to the present, where I am currently Department Manager of the Gypsum Fiber Process manufacturing plant located at Gypsum, Ohio.

3. I have been involved in the development and production of FIBEROCK® brand gypsum fiberboard products since 1994, including the start-up of the FIBEROCK® brand board products production demonstration line in 1994, and the start-up of the commercial production line in 1999.

4. I am a co-inventor of the invention claimed in the above identified application.

5. The attached tables in Figures V through VII, show the results of Robinson Floor Tests of ceramic tile floor systems made using the production FIBEROCK® brand tile backer board made in accordance with the process in US Patent Number 5,320,677 of Baig and ceramic tile floor systems made with the low fiber calcination (LFC) panels of the present invention made with the

FIBEROCK® brand panel composition with the same density and fiber content of the control panel and a third sample of LFC panel of the present invention with a lower density and fiber content than the control sample. The test were performed at my request by the USG Company Research and Technology Center under the test standard of ASTM C 627 for determining performance ratings for ceramic floor tile assemblies as classified by the Tile Council of North America. The objective of ASTM C 627 is to use a standardized procedure for evaluating performance of ceramic tile under conditions similar to actual usage to determine the highest number of cycles a floor system will pass. Deflection readings were taken both before and after each cycle while weights were loaded and a non-loaded deflection was measured after every fourth cycle. The deflection readings represent deflection of a 16 in. o.c. span floor, when stressed under a given weight. Three decks were tested under the requirements of ASTM C 627 using a conventional Robinson floor tester

6. The three test assemblies consisted of a 4 foot x 4 foot wooden frame with framing members spaced at 16 inch centers, 3/4 inch plywood subflooring adhered with Liquid Nails adhesive and nailed to the frame using #6 nails at 10 inch o.c. ANSI A118.4 Custom Building Products thin set mortar was applied on the surface and a sample of the FIBEROCK® brand gypsum fiberboard test panel (table in Figure V) and the two types of LFC test panels of the invention were placed on top and then stapled using 1/4 inch crown staples at 2 inch o.c. Another layer of the same thin set mortar was then placed on the panel and finished with 2 in. x 2 in. porcelain ceramic mosaic floor tiles. The specified shear bond strength for the assembly was 265 psi. ANSI A118.7 Tri-Poly Fortified Sanded Grout was then added to the tiles. All samples were allowed to cure for 28 days before testing.

7. All tests were done with the basic FIBEROCK® brand panel formulation (Control Sample 1), the panel of the invention which uses a portion of fiber which has not been calcined in the Low Fiber Calcination (LFC) process of

the invention (Sample 2) which has lower density and higher fiber content than the control sample 1, and with the LFC panel of the invention also made with fiber which has not been calcined (Sample 3) which has the same density and fiber content of the panel of control panel of Sample 1.

8. The control sample 1 had 95 contact tiles and 126 contacted grout lines. Failure was noted in the 6th cycle. There were 5 chipped tiles and 1 broken tile. The set deflection was 0.008 inch.

9. The low density/high fiber LFC panel of Fig. V had 90 contacted tiles and 120 contacted grout lines. Failure was noted in the 7th cycle. There were 3 chipped tiles in the 6th cycle and 9 chipped and 10 broken tiles after 107 revolutions of the 7th cycle. The set deflection after the first 4 cycles was only 0.004 in. The final set was 0.050 in.

10. The LFC panel of the present invention in Fig. VI, with the same density and fiber content as the control panel of sample 1, has 86 contacted tiles and 113 contacted grout lines. Failure was noted in the 6th cycle. There were 6 chipped tiles. The final set was 0.010 in.

11. Based upon the results of the testing reported in the tables of Figures V through VII, all of the samples met a residential rating, with the LFC panels of this invention meeting or exceeding the Cycle 6 performance of the FIBEROCK® brand gypsum fiberboard panel of the Baig US patent process.

12. As part of my duties, I have personally supervised the production of gypsum fiberboard made by both the process in the Baig reference as well as gypsum fiberboard made in commercial production using the present LFC process of our invention. Based upon the production records for all gypsum fiberboard panels made using these two processes under my direction over a two year period for FIBEROCK® brand gypsum fiberboard panels, the average

content of UHH in the final panel made by the original process of Baig was between 7.6 and 7.9 weight %, with over 50% of the panels having a UHH content of over 6%. In comparison, gypsum fiberboard panels made with the LFC process of our present invention averaged 3.2, 3.4 and 4.5 wt % for the years following the adoption of the LFC process with approximately 97% of the panels having a UHH content under 10 wt. % and only about 20 % of the panels having a UHH content of over 6 wt. % and 36% of the panels had a UHH content of 3 wt. % or less in the commercial manufacture of gypsum fiberboard panels using the LFC process and the same basic FIBEROCK® brand panel composition.

13. The following tests examine the combined effect of UHH content, fiber content and moisture uptake on the unrestrained expansion of FIBEROCK® brand gypsum fiberboard sheathing panels prepared by the process of the Baig patent. In the restrained state i.e. panels attached to framing and abutted against one another, linear expansion leads to warping, as shown in the photograph in Figure VIII. The test results reported herein show that control of all three of these variables reduce potential warping and allow for a greater measure of control of the final panel properties.

14. FIBEROCK® Brand sheathing with various levels of UHH and fiber content were produced and characterized using a "Stucco and Board Core Composition" ("STABCO") test method developed by US Gypsum Company for plant quality control testing to monitor UHH level in the panels. STABCO method was developed in the mid 1970's to calculate stucco conversion factors and utilization efficiencies to identify areas for process improvements. The STABCO analysis uses a series of mass balance calculations following the conversion of gypsum to hemihydrate and then back into gypsum in the finished panel product. The STABCO method is used to determine the amount of calcination and kiln drying. The STABCO method is also used to determine the amount and source of UHH. In accordance with the STABCO test method, sheathing panel

specimens measuring 12 in. x 3 in. were prepared for expansion testing by bonding brass buttons on a 10 in. span. The specimens were conditioned at 70 F and 50% Relative Humidity before the initial length was measured. All subsequent length measurements were referenced to the initial length to calculate the % length change (expansion). The specimens described in the TABLE in Figure IV, are placed in water at various temperatures and time periods, as described below, with subsequent length measurement:

- (A) Wet Expansion 2 hour soak @ 70°F & 120° F.,
- (B) Wet Expansion soak over 2 hours @ 70°F, and
- (C) Wet Expansion soak 2 hour soak @ 70°F and then maintained wet by wrapping in plastic.

15. Based upon the results of the wet expansion testing reported in the table in Figure IV and shown in the bar graph of the expansion results in Figures I, wet expansion following 2-Hour Soak tests at 70°F and 120°F, increasing amount of UHH and increasing fiber content each yield definite increase in wet expansion at the two temperatures, with more wet expansion occurring at the higher soak temperature.

16. The results of the wet expansion testing shown in the bar graphs of Figure I, Ila-IId and III, following longer soak times at 70°F also confirms increased expansion with increasing UHH content, increasing fiber content and increasing moisture absorption.

17. The results of the wet expansion testing shown in the bar graph of Figure I following 2 hour soak times at 70°F and maintaining the samples in a wet state by wrapping in plastic, also confirms increased expansion with higher UHH content at even modest absorption levels of about 4%, if the samples are allowed to stay wet over an extended period of time.

18. Based upon the results of the above wet expansion testing, the primary mechanism of material moisture expansion in the gypsum fiberboard appears to be directly related to the conversion of unhydrated hemihydrate (UHH) and that the presence of moisture, even at modest absorption levels over time, facilitates UHH conversion. The swelling of fibers in the presence of moisture is a secondary mechanism for expansion.

19. Based upon the above test results and my experience with the commercial process for making gypsum fiberboard, it has been found that the degree of rehydration of the hemihydrate is essential to the process of making gypsum fiber products and that the rehydration of the hemihydrate should be essentially complete before drying of the board commences. I have also found that boards which contain a significant level of un-hydrated hemihydrate (UHH) i.e. hemihydrate that fails to convert back to the dihydrate form, have reduced strength and expand to a greater degree when exposed to elevated temperature and humidity conditions.

20. We have also found that an unexpected result of the present LFC process is the formation of alpha crystals that are longer, finer and having a higher surface area. The higher aspect ratio of these alpha crystals increase the rate of conversion of calcium sulfate hemihydrate to calcium sulfate dihydrate and therefore lower the UHH content of the final gypsum fiber board product. This has been confirmed by the shorter set times in the commercial production of gypsum fiberboard when significantly lower levels of UHH are present in the slurry.

21. Another factor effecting set time with the present process is the cooler slurry temperature at the forming step, which is a direct result of the introduction of water and fiber after the calcination step in the present LFC process, immediately prior to the forming line.

22. Even with the significant reduction of the UHH content of the present process due to reduction of incomplete rehydration, it is known by those skilled in the art that skin burning of the gypsum fiberboard due to over-drying in the kiln should be avoided to keep UHH levels lower in the final dried gypsum fiberboard.

23. Therefore, based upon the results for the hydration related expansion, the UHH content for commercial gypsum fiberboard should be limited to less than 10%, and preferably below 6%, to reduce the likelihood of hydration related expansion. The conventional use of moisture resistance treatment with siloxane also provides the benefits of reducing the rate of moisture uptake and eliminating the effect of temperature on moisture absorption.

24. As discussed in paragraph 12 above, the UHH content of the low fiber calcination process of the present invention has produced an average UHH contents of as low as 3.2 %, with significant amounts of board having even lower UHH content. The lower UHH content of the gypsum fiberboard of the present process has produced gypsum fiberboard which has the same strength as the gypsum fiberboard of the Baig process and which can be used in higher moisture applications without significant hydration expansion.

25. Therefore, for all the reasons set forth above, it is my opinion one skilled in the art would not be motivated to modify the teachings of the U S Patent of Baig which requires co-calcining all of the gypsum and fiber used in the slurry to make the gypsum fiberboard, by using a significant amount of gypsum and fiber which has not been calcined, as proposed in the Office action. One skilled in the art would not expect significant reduction in the amount of co-calcined gypsum and fiber in the process of Baig to make panel with any expectation that the resulting panel would have the same strength and performance properties of the panel made by the Baig co-calcination process, much less produce a panel which has improved resistance to moisture expansion while achieving significant

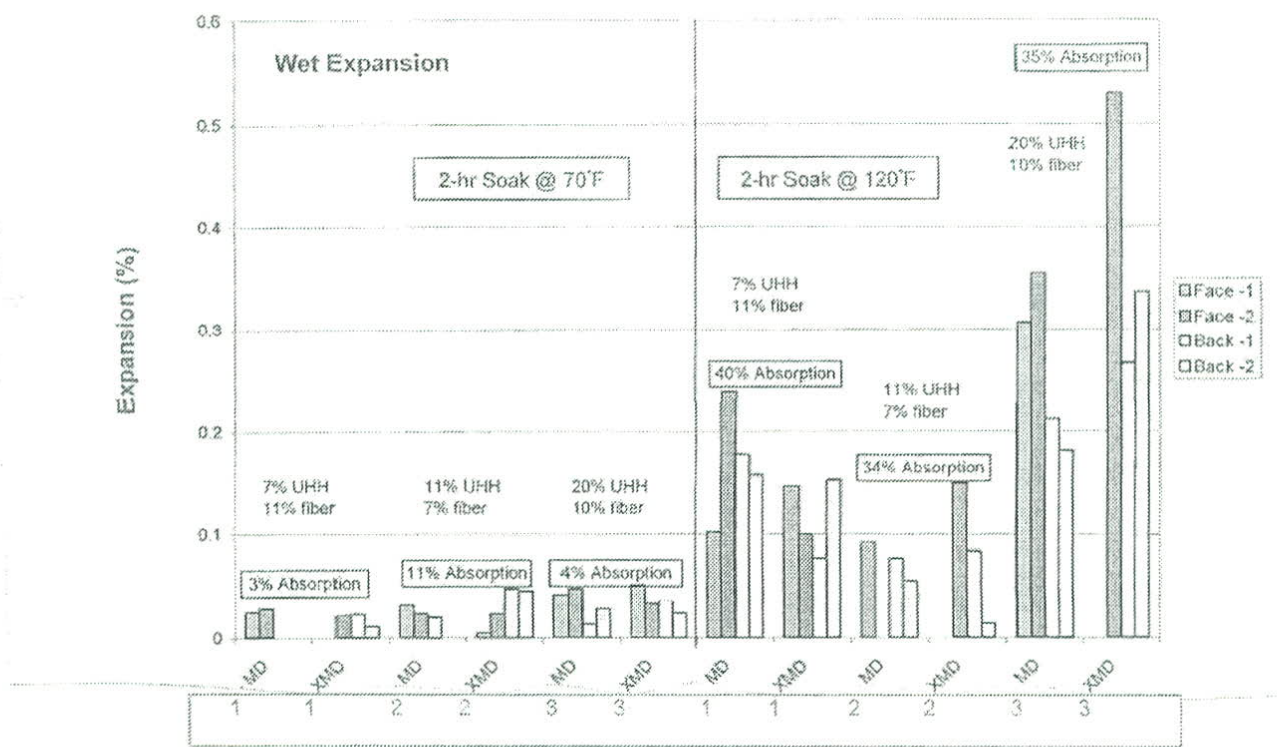
reductions in processing time and energy required to make the gypsum fiberboard panel

26. I further declare that all statements and representations made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements and representations were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued there from.

