SANDING PROPERTIES OF SEVEN LESSER-USED TIMBER SPECIES IN GHANA

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ABSTRACT

Sanding qualities of seven lesser-used timber species and two primary species used as control were investigated at 12% and 20% moisture contents using four grit sizes of sandpaper on two machine sanders. The species were extracted from three ecological zones of Ghana. Samples were prepared in accordance with American Society for Testing and Materials Standards (ASTM) D143-94 (2007) and ASTM D1666-87 (2004). The results of the chipping tendencies showed that the belt sanding machine with both grit sizes 60 and 80 performed better than the drum sander for all the species. Sandpaper of grit size 60 recorded higher percentages of defect-free samples, ranging between 74% and 95%, for the species investigated than sandpaper of grit size 80 which ranged between 33% and 68%. The surface quality of the chipped grain samples that were sanded at 20% moisture content to eliminate the chipped/torn defect was better than at 12%. The results of tests on fuzzing and scratching tendencies indicated that the performance of the belt sander was better than the drum sander. Higher percentages of fuzzy-free samples were obtained at 12% moisture content with grit sizes 100 and 120 but lower percentages of scratch-free samples were recorded at 20% moisture content. Also, sandpaper with grit size 100 had more pronounced fuzzy and scratchy defects on the wood species than with grit size 120. Generally, the texture and the density of the species had influence on their sanding qualities. On average, the sanding qualities of the medium and high density species of each of the lesser-used timber species studied were comparable to ***Milicia excelsa*** *while* ***Rhodognaphalon brevicuspe*** *(low density species) was also comparable to* ***Triplochiton scleroxylon****.*

Keywords: ***Chipping, fuzzing, grit size, sanding qualities, scratching tendencies***

INTRODUCTION

Ghana's tropical forest is characterized by a rich and complex floristic composition. According to Hall and Swaine (1981), there are over 2,100 plant species of which 730 are tree species. Hawthorne (1989) has reported that 420 out of the 730 species are common and of wide distribution. According to Agyemang *et al* (2003), currently only about 7% of species in the tropical forests of Ghana are being exploited. They added that over 70% of timber exported in 1990 was from only two species. The dependence of the Ghanaian timber industry on a few species has resulted in the "creaming" of the primary species of which some have been classified as scarlet star species (Appiah *et al*., 1998). These scarlet star species comprise the main traditional commercial timbers now under threat of economic extinction, where the

rate of cut is greater than 200% of the sustainable level of cut. This has led
to a reduction in the raw material base and an increase in the cost of sawmilling operations.

To increase the resource base of the timber industry, Ghana has adopted a strategy of promoting and marketing lesser-used timber species (LUS) as substitutes for its primary species, which is based on similarity of characteristics and end-use categorization. This is because a vast number of lesser-used (but potentially useful) timber species are available in Ghana's forests. These lesser-used timber species are wood species which show promising market potential and thus are potentially of high value. The introduction of more LUS on the market will expand the resource base and make a lot more raw material available to the timber industry thereby taking some of the pressure off the few primary species and keeping the timber industry in business. However, since technical information on the LUS to facilitate their promotion is not available, they are described as low quality timber. If the LUS can be classified based on their properties and end-uses, and the information packaged to attract the end-user, it is possible for some (if not all) of the LUS to be suitable substitutes for the few widely used species. But most of these may have some undesirable characteristics, which have to be overcome through improved processing techniques.

The technical information that needs to be developed on the Ghanaian LUS include their machining properties, which is a critical property of wood species used in the timber industry. Therefore determining the machining properties of the LUS (which includes sanding, will enable wood users to know the processing techniques to be applied and hence patronize them.

Karpat and Özel (2007) have indicated that for manufacturers to remain competitive on both local and international markets, they must increase their productivity while maintaining, if not improving, product quality. In the machining operations, according to Cus and Zuperl (2006) the production rate, cost, and product quality are three incompatible objectives. They added that as the machining industry welcomes the introduction of new materials and cutting tools, it finds itself undergoing rapid development which is giving rise to processes of highly complex and non-linear phenomena.

