

Mississippi Forest Products Laboratory

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REDUCING WEAR OF WOOD-MACHINING TOOLS

ABSTRACT

The machining required when wood is cut, planed, and shaped into useful products is a significant cost factor for the wood products industry. This research addresses that issue and indicates that significant progress is being made toward an understanding of the "wear mechanisms" involved. This knowledge is in turn being used to produce improved materials for saws, planers, etc. which has led to a significant reduction in processing costs for Mississippi manufacturers.

Tool Wear Mechanisms

"Four major mechanisms-abrasion, adhesion, diffusion and fatigue-cause wear of wood-machining tools," says Senior Research Assistant Harold A. "Sandy" Stewart of Mississippi Forest Products Laboratory (MFPL). "We're studying these mechanisms for data that will lead to tools and methods for reducing tool wear; researchers here and at other locations already have learned a lot about how to do it."

Stewart observes that each of the four mechanisms interacts with the others, but some cause more wear.

"Abrasion is traditionally seen as the leading cause of machine-tool wear," he says. "Wood species with different hardnesses and reconstituted wood products such as medium density fiberboard (MDF) contain adhesives

and silica, which have previously been thought to cause the abrasion that wears tools. Abrasion includes the rubbing, plowing and cutting of the blade by such materials.

"Adhesion is the formation of 'welds' between the tool and the workpiece. Wear results when the joint between tool and workpiece fails.

"Diffusion is the atomic transfer of one material to the other. It takes place at the tool/workpiece points of contact, and is an integral part of the other mechanisms.

"Fatigue results from stresses that build and ebb and build again at tool/workpiece interfaces. Fatigue probably is the least apparent of the four major wear mechanisms."

Stewart notes that these four mechanisms depend on time,
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temperature and pressure, and all act when tool and workpiece surfaces are forced into close contact. The researcher identifies three factors in the machining of wood and wood-based materials that affect these mechanisms: (1) the tool rubs against the freshly cut, highly oxidizable workpiece or chips from it; (2) the workpiece deforms or "gives" as the chip is formed; and (3) very high temperatures develop at the sliding interface between tool and workpiece.

The wood or wood-based product surface is a chemically reactive surface of many kinds of ions and of mechanically severed bonds, and the reactions take place under high temperatures and pressures.

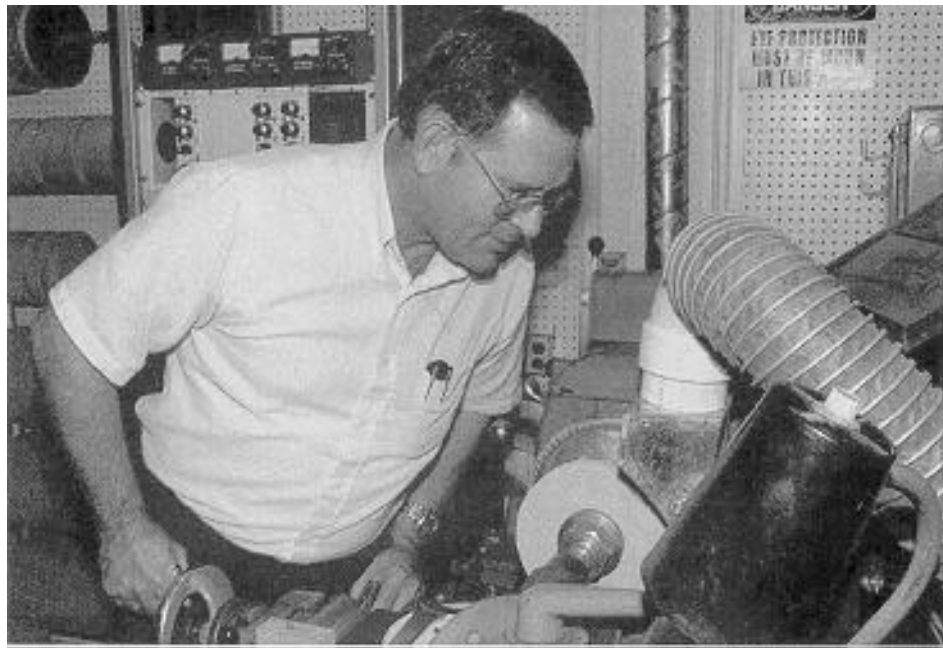
"Wood-a three-dimensional, polymeric composite-is a relatively good thermal or heat insulator," notes Stewart. Dry wood or MDF has low thermal conductivity. The workpiece or chip cannot carry heat away from the cutting zone during machining. Thus, most of the heat generated in machining goes into the tool-and we're finding that this heat is greater than previously thought. High temperatures, high pressures and chemical components of a wood workpiece create an adverse situation for cutting tools."

Research to Reduce Tool Wear

Research to find the causes of tool wear and ways of reducing it is going on at MFPL and at some other locations. Previous work at the U.S. Department of Agriculture Forest Sciences Laboratory, Carbondale, IL, by Harold Stewart and his cooperators has shown that high-temperature corrosion/oxidation is a major factor in the wearing of tungsten carbide tools when cutting MDF. Stewart reports this work resulted in development of the world's first solid ceramic router bit and new carbides with alloyed binders for machining wood and wood products.