Date: September 23, 2010

By: Marsha S. Skinner
Marsha S. Skinner

Figure I: FIBEROCK® Brand Sheathing Wet Expansion.



Figures 11a – 11d: FIBEROCK® Brand Sheathing Wet Expansion.

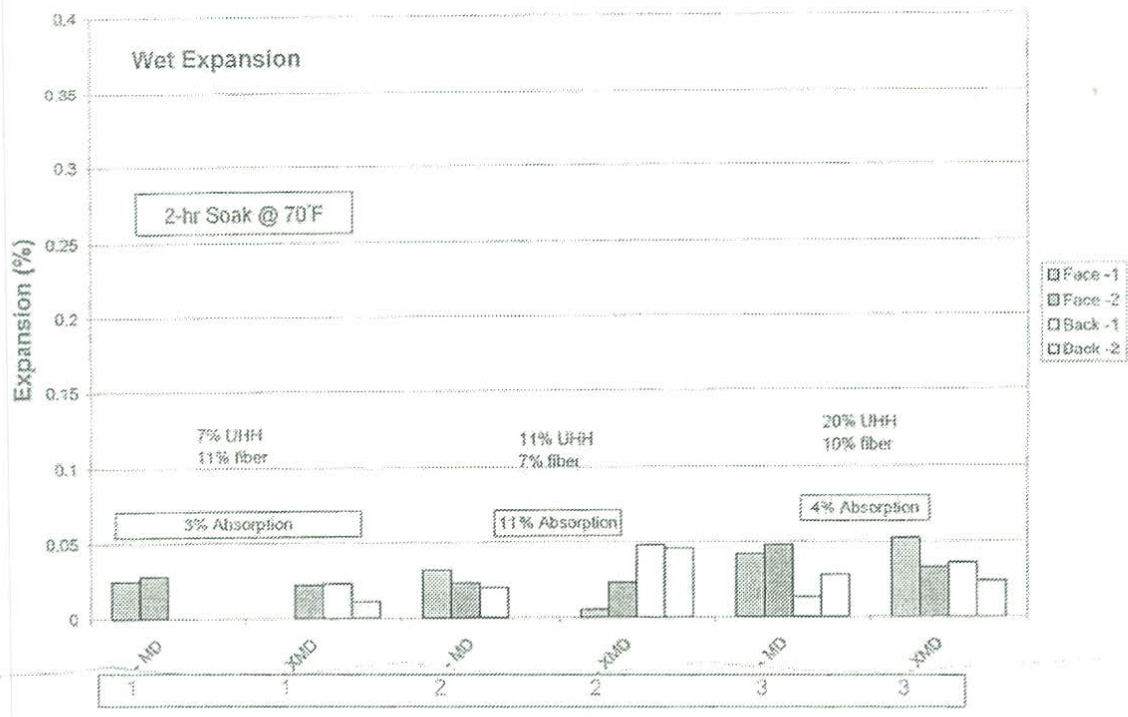


Figure II b

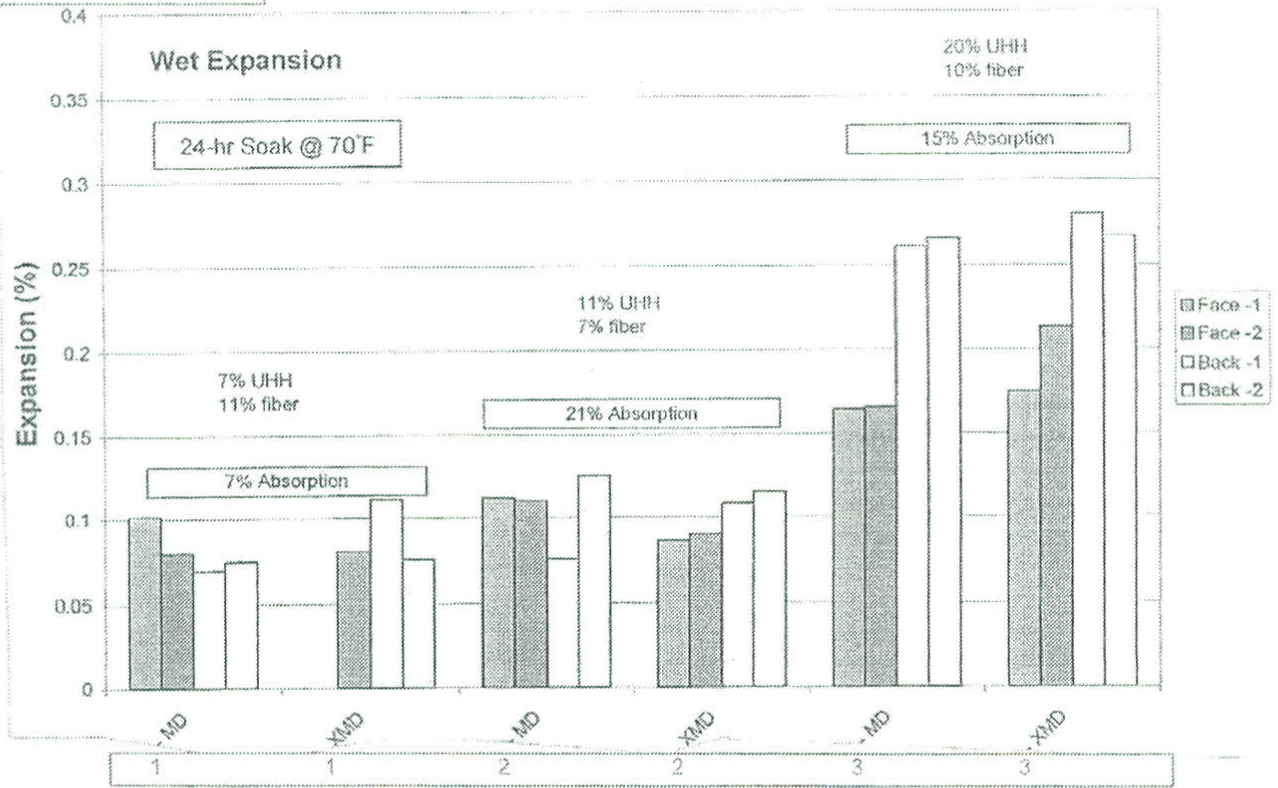


Figure II c

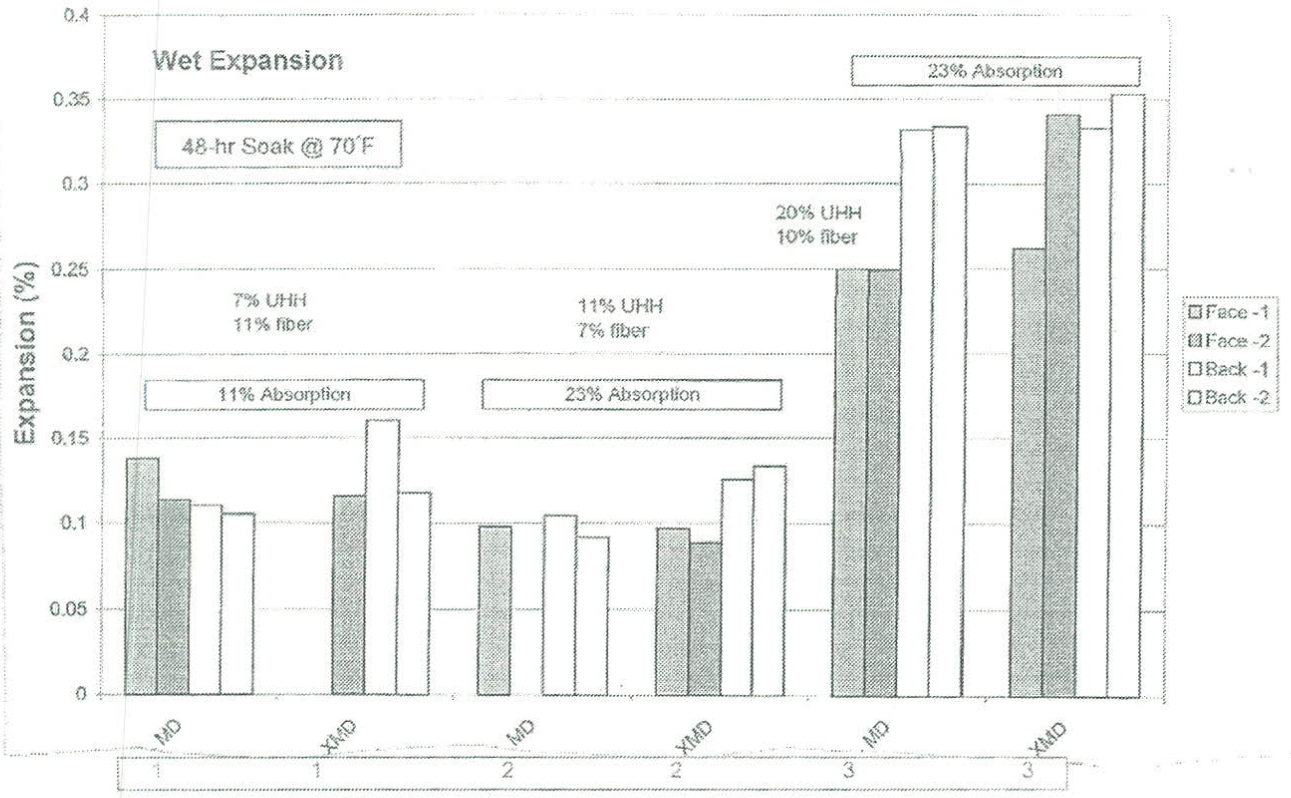


Figure II d

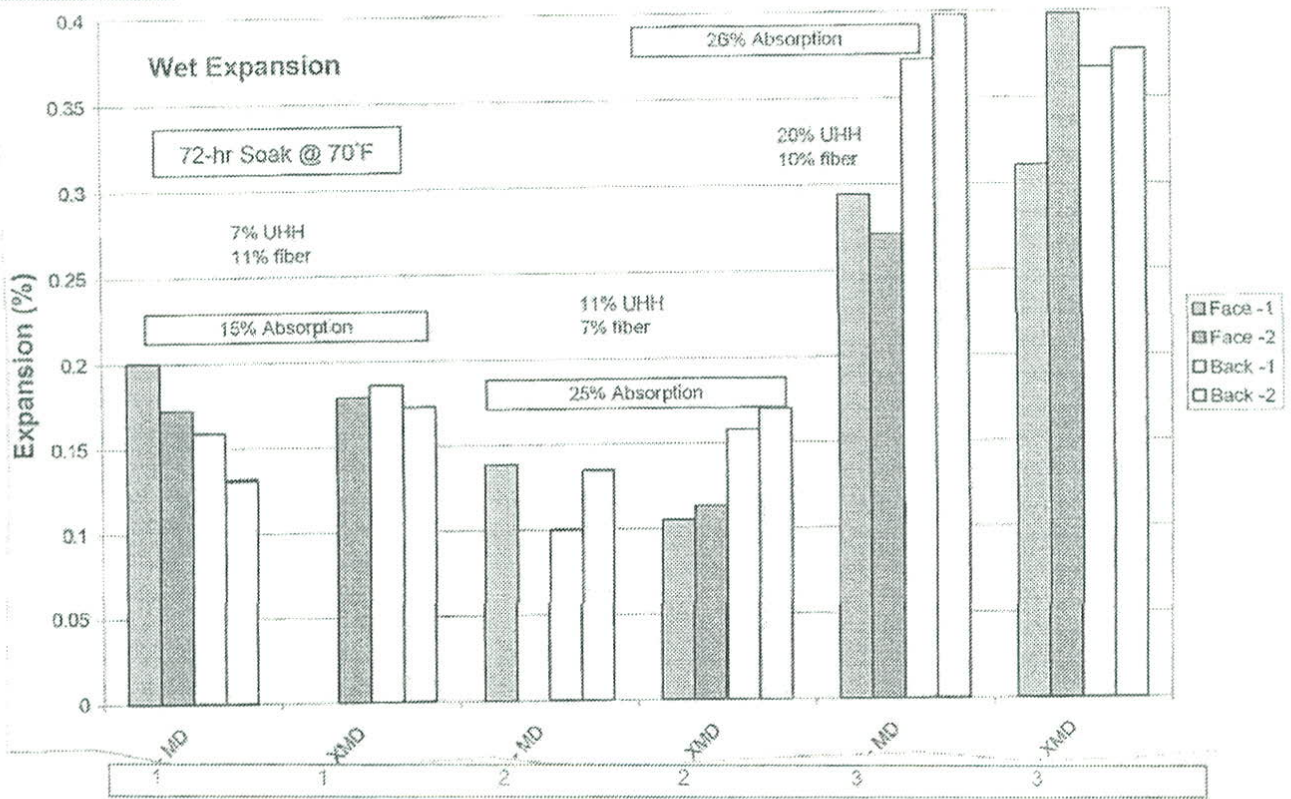


Figure III: FIBEROCK® Brand Sheathing Wet Expansion.

