Wood Fiber-Plastic Composites: Machining and Surface Quality

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ABSTRACT

Advances in plastic technologies allow use of wood fiber as an inexpensive filler material for recycled plastics, such as bottles and PVC-siding. These mixtures are used for products like decking, mouldings and rails. The quantities produced and the range of applications will significantly increase in the years to come.

For this reason, a better understanding of the properties of such materials in regard to machining and surface quality is necessary. This publication presents results obtained from ongoing research at North Carolina State University about the characterization of wood fiber-plastic composites used in secondary manufacturing applications. Focus is given to commercially available wood-plastic composite decking materials. Results from sanding, and tool wear testing were obtained.

Woodfiber plastic composites materials wear carbide tools more than solid wood does. Some products wear the tool up to six times as much compared to white pine. Also, large differences in material removal rates when sanding were detected. The largest difference between products, however, was detected when sanding belt life was compared. Some products caused a three times shorter belt life than did others.

INTRODUCTION

Pressure treated wood (mostly chromate copper arsenate [CCA] treated pine), the traditional outdoor-building product for a wide range of applications, is facing growing dissatisfaction among users for reasons ranging from health and environmental, as well as product properties related issues. These perceived or real negative attributes fuel an increased interest in alternative materials. Recently, a variety of new products to replace pressure treated decking materials surfaced on the market. Decking materials do not require high structural properties and are therefore easier to replace with other materials that are cost-competitive.

Plastics and plastic-based composites are at the center of the search for alternative decking materials. Plastic's abundance, ease of processing, and ability to mix with a wide variety of fillers along with a reasonable price make it a well suited material to replace pressure treated decking material. In addition, plastic-based replacement products are claimed to withstand temperature and moisture changes, insects and fungi attacks, and not to crack or splinter (8, 11). Powell (10) identified five general product categories for plastic lumber: (a) mixed plastic lumber (mainly polyethylene and polypropylene), (b) HDPE lumber (high density polyethylene), (c) glass-reinforced lumber, (d) rubber-plastic lumber, and (e) wood-filled lumber. Wood as a filler for plastic-based materials offers several advantages, such as: (a) low costs, (b) increased mechanical properties, (c) decreased thermal expansion, and (d) easy availability. However,

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problems with wood-based fillers are, among others, the compatibility between plastics and wood and questions regarding the ability of natural organisms to attack the embedded wood fibers.

Smith (13) estimates that woodfiber-plastic composites currently have an eight percent market share of the decking market, which translates into an estimated $65 million business in the US alone. With an increase in demand for such decking products and a widening of the product range produced using woodfiber-plastic composites, market growth for the material is expected to be significant over the years to come. Eckert (3) predicts an annual growth for woodfiber-plastic based products for buildings of 60 percent per year until at least 2005, a forecast supported by other market researchers (9). Similar growth is expected for other product groups, such as transportation, infrastructure, or industrial/consumer (9, 3).

With the increased penetration of woodfiber-plastic based materials into applications for a wide range of products, there will also be an increased need for secondary processing of such materials. Although these products can be shaped according to specifications during the initial production processes, a variety of reasons will require secondary processing. Examples for such processes could be the need for creating openings in solid surfaces, to change profiles on an existing edge of a piece, or to achieve a smoother surface for certain applications. However, very little knowledge as to the properties of woodfiber-plastic composite materials subjected to secondary processing exists so far.

This study was conducted to obtain first indications of these new materials secondary processing properties. Five commercial woodfiber-plastic decking materials were subjected to tool wear and sanding tests at North Carolina State University's Wood Machining and Tooling Research Program. This publication presents the results from these tests and offers suggestions for future research projects. Since the research was conducted in two separate projects, one being the assessment of tool wear and the other one being sanding of woodfiber-plastic composites, this paper contains two separate sections, TOOL WEAR ASSESSMENT and SANDING PROPERTIES ASSESSMENT, followed by a brief GENERAL DISCUSSION AND CONCLUSIONS section.