Surface roughness has been defined by Benardos and Vosniakos, (2003) as the superimposition of deviations from a nominal surface from the third to the sixth order where the orders of deviation are defined by international standards, DIN 4760 (1982). Correa *et al*. (2009) have also defined surface roughness as the functional behavior of a part. Unlike metal, wood, which is a non-homogenous material, has its machined surface consisting of not only the processing irregularities but also the anatomical irregularities such as fuzzy grains and deep valleys (Gurau *et al*., 2007). In view of this, the measured surface roughness values are not the true reflection of the actual processing irregularities, hence giving rise to a misinterpretation of the processing performance (Gurau, 2004). Furthermore, surface roughness of machined wood surface is not consistent in most cases but very much depends on the locations of measurement (Gurau, 2004). Studies have shown that material species is one of the significant factors for wood sanding process (Kilic *et al*., 2006; Taylor *et al*., 1999). In order to evaluate the machining performance and obtain an accurate processing roughness of the machine wood surfaces, deep valleys caused by the vessels and other cellular structures must be removed (Fujiwara *et al*., 2003).

Machining properties relate to the behaviour of wood when planed, sanded, turned, shaped or put through any other standard woodworking operation. Quality and smoothness of all machined wood articles, which will be stained, polished or lacquered depend on the sanding operation.

Sanding, which is one of the most important woodworking operations, is a means of reducing the more or less rough surface of a previously machined workpiece to a relatively smooth and flat surface. This is to prepare a wood surface for subsequent application of finish materials. The preparation of the wood surface helps to decrease the depth of sanding scratches after the general configuration of the part that has been obtained through previous operations and to create a uniform surface into which stains will penetrate as evenly as possible (Davis, 1962).

Sanding is also important in the woodworking industry because it determines the surface adhesion strength of coating films and the final perceived aesthetics of wooden products (Tan *et al*., 2010). Richter *et al*. (1995) have stated that sanded wood surface is characterized by small uniform scratches that are favourable to achieve better stain performance than planed and sawn surfaces. According to Koch (1964) and Kollman and Cote (1968), the smoothness of a sanded surface depends mainly on the size, shape and quality of the particles of grit, the speed of sander and workpiece, type of machine sander, moisture content and the orthogonal cutting. Sanding parallel to the grain provides better surface than across the grain.

It is commonly reported that grit size affects surface roughness, as sandpaper with higher grit size contains finer abrasive and produces finer sanded surface (Carrano *et al*., 2002; Fujiwara *et al*., 2005; Gurau *et al*., 2007; Hendarto *et al*., 2006; Taylor *et al*., 1999). On the other hand, feed speed sometimes shows insignificant effect on certain wood species during sanding operation.

Sandpaper, which is also referred to as glasspaper, is a heavy paper with abrasive material bonded to its surface (Dresdner, 1992; Tan *et al*., 2010). Sandpaper is part of the "coated abrasive" family of abrasive products. It is used to remove small amounts of material from surfaces, either to make them smoother (painting and wood finishing), to remove a layer of material (e.g. old paint), or sometimes to make the surface rougher for gluing. There are many varieties of sandpaper, with variations in the paper or backing, the material used for the grit, grit size, and the bond (Tan *et al*., 2010).

The oldest and best-known coated abrasive is the familiar “sandpaper” in which the mineral is quartz. In industrial woodworking, at least quartz has now been very largely replaced by garnet and aluminium oxide. Aluminium oxide, according to Koch (1964), has a hardness of 9.5 on the Moh scale and a relative density of 3.96. It is available in grit sizes of 16 to 800.

Sanding is the accepted term for the use of coated abrasives in finishing wood, and the machines that do the job are termed “sanders”. There are many types of machine sanders but the most important ones are the drum, belt, disk and spindle of which various kinds of abrasives are used depending upon the type of work to be performed. Any wood can be sanded without visible scratches provided sufficiently fine grit is used.

Drum sanders are generally large and heavy production machines used to sand materials like doors, flatwork, plywood, fibreboard and particle board whose thickness ranges from 0.79-203.2 mm (Koch, 1964). The drum of a sander is a carefully balanced and cylindrical type supported by webs on a central spindle of which the diameter is of the order of 279.4 mm and the usable length may be from a minimum of 76.2 mm to as much as 2,159 mm. Arbor-mounted motors are used to directly drive the drums at a speed range of 1,200 rpm and 1,800 rpm. The drums are rotated against the feed to give an up-milling effect. For a sander with two or more drums, the drums are covered with sandpapers with progressively fine grits.