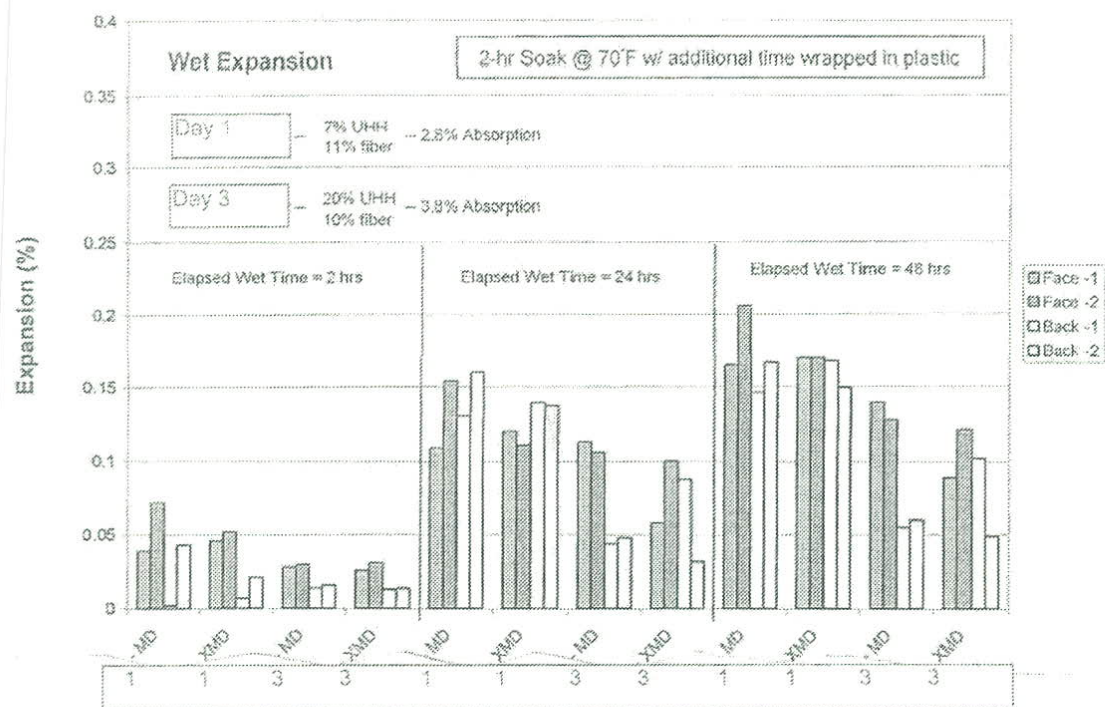


FIG. IV

Production Code	UHH Content (% by wt.)	Fiber Content (% by wt.)
Day 1	7	11
Day 2	11	7
Day 3	20	10

FIG. V

Cycle	Deflection Δ (in.)
1	0.002
2	0.006
3	0.0
4	0.002
5	0.001
6	0.002

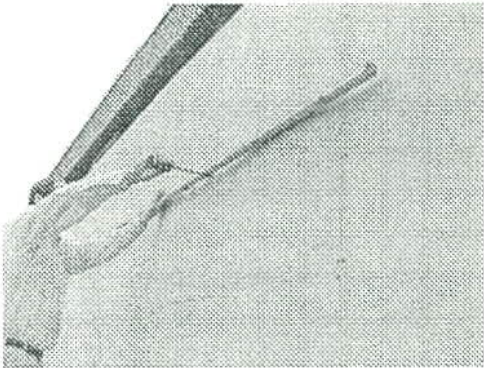
FIG. VI

Cycle	Deflection Δ (in.)
1	0.001
2	0.002
3	0.006
4	0.001
5	0.023
6	0.008
7	0.017

FIG. VII

Cycle	Deflection Δ (in.)
1	0.0
2	0.001
3	0.002
4	0.0
5	0.015
6	0.006

FIG. VIII Warping



EN LA OFICINA DE PATENTES Y MARCAS DE LOS ESTADOS UNIDOS

Solicitante: Marsha S. SKINNER y otros

Examinador: Daniel H. Lee

Solicitud No.: 11/962.031

Unidad de Grupo de la Técnica: 1791

Para: Proceso de Calcinación Bajo en Fibra para Hacer Tablero de Fibra-Yeso

Comisionado de Patentes

P.O. Box 1450

Alexandria, Virginia 22313-1450

Marsha S. Skinner - Declaración de la Regla 132

Yo, Marsha S. Skinner, declaro y manifiesto:

1. He estado empleado por U.S. Gypsum Company desde 1979 hasta el presente, en donde actualmente soy el Gerente de departamento de la planta de fabricación de Proceso de Fibra-Yeso localizada en Gypsum, Ohio.

3. He estado involucrada en el desarrollo y la producción de productos de tablero de fibra-yeso de marca FIBEROCK® desde 1994, incluyendo la puesta en marcha de la línea de demostración de producción de los productos de tablero de marca FIBEROCK® en 1994 y la puesta en marcha de la línea de producción comercial en 1999.

4. Soy la co-inventora de la invención reivindicada en la solicitud identificada anteriormente.

5. Las tablas anexas en las Figuras V a VII muestran los resultados de las Pruebas de Piso Robinson de los sistemas de piso con baldosas cerámicas utilizando el tablero de base de cerámica de marca FIBEROCK® de acuerdo con el proceso en la patente de los Estados Unidos No. 5.320.677 de Baig y los sistemas de piso con baldosas cerámicas hechos con paneles de calcinación de baja fibra (LFC) de la presente invención hechos con la composición de panel de marca FIBEROCK® con la misma densidad y contenido de fibra del panel de control y una tercera muestra de un panel LFC de la presente invención con una densidad y un contenido de fibra menores que aquellos de la muestra de control. Las pruebas fueron llevadas a cabo de acuerdo con mi solicitud por parte del Centro de Investigación y Tecnología de USG Company bajo la prueba estándar de ASTM C 627 para determinar las clasificaciones de desempeño para los ensambles de baldosas cerámicas según se encuentran clasificadas por el Consejo de Baldosas de América del Norte. El objetivo del ASTM C 627 es utilizar

un procedimiento estandarizado para evaluar el desempeño de las baldosas cerámicas bajo condiciones similares al uso efectivo para determinar el número mayor de ciclos que pasará un sistema de piso. Las lecturas de desviación se tomaron antes y después de cada uno de los ciclos mientras que se cargaban pesos y se medía una desviación no cargada después de cada cuarto ciclo. Las lecturas de desviación representan una desviación de un piso de extensión de 16 pulgadas aparte (o.c. en inglés, que significa en el centro o aparte), cuando se estresa bajo un cierto peso. Tres cubiertas fueron probadas bajos los requerimientos del ASTM C 627 utilizando un probador de piso Tipo Robinson.

6. Los tres ensambles de prueba consistían de un marco de manera de 4 pies x 4 pies con miembros de marco espaciados en centros de 16 pulgadas, sub-piso de madera contrachapada de $\frac{3}{4}$ pulgada adherido con adhesivo Liquid Nails (Clavos Líquidos) y clavado a un marco utilizado clavos #6 a 1 pulgada aparte. Un mortero de capa delgada ANSI A118.4 de Custom Building Products fue aplicado sobre la superficie y una muestra del panel de prueba de tablero de fibra-yeso marca FIBEROCK® (tabla en la Figura V) y los dos tipos de paneles de prueba LFC de la invención fueron colocados encima y luego grapados utilizando grapas de corona de $\frac{1}{4}$ de pulgada a 2 pulgadas aparte. Otra capa del mismo mortero de capa delgada fue luego colocada en el panel y terminada con baldosas de piso de mosaico de cerámica de porcelana de 2 pulgadas x 2 pulgadas. La resistencia al cizallamiento específica para el ensamble era de 265 psi. Una lechada con arena tri-poli fortificada ANSI A118.7 fue luego añadida a las baldosas. A todas las muestras se les permitió curar durante 28 días antes de las pruebas.

7. Todas las pruebas fueron realizadas con la formulación de panel básica de marca FIBEROCK® (Muestra de Control 1), el panel de la invención que utiliza una porción de fibra que no ha sido calcinada en el proceso LFC de la invención (Muestra 2) que tiene una baja densidad y un contenido de fibra más alto que la muestra de control 1 y con el panel de la invención también hecho con fibra que no ha sido calcinada (muestra 3) que tiene la misma densidad y contenido de fibra del panel del panel de control de la Muestra 1.

8. La muestra de control 1 tuvo 95 baldosas de contacto y 126 líneas de lechada contactadas. Se notó una falla en el sexto ciclo. Hubo 5 baldosas desportilladas y 1 baldosa rota. La desviación de fraguado fue 0.008 pulgadas.

9. El panel LFC de baja densidad/alta fibra de la Figura V tuvo 80 baldosas contactadas y 120 líneas de lechada contactadas. Se notó una falla en el séptimo ciclo. Hubo 3 baldosas desportilladas en el sexto ciclo y 9 baldosas desportilladas y 10 rotas después de 107 revoluciones del séptimo ciclo. La desviación de fraguado después de los primeros 4 ciclos fue únicamente de 0.004 pulgadas. La fraguada final fue de 0.050 pulgadas.

10. El panel LFC de la presente invención en la Figura VI, con la misma densidad y contenido de fibra que el panel de control de la muestra 1, tuvo 86 baldosas contactadas y 113 líneas de lechada contactadas. Se notó una falla en el sexto ciclo. Hubo 6 baldosas desportilladas. La fraguada final fue de 0.010 pulgadas.

11. Con base en los resultados de las pruebas reportados en las tablas de las Figuras V a VII, todas las muestras cumplieron con una clasificación residencia y los paneles LFC de esta invención cumplieron o excedieron el desempeño del Ciclo 6 del panel de tablero de fibra-yeso de marca FIBEROCK® del proceso de la patente de los Estados Unidos de Baig.

12. Como parte de mis responsabilidades, he supervisado personalmente la producción del tablero de fibra-yeso hecho tanto con el proceso de la referencia de Baig como el tablero de fibra-yeso hecho en la producción comercial utilizando el proceso LFC de nuestra invención. Con base en los registros de producción de todos los paneles de tablero de fibra-yeso hechos utilizando estos dos procedimientos bajo mi dirección en un periodo de dos años para los paneles de tablero de fibra-yeso con marca FIBEROCK®, el contenido de UHH promedio en el panel final hecho por medio del proceso original de Baig fue de 7.6 a 7.9% peso, con más del 50% de los paneles teniendo un contenido de UHH de más de 6%. En comparación, los paneles de tablero de fibra-yeso hechos con el proceso LFC de nuestra presente invención tuvieron como promedio 3.2, 3.4 y 4.5% de peso para los años siguientes a la adopción del proceso LFC con aproximadamente 97% de los paneles con un contenido de UHH por debajo de 10% en peso y únicamente alrededor de 20% de los paneles tuvo un contenido de más de 6% en peso y 36% de los paneles tuvo un contenido de UHH de 3% en peso o menos en la fabricación comercial de los paneles de tablero de fibra-yeso utilizando el proceso LFC y la misma composición básica del panel con la marca FIBEROCK®.