TOOL WEAR ASSESSMENT

Introduction

Wear is the process which renders usable tools unfit for ongoing use (7). Progressive wear not only leads to increased processing costs through increased power consumption, increased feed force requirements, and a deterioration of the resulting surface quality (12), but also through interruption of the production process and the required sharpening of the tool. For these reasons, a producer of materials subjected to secondary manufacturing processes, such as cutting, must try to minimize tool wear as much as possible.

This research used routing of standard length pieces as a way to assess tool wear of five commercially available woodfiber-plastic composite materials. For this purpose, North Carolina State University's Wood Machining and Tooling Program (WMTPR) standard tool wear testing methodology was employed (12).

Experimental

Measurements and Analysis: Blade wear was determined by measuring the nose width (NW) of the blades used as described in (12). Figure 1 displays details about this measurement. After a new blade was measured, wear was tracked after 31, 63, 94, and 125 feet of cutting through the material. Wear was measured at four positions along the working knife edge, the first being at the corner, then at 500, 1000, 1500, and 2000 μm from the edge that worked in the material. The Excel product, due to its hollow core, was measured at slightly different positions. The results reported are the average values from the four measurements taken every time. In addition, the surface roughness of the materials after 125 feet of cutting at three different locations on the surface cut was also measured. In particular the locations chosen were: across the cut (i.e. perpendicular to the tool movement), and lengthwise at the border and the center of the material. Three randomly placed measurements for each location were taken, and the average of these individual measurements are reported here.

Materials: For the knife wear experiments, five different, commercially available woodfiber-plastic composites for decking were used including: CHOICEDEK [producer: A.E.R.T. Inc., Springdale, AR], EXCEL decking [supplier: Cox Industries, Inc., Orangeburg, SC], FIBERON [producer: Fiber Composites Corporation, New London, NC],, SMARTDECK [producer: U.S. Plastic Lumber, Boca Raton, FL], and TREX [producer: Trex Company, Winchester, VA]. The decking material was purchased from local lumberyards and cut into two 23.5 inches long pieces.

All cuts were longitudinal along one edge and the knife cut about through two thirds of the material thickness. After 16 passes on one edge (16 passes equal 31.3 feet of cutting), the material was turned and the other edge was used for the second set of cuts. The third and fourth set of cuts (4 sets total, for a total cutting length of 125.3 feet), were done the same way on the second specimen from the same material. For control purposes, a piece of white pine (Pinus strobus) was also tested.

Blades: Exchangeable tungsten carbide knives were used for these tests. The grade was a standard 3% cobalt binder with an ultra-fine carbide grain (0.5-0.9 μm). The cutting edge of each one was checked prior to cutting and those with a NW of more than 10 microns were rejected. The blades were mounted on a single insert tool holder by Leitz and then mounted on a hydro chuck by ETP. Figure 2 shows the blade and the tool holder.

Router: A Thermwood model 40 turret router with a 9 hp spindle was used for these tests. The test specimens were clamped into a special fixture. Prior to cutting with the test knives, a cut with a minimum of 1/16 of an inch depth was made along the outside of the specimen to remove potential contaminants. Table 1 shows more details of the test set-up.

Microscope: A Keyence video optical microscope with digital picture capturing and measuring capabilities was used for measurement of the nose width.

Profilometer: We used a stylus-type instrument manufactured by Mitutoyo. This instrument is widely used and is a generally accepted method of surface roughness measurement providing numerical values in agreement with current standards (1). The Root Mean Square Roughness (Rq), which we used to quantify surface roughness, is measured as the root mean square of the profile height deviations taken within the evaluation length and measured from the mean line (15). Withehouse (15) explains the concept of surface roughness measurements in more detail.

Procedure: The procedure for the tool wear tests consisted of: {1} identify the test specimen, {2} fix specimen into specimen holder of router and fix the blade for the first cut into the blade holder, {3} reset the router program to zero position, {4} do first cut to clean the edge, then stop the router, {5} exchange blade with the appropriate one from the test series, {6} let the router do 16 passes on the edge of the specimen in the clamp, {7} remove blade and measure NW, change test specimen according to experimental plan then go to {1} until all tests are done.