Belt sanders are used to sand flat-work and straight mouldings. The sanding operation is performed by pressing an endless, abrasive belt against the work piece or vice versa and the sawdust is manually collected into bags. The long belt runs over two pulleys that are mounted individually on a cast-iron column. Between the columns is a long adjustable table that has a sidewise movement at right angles to the belt on the pulleys.

There are three processes of sanding wood to generate quality surfaces. These include sanding with just the hand backing the sandpaper, sanding with a flat block backing the sandpaper and sanding with a vibrator or random-orbit sander (Dresdner, 1992). In wood sanding processes, wide-belt is mostly used especially for sanding flat panel products. The quality of wide-belt sanded surface is a function of variables such as abrasive, grit size, feed speed, pressure, and roller (Tan *et al*., 2010). Therefore understanding of the effects of these variables is imperative in achieving the required surface quality at optimum machining condition. Also Pontes *et al*. (2010) have stated that the most common practice whereby surface quality at optimum machining condition could be achieved is the selection of conservative process parameters.

Sanding with the grain of the wood is most appropriate, because cross-grain sanding can leave permanent and very obvious scratches. Again, using a sanding block exerts even sanding pressure. According to Dresdner (1992) the objective of sanding wood is to remove mill marks, which are caused by woodworking machines, and to remove other flaws such as dents and gouges that may have been introduced in handling. The most efficient method of doing this is to begin sanding with a coarse enough grit of sandpaper to cut through and remove the problems quickly, then sand out the coarse-grit scratches with finer and finer grits until the required smoothness is achieved.

The aim of the study was to determine the appropriate sanding conditions for seven lesser-used timber species, based on their characteristics, for their promotion and efficient utilization.

MATERIALS AND METHODS

Selection of species and sources

Three trees of each of the nine species (seven lesser-used and two control species) were extracted from each of the three selected ecological zones in Ghana. These were Moist Evergreen (Bura river forest reserve), Wet Evergreen (Draw river forest reserve) and Dry Semi-deciduous (Opro forest reserve) forest zones. These forest zones were selected because of their differences in soil and climatic conditions, which may have influence on the characteristics of the wood species.

The selection of the seven lesser-used timber species (LUS), as shown in Table 1 was based mainly on their availability in the forest (high stocking level), diameter sizes and aesthetic value. Again, some of their physical properties had indicated some specific end-use potential, which could compete successfully on the world market. For comparison, two traditional timber species, Odum (Iroko; *Milicia excelsa*) and Wawa (Obeche; *Triplochiton scleroxylon*) were added as control species.

Selection of sample material and sample size

The logs were taken from the butt, middle and top sections of each of the trees felled and were coded according to the species, tree number and source. A bandsaw milling machine was used to process all the logs into lumber at SWISS Lumber Sawmills (in the Western region) and Fabi Timbers Ltd. (in Ashanti region). The flat (live) and quarter sawing methods were used to saw the logs since they are the methods mostly used in Ghana. The lumber pieces obtained at SWISS Lumber were then transported to Fabi Timbers for drying. The lumber from both sawmills were kiln dried to moisture contents of 20% and 10% after which the lumber at 10% moisture content were conditioned at a moisture content of 12%. The lumber at both 12% and 20% were randomly selected, ripped and cross-cut into dimensions of 25 x 100 x 1,000 mm. The selection, preparation, testing and evaluation of the test samples for the study were based on American Society for Testing and Materials Standards (ASTM) D143-94 (2007) and ASTM D1666-87 (2004).

Thirty test samples per species for each sanding operation were prepared. Both faces of each test sample were sanded and evaluated hence a sample size of 60 for each operating condition. A belt and drum (with one cylindrical drum) machine sanders with sandpapers of grit sizes 60, 80, 100 and 120 were used. The width of the sandpapers was 12 cm. These were selected since they are mostly used in small and medium scale enterprises (SMEs) in Ghana for the smoothening of wood surfaces before finishing.

The cylindrical drum of the drum sander was 25 cm in diameter and 60 cm long with a shaft diameter of 14 cm. The length and width of the belt sander used were 293 cm and 100 cm, respectively, while the distance between the two supporting pulleys was 385 cm.