13. Las siguientes pruebas examinar el efecto combinado del contenido de UHH, el contenido de fibra y la absorción de humedad en la expansión no contenida de los paneles de tablero de recubrimiento de fibra-yeso de marca FIBEROCK® preparados por medio del proceso de la patente de Baig. En el estado contenido, esto es, los paneles fijados a un marco y apoyados el uno contra el otro, la expansión lineal conlleva al pandeo, tal como se muestra en la fotografía de la Figura VII. Los resultados de las pruebas reportados en el presente muestran que el control de todas estas tres variables reduce un pandeo potencial y permite una mayor medida de control de las propiedades finales del panel.

14. Revestimientos con la marca FIBEROCK® con diversos niveles de contenido de UHH y fibra fueron producidos y caracterizados utilizando un método de prueba de "Composición de Estuco y Núcleo de Tablero" ("STABCO") desarrollado por la US Gypsum Company para control de calidad en la planta para monitorear los

niveles de UHH en los paneles. El método STABCO fue desarrollado a mediados de los años 70 para calcular los factores de conversión del estuco y las eficiencias de utilización para identificar áreas para mejoras en el proceso. El análisis STABCO usa una serie de cálculos de balance de masa después de la conversión del yeso a hemihidrato y luego de vuelta a yeso en el producto de panel terminado. El método STABCO es utilizado para determinar la cantidad de fuente de UHH. De acuerdo con el método de prueba STABCO, las muestras del panel de revestimiento que miden 12 pulgadas x 3 pulgadas fueron preparadas para pruebas de expansión por medio unir botones de bronce en una extensión de 10 pulgadas. Las muestras fueron acondicionadas a 70°F y 50% Humedad Relativa antes de que se midiera la longitud inicial. Todas las mediciones de longitud posteriores hicieron referencia a la longitud inicial para calcular el porcentaje de cambio de longitud (expansión). Las muestras descritas en la Tabla en la Figura V son colocadas en agua a diversas temperaturas y periodos de tiempos, con mediciones de longitudes posteriores:

- (A) Expansión por humedad 2 horas de inmersión a 70°F & 120°F,
- (B) Expansión por humedad inmersión por más de 2 horas a 70°F, y
- (C) Expansión por humedad 2 horas de inmersión a 70°F y luego mantenido húmedo por medio de envolver en plástico

15. Con base en los resultados de las pruebas de expansión por humedad reportados en la tabla en la Figura IV y mostrados en la gráfica de barra de la Figura I, la expansión por humedad después de un tiempo de inmersión de prueba de 2 horas a 70°F y 120°F, un contenido de UHH y un contenido de fibra en aumento cada uno proporciona un aumento definitivo en la expansión por humedad en las dos temperaturas con más expansión por humedad sucediendo en la temperatura de inmersión más alta.

16. Los resultados de las pruebas de expansión por humedad mostrados en la gráfica de barra de las Figuras I, IIa-IIId y III después de tiempos de inmersión más largos a 70°F también confirman una expansión aumentada con un contenido de UHH en aumento, un contenido de fibra en aumento y una absorción de humedad en aumento.

17. Los resultados de las pruebas de expansión por humedad mostrados en la gráfica de barra de la Figura I después de un tiempo de inmersión de 2 horas a 70°F y manteniendo las muestras en un estado húmedo por medio de envolverlas en plástico, también confirman una expansión aumentada con un contenido de UHH mayor a inclusive niveles modestos de absorción de aproximadamente 4%, si se permite que las muestras permanezcan húmedas durante un periodo prolongado de tiempo.

18. Con base en los resultados de las pruebas de expansión por humedad anteriores, el mecanismo principal de expansión por humedad material en el tablero de fibra-yeso parece estar directamente relacionado con la conversión de hemihidrato no hidratado (UHH) y que la presencia de humedad, inclusive en modelos niveles de absorción con el tiempo, facilita la conversión de UHH. El hinchamiento de fibras en la presencia de humedad es un mecanismo secundario de expansión.

19. Con base en los resultados de las pruebas anteriores y mi experiencia con el proceso comercial para hacer tableros de fibra-yeso, se ha encontrado que el grado de rehidratación del hemihidrato es esencial para el proceso de hacer productos de fibra-yeso y que la rehidratación del hemihidrato debe estar esencialmente completada antes de que inicie el secado del tablero. También he encontrado que los tableros que contienen un nivel significativo de hemihidrato no hidratado (UHH), esto es hemihidrato que no puede volver a convertirse a la forma dihidrato, tienen una resistencia reducida y se expanden en una mayor medida cuando son expuestos a un condiciones elevadas de temperatura y humedad.

20. También hemos encontrado que un resultado inesperado del presente proceso LFC es la formación de cristales alfa que son más largos, más finos y que tienen una superficie de área mayor. La proporción de aspectos mayores de estos cristales alfa aumentan la proporción de conversión de hemihidrato de sulfato de calcio a dihidrato de sulfato de calcio y, por lo tanto, un menor contenido de UHH en el producto final de tablero de fibra-yeso. Esto ha sido confirmado por los tiempos de fraguado más cortos en la producción comercial del tablero de fibra-yeso cuando se encuentran presentes niveles significativamente más bajos de UHH en la lechada.

21. Otro factor que afecta el tiempo de fraguado con el presente proceso es la temperatura de la lechada más fría en el paso de formación, lo cual es un resultado directo de la introducción de agua y fibra después del paso de calcinación en el presente proceso LFC, inmediatamente antes de la línea de formación.

22. Inclusive con la reducción significativa del contenido de UHH del presente proceso debido a la reducción de la rehidratación incompleta, es conocido por aquellos versados en la materia que la quemadura en la piel del tablero de fibra-yeso debido al secado excesivo debe ser prevenida para mantener los niveles de UHH bajos en el tablero de fibra-yeso final ya secado.

23. Por lo tanto, con base en los resultados de la expansión relacionada con la hidratación, el contenido de UHH para el tablero de fibra-yeso comercial debe estar limitado a menos del 10%, y preferiblemente menos del 6%, para reducir la posibilidad de la expansión relacionada con la hidratación. El uso convencional de

un tratamiento resistente a la humedad con siloxano también suministra los beneficios de reducir la proporción de absorción de humedad y eliminar el efecto de la temperatura en la absorción de humedad.

24. Tal como se discutió en el párrafo 12 anterior, el contenido de UHH del proceso de calcinación bajo en fibra de la presente invención ha producido un contenido promedio de UHH tan bajo como 3.2%, con cantidades significativas de tablero que tienen un contenido de UHH inclusive menor. El contenido de UHH menor del tablero de fibra-yeso del presente proceso ha producido un tablero de fibra-yeso que tiene la misma resistencia del tablero de fibra-yeso del proceso de Baig y que puede ser utilizado en aplicaciones de mayor humedad sin una expansión por hidratación significativa.

25. Por lo tanto, por todas las razones indicadas con anterioridad, es mi opinión que una persona versada en la materia no estaría motivada a modificar las enseñanzas de la patente de Baig la cual requiere de co-calcinar todo el yeso y la fibra utilizados en la lechada para hacer el tablero de fibra-yeso, tal como lo indica la acción oficial. Una persona versada en la materia no esperaría una reducción significativa en la cantidad del yeso y la fibra co-calcinados en el proceso de Baig para hacer un panel con expectativas de que el panel resultante tendría la misma resistencia y propiedades de desempeño del panel hecho por medio del proceso de co-calcinación de Baig, mucho menos que produzca un panel que tenga una resistencia mejorada a la expansión por humedad mientras que alcanza reducciones significativas en el tiempo de procesamiento y en la energía requerida para hacer el panel de tablero de fibra-yeso.

26. Además declaro que todas las declaraciones y enunciaciones hechas en el presente de mi propio conocimiento son verdaderas y todas las declaraciones hechas con base en información y creencia se cree que son verdaderas; y además que estas declaraciones y enunciaciones fueron hechas con el conocimiento de que declaraciones falsas intencionales y las hechas de manera similar son punibles por medio de multa o prisión, o ambas, bajo la Sección 1001 del Título 18 del Código de los Estados Unidos y que dichas declaraciones falsas intencionales pueden perjudicar la validez de la solicitud o cualquier patente expedida sobre la misma.

Fecha: 23 de septiembre de 2010

Por: Firmado por Marsha S. Skinner

Figura I: Expansión por Humedad de los Revestimientos con Marca FIBEROCK®

Figura IIa - IIId: Expansión por Humedad de los Revestimientos con Marca FIBEROCK®

Figura III: Expansión por Humedad de los Revestimientos con Marca FIBEROCK®

Wet expansión: Expansión por humedad
Absorption: Absorción
Soak: Inmersión
Expansion: Expansión
Fiber: Fibra
Face: Cara
Back: Respaldo
W/additional times wrapped in plastic: Con tiempo adicional envuelto en plástico
Day: Día
Elapsed wet time: Tiempo de humedad transcurrido

Figura IV

Código de Producción	Contenido de UHH (% en peso)	Contenido de fibra (% en peso)
Día 1	7	11
Día 2	11	7
Día 3	20	10

Figuras V, VI y VII

Ciclo	Desviación (pulgadas)
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Nota del traductor: Se traduce solo los encabezados de la tabla pues el resto está compuesto por números que no requieren traducción

Figura VIII Pandeo (Fotografía)



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United States Patent
Skinner et al.

(10) Patent No.: **US 7,918,950 B2**
(45) Date of Patent: **Apr. 5, 2011**

(54) **LOW FIBER CALCINATION PROCESS FOR MAKING GYPSUM FIBERBOARD**
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(73) Assignee: **United States Gypsum Company**, Chicago, IL (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 479 days.
(21) Appl. No.: **11/962,031**
(22) Filed: **Dec. 20, 2007**

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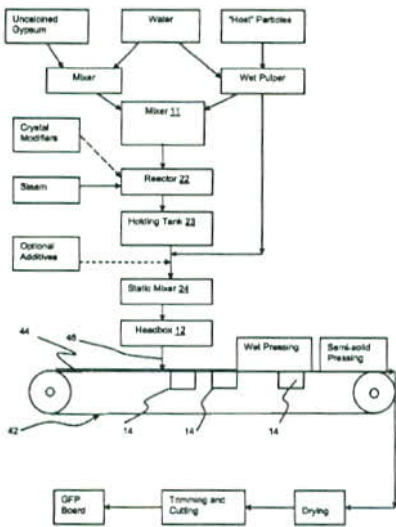
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B32B 3/18 (2006.01)
(52) **U.S. CL.** **156/42; 156/39; 106/780**
(58) **Field of Classification Search** **156/42; 106/772, 778, 779, 780**
See application file for complete search history.

Primary Examiner — Kat Wyrozebski
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(57) **ABSTRACT**
An energy efficient method for making a gypsum cellulose fiberboard comprising adding a first portion of cellulose fiber to gypsum before the gypsum and cellulose fiber are co-calcined in a reactor, adding a second portion of cellulose fiber to the slurry after it leaves the reactor to form a second slurry, depositing the slurry to form a mat, dewatering the mat, rehydrating the mat and then finishing the mat to form a final gypsum cellulose fiberboard. A reduction of up to about 40% to 50% of steam energy used can be achieved when the second portion of added cellulose fiber is 50% or more of the total cellulose fiber used in the final board compared to gypsum cellulose board made with the same ingredients but when all of the fiber is added to the gypsum prior to the reactor.