Results

Tool wear as measured by NW differed widely among the materials tested. ChoiceDek was the product that wore the knife most heavily, achieving a NW of 65 µm after 125 feet of cutting. Fiberon, on the other hand, was the composite material that wore the knife the least with an average NW of 25 µm after 125 feet of cutting. The Excel, Smartdeck, and Trex products had NW of 31.5, 37.0, and 25.4 µm, respectively. This was less NW than measured for ChoiceDek, but more than measured for Fiberon. However, all the woodfiber plastic materials did wear the knife more than the control sample (white pine), whose NW was 10 µm after 125 feet of cutting. Table 2 displays the results from the knife wear tests performed.

Differences were also found between the variability of wear along the same knife's nose. Here again, after 125 feet of cutting, ChoiceDek had a standard deviation higher than 10 µm, whereas all the other materials' variability was clearly below 10 µm. The NW for ChoiceDek at edge of the knife, i.e. at 0 µm, and at 500, 1,000, 1,500, and 2,000 µm were 50, 58, 85, 70, and 65 µm, respectively, after 125 feet of cutting. The NW of the control specimen, i.e. the white pine sample, showed almost no variability in wear along the entire nose length used to cut the material.

Surface roughness showed less variability among the five specimens. Roughness across the surface cut (i.e. perpendicular to the cutting direction) after 125 feet of cutting, ranged from 139 µin. for the Fiberon material to 308 µin. for the ChoiceDek material. Variability as measured by the standard deviation ranged from 59 µin for ChoiceDek to 4 µin for Fiberon. The roughness across the surface could not be determined for the Excel product due to its hollow core. Table 3 shows all the individual measurements across the cutting surface for the different materials. Also shown in Table 3 are the measurements lengthwise, at the border of the piece and at the center. Fiberon, with a roughness of 90 µin. at the border and 60 µin. at the center, again had the smoothest surface. Fiberon is followed by Excel at the border (103 µin.), but no measurement for Excel at the center could be taken due to the hollow core of this material. Trex was the next smoothest material, with 187 µin. and 198 µin at the border and the center, respectively. The roughness of the surface of the control sample was 188 µin, 99 µin, and 88 µin perpendicular, and lengthwise at the border and at the center, respectively.

Discussion

Large differences were noted among the five woodfiber plastic composites tested in terms of knife wear. The white pine specimen we tested showed by far the least impact on knife sharpness of all materials used in this study. In fact, when cutting 125 feet of white pine, the NW of the knife, on average of the five points measured, increased only slightly from 9.0 µm to 10.4 µm (Table 2). The next benign materials, Fiberon and Trex, dulled the knife's cutting edge (NW) from 5 and 8 µm to 25.0 and 25.4 µm, respectively. The Excel and the Smartdeck material dulled the knife's nose somewhat more than Fiberon and Trex (average NWs for Excel and Smartdeck after 125 feet of cutting were found to be 31.5 and 37.0 µm, respectively). However, it was the ChoiceDek material that had the biggest impact on the knife. ChoiceDek wore the cutting edge (NW) of the blade from 7.0 µm prior to cutting (Figure 3) to 40.0 µm after just 31.3 feet of cutting and to 65.6 µm after 125 feet (Figure 4). This blade, although not entirely dull, would no longer be able to achieve the quality surface required in some applications. For comparison, Figure 5 shows the knife used to cut the white pine material after 125 feet of cutting.

Several reasons may be involved in making woodfiber plastic materials more abrasive to knives than solid wood. One is the issue of impurities. Since all of these products are made from recycled wood and most of them are made using recycled plastic (mainly HDPE), contamination of these materials cannot be completely prevented. Contamination could explain a part of the difference between, for example, the wear observed with the ChoiceDek (NW after 125 feet of cutting 65.6 μm) and the Fiberon (NW 25.0 μm) material. To our knowledge, ChoiceDek uses post-consumer recycled plastic, whereas Fiberon is made from virgin HDPE. However, this would still leave the difference in wear between, for example, ChoiceDek and Trex (NW 25.4 μm), both of which are made from recycled, post-consumer plastic. Also, contamination does not explain the differences in wear observed between the woodfiber plastic materials and solid wood. The smallest difference observed between these two materials was with the Fiberon material. Still, Fiberon's NW was with 25.0 μm more than double the one measured for white pine (NW 10.4 μm) after 125 feet of cutting. One explanation for this phenomenon could be that the pigments used to color the composite material, which are often made from minerals, have a negative effect on knife sharpness. Other reasons such as, for example, cutting speed, knife material composition, or the appropriate rake angle, could also play an important role.