Tests procedure

All the prepared test samples (480 per species) of dimensions 25 x 100 x 1,000 mm were passed through a two-cutter combined surfacing and thicknessing planer of the type 610 x 230 mm "D.A.A." of which both faces (one face at a time) were planed. A 2 mm depth of cut and a spindle speed of 5,200 rpm were used. After planing, the chipped/torn graded samples were sorted out for sanding. The samples, 30 per species at each operating condition, were sanded on both faces (hence 60 samples) by a one-drum sander using the coarser grits 60 and 80 (of the aluminium oxide type) independently to eliminate the chipped/torn grain defects at the two moisture contents. These operational conditions were repeated with another set of defective samples using a belt sanding machine. The non-chipped graded samples at 12% and 20% moisture contents were also sanded with grits 100 and 120 in the machine sanders to observe the fuzzing and scratching tendencies. The speeds for the drum and belt sanders were 1,500 rpm and 1,750 rpm respectively.

Table 1: The selected lesser-used species studied

Botanical name	Standard trade name	Local Ghanaian name
Strombosia glaucescens	Afena	Afena
Cylicodiscus gabunensis	Okan	Denya
Petersianthus macrocarpus	Essia	Essia
Amphimas pterocarpoides	Yaya	Yaya
Sterculia oblonga	Sterculia yellow	Ohaa
Celtis mildbraedii	Celtis (African)	Esa
Rhodognaphalon brevicuspe	Bombax	Onyina-koben

After the operations, the samples that were sanded with grits 60 and 80 were inspected on both faces, with the help of a hand lens, for the quality of surfaces (the degree of elimination of chipped/torn grain defects), and graded. The same procedure was used for those samples that were also sanded with grits 100 and 120 for both fuzzy and scratchy defects. The grading was done on a numerical scale of 1 to 5, as an indication of the seriousness of any defects that were present, in accordance with ASTM D 1666-87. Grade 1 was considered as excellent (defect-free); grade 2 – good; grade 3 – fair; grade 4 – poor; and grade 5 – reject (very poor – no amount of sanding can redeem the faces of the wood).

To facilitate comparisons, the percentages of the graded samples were calculated. In addition, a rating was obtained by averaging the grades of the test samples. The lower the rating value, the less the degree of surface defectiveness, hence the better the sanding quality.

The defects that were observed and evaluated in the sanding tests are defined as follows: Chipped/torn grain, is a surface condition where short particles are broken out below the line of cut but was not redeemed after sanding. Fuzzy grain, consists of small particles, groups of small particles or groups of fibers that do not sever cleanly after sanding but stand up above the general level of the surface. Scratching defect is wavy and or straight line markings (deep or shallow) that are found on the surface of wood after sanding.

RESULTS AND DISCUSSION

The relative sanding qualities of the species tested are shown in Figures 1-6 while the average ratings are also presented in Tables 2 - 4. At all operating conditions there were statistical differences between the grading levels at P-value ≤ 0.05 using Chi-square test.

Relative freedom of chipped grain defect

At 20% moisture content and with grit sizes 60 and 80, the percentage defect-free samples were higher than at 12% for both sanders (Figures 1 and 2). *Triplochiton scleroxylon* and *Rhodognaphalon brevicuspe* with grit 60 in the belt sander and at 20% moisture content recorded 100% excellent samples each while at 12% moisture content relatively lower scores of 97% and 95% respectively were made. From the ratings, as shown in Table 2, the percentage defect-free samples of the drum and belt sanders at 20% moisture content were lower than that at 12% moisture content. These indicate that the higher the moisture content, the easier it is to eliminate any chipped/torn grain defects on the wood species.

