PERP Program – Thermoplastic Wood Composites

New Report Alert

June 2007

Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***Thermoplastic Wood Composites (05/06S2)***. To view the table of contents or order this report, please click on the link below: http://www.chemsystems.com/reports/index.cfm?catID=2

Introduction

Fillers have long been used in the plastic industry as a means of supplementing plastic resins with materials ranging any where from wood chips and sawdust to mica and fiberglass. In some instances, the decision to use fillers is a cost saving measure, replacing the expensive plastic resin with less expensive fillers and in other cases, the filler is used to alter the mechanical properties of the original resin. In 2000, the plastics industry was estimated to have used 2.5 million tons of fillers. Calcium carbonate, the most abundantly used filler globally, has been shown to not only provide reinforcement effects, but also helps aid in the crystallinity of the polymer. While inorganic fillers have proven effective at enhancing mechanical and physical properties, they also add weight to the composite which limits potential applications. Wood products do not have this disadvantage; they are significantly less dense than inorganic materials, allowing them to offer weight reduction. This has allowed them to be used in a wider variety of new applications that other composites are not suitable for.

For purposes of this report, WPCs (wood plastic composites) are considered composite materials that combine wood or other cellulosic material, with a thermoplastic resin (polyethylene, polypropylene, polyvinyl chloride, etc). This report does not consider thermoset wood composite products (e.g., chip board on "engineered" wood). The cellulosic material can be from a wide range of sources including hardwoods, softwoods, rice hulls, straw, bamboo, switchgrass, Kenaf, flax or other natural materials. Unlike other plastic/inorganic composites, the use of the wood filler gives a product which is relatively close to wood in terms of its fabrication techniques; that is WPCs can be sawed, drilled, routed or milled.

The first commercial use for a wood plastic composite was in the automotive industry with Rolls Royce in 1916 (Gordon, 1988) where they were used as a gearshift knob. Since then, WPCs have found other applications within the automotive industry, such as interior panels and structural components of doors, based on their light weight and structural durability.

The next developmental influence for WPCs was provided by window manufacturers that were able to combine a working knowledge of both plastics and wood. The composites they produced were initially integrated into window frames, where they successfully replaced the wood component and offered a weight reduction compared to some other alternative materials. They also added a level of

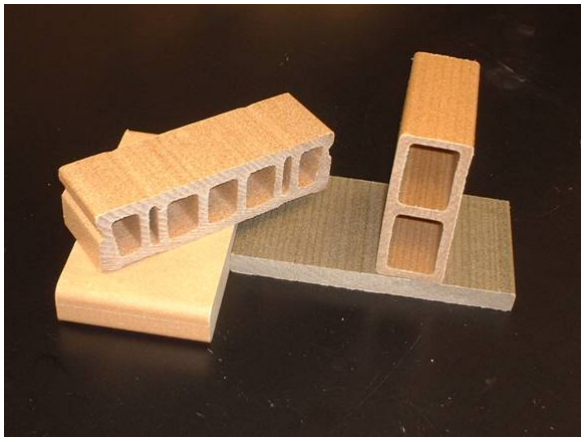
weather resistance to the frames that was superior to natural wood, as the outdoor elements make wood prone to decay and warping.

It wasn't until the 1990s that WPCs were able to achieve significant growth as improvements in processing and composite appearance allowed them to be integrated into the outdoor residential decking industry, particularly in the United States. Through Mobil Oil's research into a method of recycling old plastic bags, the firm was able to combine recycled polyethylene and sawdust to produce a composite that could be used as boards for decking. This division would later go on to become Trex, which has since been a leader in the North American wood composite industry. Also in the early to mid 1990s, the Strandex Corporation began offering WPCs as pre-formed shapes that required limited to no additional milling after extrusion, a technology that the company continues to license.

Since then, significant improvements have been made to produce composites with higher structural functionality and a more natural wood-like appearance. They have also been integrated in to a variety of end uses beyond the decking industry. In 1993, Anderson Corporation included wood plastic composites as sub-sills in their French doors, continuing the expansion of the window and door profiles market. In this manner, Anderson was able to use recycled materials from both its wood and plastic manufacturing processes.

Throughout the mid 1990s, the wood plastic composite industry continued to grow dramatically, particularly in the US, through new applications and technology development. Compounders began producing feedstocks made from plastics and wood in the form of pellets that can then go on to be extruded into various boards and shapes as required. Presently, WPCs are commercially available in a wide range of profiles and appearances as shown in Figure 1.