The surface roughness of the woodfiber plastic composite materials was lower or similar to the one of the solid wood control sample (white pine). Fiberon had, with Rqs of 139, 90, and 60 μin. across the surface, and lengthwise at the border and in the center, respectively, the smoothest surface of all specimens tested (Table 3). ChoiceDek, on the other hand, had, with the exception of lengthwise in the center, the roughest surface with Rqs of 308, 153, and 209 μin. across the surface, and lengthwise at the border and in the center. Smartdeck, whose surface roughness in the center was larger than the one for ChoiceDek, had values of 275, 193, and 251 μin. for the same measurement points. In comparison, the control sample's (white pine) values for the same measurements were 188, 99, and 88 μin. This data shows that woodfiber plastic composite surfaces, although rougher than the ones of properly cut solid wood, seem to be rather smooth after cutting. The high roughness values of ChoiceDek are no surprise, given the higher wear that this material causes on the tool. Besides the size and immersion of the wood particles mixed with the plastic, a potential reason for the rougher surface of the composites could be the moisture content uptake of the woodfibers freshly cut by the knife. Since these fibers are dried below the ambient equilibrium moisture content prior to being encapsulated in the plastic, it would appear that these fibers, when again coming into contact with the environment, would take up moisture and thus swell. This, of course, would lead to a rougher surface.

Conclusions

There are differences in respect to tool wear and surface roughness between the five different woodfiber plastic products tested. Differences also exist when these materials are compared to solid wood. Knife wear was smallest when cutting the solid wood (white pine) control sample. Of the five composite products, Fiberon was the one wearing the knife the least, whereas ChoiceDek wore the knife the most. Reasons for these differences could be possible contaminants contained in some of the woodfiber plastic composites and the pigments used for coloring. However, specific analyses of these observations have yet to be conducted.

Surface roughness after cutting of the woodfiber plastic composite materials is more similar to solid wood than was the tool wear. In fact, some of the materials tested had a smoother

surface after cutting than did the wood control sample (white pine). Others, especially the ones that wore the knife heavily, had slightly rougher surfaces than the control sample. Potentially, the moisture uptake of the woodfibers in the composite materials could lead to a rougher surface after cutting due to swelling. However, no investigation into this theory was conducted.
Further research is needed to substantiate these findings and to explain the phenomena observed. Also, without a doubt, a better understanding of the necessary process parameters to cut these materials will lead to improved results with respect to tool wear and surface roughness.

SANDING PROPERTIES ASSESSMENT

Introduction

In the wood products industries, sanding is used to create smooth surfaces for semi-finished or finished products by means of coated abrasives using either hand or machine operations (5). The abrasive action of the edges of the abrasive grain leads to a smooth, regular surface (2). Since the quality of the sanding operation is readily visible on the finished product and little or no opportunity exists to improve the quality of the surface after sanding, sanding is correctly considered as a crucial operation for the quality of a product.

Carrano (2) classified sanding into [1] "*white sanding*", which refers to all sanding operations that are done on the original material, prior to applying any finishing; and [2] "*finish sanding*", which refers to all sanding operations used to improve the quality and performance of the finishing materials applied.

The goal of this research was to describe the characteristics and behavior of four different woodfiber-plastic composite materials during sanding. A series of tests was undertaken to measure the material removal rate, the roughness of the sanded surface of the test specimens and the life of the sanding belts employed.