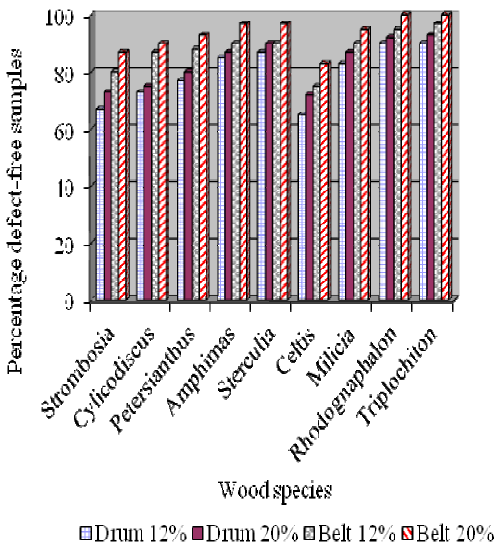

Figure 1: Relative freedom from chipping after sanding with grit size 60

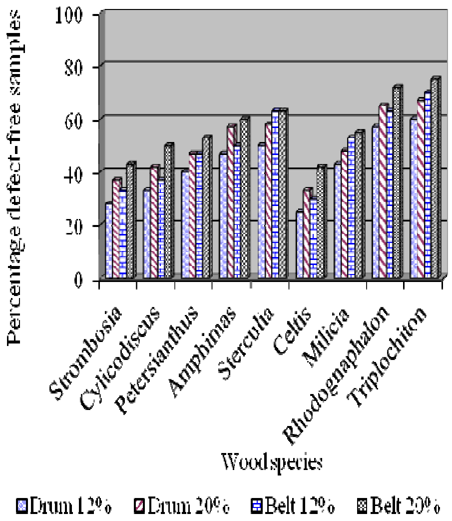

Figure 2: Relative freedom from chipping after sanding with grit size 80

This confirms Dinwoodie's earlier observation that wet thin-walled cells are more easily deformed than dry walled cells. However, the frequency of clogging of the sandpaper was observed to be higher with test samples at 20% moisture content
than at 12%.

The results also indicated that grit 60 had a higher tendency to eliminate chipped/torn grain defects than grit 80. For instance, grit 60 in the belt sander and at 20% moisture content sanded off the chipped/torn defects on all the samples of *Triplochiton scleroxylon* and *Rhodognaphalon brevicuspe* hence 100% score but with grit 80 under the same operating conditions, the species scored 75% and 72% respectively (Figures 1 and 2). Again, out of a total of 240 samples (for the four operating conditions), *Strombosia glaucescens* with grit 60 scored 184 (77%) defect-free samples while with grit 80 the score was 85 (35%). These show that the coarser or lower the grit size the easier the chipped or torn grain defects are sanded off hence the better the surface quality. The rating, which shows the quality of sanded samples, has a range of 1.0 – 1.63 with grit 60 and 1.35 – 2.55 with grit 80 (Table 2). The sanding of the chipped/torn grain samples with the two grits seemed to have no clear relationship with the density of the species.

From Figures 1 and 2, the belt sander produced a greater percentage of excellent samples as compared with that of the drum sander. Thus the belt sander seemed to have better performance. For example, *Cylicodiscus gabunensis* with grit 60 at 12% and 20% moisture contents scored 87% and 90% excellent samples respectively with the belt sander as against 73% and 75% with the drum sander (Figure1). At 12% and 20% moisture content, the belt sander had better sanding quality (lower ratings) than the drum sander. This is in agreement with Davis (1962) who has reported that belt sander is more efficient than drum sander.

Relative freedom from fuzzing

Fuzzy defect was observed to be bits of wood fibers that are attached to the board at one end and are absent at the other. The results of the study showed that significant differences exist between moisture content, grit size and the machine sanders at p-value ≤ 0.05.

The percentage defect-free samples for all the species were higher at 12% moisture content than at 20%. With grit 100 on *Petersianthus macrocarpus*, as shown in Figure 3, the belt and drum sanders recorded 83% and 70% defect-free samples respectively at 12% moisture content while 75% and 68% were recorded at 20% moisture content. Similar trends were observed with grit 120 and for all the species (Figure 3). The rating values of the species at 12% moisture content using the drum and the belt sanding machines were minimal (an indication of better surface quality) than those at 20% moisture content (Table 3).

Table 2: Rating of species on their chipping quality after sanding with grit sizes 60 and 80

Species	Grit size 60				Grit size 80			
	Drum 12%	Drum 20%	Belt 12%	Belt 20%	Drum 12%	Drum 20%	Belt 12%	Belt 20%
Strombosia glaucescens	1.58	1.42	1.25	1.12	2.40	2.20	2.27	2.02
Cylicodiscus gabunensis	1.43	1.42	1.17	1.10	2.37	2.07	2.15	1.90
Petersianthus macrocarpus	1.35	1.28	1.15	1.07	2.25	1.92	1.97	1.83
Amphimas pterocarpoides	1.27	1.23	1.12	1.03	2.12	1.83	1.83	1.73
Sterculia oblonger	1.25	1.13	1.10	1.03	2.02	1.70	1.77	1.60
Celtis mildbraedii	1.63	1.48	1.40	1.22	2.55	2.33	2.40	2.15
Milicia excelsa	1.25	1.10	1.23	1.05	2.12	1.93	1.93	1.75
Rhodognaphalon brevicuspe	1.13	1.08	1.05	1.00	1.65	1.63	1.63	1.45
Triplochiton scleroxylon	1.12	1.08	1.03	1.00	1.62	1.52	1.50	1.35

