

# **VARIATIONS ON 3-D FORMING TECHNOLOGY**

# 2-Sided Panel, One-Step Forming

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## ABSTRACT

A process to form a two-sided fiber panel in one step is proposed. This process uses conventional paper making or fiberboard forming technology with inflatable molds.

A slurry of fibers, cellulose, non-cellulose, or both, and water (or other carrier fluid) is distributed above a forming screen. A layer of fibers are formed on a screen as vacuum is applied on the bottom side of the screen pulling the water through the screen. An array of inflatable molds are brought into position just above the layer of fibers on the forming screen. Vacuum continues to pull the slurry toward the screen, thus depositing the fibers in and around the inflatable molds. The vacuum is maintained and the layer of fibers continues to form on top of the inflatable molds.

The fiber structure and inflatable molds are placed in a cold and hot press. The press is closed to a specific position and the molds are inflated. As the pressure increases the carrier fluid is mechanically removed. Internal pressure is maintained and heat is applied to the structure to drive off the water. Once the structure is dried, the mold is deflated and retracted from the side of the structure.

The finished panel is two-sided with an integral core rib structure. Holes remaining after retracting the array of inflatable molds are located at the neutral axis of the core rib structure.

# 2-sided Panel - 1 step Forming

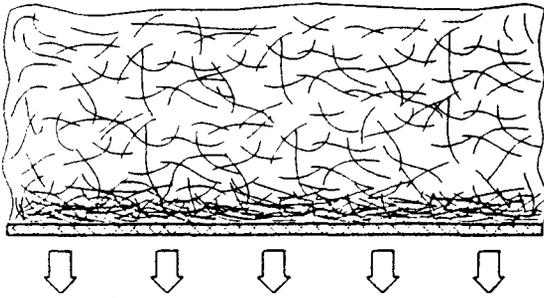


Figure 1. Fibers are distributed over a forming screen.

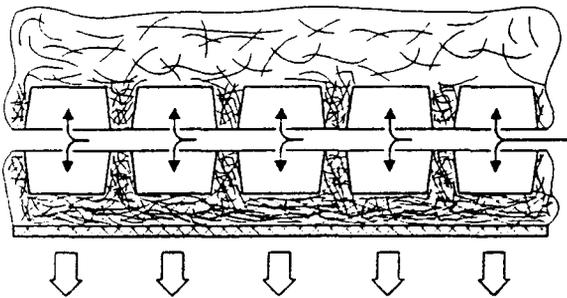


Figure 2. Fibers form in and around an inflatable mold.

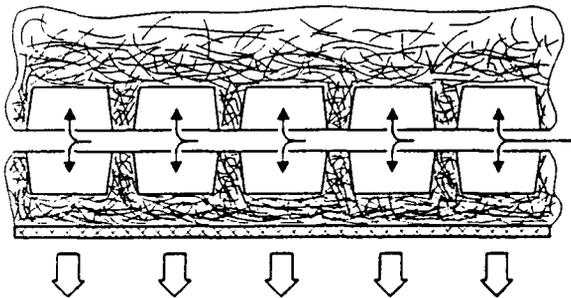


Figure 3. Fibers form a second layer on top of the inflatable molds.

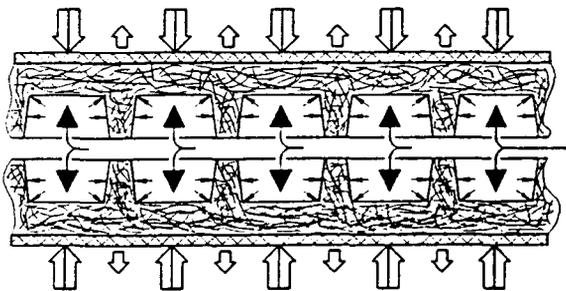


Figure 4. Fibers are consolidated with external and internal pressure.

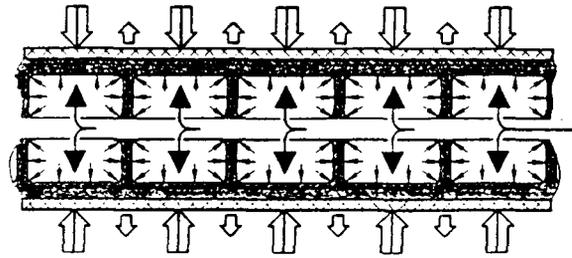


Figure 5. Pressure is increased and heat applied to dry the structure.

