Case Study No. 8 Low-VOC/HAP Coatings and Waterborne Adhesives
Crystal Cabinet Works, Inc.
Princeton, MN

Background

Crystal Cabinet Works (Crystal) was founded in 1947 and produces high-quality custom cabinetry for kitchen, bath, or home theater use. There are two facilities located in Princeton, Minnesota: a small component manufacturing facility and a larger facility that machines, builds, finishes, and assembles cabinetry. Total weekly production averages around 2,300 cabinets a week, of which 90 to 95 percent are coated. In mid-1995, Crystal began to reformulate their coatings and adhesives as part of an overall pollution prevention effort.

Product sample

Manufacturing and Coating Operations

Crystal's products consist of solid wood (birch, red oak, hickory, cherry, pine, maple, or heartwood maple) or engineered wood products (particleboard, MDF, or plywood). One facility mills the solid lumber into moldings, linear material for door stiles and rails, and some door panels. These components are transported to the other larger facility, combined with other components that are milled at that facility, then shaped, finished, and assembled to produce the final product.

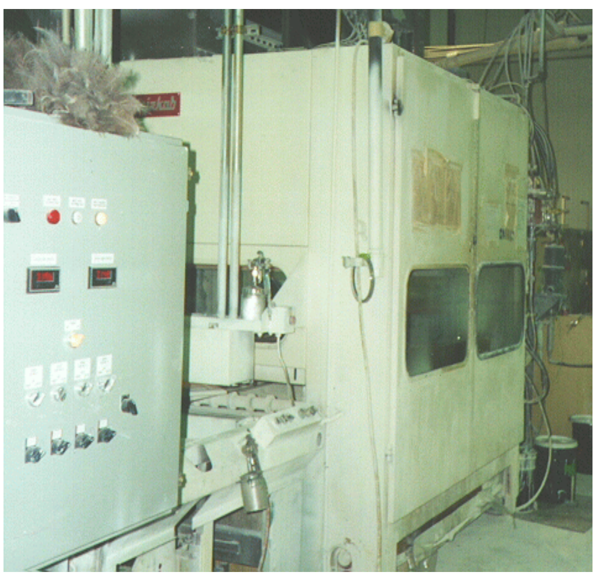
The cabinet components first are cut, shaped, and sanded. The type of shaping and sanding machines depends on the style of the desired final product. Waste solid wood door panels are collected, returned to the milling plant, taken apart, glued together into new door panels, then planed to a half-inch thickness for use as thinner panel inserts. This practice allows Crystal to reuse defective door panels and reduce the amount of wood waste generated. The wood waste that cannot be reused is chipped and sold as animal bedding. After shaping and sanding, the parts are taken to either the assembly or finishing areas. Products are finished before assembly, after assembly, or a combination of the two.

The first step in the finishing department is to clean the product with an automated brush/vacuum machine to remove all sanding dust or particles. Crystal has two finishing lines: an automated flat line and a manual cart line. The manual line is used to finish assembled, or partially assembled, three-dimensional products that cannot be accommodated by the automated flatline system. On the manual line, the parts are placed on tow carts that move automatically through the spray booths. The coatings are applied manually with air-assisted airless guns, which have a manufacturer-rated transfer efficiency of 75 to 80 percent.

First, a stain is applied and hand wiped in the stain booth. Next, a sealer or primer is applied, then dried in an oven and hand sanded. This sealer or primer step is then repeated, passing through the same oven. The final coating is either a clear topcoat or enamel and is applied in the topcoat booth and dried in the second oven. When the finishing process is complete, the product is unloaded and prepared for assembly.


Spray booth

The spray booths on the automated flat line have several features to help increase efficiency and prevent pollution. First of all, electronic eyes minimize overspray and wasted finishing material by triggering the guns only when the eye senses product as it travels through the spray booth. The spray guns themselves are air-assisted airless guns, again with a manufacturer-rated transfer efficiency of 75 to 80 percent.


Automated line

In the first automated spray booth on the flat line, the product receives a stain, primer, or glaze. Stains or glazes are hand wiped. All coatings applied on the flat line are dried in one of two stack ovens, with a required residence time of approximately 45 minutes to dry the coating. The time required varies depending on the type of coating applied. For primer coats, a halogen IR oven is used. The IR oven has a cure time of approximately 2½ minutes; the exact time varies by coating. The proper cure is achieved by varying the line speed through the oven, the air flow, and the temperature of the oven. The process then is repeated for the other side of the panel.

In the second spray booth on the automated line, the product receives a coat of sealer and is dried in a conventional stack oven. Both sides of the piece are coated and dried. The product is sanded, and a second coat of sealer is applied to both sides. The third line is used to apply the topcoat. The product is dried in a stack oven, and the opposite side of the piece receives a topcoat and is dried.

Most wood coatings and solvents are received in 55-gallon drums and 5-gallon buckets. Sealer and topcoat are shipped by dual tanker trucks and stored in bulk storage tanks. As needed, these coatings are dispensed into 55-gallon drums. Some used drums collect hazardous waste (cleaning solvent or waste coating) and the rest are recycled or sent back to the manufacturer.