Rating: the nearer it approaches 1.0 the better the quality
Grade I = High Machining Quality (1.0-2.0); Grade II = Medium Machining Quality (2.1-4.0); Grade III = Low Machining Quality (4.1-5.0)
M. C. = Moisture Content

Table 3: Rating of species on their fuzzing quality after sanding with grit sizes 100 and 120

Species	Grit size 60				Grit size 80			
	Drum 12%	Drum 20%	Belt 12%	Belt 20%	Drum 12%	Drum 20%	Belt 12%	Belt 20%
Strombosia glaucescens	1.32	1.52	1.20	1.37	1.23	1.32	1.00	1.08
Cylicodiscus gabunensis	1.33	1.53	1.18	1.43	1.15	1.30	1.00	1.10
Petersianthus macrocarpus	1.40	1.50	1.30	1.48	1.25	1.35	1.07	1.18
Amphimas pterocarpoides	1.48	1.60	1.28	1.55	1.33	1.37	1.15	1.25
Sterculia oblonger	1.43	1.68	1.25	1.55	1.27	1.37	1.10	1.18
Celtis mildbraedii	1.38	1.57	1.27	1.43	1.28	1.42	1.02	1.13
Milicia excelsa	1.55	1.75	1.33	1.53	1.40	1.52	1.17	1.33
Rhodognaphalon brevicuspe	1.67	1.92	1.48	1.73	1.52	1.57	1.28	1.43
Triplochiton scleroxylon	1.67	1.93	1.50	1.68	1.42	1.52	1.25	1.38

Rating: the nearer it approaches 1.0 the better the quality
Grade I = High Machining Quality (1.0-2.0); Grade II = Medium Machining Quality (2.1-4.0);
Grade III = Low Machining Quality (4.1-5.0)
M. C. = Moisture Content

These show that higher moisture content facilitated the generation of fuzzy defect on the species and hence decreased their sanding qualities.

Grit 120 in the two sanding machines generated fewer fuzzy defects on the wood samples at both 12% and 20% moisture contents than with grit 100 (Figures 3 and 4). From the same graphs, grit 120 in the two sanders and at 12% and 20% moisture contents recorded a total of 196 (82%) excellent samples as against 173 (72%) with grit 100 for *Amphimas pterocarpoides*. The range of the rating for grits 100 and 120 were between 1.3 to 2.1 and 1.1 to 1.6 respectively. In terms of surface quality, grit 120, with lower ratings of the species, was the better option.

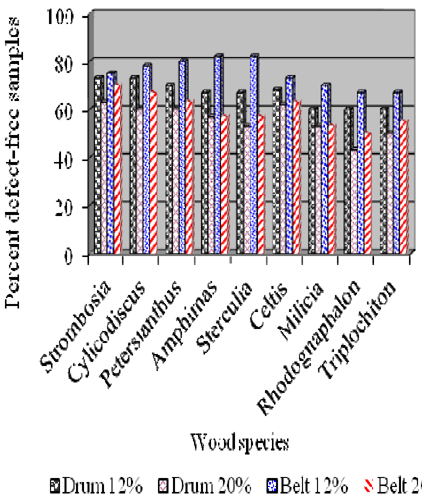

Figure 3: Relative freedom from fuzzing after sanding with grit size 100

The results from the belt and drum sanding machines with grit 100 (Figure 3) indicates that at both 12% and 20% moisture contents the percentage of defect-free samples of the belt sander for each species was higher than those sanded with the drum sander. For instance, *Sterculia oblonga* at 12% moisture content recorded 83% defect-free (excellent) samples with the belt sander using grit 100 as against 70% for the drum sander. The trend which was similar with grit 120, recorded 93% and 80% for the belt and drum sanders respectively. From Table 3, the rating for grit 100 and with the drum sander and at the two moisture contents ranged from 1.4 to 2.1 and that of the belt sander ranged from 1.3 to 1.9, implying that the belt sander performed better than the drum sander.