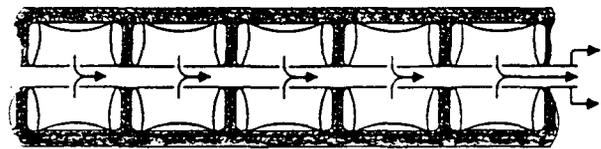
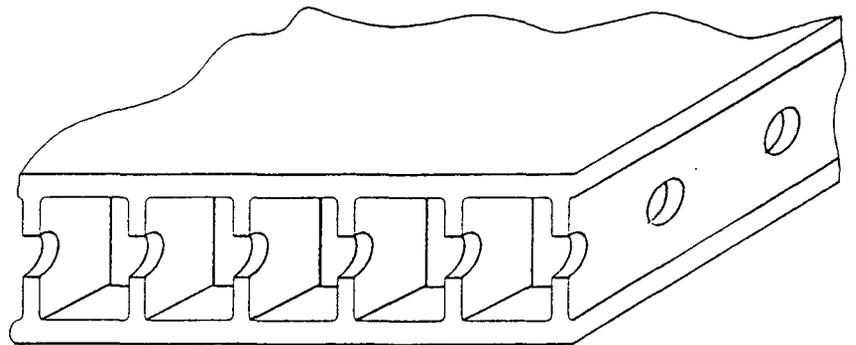


Figure 6. Mold is deflated and removed from the side.



Figure 7. 2-sided panel formed from an inflatable mold.



Finished Panel

# Non-Cellulose 3-D Composite Structures

## ABSTRACT

A process to form non-cellulosic composite structures is proposed. This process is a variation of the patented FPL Spaceboard process.

A slurry of fibers, cellulose and non-cellulose, or non-cellulose only, and water (or other carrier fluid) is distributed above a FPL Spaceboard forming screen. A three-dimensional (3-D) fiber mat is formed on and around the 3-D mold as vacuum is applied on the bottom of the screen. Pressure is applied to the fiber mat and mold to consolidate the fiber mat. The non-cellulose fibers may be a polymer, metal, or inorganic material.

If cellulose fibers are used, they are used for two purposes. One purpose is to provide “green strength” to the structure after wet-pressing to transfer the consolidated mat off the mold. The other purpose is to provide void volume for the non-cellulose composite structure. Once formed, the new 3-D structure is placed in a high temperature oven. The temperature is sufficiently high to burn off the cellulose fibers. The temperature may also be high enough to sinter the non-cellulose fibers together.

if no cellulose fibers are used, the consolidated non-cellulose fiber mat is dried or transferred directly to the high temperature oven to sinter the fibers.

The final structure is porous that may or may not be sintered. This structure could then be used as is or could be filled with a matrix material to form a composite that is formed to finished or near finished dimensions.

# Non-Cellulose 3-D Composites Structures

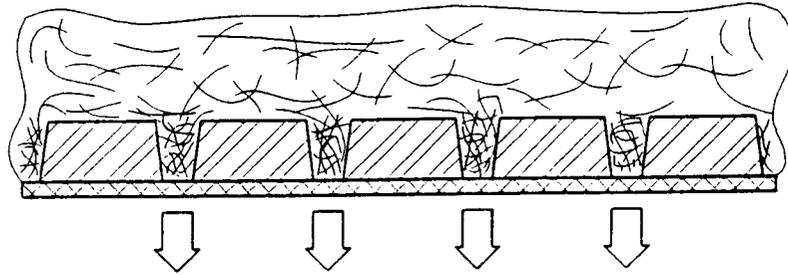


Figure 1. Fibers form into a 3-D mat.

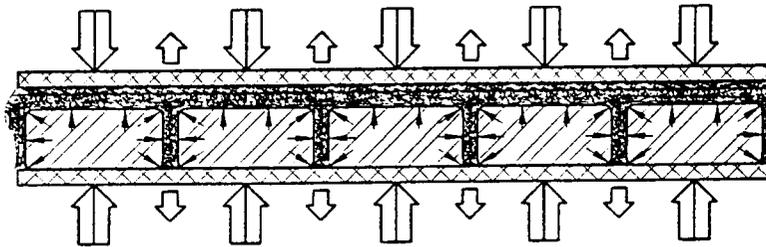


Figure 2. Fibers Consolidated  
to final shape.

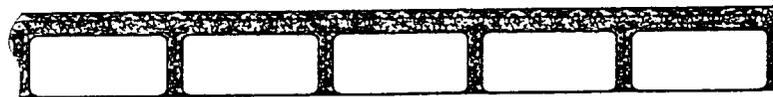


Figure 3. "Green Structure"  
removed from the forming mold.

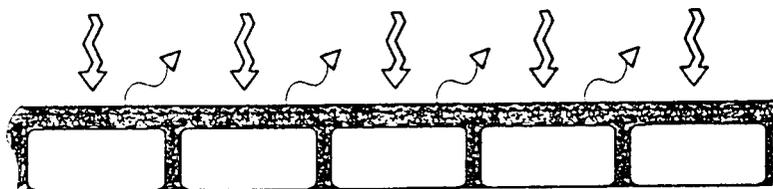


Figure 4. Heat burns off cellulose  
or binding material and sinters fibers  
into a porous 3-D structure.