Experimental

Measurements and Analysis: Three variables were selected to be measured, material removal rate (MRR in lb/min), material surface roughness (μin), and belt life (min). The material removal rate was determined by weighing the woodfiber-plastic piece before and after each machining cycle. A machining cycle is defined as the time a piece is subjected to the machining process between two weight measurements. For this sanding study, a machining cycle was set at one minute. The surface roughness was measured by using a stylus-type profilometer. The belt life was determined by repeating the sanding process until the weight difference before and after a machining cycle was no greater than 0.002 pounds for at least 3 consecutive measurements. Two repetitions of the tests were performed. The average of these two repetitions is stated here. Further replications and statistical analysis will be done in the future.

Materials: For the sanding experiments, four different, commercially available woodfiber-plastic composites for decking were used. These are the same products as described in the tool wear section of this publication, namely: ChoiceDek, Fiberon, Smartdeck, and Trex. The fifth product, Excel, described in the tool wear section could not be tested for sanding due to this product's hollow core. For comparison, hard maple (Acer saccharum) was sanded and analyzed identically to the woodfiber-plastic samples. The hard maple was sanded parallel to the grain, i.e. along the longitudinal axis of the sample. In fact, all samples were sanded along the longitudinal axis, i.e. the woodfiber-plastic samples were sanded along the longitudinal axis they were extruded. The material was stored in ambient conditions prior to use.

Interface Pressure: Interface pressure greatly influences the material removal rate, surface roughness, and the belt life. Work by Franz and Patronsky (4) and Hinken (6) used pressures of 0.40, 0.80, 1.20, and 1.60 psi. Stewart, in 1978 (14) used pressures of 0.50, 0.75 and 1.00 psi for his research, whereas Carrano (2) found that 0.50 and 0.75 psi were the two levels appropriate for measuring the outputs desired. For this research, a pressure of 0.50 psi was selected, mainly to avoid possible melting of plastic during the sanding process. The pressure was applied by means of a weight on top of the flat test specimen such that the resulting pressure of the specimen on the belt was equal to 0.50 psi. Figure 6 illustrates this set-up.

Abrasive Mineral: Different kinds of abrasives are currently used in the industry. The major ones are aluminum oxide and silicon carbide. For this study, aluminum oxide, as it is the most commonly used abrasive in the industry, was employed.

Grit Size: We selected a grit size of P100, based on experiences with wood. This decision is supported by Carrano's experimental design (2), which also employed grit size P100.

Sanding Belt: 3M delivered standard 6"x48" aluminum oxide, closed coat, cloth backing sanding belts. The belts were stored in an environmentally controlled room prior to use.

Belt Sander: A grinder-belt sander made by Grizzly, with an abrasive belt of 6"x48" and a speed of 2500 surface feed per minute (s.f.p.m), was used. The sander can be seen in Figure 6.

Profilometer: The same Mitutoyo profilometer used for the tool wear experiments was used to assess the surface quality of the tool wear samples. As for the sanding experiments, Rq was used as the measure for surface roughness. Rq is explained in more detail in the Experimental section for tool wear assessment above.

Procedure: A test procedure was developed to assure consistency. The procedure consisted of {1} identify the test piece, {2} change sanding belt and adjust belt on sander, {3} weigh test specimen and record weight, {4} fix test specimen to pressure weight, {5} sand for one minute, {6} remove dust from specimen, measure specimen weight and record it, {7} repeat {3} to {6} until weight loss of three subsequent measurements is less than 0.002 lb. If weight loss is less than 0.002 lb for three consecutive tests, measure surface roughness three times at random places perpendicular to the sanding direction.

Results

Contrary to what was expected, these four products did not all perform similarly, but reacted individually to the sanding. The material removal rate (MRR) ranged from 0.005 lb/min on average of all intervals for the Smartdeck product to 0.012 lb/min for the ChoiceDek product. Maximum removal rate was 0.030 lb/min for the ChoiceDek product, whereas the maximum material removal rate for our control sample, the hard maple specimen, was only 0.010 lb/min. The material removal rate of the various specimens for each interval is depicted in Figure 7. Table 4 presents the individual results.

More similar results could be observed for the roughness perpendicular to the sanding direction. Smartdeck had the smoothest surface (508 μin), which was almost as smooth as the surface of the control specimen, maple (503 μin). Fiberon had, with 531 μin, the roughest surface. These results are displayed in Table 4.