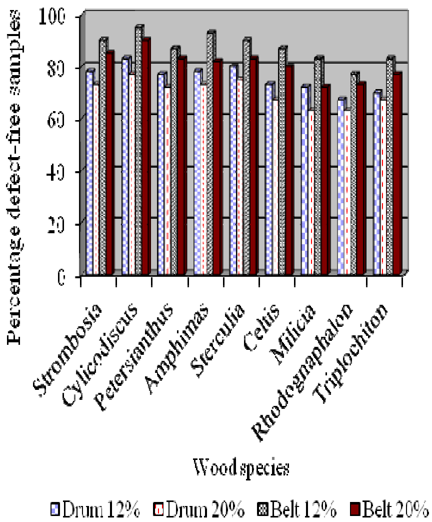

Figure 4: Relative freedom from fuzzing after sanding with grit size 120

The relative freedom from fuzzing in the species studied seemed to have been influenced by their densities and that the higher the density the better the surface quality. For instance, *Strombosia glaucescens* with a density of 950 kg/m^3 recorded a total of 188 (78%) and 220 (92%) excellent samples with grits 100 and 120 respectively while *Milicia excelsa* of density 650 kg/m^3 scored 165 (68%) and 185 (77%) under the same conditions (Figures 3 and 4). The highest and lowest percentages of defect-free samples were recorded by *Strombosia glaucescens* and *Rhodognaphalon brevicuspe* respectively.

The species with the minimum rating of 1.32 (best surface quality) with grit 100 were *Cylicodiscus gabunensis*, *Amphimas pterocarpoides* and *Sterculia oblonga* and the maximum rating of 1.93 was recorded by *Rhodognaphalon brevicuspe*. With grit 120 the surface qualities of the species, on the basis of their rating, ranged from 1.0 to 1.57 as shown in Table 3.

Relative resistance to scratching

The scratches that were developed on the wood species by the cylindrical drum of the drum sander were observed to be wavy, making "snake tracks" while those made by the belt sander were straight lines. The results of the study seemed to suggest that the finer the texture of the species, the more pronounced the scratching defect.

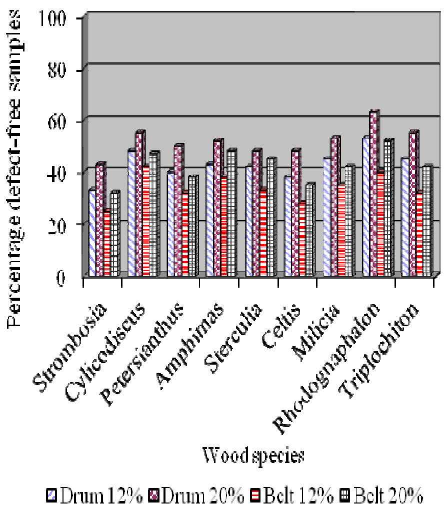

Figure 5: Relative resistance to scratching after sanding with grit size 100

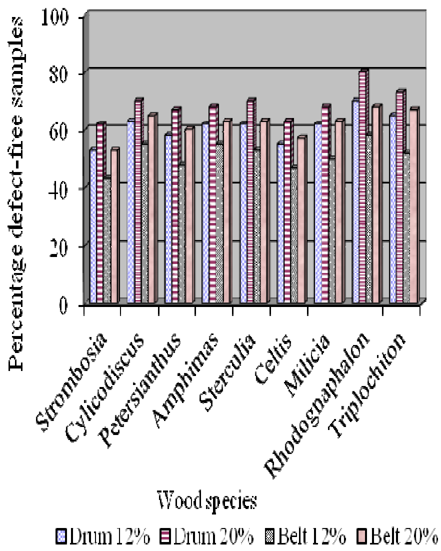

Figure 6: Relative resistance to scratching after sanding with grit size 120

For instance, *Strombosia glaucescens* and *Celtis mildbraedii*, which are fine textured species, were the last two species that recorded the lowest percentages of excellent samples while *Rhodognaphalon brevicuspe*, *Cylicodiscus gabunensis*, *Triplochiton scleroxylon* and *Milicia excelsa* known to be moderately coarse species, scored higher percentages at all the operating conditions as shown in Figures 5 and 6.

The scratching defect was observed to be comparatively severe on all the species with grit 100 than with grit 120 and the maximum rating scores for these grits were 2.15 and 1.75, respectively (Table 4). From Figure 9, the percentage defect-free samples for each of the species with grit 120 were higher than with grit 100. From the results the highest and lowest percentages of scratch-free samples with grit 120 were 80% and 43%, indicating that some of the samples were still defective. Therefore grit 120 cannot satisfactorily prepare the surfaces of the wood species for the application of finishes but rather smoothened the surfaces of the wood before finishing. In effect, sandpapers of grit sizes higher than 120 are expected to give the best surface finish of the wood species studied.

