A VISION FOR THE INDUSTRY - PROCESSES: HOW WILL THEY CHANGE IN THE NEW MILLENNIUM?

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Summary

The role of new processes in wood preservation in the next 10 to 25 years is discussed. While processes such as vapor boron and supercritical fluid impregnation show promise, the conservative nature of the industry and its customers generally slow adoption of these new technologies. Despite sluggish change, the potential and need to develop new treatment processes remains high.

Introduction

When I was asked to give this paper, my first response was that there was no point in pondering what new processes might arise since January 1 of the New Year would plunge our society into a darkness unrivaled since the middle ages (which I understand was darker than dark). Why worry about treatment technologies when we'd be sitting around fires and using stone tools? Alternatively, I wondered which of Nostradamus' predictions would hold true. Finally, I concluded that there was much ado about nothing. After all, only the Christian calendar calls the coming year a millennium and there is even debate about whether the celebratory year is 2000 or 2001. Consider that the Islamic, Hindu, Hebrew and Chinese cultures, with populations that far exceed those of Christian calendar cultures, all passed 2000 some years back. Putting these paradoxical thoughts aside, any time is a good time to review history and to ponder the future.

Where Have We Been?

For centuries, wood users have attempted to enhance the performance of wood products against the various agents of biological and abiotic deterioration (Graham, 1973). These efforts were largely unsuccessful until approximately 160 years ago when an enterprising engineer patented the impregnation process that bears his name. Along with a patent for creosote, John Bethel's work propelled the treatment of wood to industrial prominence and provided the basis for our current industry. As we approach the next millennium, it is useful to briefly review how processes have changed over the past century and perhaps look forward to potential changes in the future.

The early part of the this century saw the development of the two other primary processes used to treat wood (Hunt and Garratt, 1967). The Rüping and Lowry processes or empty cell treatments were developed to reduce the amount of chemical delivered into the wood. Both were largely extensions of the existing processes. The early part of this century also witnessed the development of a number of less successful treatment methods including Kyanizing (mercuric chloride), the Boucherie treatments and Double diffusion, as well as vacuum processes that continue to be used for some window treatments.

All of these processes were eventually limited by the fundamental difficulties associated with forcing liquids through a semi-permeable material (Baines and Saur, 1985). In essence, all are largely limited to treatment of the sapwood. This poses a particular challenge in Canada, since most native species contain high percentages of heartwood. As a result, Canadian research has concentrated on methods for improving treatment, notably using incising and ammonia-based preservative systems.

Incising technologies have evolved from a largely industrial process with little concern about appearance to a sophisticated process that uses many fine teeth to reduce potential surface effects (Perrin, 1975; Winandy et al., 1995; Goodell et al., 1991). Incision densities have increased from as few as several hundred to upwards of 12,000 per square meter. Despite these advances, however, incising is widely viewed as a negative process both from appearance and material properties perspectives (Lam and Morris, 1991; Winandy and Morrell, 1998). One exception is needle incising, which uses very fine incisions. This approach, while useful, remains a limited commercial success. While incising is unlikely to completely overcome the inherent difficulties in treating refractory wood, it represents the only commercial method for achieving acceptable treatment of many wood species.

Like incising, through-boring and radial drilling increase the potential for longitudinal fluid movement through larger timbers or poles of refractory wood species. These processes have been available for nearly 40 years, but have only recently become widely adopted. There remains some potential to extend these techniques to other structural materials, as well as an opportunity to optimize boring patterns to enhance treatment while minimizing potential effects on strength.

Although they are not directly related to processing, the emergence of preservative systems using ammonia to solubilize copper has the potential to markedly enhance treatment. The first ammoniacal-system, ammoniacal copper arsenate (ACA), was developed in response to the difficulties in treating thin sapwoods species with acid-based systems such as chromated copper arsenate (Hartford, 1973). Ammonia based systems are believed to enhance penetration of fluid via a combination of wood swelling and dissolving extractives encrusting pits to increase permeability. In the absence of more radical processes, ammonia based systems represent a simple approach to improving treatment.

The other approach to overcoming treatability difficulties is to alter the process or characteristics of the treatment medium. Over the past century, a number of variations on pressure processes have been proposed, but most have not proven useful. More recently, modified processes have been environmentally driven. For example, long vacuums reduce bleeding, while modified full cell-processes reduce the final weight of the treated product. The Oscillating and Alternating Pressure Methods (OPM, APM) were developed according to the principle that pressure changes could dislodge aspirated pits to enhance fluid movement through wood (Hudson and Hendricksson, 1956). Initial studies on spruce suggested that the OPM could enhance treatment; however, other research has shown that pressure changes deep in the wood during these processes are relatively insensitive to the pressure cycling occurring nearer the surface (Flynn and Goodell, 1996; Peek and St. Goetsch, 1990, Schneider and Morrell, 1997). As a result, changes in process conditions, while producing incremental improvements in the treatment of some species are probably unlikely to produce the quantum improvements desired. In the absence of substantial changes in conventional processes, enhancing treatment will require a rethinking of how wood is treated. One approach is to alter the properties of the treatment fluid.

