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Material Preparation and Process Improvements for Recycled HDPE Scuff Board

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The Chelsea Center for Recycling and Economic Development, a part of the University of Massachusetts' Center for Environmentally Appropriate Materials, was created by the Commonwealth of Massachusetts in 1995 to create jobs, support recycling efforts, and help the economy and the environment by increasing the use of recyclables by manufacturers. The mission of the Chelsea Center is to develop an infrastructure for a sustainable materials economy in Massachusetts, where businesses will thrive that rely on locally discarded goods as their feedstock and that minimize pressure on the environment by reducing waste, pollution, dependence on virgin materials, and dependence on disposal facilities. Further information can be obtained by writing the Chelsea Center for Recycling and Economic Development, 180 Second Street, Chelsea, MA 02150.

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1. Abstract

Recycline develops and delivers to market quality products made from recycled materials. The company's first product, the Preserve[®] toothbrush, is a dentist-engineered and environment-friendly toothbrush, with a handle made from recycled polypropylene. Recycline is currently developing its first product designed for commercial users, a scuff board for tractor trailers called the Ultra-Slide.

With grants from the Chelsea Center for Recycling and Economic Development, Recycline and its contract manufacturer, Arlin Manufacturing Co., explored ways to improve the manufacturing process for the Ultra-Slide, including the installation of new equipment. Recycline purchased 14,000 lbs. of post-consumer recycled high density polypropylene (HDPE) and hired a company to compound 3,000 lbs. of the 14,000 lbs. with glass fibers. Arlin used this material to test improvements to its manufacturing process, including modifications to extruder dies and downstream cooling equipment.

The compounded product and manufacturing changes produced a superior product.

2. Background

A scuff board is a product used in the trucking industry to protect the base of the interior walls of tractor trailers. Scuff boards are currently made predominantly from oak, steel, and aluminum. Those made of oak are considered high-quality boards while the latter two are considered lower performance alternatives. Plastic scuff boards have recently been developed and are recognized as being superior to oak boards in durability, availability, and often in cost, as oak prices can fluctuate widely as supply levels vary.

The one major producer of plastic scuff boards is making headway into the oak board market due to the many performance benefits and greater availability of plastic. However, this product has a recognized quality problem: due to the greater thermal expansion of plastic compared to wood, the plastic product warps and buckles. In addition, this plastic scuff board is produced by Trail Mobile, a tractor trailer manufacturer and a competitor of the primary buyers of the product.

Recycline's Ultra-Slide is engineered to address the quality problems of the Trail Mobile board and to introduce additional performance advantages. Consequently, it will not only satisfy a need among wood scuff board users for better performance and availability, but will also appeal to plastic scuff board users seeking improved quality and engineered advantages.

Research performed at the University of Massachusetts Lowell on the material formulations for this product determined that adding fillers to the HDPE would improve the plastic's performance in scuff boards. A glass fiber additive produced the greatest impact on stiffness and strength, but also resulted in a significant reduction in the ductility of the HDPE, even at a low concentration. The glass fiber additive also had the greatest effect on the coefficient of thermal expansion (CTE). The CTE for HDPE is very high, leading to warping in products like scuff boards. Tests showed that adding 10% glass filler reduced the CTE value for the HDPE by 50%.

3. Description and Results of the First Production Trial

With funding from a prior Chelsea Center grant, several experiments were performed on a laboratory extrusion line. A small-scale forming roll was made and used to determine the feasibility of the forming process. In these experiments, the profile of the Ultra-Slide was successfully formed on a small scale, giving the companies the confidence to invest in the required equipment for the two production trials described below.

The first trial was performed with available equipment. Arlin completed three production tests with the material provided. In each, the production process produced increasingly improved results. Arlin tested several different cutting and trimming processes to determine the best downstream timing techniques and the best location of the trimming process. They also noted the difference in the quality of boards extruded with talc and without talc. Arlin also improved the equipment and holding tanks used to cool the plastic boards.

Three lessons were learned from this first trial:

1. The available extrusion die could not produce the thickness required for the product. The die would require a larger gap opening.
2. The product would need to be held and cooled for a longer period of time after the forming process. Additional conveyors would have to be installed for this purpose.
3. Temperatures of the cooling rolls were varied, and it was found that the coldest roll temperature settings gave the best-looking profile.