Belt life varied widely. The Trex material achieved a belt lifetime of only 31 minutes whereas the Fiberon product lasted 150 minutes under the exact same circumstances. The lifetime of the belt for the hard maple control specimen was 54 minutes.

Discussion

Sanding is one of the most widely employed processes in the industry. Sanding determines the quality of the finished piece and thus has a large impact on the perceived quality of the product. Both material removal rate and surface roughness are the two main parameters to characterize the quality of the process. Belt life, on the other hand, determines the economics of using a particular product for a specific application.

It was found that the density of the individual products correlated with the material removal rates (MRR) measured to some extent. Since the density varied widely, MRR varied, too. However, further research is needed to more specifically quantify this observation. The high variability in MRR for the same material throughout a single test (as can be seen in Figure 7), may also be explained by the varying density profiles throughout the material.

Surface roughness measurements differed less than the MRR or the belt life among products. However, there were measurable differences for the different products. Fiberon, with a roughness of 531 μin had the roughest surface of any of the products tested. This is despite the fact that this product appears to be made with smooth, consistent material and uses very fine ground wood particles. Also, it must be emphasized, that the differences measured were not readily apparent to the eye or touch of a person.

The difference in belt life was large. The performance of the Fiberon product was three to four times better than all the other specimens tested, including the hard maple specimen. Very likely, the explanation for this observation will be found in the material composition of the different products. As it appears visually, Fiberon is a very fine, smooth product with few impurities.

As the sanding study showed, there are differences in regard to sanding between the four woodfiber-plastic products tested. As these products become more widely used, these differences will become more important in the selection process for users. Also, the industry that is working in the area of sanding will start looking into better, more efficient ways to achieve high quality sanded surfaces using these new composites. Of particular concern to any of them should be the problem of heat generation and dissipation during sanding in order to avoid changing the profiles and surfaces of the materials sanded.

Conclusions

Four commercially available decking woodfiber-plastic composite products were subjected to a controlled sanding experiment. The study showed that there are detectable differences among these materials in a variety of characteristics. ChoiceDek's material removal rate (MRR) was more than twice as high as the one found for Smartdeck, with Fiberon and Trex being in between. However, the roughness of the Fiberon product after sanding was higher, although only slightly, than the one of the Trex and the ChoiceDek. Belt life varied the most among products, with Fiberon achieving a belt lifetime of three to four times as long as the other products, including the maple control specimen.

GENERAL DISCUSSION AND CONCLUSIONS

This preliminary study into the material properties of woodfiber plastic composites when exposed to secondary manufacturing processes exposed differences between solid wood and the composite materials. Tool wear after cutting 125 linear feet was drastically different among the products tested. None of the composite materials wore the knife as little as did the solid wood control sample. One of the woodfiber plastic composites did wear the knife almost twice as much as did the other samples. Surface roughness after cutting varied somewhat, also. This was not surprising when the wear of the knives was so different as observed. Surface roughness after sanding was similar for all specimens including the wood control sample, though the material removal rate (MRR) and the sanding belt life were very different.

Further research efforts into the phenomena observed in this study are necessary. First, the findings made have to be substantiated with more repetitions. Then, hypotheses for specific observations have to be made and tested.

Only by gaining a better understanding of these new materials and their respective behavior when subjected to secondary manufacturing processes can these products be made a competitive alternative for various applications. There is no question that woodfiber plastic composite offers a viable alternative for various applications in the area of secondary forest products. The research efforts at North Carolina State University will help industry to overcome the obstacles in implementing these materials and open new, more competitive alternatives for a wide variety of products.

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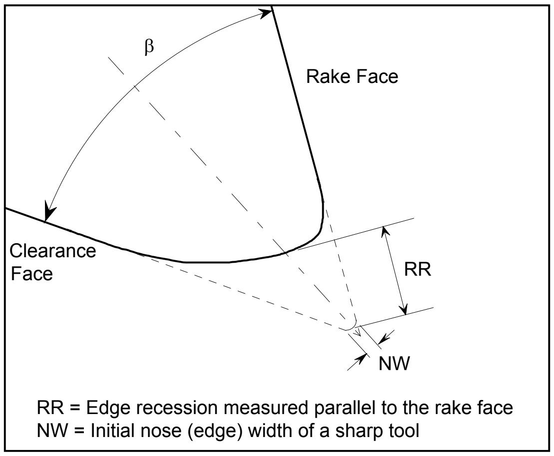

Figure 1. – Determining knife wear by measuring the nose width (NW) after each test cycle.