The alteration of fluid characteristics to enhance treatment has received continued interest in this century. Two commercial approaches were the Cellon or Dow processes, which use liquified petroleum gas or methylene chloride, respectively, as the solvent (Henry, 1959). The less viscous solvents were reported to penetrate more deeply into the wood. This penetration is evidenced by the presence of considerable amounts of solvent in the interior of Cellon-treated poles 15 to 20 years after treatment. Even these processes, however, produced only incremental treatment improvements and the lack of a heavy oil solvent had serious negative impacts on the performance of the preservative (pentachlorophenol) (Arsenault, 1973). As a result, this process is no longer in commercial use. While the light solvent process was less than successful, it illustrates the potential for improving treatment by varying solvent properties such as viscosity and diffusivity.

The vapor boron process, simultaneously developed by the Forest Research Institute in New Zealand and Imperial College in the United Kingdom, is one example of the use of more volatile treatment condition to enhance preservative penetration (Murphy and Turner, 1989). Trimethyl borate has a high vapor pressure and this volatility is enhanced by drawing a vacuum over the wood prior to exposure to the chemical. The boron volatilizes to diffuse into the wood where it reacts with water producing methanol and depositing boron. Vapor boron is best suited for use when the wood moisture content is 6 to 8%. Drying solid wood to this level can induce serious structural defects. As a result, vapor boron is best suited for composites since the moisture levels of these materials are typically lower (Murphy, 1995). Another disadvantage of the vapor boron process is that the boron is not fixed to the wood and can leach from the wood. An alternative process uses vapor copper, but this process has only been studied on a laboratory scale (He et al., 1995).

The most extreme shift in treatment fluid characteristics are supercritical fluids. Supercritical fluids are materials that are heated and pressed above their critical temperature and pressure. Supercritical fluids have diffusivities that are similar to gases and solvating properties that can approach those of a liquid. Preliminary tests indicate that biocides solubilized in SCFs can completely penetrate most wood-based materials (Acda et al., 1997; Morrell et al., 1993). Concerns about the potential effects of elevated pressures on wood properties appear to be less of a problem because the interstitial voids in these materials provide pathways for rapid pressure equalization. There are, however, certain wood species that may not be suitable for use in these processes (Kim and Morrell, in press).

At present, SCF processes are probably not economically feasible, but changing environmental regulations, public perceptions about chemicals and the continued emergence of engineered wood products, could markedly alter the economics. The process however, represents a revolutionary approach to impregnation offering the potential for uniformly treating all wood based materials.

What Will Force Change?

The treating industry and its customers have a well-deserved reputation for being staunchly conservative and of being slow to adopt new technologies. This hesitancy is borne of the need for products with exceptional reliability for periods of 30 to 40 years. Change, however, has continued to occur in the industry and we should expect to see continued evolution. There are a number of external factors that will continue to drive these changes including:

- Increasing concerns about preservative migration from treated wood
- Negative public perceptions about chemicals
- The changing regulatory environment
- Increased use of engineered wood products
- Increased competition for a limited wood supply
- Pressure from alternative, non-wood materials

Given the evolutionary nature of wood protection process development, it is unlikely that the first 20-30 years of the next century will see revolutionary change. Most of the research on new processes that might impact treaters is probably underway. While this gives the impression of that we face an exceedingly pedestrian future, it really reflects the need to fully prove technology before implementation. Consider, for example, pentachlorophenol. In 1977, the U.S. Environmental Protection Agency listed this chemical as a part of its Rebuttable Presumption Against Registration (RPAR) (USDA, 1980). As a result of this process, the use of penta was restricted to those licensed by their respective states and there were considerable efforts to ban this chemical. Nearly 20 years later, penta usage has only declined slightly and there is no indication this will change. This example illustrates the conservative nature of both the wood treating industry and its customers. This is not to say that change will not occur, but it will occur slowly in the absence of external forces.

Given these factors, what are the trends for the next century? Although it is difficult to predict, we may see some of the following:

- Reduced dependence on the metallic preservatives
- Increasing use of building membranes that stop moisture near building members
- Increased use of engineered wood products in applications where moisture contact is likely
- Continued efforts to completely contain chemicals from synthesis to disposal

The role of process development will depend, to a large extent, on regulatory changes and new materials development. All of these trends should stimulate the creation of more efficient processes for protecting wood-based material. We may also entertain the notion that these efforts will be accompanied by enhanced building technologies that will reduce the possibility of moisture entry and subsequent decay.

The treating industry has gradually evolved over the past century. For it to survive through the 21st century, it must be capable of responding to continued public and regulatory pressure to produce products with minimal risk to humans and the environment. Processing must clearly be an integral component of that effort to ensure that the industry is able to take advantage of new opportunities in the protection of wood-based building materials.

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