4. Description and Results of the Second Production Trial

The purpose of the second trial was to produce the scuff board at the required thickness and to answer questions regarding production rates, product yields, post-production material handling, and packaging concerns.

Equipment modifications were made for the second trial. Arlin purchased, installed, and fine-tuned the equipment. The die was fixed with a new lip for a larger gap. The cooling section of the extrusion line was lengthened to allow for more heat transfer before the product was trimmed.

With these modifications, the line was set up to run production samples with two raw material formulations provided by Recycline. The first formulation used recycled HDPE with no fillers. The second formulation used recycled HDPE compounded with 5% filler to help control shrinkage.

Recycline obtained the recycled HDPE from L. Fine & Co., a Massachusetts material supplier, and shipped 11,000 lbs. of recycled HDPE directly to Arlin. Recycline also shipped 3,000 lbs. to New Frontier Plastic Company, a Massachusetts compounder, for compounding with 5% glass fiber. Following compounding, New Frontier then shipped the compounded materials to Arlin. In the production process, talc filler was also introduced to the material in a concentrated form. Compounding a fraction of the entire quantity of material, or producing a “concentrate” which is then blended with the remaining amount of material, produces the desired finished product and reduces the compounding charge.

The unfilled material was used first. The new die lip provided the thickness required for the product. The extended cooling section allowed the product to be cool to the touch at the cut off point. However, no matter what adjustments were made to the equipment, a good profile could not be formed. The front of the board had many sink marks (giving it a puckered appearance) and the ribs on the backside would not form correctly.

The next run used the filled material, which formed successfully. The front of the board had a smooth appearance with the only sink marks occurring at the thick rib section. On the backside, the ribs formed correctly, except at the outside edges where complicated profiles exist. The edge trim or flash seemed to create stresses at the outside edges of the product due to the differences in cooling rates. This caused waviness in the machine direction in the product. After the samples sat flat for one day, bowing in the cross direction was apparent.

Two 30-foot samples were rolled into five-foot diameter circles and left to sit for two weeks to see what effect it had on the product. One sample had the ribs on the inside of the circle; the other sample had the ribs on the outside of the circle. When the sample with the ribs on the outside was unwound, it still had significant warping in the machine direction. The sample with the ribs on the inside unwound relatively flat. The machine direction warping was apparent, but it was not as pronounced as the samples that were never wound or the sample that was wound in the opposite direction. The ability to successfully roll lengths of board not only reverses some of the post-production warping and cross-directional bowing, but also enables shipping of the rolled boards by common carrier.

Though one of the goals of the project was to answer questions regarding production rates and yields, the focus became finding the right settings to produce a good product. Despite this shift, the production rate was at least as good as originally estimated, and the yield (feet of board/lb.) was about 20% better than originally estimated.

In addition, the trimming and cooling of the board has produced a much better looking product that will perform to the standards required.

5. Lessons Learned

The lessons learned from the production tests are as follows:

- Fillers to control shrinkage during cooling must be used with this material.
- Reducing the excess trim, or flange, produced in the production process reduces the warping and bowing of the board.
- Trimming the excess flange during an exact moment and in an exact location in the cooling process produces the best results for the finished product. Trimming too early pulls and disturbs a quality surface and trimming too late allows the flange to warp and bow the board.
- Increasing the length of the cooling process greatly improves the quality of the finished product.
- Coiling the completed board into a rolled shape helps reduce warping and bowing of the board and makes shipping the product easier.

- The production rates and product yield were as good or better than what had been estimated, indicating that the outputs are still commercially acceptable.

6. Transferability of Lessons/Research

Under the contract manufacturing agreement between Arlin and Recycline, the production processes for this product are proprietary to Arlin. Any transferability would be limited to similar products using the same raw materials.

7. Recommendations for Future Work

- Additional samples of materials with different levels of fillers should be tested. This could help reduce and may even eliminate the problems associated with warping.
- A trim station located close to the cooling rolls to remove the edge trim or flash earlier in the cooling process will reduce the trim's effect on machine direction warping.
- A winder to automatically roll the finished product will be required.

8. Conclusions

The compounded materials and manufacturing process improvements made possible by the Chelsea Center grants have enabled Recycline and Arlin to improve production of the Ultra-Slide so that samples can be produced for prospective clients. Production rates and product yields under these conditions are commercially viable.

Recycline expects to release the Ultra-Slide to market before the end of 2000.