Figure 2. – Carbide insert and tool holder

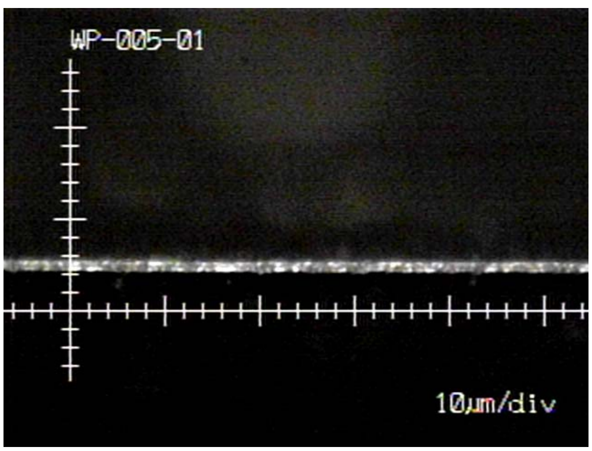

Figure 3. – Blade used to cut ChoiceDek material prior to cutting.

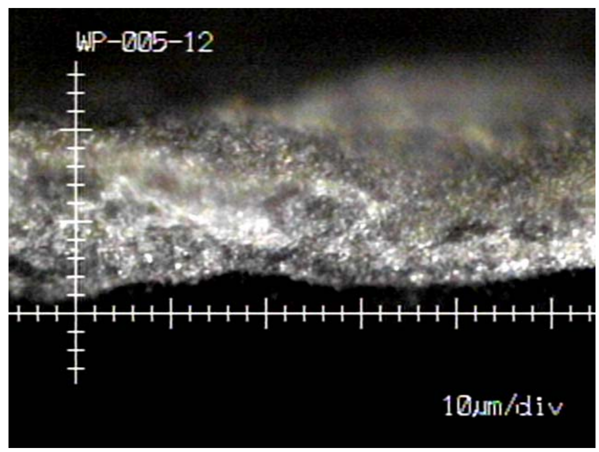

Figure 4. – Blade used to cut ChoiceDek material after 125 feet of cutting.

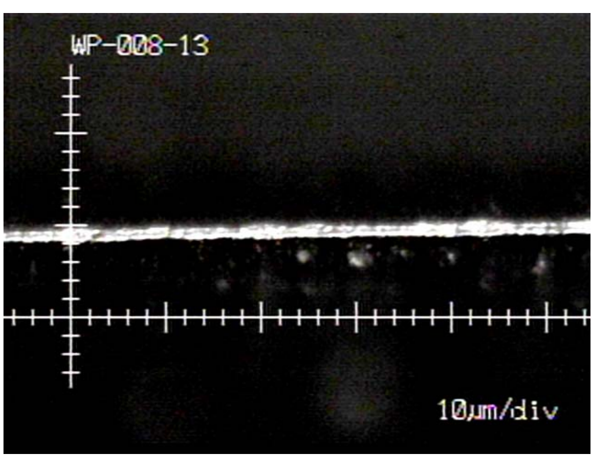

Figure 5. – Blade used to cut with pine after 125 feet of cutting.

Figure 6. – Belt sander with specimen and weight.