# Resin Impregnation of 3-D Fiber Structures

## **ABSTRACT**

A process to form resin impregnated FPL Spaceboard structures is proposed. This process is a variation of the patented FPL Spaceboard process.

A slurry of fibers, cellulose, non-cellulose, or both, and water (or other carrier fluid) is distributed above a FPL Spaceboard forming screen. A three-dimensional (3-D) fiber mat is formed on and around the 3-D mold as vacuum is applied on the bottom of the screen. Pressure is applied to the fiber mat and mold to consolidate the fiber mat.

The consolidated fiber mat is dried on or off the mold. The porosity of the mat is modified depending on the fiber type(s) and pressure used to dry the fiber mat.

The dried fiber mat is impregnated using one of two methods. One method transfers the mat to a second mold and indexed to the correct position. Resin is in the mold or applied to the fiber mat before pressure is applied. Resin is uniformly distributed throughout the fiber mat and cured under pressure. Another method uses vacuum to pull resin through the fiber mat. The fibers and fiber crossings are coated with the resin but the structure remains slightly porous.

The final structure is a composite having a variable fiber to resin ratio depending on the desired performance requirements.

# Resin Impregnation of 3-D Fiber Structures

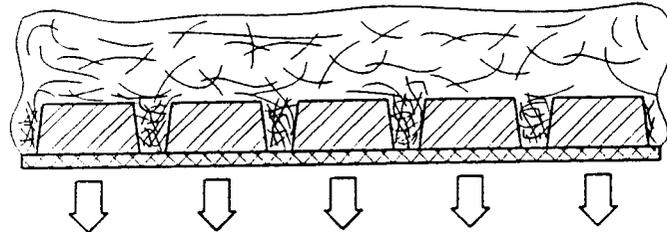


Figure 1. Fibers form into a 3-D mat.

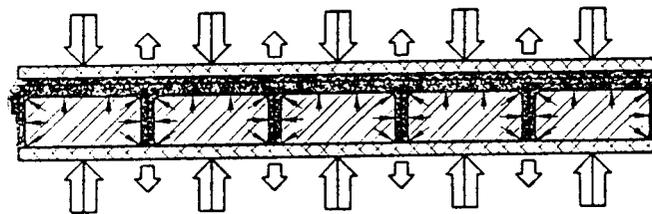


Figure 2. Fibers consolidated to the final shape.

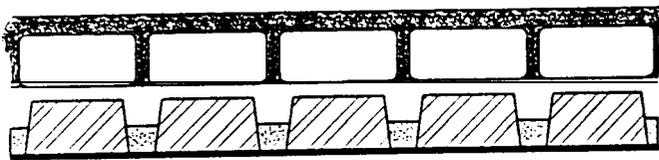


Figure 3a. Resin is distributed in the mold and 3-D mat is indexed on the mold.

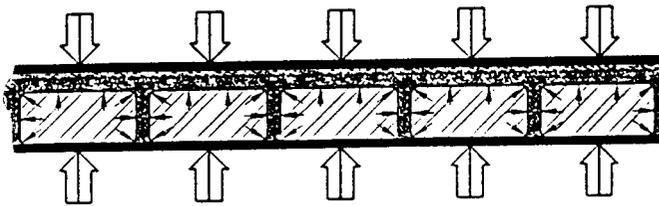


Figure 4a. Fiber and resin are consolidated and cured to the final shape.

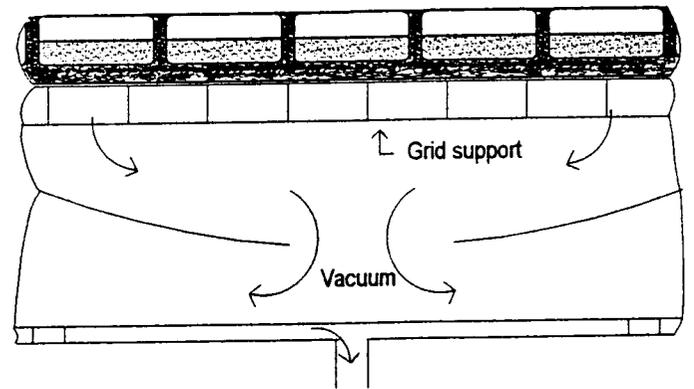


Figure 3b. Resin is distributed in the fiber mat and pulled through with vacuum.



Figure 4b. Fiber and resin and cured to the final shape.

# **SPACEBOARD LICENSEES**

**Sonoco Products Company**  
**Hartsville, South Carolina**

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## **LICENSED FIELD OF USE:**

packaging products that carry and protect goods

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# **Gridcore Systems** **International** **Long Beach, California**

## LICENSED FIELDS OF USE:

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- ◆ furniture, furnishings and related uses
- ◆ arts, crafts, games toys and sports
- ◆ miscellaneous industrial and commercial applications
- ◆ tools and weapon handles
- ◆ exterior and interior structural and non-structural parts for transport vehicles

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