18 Claims, 2 Drawing Sheets



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FIG. 1

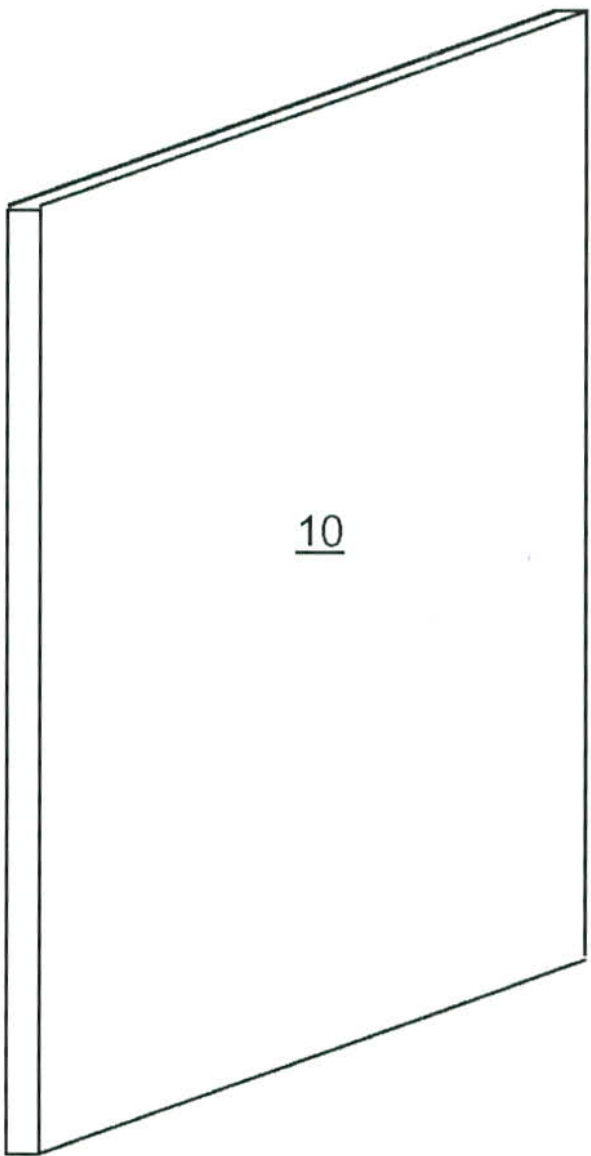
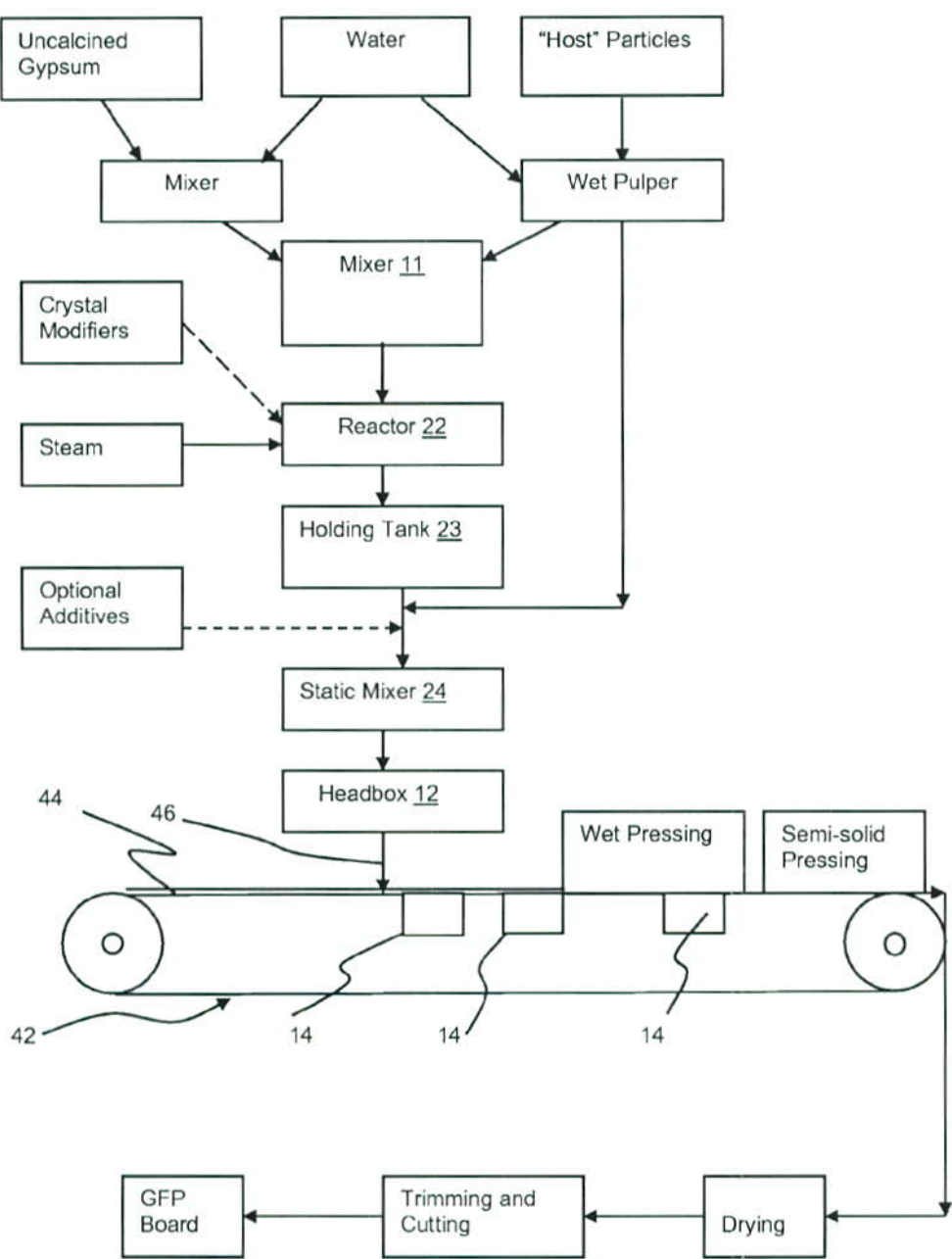


FIG. 2



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LOW FIBER CALCINATION PROCESS FOR MAKING GYPSUM FIBERBOARD

FIELD OF THE INVENTION

This invention relates generally to an improved gypsum cellulose fiber composite panels suitable for building applications for wallboard ceiling applications, framing and sheathing elements, siding elements, and other building construction types having significant lower density and more flexibility while significantly reducing the amount of total cellulose fiber that is added to gypsum to react with gypsum in a reactor for calcining the gypsum before additional cellulose fiber slurry is added to the calcined gypsum and cellulose fiber slurry, the slurry is formed into a mat, that is dewatered, rehydrated into gypsum, and then dried to form a fiber reinforced gypsum fiberboard panel (hereinafter referred to as "gypsum fiber board panels" or "GFP").

BACKGROUND OF THE INVENTION

Gypsum fiber board panels have been used in the construction industry to form the interior and exterior walls of residential and/or commercial structures. However, a drawback of such conventional panels is that they do not have sufficient flexural toughness to the extent that such panels may be comparable to wood-based panels such as plywood or oriented strand board (OSB).

Building structures during their lifetimes are subjected to a variety of impact loads (e.g., hail damage, or damage from objects hurled at the buildings due to tornados or hurricanes). Not all building sheathing panels are sufficiently tough to withstand such impact loads. Where it is necessary to demonstrate impact load resistance, the sheathing panels are measured to determine the impact the panel can resist without failure.

Flexural toughness as characterized in this specification is measured as equal to the total area under the flexural load versus deflection curve for a specimen loaded in three-point bending.

One example of flexural toughness is measured as the total area under the load versus deflection curve for a flexural specimen loaded in a 3-point bending according to ASTM D1037 test method.

Wood-based panels achieving significant flexural toughness usually are plywood or oriented strand board (OSB), which consist of wood veneers or large chips that are glued together. These panels can provide flexural toughness, but each is combustible and in many cases other than marine plywood, these panels are not durable when exposed to water. A panel made of hydraulic cement will resist water, but is much heavier than the wood panels. It is believed that there is no panel currently available at a comparable cost which can provide the flexural toughness of the present invention, while avoiding the deficiencies of plywood or OSB panels.

Furthermore, the need for gypsum fiber panels configured to behave in the construction environment similar to plywood and OSB means the panels are nailable and can be cut or worked using conventional saws and other conventional carpentry tools.

The panel should be capable of being cut with the circular saws used to cut wood. The panel should also be capable of being fastened to framing with nails or screws.

The panel should be dimensionally stable when exposed to water, i.e., it should expand as little as possible, preferably less than 0.1% as measured by ASTM C 1278. The Standard specification for some gypsum fiberboard panels is listed at

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5% moisture uptake in a 2 hour soak, although other gypsum fiber board panel products can have as much as 10% moisture uptake in a 2 hour soak test. The panel should not be biodegradable or subject to attack by insects or rot. However, the panel should provide a bondable substrate for exterior finish systems.

The flexural strength of a 0.5 inch (12.7 mm) thick gypsum fiberboard panels (GFP) having a density of about 714 kg/m³ (50 lb/ft³) to about 1000 kg/m³ (70 lb/ft³) is at least 5.2 MPa (750 psi), and preferably greater than 6.9 MPa (1000 psi) as measured by the ASTM D1037 test.

It should be evident that the currently available gypsum fiber based and wood-based products and composites meet some, but not all, of the above performance characteristics. In particular, there is a need for improved gypsum fiber based panels that are lightweight having improved flexural toughness and which exceed the capability of the currently-used gypsum fiber board and wood-based by providing non-combustibility and water durability.

Although glass fibers have been used to reinforce gypsum board and gypsum fiber board, other fibers have been suggested to reinforce gypsum board, such as metal fibers, wood or paper fibers, carbon fibers, or polymer fibers.

U.S. Pat. No. 5,320,677 to M. Baig, incorporated herein by reference in its entirety, discloses a composite gypsum/wood fiber (GWF) material product and a process for forming the product in which a dilute slurry of gypsum particles and cellulosic fibers are heated under pressure to convert the raw gypsum to calcium sulfate hemihydrate by calcining the gypsum in the presence of wood fibers. The dissolved calcium sulfate wets the voids in the fiber and the resulting hemihydrate eventually forms crystals in situ in the voids of the cellulose fiber. However, it would be desirable to further improve the GWF to reduce the density and improve the flexibility of the panel, reduce the amount of unreacted hemihydrate that can not be readily rehydrated to gypsum in the GWF production process, and reduce the setting time of the panel while significantly reducing the amount of steam energy required to calcine the gypsum to calcium sulfate hemihydrate.

U.S. Pat. No. 6,508,895 to Lynn et al, incorporated herein by reference, discloses a paperless gypsum/fiberboard which has improved impact resistance compared to gypsum/fiberboard by use of a process wherein a multilayer gypsum/fiber board is formed having a flexible mesh, preferably fiberglass mesh embedded in the backside of the board, to provide improved impact resistance. In the process, the mesh is fed into the forming area of the panel before the panel is pressed prior to drying. Optionally, a second layer of mesh can be embedded in the top layer of the gypsum/fiberboard.

U.S. Pat. No. 4,199,366 A to Schaefer et al., incorporated herein by reference, discloses a fiber-reinforced cement material having short polyvinyl alcohol fibers in an amount of at least 2 volume % based on the total volume of the material. These fibers have an elongation at break of between about 4 and 8% and a modulus of more than 130 g/dtex. A process for the preparation of the material is also disclosed.

U.S. Pat. No. 4,306,911 A to Gordon et al., incorporated herein by reference, discloses a method for the production of a fiber-reinforced hydraulically obtained setting material.

U.S. Pat. No. 4,339,273 A to Meier et al., incorporated herein by reference, discloses a process for producing a fiber-reinforced, hydraulically setting composition, the composition produced, and the use thereof.

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U.S. Pat. No. 5,298,071 A to Vondran, incorporated herein by reference, discloses a fiber-hydratable cement composition comprising a uniform dispersion interground fiber in hydratable cement powder.

U.S. Pat. No. 5,817,262 A to Englert, incorporated herein by reference in its entirety, discloses a process for making a gypsum wood fiber board with improved moisture resistance through addition of an aqueous siloxane emulsion to the calcined gypsum and wood fiber slurry at a temperature above the point at which the hemihydrate will rehydrate to gypsum.

U.S. Pat. No. 6,010,596 to Song, incorporated herein by reference in its entirety, discloses a process for making a moisture resistant gypsum wood fiberboard by adding a wax emulsion to calcined gypsum and wood fiber slurry before the calcium sulfate hemihydrate will rehydrate to gypsum.