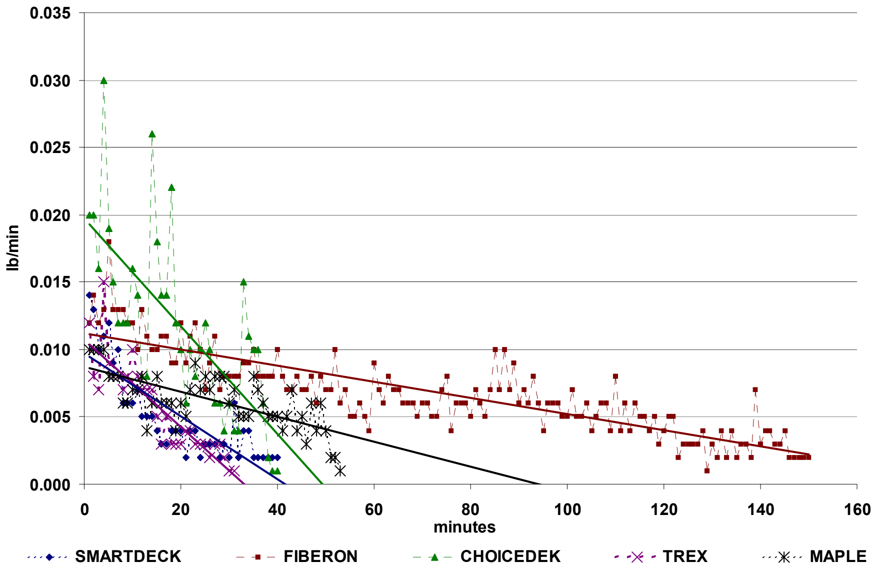

Figure 7. – Material removal rates (lb/min) for various specimens against time. The trendlines are calculated using least square regression.

TABLE 1. – Summary of test parameters for the tool-wear measurements.

Parameter	Setting
Spindle speed	18,000 rpm
Feed Speed	350 ipm
Depth of cut	1/16 inches/pass
Blade carbide grade	Sandvik H3F
Length of cut	23.5 inches/pass
Cuts per test	16
Number of tests	4
Mode of cut	Conventional

TABLE 2. – Average NW and standard deviations for all six materials tested at 0, 31, 63, 94, and 125 feet cutting length.

Material	Measure-ment	NW (µm) and standard deviation after				
		0 feet	31 feet	63 feet	94 feet	125 feet
CHOICEDEK	µm	7.0	40.0	53.0	57.0	65.6
	std. dev.	N/A	12.7	13.5	11.5	13.2
EXCEL	µm	9.0	18.3	20.3	23.4	31.5
	std. dev.	N/A	2.2	0.7	3.2	2.3
FIBERON	µm	5.0	N/A	18.0	22.0	25.0
	std. dev.	N/A	N/A	N/A	N/A	3.5
SMARTDECK	µm	7.0	14.6	21.4	27.4	37.0
	std. dev.	N/A	5.1	2.2	3.7	4.5
TREX	µm	8.0	15.4	20.0	22.0	25.4
	std. dev.	N/A	5.8	1.4	2.1	3.6
WHITE PINE	µm	9.0	10.0	10.0	10.4	10.4
	std. dev.	N/A	0.0	0.0	0.5	0.5

TABLE 3. – Average surface roughness (Rq) and standard deviation for all six materials tested after 125 feet of cutting.

Material	Measu-rement	Roughness perpendicular Rq	Roughness border lengthwise Rq	Roughness center lengthwise Rq
CHOICEDEK	µin	308	153	209
	std. dev.	59	20	63
EXCEL	µin	NA	103	NA
	std. dev.	NA	22	NA
FIBERON	µin	139	90	60
	std. dev.	4	23	9
SMARTDECK	µin	275	193	251
	std. dev.	24	32	26
TREX	µin	276	187	198
	std. dev.	30	27	22
WHITE PINE	µin	188	99	88
	std. dev.	39	13	11

TABLE 4. – Average MRR, average roughness, and belt life obtained from the sanding tests.

Material	Measu-rement	MRR lb/min	Roughness µin	Belt Life min
CHOICEDEK	value	0.012	526	40
	std. dev.	0.0065	15	NA
FIBERON	value	0.010	531	150
	std. dev.	0.0031	39	NA
SMARTDECK	value	0.005	508	40
	std. dev.	0.0033	13	NA
TREX	value	0.006	529	31
	std. dev.	0.0033	20	NA
MAPLE	value	0.006	503	54
	std. dev.	0.0020	24	NA