Figure 1 – Thermoplastic Wood Composites



Source: UC Davis

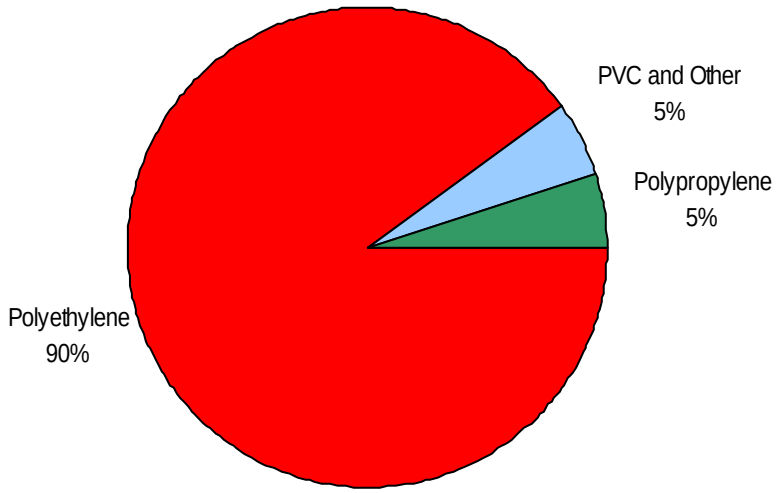
Materials

A variety of thermoplastic resins can be used for wood-plastic composite production. The resin itself will have greatest impact on the final physical properties of the WPC and the properties required for the end use functionality of the composite will play a large role in determining the thermoplastic resin chosen.

The wood component, and other natural products used, will degrade at high temperatures. To avoid this, the processing temperatures of the thermoplastic resins chosen must be below 200ºC (392ºF). This temperature stipulation is the primary limiting factor for the type resins used in the production of WPCs.

The resins used can be either recycled materials, virgin resin, or a mixture of both. Polyethylene, primarily HDPE, is the dominant resin used in the production of WPCs, with about 90 percent of the composites being produced using either virgin or recycled polyethylene (Figure 2). PVC, polypropylene, and polystyrene are also typically used. As mentioned above, the physical properties of the resin play a large part in determining the thermoplastic resin used, however, availability and cost will also affect the decision.

Figure 2
North American Wood Plastic Composite Resin Use, 2006



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The species of wood used for WPCs is more often dictated by cost and availability. Studies have shown that typically softwood species tend to have better impact performance than hardwoods. On the other hand, hardwood species tend have better flexural strength than softwood filled composites. Hardwood species have also been found to provide greater improvements in heat deflection,

although softwood species still out perform unfilled polypropylene. Typical wood plastic composites consist of 40-60 percent wood filler in a thermoplastic resin.

Economics

Cost of production economics for polyethylene and PVC wood composites are provided in the report. The thermoplastic wood composite plants are assumed to operate 8,000 hours per year. The compounding equipment is assumed to be operated 24 hours per day, five days per week. This is representative of the industry, which uses the weekends for maintenance and to meet periods of high demand. The on-stream factor is 96 percent; thus the lines are running at 6,000 hours per year. Utilities consist mainly of power, although a constant five dollars per ton was allowed for miscellaneous utility costs such as effluent treatment and waste disposal.

Most of North America uses the high torque 92mm twin screw, while most of Western Europe uses the high torque 58mm twin screw. It is evident from the economic analysis that those materials produced from the 92mm twin screw are less costly to produce than the materials produced from the 58mm twin screw. The economics presented do not include special additives such as pigment or UV absorbers, nor do they include overhead costs such as application development or technical support costs, which can be considerable depending on the application.

Commercial Analysis

Driven by an ample supply of recycled plastics, mainly HDPE bottles collected as part of curbside recycling programs, a large and growing decking market, and strong demand for low-maintenance materials, wood plastic composites (WPCs) have grown extremely rapidly in North America. Other WPC growth drivers include rising prices for wood, restrictions and phase-out of copper arsenate, an effective and relatively low-cost wood preservative, and a perception of greater durability and longer life.

The wood plastic composites initially produced in North America were of relatively poor quality - in essence, North American WPCs were “cheap and good enough”. Fortunately, the North American decking and outdoor construction market was nevertheless receptive to low-cost, low-quality products. Equally important, WPC producers soon realized that their products needed to be improved, and began to do so through a variety of methods including better recyclate cleaning techniques, use of better quality recycled materials and resins, use of coupling agents, a variety of co-extrusion techniques, and improved pigments and other additives.

The largest end-use market for WPCs in North America, by far, is the decking and railing market which accounts for an estimated 84 percent of total demand. Presently, WPCs represent an estimated 15 percent of North American demand for decking and railing products (board-feet of lumber basis; excludes deck sub-structure) and 20 percent of the market on a wholesale market value basis.

The West European market for thermoplastic wood composites is vastly different than the WPC market in North America. The primary differences are a much smaller decking market, a bias toward natural materials for outdoor applications, and a preference for quality products in deference to inexpensive materials. All of these factors have greatly slowed the penetration of WPCs into West European applications.

In Western Europe, stone is the traditional terrace (patio) material, with the patio located directly behind the house. Then, there is a garden on the other side of the patio. Unlike North America, there is a trend in Europe to let wood decks weather and turn gray – undermining the lower-maintenance argument which favors WPCs in North America. Conversely, other trends are increasingly favoring the use of WPCs in Western Europe. The prices of wood – especially the hardwoods preferred in Europe – continue to rise. Increasingly, eco-taxes are being employed to encourage the use of recycled materials.

With an emphasis on traditional materials and quality products, low-priced WPCs have never made much of an inroad into West European end-use applications. Instead, European WPC producers are using high quality raw materials to manufacture branded, high-performing products. Since a "mass market" for WPC products has yet to develop in Western Europe, producers also have to target specific product niches to drive growth.

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