U.S. Pat. No. 6,221,521 B1 to Lynn, incorporated herein by reference in its entirety, discloses a three layer paperless fiber reinforced gypsum/fiberboard product that is non-combustible and which uses no more than 3% by weight organic material in its core layer and 10-30% paper reinforcing fiber added to calcined gypsum in its surface layers.

U.S. Pat. No. 6,268,042 B1 to Baig, incorporated herein by reference in its entirety, discloses a high strength low density fiber board panel for use in furniture made from mineral wool, lightweight aggregate, 20 to 35% cellulose fiber, binder and up to 23% gypsum solids.

U.S. Pat. No. 6,406,779 B1 to Carbo et al., incorporated herein by reference in its entirety, discloses a paperless gypsum/fiberboard made with calcined gypsum and added cellulose fiber with improved surface characteristics by addition of a heat curable primer comprising an aqueous emulsion of a film forming polymeric material.

U.S. Pat. No. 6,508,895 B2 to Lynn et al., incorporated herein by reference in its entirety, discloses a paperless multi-layered gypsum fiberboard with improved impact resistance that has a fiberglass mesh embedded in its back side.

U.S. Pat. No. 6,531,210 B2 and U.S. Pat. No. 7,056,460 to Englert, incorporated herein by reference in its entirety, discloses a process for preparing an improved gypsum/wood fiberboard by addition of a stable methylenediphenyldiisocyanate emulsion to an aqueous slurry of calcined gypsum and wood fiber just prior to the slurry being fed to the headbox in the process described in U.S. Pat. No. 5,558,710 A, above.

U.S. 2005/0161853 to Miller et al., incorporated herein by reference in its entirety, discloses an improved process for calcining gypsum and cellulose fiber in the manufacture of gypsum/cellulose fiber products by addition of crystal modifiers prior to heating to reduce the time and temperature necessary to complete calcination or to increase the aspect ratio of the acicular crystals formed during calcination process.

US. 2006/0243171 to Yu et al., incorporated herein by reference in its entirety, discloses a wet gypsum accelerator comprising an organic phosphonic compound, a phosphate-containing compound and mixtures thereof for increasing the rehydration of calcined gypsum.

US2007/0056478 to Miller et al., incorporated herein by reference in its entirety, discloses an improved method for making a water resistant gypsum fiberboard that comprises adding a silicone compound and magnesium oxide to a calcined slurry of calcium sulfate hemihydrate and cellulose fiber after the calcination step and before dewatering the slurry to form a filter cake.

SUMMARY OF THE INVENTION

The present invention relates to an improved gypsum fiberboard and an energy efficient process with significantly faster

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setting times than current manufacturing processes for gypsum fiberboard and which produces an improved cellulose fiber-reinforced gypsum fiberboard having essentially no unhydrated hemihydrate (hereinafter referred to as "UHH") that can not be readily rehydrated to gypsum without addition of water. Although UHH can be rehydrated to gypsum after drying by addition of water, the amount of UHH is particularly important since the resulting GFP made with this rehydrated UHH will have less strength than panels which are made from hemihydrate that has been rehydrated to gypsum prior to the drying of the mat. The improved gypsum fiberboard has a lower density more flexibility and a significantly reduced setting time than gypsum fiberboard which is made with the same amount of cellulose fiber but which adds all of the cellulose fiber to the gypsum before the gypsum is calcined.

In the process, uncalcined gypsum and a first portion of the host particle e.g. paper fiber, are mixed together with sufficient liquid to form dilute slurry which is then heated under pressure with steam to calcine the gypsum, converting it to an alpha calcium sulfate hemihydrate. While the micro-mechanics of the invention are not fully understood, it is believed that the dilute slurry menstuum wets out the host particle, carrying dissolved calcium sulfate into the voids therein. The hemihydrate eventually nucleates and forms crystals, predominantly acicular crystals, and in-situ in and about the voids of the host particle. Crystal modifiers can be added to the slurry if desired. The resulting composite is a host particle physically interlocked with calcium sulfate crystals. This interlocking not only creates a good bond between the calcium sulfate and stronger host particle, but prevents migration of the calcium sulfate away from the host particle when the hemihydrate is subsequently rehydrated to the dihydrate (gypsum).

A plurality of such composite particles form a material mass which can be compacted, pressed into boards, cast, sculpted, molded, or otherwise formed into desired shape prior to final set. After final set, the composite material can be cut, chiseled, sawed, drilled and otherwise machined. Moreover, it exhibits the desirable fire resistance and dimensional stability of the gypsum plus certain enhancements (particularly strength and toughness) contributed by the substance of the host particle.

According to a preferred embodiment of the invention, the host particle is a paper fiber. Referring to FIG. 2, the paper is first pulped and then mixed with water to form slurry containing about 3% to 4.5%, by weight (based on the total solids). Ground, uncalcined gypsum is also mixed with enough water in a mixer to form slurry having about 65%-85% by weight water. The slurries of ground gypsum and pulped paper are then blended together in another mixer 10 to form a homogeneous slurry before being sent to a pressure vessel (reactor system) 22. The slurry is heated in the pressure vessel (reactor system) at a temperature sufficient to convert the gypsum to calcium sulfate hemihydrate. It is desirable to continuously agitate the slurry in the pressure vessel with gentle stirring or mixing to break up any fiber clumps and keep all the particles in suspension. In the pressure vessel the hemihydrate precipitates out of solution and forms acicular alpha hemihydrate crystals. Then the pressure on the product slurry is relieved when the slurry is discharged from the reactor system, to a holding tank 23. The balance of the "host" fibers ("pulped paper"), i.e. the second portion of paper fibers is added to the gypsum fiber slurry along with other optional ingredients in a static mixer 24. The host fibers are typically paper fibers. The added ingredients can include selected process modifying or property enhancing additives, such as accelerators, retarders, weight reducing fillers, water resistance additives, etc. While still hot, the resulting product

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slurry 46 from static mixer 24 is discharged through a head box 12 onto a continuous felting conveyor 42, such as the type used in paper making operations, to form a filter cake and remove as much uncombined water as possible. As much as 90% of the water can be removed from the filter cake by the felting dewatering conveyor 42. As a consequence of the water removal and air pulled through the formed mat through vacuum boxes 14, the filter cake is cooled to a temperature at which rehydration may begin. However, it may still be necessary to provide additional external cooling to bring the temperature low enough to accomplish the rehydration within an acceptable time.

Before extensive rehydration takes place, the filter cake is preferably consolidated into a board of desired thickness and/or density. If the board is to be given a special surface texture or a laminated surface finish, it would preferably occur during or following this step of the process. During the wet pressing, which preferably takes place with gradually increasing pressure to preserve the product's integrity, additional water, e.g. about 50-60% of the remaining water, is removed. The mat is then further pressed in a semisolid dry pressing step. As a consequence of the additional water removal, the filter cake is further cooled to a temperature at which rapid rehydration occurs. The calcium sulfate hemihydrate hydrates to gypsum, so that the acicular calcium sulfate hemihydrate crystals are converted to gypsum crystals in situ in and around the cellulose fibers. After some rehydration, the boards can be dried in a kiln and then cut and trimmed, if desired. Preferably, the drying temperature should be kept low enough to avoid recalcining any gypsum on the surface.

The cellulose fibers are uniformly distributed in the gypsum cellulose fiber slurry. Although it is preferred that the cellulose fibers be added to the slurry at the static mixer prior to the headbox, the cellulose fibers may be added to the gypsum fiber slurry in the headbox provided that the fibers are uniformly dispersed in the product slurry 46 prior to being deposited on the conveyor 42.

The process of the present invention has been found to be able to reduce the amount of the total cellulose fiber added to the gypsum in the calcination stage of the process by 50% up to about 70% of the total added cellulose fiber or, about 3 wt % to about 4.5 wt % cellulose fibers. The balance of the cellulose fiber is added after calcination, without reducing the properties of the gypsum cellulose fiber board. The process reduces the total energy requirement for calcination by at least about 35 to 40% or more and the calcination time to about 15-18 minutes, and unexpectedly also reduces the setting time of the gypsum fiber board panel (GFP) without reducing the properties of the gypsum fiber board.

The process of this invention also allows for the increased amount of calcined gypsum and reduced amounts of high grade paper or cellulose fibers in the calcination process without loss of the structural properties of gypsum fiber board required in the industry.

As previously discussed, there is a need for building panels that are lighter in weight and are capable of replacing currently available gypsum fiber board panels which suffer from the following deficiencies: heavy product density, inferior toughness performance, poor handelability during installation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a perspective view of an embodiment of the gypsum cellulose fiber panel 10 of the present invention.

FIG. 2 is a schematic diagram of an embodiment of the method of producing the gypsum fiber board panel of the invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. The Panel

The present invention relates to a reinforced, dimensionally stable gypsum cellulose fiber board panel. FIG. 1 shows a perspective view of a panel 10 of the present invention.

The panel includes a continuous phase resulting from the curing of an aqueous mixture of gypsum and cellulosic fibers, the panel comprising, on a dry basis, 95-70 wt. % gypsum, 5-10 weight % cellulosic fiber, and about 0 to 3 weight % unhydrated hemihydrate ("UHH").

The principal starting materials used to make panels of the invention are inorganic binder, e.g., alpha calcium sulfate alpha hemihydrate, cellulosic fiber from "host particle", water, and optional additives as well as the added cellulose fiber added to the calcined gypsum slurry before the slurry is formed into a mat.

In many applications, for example in siding, the panels will be nailed or screwed to vertical framing.

Another feature of the present invention is that the resulting GFP panel is constructed so that the added cellulose fibers are uniformly distributed throughout the panel. The percentage of fibers relative to the weight of the final product preferably constitutes approximately in the range of 6% to 10%, for example 6 wt. %.

Other methods of depositing a mixture of the slurry and adding cellulose fibers will occur to those familiar with the panel-making art. For example, rather than using the present continuous process of making panel on a continuous sheet, a batch process could also be used to make panels in a similar manner, which after the material has sufficiently set, can be cut into panels of the desired size.

B. Formulation

The components used to make the panels of the invention are calcium sulfate dihydrate, paper or other cellulose fibers, alpha calcium sulfate alpha hemihydrate, and water. Small amounts of binders, accelerators and/or retarders may be added to the composition to control the setting characteristics of the green (i.e., unhydrated) material. Typical non-limiting additives include accelerators for alpha calcium sulfate hemihydrate such as gypsum.

Panels of the invention include a continuous phase in which some of the cellulose fibers are uniformly distributed. As shown in FIG. 2, the continuous phase results from the curing of an aqueous mixture of the calcined gypsum and cellulose fibers from a pressurized reactor and an aqueous slurry of additional cellulose fibers introduced into the gypsum fiber slurry after it leaves the reactors and immediately prior to a slurry headbox, where it is fed to the forming belt at a temperature of about 180°-200° F. at atmospheric pressure.

Typical broad weight proportions of embodiments of the formulations of the invention, based on dry weight, are shown in TABLE 1, below.

TABLE 1

TYPICAL MIXTURE WEIGHT PROPORTION (DRY BASIS)	BROAD RANGE WT. %	TYPICAL RANGE WT. %	MORE TYPICAL RANGE WT. %
Gypsum	70-95	90-94	90-92
Cellulose	2-15	3-5	3-4.5
Fibers Added To GYPSUM BEFORE CALCINATION			

TABLE 1-continued

TYPICAL MIXTURE WEIGHT PROPORTION (DRY BASIS)	BROAD RANGE WT. %	TYPICAL RANGE WT. %	MORE TYPICAL RANGE WT. %
CELLULOSE FIBER ADDED TO SLURRY AFTER LEAVING CALCINATION REACTOR	3-15	3-5	3-4.5
TOTAL Cellulose Fiber	5-30	6-10	8-9
UHH Additives	5.0-10.0 1.0	0.0-3.0 1.0	0.0-3.0 1.0
Totals	100	100	100

In the first embodiment of the invention, the dry ingredients of the composition will be gypsum and cellulose fibers and the wet ingredients of the composition will be water. The dry ingredients and the wet ingredients are combined to produce the panel of the invention. The cellulose fibers added to the gypsum cellulose fiber leaving the reactor are uniformly distributed in the matrix throughout the full thickness of the panel. Of the total weight of dry ingredients, the panel of the invention is typically formed from about 90 to 95 wt. % gypsum and 5-10 wt. % cellulosic fiber, with a first portion of cellulose fiber being added before the calcination and a second portion of cellulose fiber, typically at least half of the total cellulose fibers in the final panel being added after the gypsum cellulose slurry emerges from the reactor. In a typical commercial embodiment, the panel would be formed from about 90 to 92 wt. % gypsum and about 8 to 10 wt. % cellulose fiber, on a dry ingredient basis.