"These new tools are being used virtually around the world in forest products and woodworking industries," he says. "They are used-but could be more widely used-in Mississippi."

Stewart explains that high-temperature corrosion is associated with extraordinary reactions that cause a salt deposit to form on a metal or metal oxide surface during combustion or burning of fossil fuels. The rate of hot corrosion depends on many variables: kind of material being cut,



Senior Research Assistant Harold A. "Sandy" Stewart carries out tool-wear tests and observes performances of different tool materials. Here he is machining medium density fiberboard.

microstructure, composition of the salt deposit, atmosphere, temperature, extent of thermal cycling (alternate cooling and heating) salt or scale thickness, shape of the workpiece, and erosive conditions.

Tool surfaces were examined for high-temperature corrosion with the scanning electron microscope. Elemental analysis by Auger microscopy was also performed. Stewart says, "Cutting a reconstituted wood product such as MDF with a tungsten carbide tool seems to provide the conditions for a high degree of high temperature corrosion/oxidation."

He adds, "Increasing water vapor could speed high temperature corrosion. So, decreasing water vapor or otherwise changing the environment at the cutting zone in almost any way could reduce tool wear."

Summing up, he says, "Our studies imply that high-temperature corrosion (often simply called hot corrosion) causes as much wear to tungsten carbide tools as does a combination of the mechanisms mentioned,"

Cutting tests with tool materials "singing ion implantation, boriding, alloying the cobalt binder of tungsten carbide with elements such as boron, titanium nitride coatings, new ceramics, and polycrystalline diamond have been undertaken. Some of these methods could greatly reduce tool wear from cutting MDF.

Tests are not complete, but re-

searchers believe their results may also be applicable when machining other materials and when using other wood-machining processes. They feel adhesives, catalysts, pigments, finishes and other materials that are added to wood products affect tool wear.

"For example," Stewart reports, "chloride and sulphate salts are common adhesive catalysts. These could increase tool wear by causing chemical reactions. Thus, changes in chemical additives to reduce formaldehyde emissions or for other reasons which could also affect tool wear should be considered."

New Tool Materials

A significant way to reduce tool wear is to select tool materials or tool treatments that are chemically inert at high temperatures, and/or those capable of conducting heat away from the cutting zone.

One such tool material, according to Stewart, was described in the article "Tough New Carbide Shows Its Mettle" in *Wood & Wood Products*, July 1988. The material is a new grade of carbide which is said to outlast other grades of carbide on the market. The product, Dyanite, (from DML, Inc.) was reported to greatly lengthen the life of saw blades, router bits and molder/shapers.

Ernie Buechlein of DML reported, "We tested Dyanite in numerous field applications-cutting particleboard,

hardwoods,, green oak and copper- and each time Dyanite outperformed other blades by a surprising margin.

“Used to cut 45-pound, double- and single-sided, vinyl laminated particleboard in independent field tests, saw blades with Dyanite cut more than twice as many board feet as any standard carbide blade, including C-4 tungsten carbide,”

Buechlein added that blade life was increased by more than 100 percent. Other tests have shown that tools with Dyanite had an extended cutting life of 20 to 30 percent on hard aggregate and 1,100 percent on green oak.

DML engineers labeled the substance a tough carbide material that is very resistant to acids and is capable of withstanding great wear for a long time.

“Another example of the new generation of tools is the solid ceramic router bit,” Stewart reported. Mark O’Brien, director of research and development at Onsrud Cutter, confirmed that ceramic material was a good material for manufacture of router bits. Tool life was said to be three to ten times as long as for older tool types, at a cost between that for carbide and that for diamond.

Onsrud’s Cool-rout ceramic bit operates at a recommended spindle speed of 18,000 to 25,000 rpm with a feed rate of 200 to 500 inches per minute (ipm). According to a company representative, the ceramic bit is suitable for wood or plastic composites and hardwoods, but the material is brittle and must be used in a fixed-not hand-held-router, with runout no greater than 0.001-inch.

Both the solid ceramic router bit and Dyanite have won Challengers awards within the past 4 years. The awards are the industry’s most prestigious and are awarded at the Atlanta International Woodworking Fair for innovative technology for woodworking.

Future Research

The MFPL is continuing its research in tool wear and the development of tool materials for the forest products and woodworking industries. Researchers are helping companies develop wood composites, adhesives, and tool materials that will reduce tool wear, which will in return reduce wood processing costs.

“As a spin-off, this research is also providing the basis for improving tool wear in the machining of aerospace

composites, plastics and non-ferrous metals, as well as wood,” says Stewart. “In future research, we’ll try to determine other factors affecting tool wear. That will help us in further development of tool materials or machining methods for the future.”

One of the new ceramic composite router bits. It has a silicon carbide “whisker” (for strength and heat distribution) in a powder-aluminoxide matrix. The tool is based on Stewart’s earlier work.



Advances in tool-wear reduction research at Mississippi Forest Products Laboratory and elsewhere have been reported in many refereed journals and trade publications.