Gluing Operations

Crystal also replaced a solvent-borne contact adhesive with a waterborne alternative. Prior to 1995, the contact adhesive used at Crystal to adhere laminates to engineered wood contained methylene chloride, a suspect carcinogen and known HAP. This system was replaced by a waterborne neoprene-rubber contact adhesive that is applied by HVLP guns and dried by IR lamps. The final waterborne system provides better adhesion than the original glue and greater coverage per drum, reducing overall costs. The environmental and health benefits are even greater, although not as easily quantified.

Cleaning Operations

Due to the high volume of custom work, color changes are frequent at Crystal. Each time the color is changed, the lines must be flushed with cleaning solvent to remove all of the previous color. This practice can produce a high volume of solvent waste, the majority of which is acetone, toluene, and methyl ethyl ketone (MEK). However, in March of 1999, Crystal installed an automatic color changer on its flat line in order to reduce amount of flushing solvent and time required to switch colors.

In addition to cleaning the lines, the spray equipment and conveyors also must be cleaned. To reduce the amount of cleaning solvent used, the spray booths are cleaned with dry methods, such as chipping off dried coating that has accumulated on the walls of the spray booths.

Conversion to Low-VOC/HAP Coatings and Waterborne Adhesives

The switch to low-VOC/HAP finishes was relatively easy for Crystal Cabinet Works. Because high-solids coatings already were in use, equipment changes were unnecessary and adjustments to the sealer and topcoat were minimal. The sealer and topcoat already were high-solids catalyzed coatings and required only minor adjustments to comply with any regulatory requirements. The stains required more reformulation however, and color matching was a problem. Each color was tested two to five times before a suitable finish was established, a process that required 18 months. Once the change was made, the quality of the finish was equivalent to that of the original finish and the change was generally unnoticed by customers. Increased drying time also was an issue, but was resolved with the addition of IR lamps to the coating line to replace conventional ovens.

The change in glues was more difficult, expensive, and labor-intensive than the coatings reformulation project. However, methylene chloride's status as both a suspect carcinogen and HAP provided several incentives for changing the glue: reduced environmental impacts, improved employee health, and compliance with increasingly stringent EPA and OSHA regulations. Methylene chloride emissions from gluing operations were substantial, at 24 tons per year for both facilities combined. Although it would have been possible to switch to another solvent-borne adhesive, Crystal recognized the opportunity to change to a high quality waterborne glue, virtually eliminating the environmental and health hazards.

Because of previous experience with glue failure, Crystal spent extra time and resources to ensure the best combination of technology was utilized. Over a period of 18 months, 16 glues were tested for several characteristics. The primary characteristic sought for this new glue was bond strength: in order to maintain product quality, it had to be equivalent to (or better than) the methylene chloride-based glue. The workability of the glue also was important; it had to both maximize tackiness and minimize dry time. Each glue was tested under different process variables to find the most effective application method. These process variables included: drying method (air or IR), application method (spraying or roll coating), and setting/bonding pressure (J-roll or pinch-roll). A waterborne neoprene-rubber contact adhesive was chosen, applied by HVLP guns, and dried by IR lamps. This system provides not only a safer glue with virtually no HAP or VOC emissions, but also one with greater bond strength than the glue it replaced.

Costs

Costs to reformulate the finishes were minimal because the sealer and topcoat required only very minor changes. However, the stains required several reformulations to achieve the desired appearance. This reformulation took approximately 18 months of research and development to accomplish. No new equipment was required because high-efficiency guns already were in use.

The methylene chloride-based glue was not only an environmental hazard, but dangerous to the health of the employees as well. Therefore, Crystal felt they needed to provide a better working environment for their employees. The equipment costs, including new HVLP guns and IR lamps, were approximately $110,000. In addition, labor costs from research and development, although not measured, were substantial because three full-time employees worked on the project for 18 months. However, the waterborne glue is only marginally more expensive per gallon ($16.50 compared to $15.00 for the methylene chloride-based glue) while the coverage is more than twice that of the old glue. In 5 months, 15 drums of the old glue were used; during an equivalent period of time, only 7 drums of the new waterborne glue are used. This increase in coverage has halved the glue supply costs.

Emissions

According to Crystal, the reformulation of the finishing materials caused a significant decrease in their annual VOC emissions. In 1994, 472 tons of VOCs were emitted. By 1997, this number had been reduced to 152 tons of VOCs, representing a decrease of over 67 percent. The HAP emissions also decreased dramatically; Crystal is subject to the Wood Furniture NESHAP and was in compliance by late 1996. The change to a waterborne glue provided most of the HAP decrease; the previous glue was 88 percent methylene chloride. The new waterborne glue also has a low VOC content, only 0.10 pound VOC per gallon. Facility personnel stated that when Crystal converted to the waterborne glue, their toxic chemical use was reduced by 16 tons per year.