1. Calcium Sulfate Hemihydrate

Calcium sulfate hemihydrate, which may be used in panels of the invention, is made from gypsum ore, a naturally occurring mineral, (calcium sulfate dihydrate $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$) or other chemical byproduct sources. Unless otherwise indicated, "gypsum" will refer to the dihydrate form of calcium sulfate. The raw gypsum is thermally processed to form a settable calcium sulfate, but more typically is the hemihydrate, $\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$. For the familiar end uses, the settable calcium sulfate reacts with water to solidify by forming the dihydrate (gypsum). The hemihydrate has two recognized morphologies, termed alpha hemihydrate and beta hemihydrate. These are selected for various applications based on their physical properties and cost. Both forms react with water to form the dihydrate of calcium sulfate, typically with large aspect ratio. The alpha hemihydrate forms more dense microstructures having higher strength and density than those formed by the beta hemihydrate. This may be due to the fact that alpha hemihydrate requires less water to form a flowable slurry, thereby resulting in a denser cast and greater strength. Thus, the alpha hemihydrate could be substituted for beta hemihydrate to increase strength and density or they could be combined to adjust the properties.

A typical embodiment for the inorganic binder used to make panels of the present invention comprises a blend containing alpha calcium sulfate hemihydrate and lignocellulosic fiber from paper, such as Kraft paper, waste paper, etc.

2. "Host Particle"

The term host particle is meant to cover any macroscopic particle as a fiber, a chip, or a flake, of a substance other than

gypsum. The particle, which is generally insoluble in the slurry liquid, should also have accessible voids therein; whether pits, cracks, fissures, hollow cores, or other surface imperfections, which are penetrable by the slurry menstuum and within which calcium sulfate crystals can form. It is also desirable that such voids are present over an appreciable portion of the particle; because the more and better distributed the voids, the greater and more geometrically stable will be the physical bonding between the gypsum and host particle. The substance of the host particle should have desirable properties lacking in gypsum, and preferably at least higher tensile and flexural strength. A ligno-cellulosic fiber, particularly a paper fiber, is an example of a host particle especially well suited for the composite material and process of the invention. Therefore, without intending to limit the material and/or particles that are suitable as host particles, paper fiber is often used hereinafter for convenience in place of the broader term.

3. Gypsum/Cellulose Fiber

The term gypsum fiberboard or gypsum fiber panel (GFP), as used herein is meant to cover mixtures of gypsum and host particles including cellulose fibers, e.g. paper fibers, which are used to produce boards wherein at least a portion of the gypsum is in the form of acicular calcium sulfate dihydrate crystals positioned in the voids of the host particles, wherein the dihydrate crystals are formed in situ by the hydration of acicular calcium sulfate hemihydrate crystals in and about the voids of the particles. The gypsum fiber boards are produced by a process shown in FIG. 2, which is a modified process from the original process of making a gypsum fiberboard in U.S. Pat. No. 5,320,677.

Typically the paper fibers are available in the large pieces that are wet pulped into a uniform slurry of about 4% by weight solids.

B. Making a Panel of the Present Invention

1. Mixing Slurry

A method for making the composite wallboard of the present invention is illustrated in the diagram of FIG. 2.

The process begins by mixing uncalcined gypsum and host particles (e.g. paper fibers) with water to form dilute aqueous slurry. The source of the gypsum may be from raw ore or from the by-product of a flue-gas desulphurization or phosphoric acid process. The gypsum typically should be of 82-98% purity, and typically be finely ground, for example, to 92-96%-minus 100 mesh or smaller. Larger particles may lengthen the conversion time. The gypsum can be introduced either as a dry powder or via aqueous slurry.

The invention co-calcines gypsum and cellulose fiber slurry by any suitable process. A typical process for making such composite slurry is disclosed by U.S. Pat. No. 5,320, 677, incorporated herein by reference in its entirety. The present process provides a gypsum cellulose fiber layer with added cellulose fiber on a forming screen 44 on dewatering conveyor 30 using GFD fiber slurry through a head box 12 and dewaterers it using a vacuum station 14 to provide a layer of gypsum paper fiber slurry on the porous forming belt (screen) 42.

Referring again to FIG. 2, the basic process begins by mixing uncalcined gypsum with water to form a first slurry, pulping paper with water to form a uniform slurry and combining the two slurries in a mixer 11 equipped with an agitator (not shown) to form a dilute aqueous slurry. The source of the gypsum typically may be from raw ore or from the by-product of a flue-gas-desulphurization. The gypsum should be of a relatively high purity, i.e., preferably at least about 92-96%, and finely ground, for example, to 92-96%

minus 100 mesh to minus 200 mesh or smaller. Larger particles may lengthen the conversion time. The gypsum is typically introduced as a aqueous slurry.

The host particle is preferably a cellulosic fiber which may come from waste paper, wood pulp, wood flakes, and/or another plant fiber source. It is preferable that the fiber be one that is porous, hollow, split and/or rough surfaced such that its physical geometry provides accessible interstices or voids which accommodate the penetration of dissolved calcium sulfate. In any event the source, for example, wood pulp, may also require prior processing to break up clumps, separate oversized and undersized material, and, in some cases, pre-extract strength retarding materials and/or contaminants that could adversely affect the calcination of the gypsum; such as hemi-celluloses, acetic acid, etc.

The ground gypsum slurry, which is typically 40% by weight solids, and the cellulose fiber e.g. paper fiber slurry, which is typically at about 4% consistency, are mixed together with sufficient water to form a composite slurry typically containing about 15-35% by weight solids. The solids in the slurry should comprise from about 0.5% to 5.0% by weight of cellulose fibers and the balance being mainly gypsum.

2. Conversion to Hemihydrate

The slurry is fed into a pressure vessel(s) or autoclave(s) 22 equipped with a continuous stirring or mixing device. Crystal modifiers, such as organic acids, can be added to the slurry at this point, if desired, to stimulate or retard crystallization or to lower the calcining temperature. Steam is injected into the reaction vessel 22 to bring the interior temperature of the vessel up to between about 100° C. (212° F.) and about 177° C. (350° F.), and up to 70 psig for saturated steam; the lower temperature being approximately the practical minimum at which the calcium sulfate dehydrate will calcine to the hemihydrate state within a reasonable time; and the higher temperature being about the maximum temperature for calcining hemihydrate without risk of causing some the calcium sulfate hemihydrate to convert to anhydrite. The reaction vessel temperature is preferably on the order of about 140° C. (285° F.) to 152° C. (305° F.).

When the slurry is processed under these conditions for a sufficient period of time, for example on the order of 18 to 23 minutes, enough water will be driven out of the calcium sulfate dihydrate molecule to convert it to the hemihydrate molecule. The solution, aided by the continuous agitation to keep the particles in suspension, will wet out and penetrate the open voids in the host particles. As saturation of the solution is reached, the hemihydrate will nucleate and begin forming crystals in, on and around the voids and along the walls of the host fibers.

The first significant improvement of the current process is that when only half of the cellulose fiber used is added to the reactor to co-calcine with the gypsum, the amount of steam required to calcine the mixture is reduced by 30-40% or more of that used when all of the cellulose fiber is added prior to the reactor 22.

It is believed that during the autoclaving reaction operation, the dissolved calcium sulfate penetrates into the voids in the cellulose fibers and subsequently precipitates as acicular hemihydrate crystals within, on and about the voids and surfaces of the cellulose-fibers. When the conversion is complete, the pressure on the autoclave is reduced, any desired additives, including wax emulsion, can be introduced, typically at or before the head box 12, and the slurry 46 is discharged onto a traveling porous belt 44 of a dewatering conveyor 42. The additional cellulose fibers are typically added to the gypsum cellulose slurry at this point in the process after

the slurry leaves the reactor 22 and the holding tank 23 is introduced into a static mixer 24. The mixed gypsum cellulose slurry including the second portion of added cellulose fiber from the wet pulper and any optional additives are then fed into the headbox 12. Conventional additives including accelerators, retarders, preservatives, fire retardants, water resistant core additives and strength enhancing agents may be added to the slurry prior to the static mixer 24 and headbox 12 before the combined slurry 46 from the headbox 12 is deposited on the belt 44.

3. Dewatering

The added cellulose fiber and calcined gypsum fiber slurry 46 is passed through the head box 12 which distributes the slurry onto the surface of the flat porous belt 44 to produce a filter cake. The filter cake is dewatered by the water in the slurry passing through the porous belt surface 44, preferably aided by vacuum from vacuum stations 14. Although the dewatering causes cooling of the filter cake, additional external cooling may be applied during the dewatering step. As much of the water is removed as possible through pressing through rollers in the wet pressing while the temperature of the product slurry is still relatively high and before the hemihydrate is substantially converted into gypsum. As much as 90% of the slurry water is removed in the dewatering device, leaving a filter cake of approximately 35% water by weight. At this stage the filter cake preferably consists of cellulose fibers interlocked with rehydratable calcium sulfate hemihydrate crystals and can still be broken up into individual composite fibers or nodules, shaped, cast, or compacted to a higher density.

4. Pressing and Rehydration

The dewatered filter cake is preferably first wet-pressed using suction rolls (not shown) and then presses in a semi-solid pressing step to further reduce the water content and to compact the filter cake into the desired shape, thickness and/or density before substantial rehydration of the hemihydrate occurs. Although the extraction of the bulk of the water in the dewatering step will contribute significantly to lowering the filter cake temperature, additional external cooling may be required to reach the desired rehydration temperature within a reasonable time. The temperature of the filter cake is preferably reduced to below about 49° C. (120° F.) so that relatively rapid rehydration can take place. The rehydration recrystallizes the alpha hemihydrate crystals into acicular gypsum crystals in place, physically interlocked with the cellulose fibers.

Depending on the accelerators, retarders, crystal modifiers, or other additives provided in the slurry, hydration may take from only a few minutes to an hour or more. Because of the interlocking of the acicular crystals with the cellulose fibers, and the removal of most of the carrier liquid from the filter cake, migration of the calcium sulfate is averted, leaving a homogeneous composite. The rehydration effects recrystallization of the hemihydrate crystals to dihydrate crystals in situ, i.e. within and about the voids of the cellulose fibers, thereby preserving the homogeneity of the composite. The crystal growth also connects the calcium sulfate crystals on adjacent fibers to form an overall crystalline mass, enhanced in strength by the reinforcement of the cellulose fibers.

When the hydration is complete, it is desirable to promptly dry the composite mass to remove the remaining free water in order to develop maximum physical properties.

5. Drying

The pressed board, which typically contains about 30% by weight of free water, is then promptly dried at a relatively high temperature in order to reduce the free water content to about 0.5% or less in the final product. Obviously, drying conditions

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which tend to calcine the gypsum should be avoided. It has been found that it is desirable to carry out the drying under conditions in which the product achieves a core temperature of no more than 93.3° C. (200° F.), preferably no more than about 74° C. (165° F.), so that recalcination of the gypsum does not occur. The set and dried board can be cut and otherwise finished to desired specification.

When finally set, the unique composite material exhibits desired properties contributed by both of its two components. The cellulose fibers increase the strength, particularly flexural strength, of the gypsum matrix, while the gypsum acts as a coating and binder to protect the cellulose fiber, impart fire resistance and decrease expansion due to moisture.

In the modified process of this invention, the calcined gypsum cellulose fiber slurry from headbox 12 of the process is deposited on the continuous porous belt 44 of the conveyor 42. The cellulose fiber and GFP slurry 46 is dewatered through use of the vacuum stations 14 as it passes through a wet pressing which consists of suction rolls, and a porous belt, and then a semi-solid pressing to further dewater and consolidate the mat under the combined effect of vacuum and pressure to a moisture content (wet basis) of 23-35% (30-55% on a dry basis). The spacing between the primary wet pressing and a secondary semi-solid pressing is used to impart smoothness, depending upon the belt surface used. The semi-solid pressing also decreases thickness variation by setting it at a fixed-gap nip slightly less than the desired end result board thickness.

The GFP production process forms panels at a temperature of about 93.3° C. (200° F.) at a moisture content of about 25% to about 35%, wet basis after dewatering. The higher gypsum solids content of the gypsum cellulose fiber mixture reacted in the calcining reaction in the present process versus the higher fiber content used in earlier gypsum-cellulose fiber processes has allowed the calcining process to be operated on significantly reduced amount of steam, e.g. about 30-40% less steam, while essentially eliminating all unreacted hemihydrate that can not be rehydrated to gypsum in the final formation of the GFP panel.

The gypsum cellulose fiber crystals emerging from the reactor are slightly more elongated and have a higher aspect ratio or surface area than the crystals prepared in the prior art process when all of the cellulose fibers were co-calcined with the gypsum. The modified crystals along with the reduction of unhydrated hemihydrate ("UHH") from up to 30% in the prior art process to an average of about 10% UHH and in at least a couple of instances with products that do not contain a siloxane, essentially 0% UHH. This reduction in UHH in the current process is believed to result in the noted decrease in required setting time of the resulting gypsum fiberboard, which has reduced the setting time from the best current range of 30-40 minutes to about 16-25 minutes during plant trial runs when half of the fiber e.g. 4.0-4.5% fiber is added after the calcination process. Since the production process is dependent upon the setting time of the formed panel, this reduction has a very pronounced increase in the production line speed and panel production rate.

Panel Properties

Panels of the present invention typically have the following additional properties:

The density of the panel of the current invention is essentially the same as a conventionally prepared gypsum cellulose fiberboard where all of the paper fiber is added prior to calcination. However, it is possible to lower the density of the present gypsum fiberboard when more fiber is added after calcination if this is desired.

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TABLE 2 provides a description of the target mixture compositions for the following examples. The weight fractions of various ingredients shown in this table are for the wet slurry.

TABLE 2

Target gypsum fiber mixture composition of examples	
Ingredient	(Dry Basis Weight %)
Gypsum	90.0-93.0%
cellulose fiber	7.0-10.0%
Additional Additives ¹	up to 3.0%
Total	100%

¹Additional additives include setting accelerators, crystal modifiers and water resistant additives such as wax about 1-2% and siloxane (about 1.0%)

The panels were made as described in the section entitled "Making A Panel Of The Invention"

EXAMPLE 1

Extended trials were conducted on a commercial GFP production line modified to add a first portion of paper cellulose fiber to a gypsum slurry before being fed to reactor 22 and a second portion of paper cellulose fiber added to the slurry after reaction in reactor 22. The first portion of fibers was added in an amount of 4.5 wt % on a dry basis to an aqueous slurry of gypsum that is mixed before being fed into the reactor 22. The overall slurry consistency was 25%, which was a substantial increase compared to a typical level of 16% to 18% for conventional slurries with 8.5 wt % fiber. Consistency, which is also known as "water demand" is a term of art and is determinable according to ASTM Procedure C472, or its substantial equivalents. It is defined as the amount of water in grams per 100 grams of stucco. Consistency for purposes of gypsum board manufacture may be defined as the water volume required giving a standard viscosity or flow when 100 grams of stucco is dispersed by mechanical mixing in a laboratory high speed blender at high shear intensity and for 7 seconds which is equivalent to the mixing encountered in the board forming line. The particular numerical value is variable from one process to the next depending on the particular stucco and the rate of production.

The increased slurry consistency resulted in a reduction in the steam demand of approximately 38 to 40% from the level of steam normally required for the duration of the production run. The reduction in fiber content in the slurry in the reactor also improved calcination and created alpha crystals that were thinner and with a higher aspect ratio as compared to those from a conventional production run with 8.5 wt % paper cellulose slurry fed to the reactor. The time required for calcination of the gypsum and paper fiber slurry ranged from as little as 15 minutes to about 25 minutes, with commercial production trials being adjusted for the particular production line to give a calcination reaction time within the range of about 18 to 22 minutes. This is a significant reduction from the time required to calcine the gypsum and all of the paper fiber in the slurry used in the standard production process.

The resulting calcined gypsum/fiber slurry was pumped to a fourdiner style headbox along with a stream of additional pulped fiber to give a total fiber content of about 10 wt %. The composite slurry was then deposited on a porous forming fabric and was then dewatered through the porous forming fabric with the use of vacuum boxes 14, followed by additional vacuum applied in combination with pressure to further consolidate the mat. Rehydration was then begun and after a portion of the rehydration had occurred, additional pressing

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was used to produce a panel with the desired thickness and surface appearance. The setting time for the panels was in the range of as low as about 15 minutes to about 25 minutes, compared to the standard production process that requires over 28 minutes. Following completion of rehydration, the panels were loaded into a kiln to dry the panel and remove any remaining free moisture. The resulting panel had 90 to 92 wt % gypsum and essentially no unhydrated hemihydrate.

EXAMPLE 2

The trial of example 1 was repeated with a trial run of about one hour with the use of about 3.25 wt. % paper cellulose fiber in the first portion added to aqueous slurry of gypsum that is mixed before being fed to the reactor for co-calcination. The overall consistency of the slurry was 25%-28%. The overall increase in consistency resulted in a reduction of steam energy required to calcine the slurry of over about 45% was achieved relative to the amount of steam required to calcine the slurry with conventional 8 to 10% cellulose fiber in the reactor. The calcination time was reduced to about 16-22 min.

The resulting calcined gypsum/fiber slurry was pumped to a fourdiner style headbox along with a stream of a second portion of pulped fiber to that was added to give a total fiber content of about 10 wt %. The composite slurry was then deposited by the headbox onto a porous forming fabric and then dewatered through the porous forming fabric with the use of vacuum boxes 14, followed by additional vacuum applied in combination with pressure to further consolidate the mat. Rehydration was then begun and after a portion of the rehydration had occurred, additional pressing was used to produce a panel with the desired thickness and surface appearance. Following completion of rehydration, the panels were loaded into a kiln to dry the panel and remove any remaining free moisture. The resulting panel had 90 to 92 wt % gypsum and essentially no unhydrated hemihydrate.

The amount of the first portion of the cellulose fiber reacted with gypsum in the co-calcination reaction of the process of this invention can be reduced to about 3.0 to 4.5 wt % of the slurry. The first portion is generally up to 50% of the total added cellulose fiber, e.g. about 3 to 5 wt % additional benefits in the reduction of energy required to complete the calcination reaction, reduction of panel final setting time and reduction in the amount of unhydrated hemihydrate in the final panel do not increase if the first portion of added cellulose fiber is more than about 70% of the total added cellulose fiber in the calcination reaction. Moreover the reduction of the cellulose fiber in the calcination reaction below about 3 wt % cellulose fiber reduces the amount of the co-calcined gypsum and "the host" cellulose crystalline structure without significantly reducing the steam energy requirements or setting time. In fact it has been noted that the reduction of fiber content in the calcination stage to a level of 50% to 70% of the total added fiber has resulted in a reduction in the rate of dewatering with the crystalline structure unless a drainage aid is also used. Thus although it is possible to further reduce the amount of cellulose fiber added in the first portion to the gypsum in the calcination stage, the benefits of the reduction below about 50 to 70% are not commercially significant in terms of the process improvements and the estimated reduction of steam energy above about 50% will require the use of addition drainage aids and crystal modifiers to retain desired setting times and crystalline properties of the co-calcined product GFP product originally disclosed and claimed in U.S. Pat. No. 5,320,677 to Baig.

While particular embodiments of the present invention have been shown and described, it will be appreciated by

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those skilled in the art that changes and modifications may be made thereto without departing from the invention in its broader aspects and as set forth in the following claims.

We claim:

1. A method of making a gypsum fiberboard panel comprising:

providing an aqueous slurry comprising gypsum and a first portion of cellulose fibers to a reactor, reacting the gypsum and a first portion of cellulose fiber in the reactor to produce a calcined crystalline gypsum and cellulose fiber slurry,

uniformly reinforcing the calcined crystalline gypsum and cellulose fiber slurry with a second portion of cellulose fiber after the reacting step to form a second slurry,

depositing the second slurry to form a mat,

dewatering the mat,

rehydrating the mat to form a gypsum cellulose fiber mat, and then drying, cutting and finishing the mat into a final gypsum fiberboard panel,

wherein no more than one half of the total cellulose fiber in the final gypsum fiberboard panel is added in the first portion to the reactor for calcination with the gypsum and wherein the amount of steam energy used in the reactor to calcine the gypsum and fiber is about 40% to 50% less than when all of the total cellulose fiber is added in the first portion to the reactor, and

wherein the amount of unhydrated hemihydrate in the final gypsum fiberboard panel is reduced by more than 50% from the level of unhydrated hemihydrate in a panel made with a slurry with all of the cellulose fiber calcined with the gypsum.

2. The method of claim 1 wherein the final panel contains 0.0 to 3.0 weight % unhydrated hemihydrate.

3. The method of claim 1 wherein the gypsum supplied to the reactor is in the form of an aqueous slurry and the first portion of cellulose fiber that is added to the reactor is also in the form of an aqueous slurry and the two slurries are blended together before entering the reactor.

4. The method of claim 3 wherein the second portion of cellulose fiber is also added to the calcined gypsum and cellulose fiber slurry in the form of an aqueous slurry.

5. The method of claim 1 wherein the first portion of cellulose fiber is about 3.0 wt % to 4.5 wt % of the aqueous slurry on a dry basis prior to the reacting step.

6. The method of claim 1 wherein the total cellulose fiber content of the gypsum fiberboard panel is about 8% to 10% by weight.

7. The method of claim 1 wherein the consistency of the gypsum and cellulose fiber slurry in the reactor is about 25% to 30% by weight.

8. The method of claim 1 wherein about 50 wt % to 70 wt % of the total cellulose fiber is added as the second portion to the calcined gypsum and cellulose fiber slurry after the slurry leaves the reactor.

9. The method of claim 1 wherein the mat formed sets within about 15-25 minutes of formation and rehydration.

10. The method of claim 9 wherein the time required to calcine the gypsum and first portion of cellulose fiber is about 18 to 22 minutes.

11. The method of claim 1 wherein the time for calcining the gypsum and first portion of cellulose fiber is about 15 to 25 minutes.

12. The method of claim 1 wherein the final gypsum fiberboard panel is more flexible and has a density less than panels made from the same ingredients wherein all of the cellulose fiber is reacted with gypsum in the reactor.

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13. The method of claim 1 wherein the density of the final gypsum fiberboard panel is about 53 to 70 pounds per cubic foot.

14. The method of claim 1 wherein the final gypsum fiberboard panel comprises, on a dry basis, 90-94 wt. % gypsum, 6-10 weight % cellulosic fiber and about 0.0 to 3.0 weight % of unhydrated hemihydrate. 5

15. The method of claim 14, wherein the final gypsum fiberboard panel comprises, on a dry basis, 94 to 92 wt. % gypsum and 6-8 wt. % cellulose fibers. 10

16. The method of claim 1 wherein a continuous phase of the final gypsum fiberboard panel comprises a co-calcined gypsum cellulose fiber crystalline slurry which is uniformly reinforced with cellulose fibers added in a second portion to the calcined gypsum cellulose fiber crystalline slurry after the calcination step. 15

17. The method of claim 1, wherein the final gypsum fiberboard panel has a thickness of about 6.3 to 15.9 mm (0.25 to 0.625 inches). 20

18. A method of improving the moisture expansion properties of gypsum fiberboard comprising:

providing an aqueous slurry comprising gypsum and a first portion of cellulose fibers to a reactor, reacting the gyp-

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sum and a first portion of cellulose fiber in the reactor to produce a calcined crystalline gypsum and cellulose fiber slurry,

uniformly reinforcing the calcined crystalline gypsum and cellulose fiber slurry with a second portion of cellulose fiber after the reacting step to form a second slurry, depositing the second slurry to form a mat, dewatering the mat,

rehydrating the mat to form a gypsum cellulose fiber mat, and then drying, cutting and finishing the mat into a final gypsum fiberboard panel,

wherein no more than one half of the total cellulose fiber in the final gypsum fiberboard panel is added in the first portion to the reactor for calcination with the gypsum and wherein the amount of steam energy used in the reactor to calcine the gypsum and fiber is about 40% to 50% less than when all of the total cellulose fiber is added in the first portion to the reactor, and

wherein the amount of unhydrated hemihydrate in the final gypsum fiberboard panel is reduced by more than 50% from the level of unhydrated hemihydrate in a panel made with a slurry with all of the cellulose fiber calcined with the gypsum.

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