Figures 5 and 6 show that the samples at 20% moisture content recorded higher percentage of scratch-free samples for each of the species than at 12%. The rating results (Table 4), which is an indication of the sanding quality as it approaches 1.0, have lower records for the species at 20% moisture content than at 12% moisture content. This is in disagreement with Dinwoodie (1980) whose report indicates that timber of high moisture content does not produce as good surface finish as dried wood. This finding might be due to the recovery of fibres through swelling because of the high moisture in the wood. Again, the scratches observed on the wood surfaces at 12% moisture content were more pronounced than at 20%.

In Figures 5 and 6, there were relatively higher proportions of scratch-free samples in all the species with the belt sander relative to the drum sander. For instance, the wood samples at 12% and 20% moisture content recorded 53% and 63% excellent samples for *Rhodognaphalon brevicuspe* and 45% and 55% for *Triplochiton scleroxylon* with grit 100 in the belt sander while 40% and 52% and 35% and 42% were recorded with the drum sander for the same species (Figure 5). A similar trend was observed with grit 120. Again, the ratings of the species with the belt sanding machine for both grits were lower (indicating a better sanding quality) than with the drum sanding machine (Table 4).

Table 4: Rating of species on their scratching quality after sanding with grit sizes 100 and 120

	Grit size 60				Grit size 80			
Species	Drum	Drum	Belt	Belt	Drum	Drum	Belt	Belt
	12%	20%	12%	20%	12%	20%	12%	20%
Strombosia glaucescens	2.15	1.83	1.97	1.63	1.75	1.58	1.53	1.43
Cylicodiscus gabunensis	1.77	1.65	1.97	1.48	1.57	1.35	1.42	1.32
Petersianthus macrocarpus	1.98	1.78	1.60	1.53	1.67	1.47	1.50	1.37
Amphimas pterocarpoides	1.97	1.62	1.80	1.53	1.58	1.45	1.43	1.35
Sterculia oblonger	1.92	1.65	1.78	1.57	1.52	1.40	1.40	1.32
Celtis mildbraedii	2.20	1.90	1.90	1.70	1.73	1.58	1.62	1.42
Milicia excelsa	1.95	1.72	1.65	1.52	1.62	1.43	1.45	1.37
Rhodognaphalon brevicuspe	1.65	1.55	1.53	1.40	1.52	1.35	1.32	1.22
Triplochiton scleroxylon	1.82	1.72	1.60	1.47	1.62	1.38	1.38	1.30

Rating: the nearer it approaches 1.0 the better the quality
Grade I = High Machining Quality (1.0-2.0); Grade II = Medium Machining Quality (2.1-4.0); Grade III
M. C. = Moisture Content

CONCLUSION

The results of the study have shown that grit 60 had a higher tendency of eliminating chipped/torn grain defects that were generated on the wood samples than grit 80. Under the same operating conditions, the performance of the belt sander was better than the drum sander. The surface quality in terms of chipping tendencies at 20% moisture content were better after sanding than those at 12% moisture content. Notwithstanding relatively few anomalies that were recorded, elimination of the chipped/torn grain defects were easier with low density species than with the high density species, hence *Rhodognaphalon brevicuspe* and *Triplochiton scleroxylon* had better surface qualities with grits 60 and 80 than the rest of the species studied.

Further, the results have indicated that grit 120 had the higher tendency to remove fuzzy defect more than grit 100, owing to its finer particle size. The belt sanding machine performed better than the drum sanding machine. More of the wood samples were fuzz-free at 12% moisture content than at 20% moisture content. The sanding quality of the species under fuzzing tendencies was better with increasing density and the deviations observed may be attributed to the difference in texture of the species.

The species were more resistant to scratching with sandpaper of grit size 120 than that of 100. The degree of scratching defect on the wood samples was lower with the belt than with the drum sander. Scratches generated on the wood species at 12% moisture content were comparatively more than at 20% moisture content. *Strombosia glaucescens* and *Rhodognaphalon brevicuspe* recorded the lowest and highest scratch-free wood samples respectively.

This study considered those facilities that were available at the time of the study and hence could not take into account other influential factors that affect sanding of wood species. There is the need, therefore, for such factors (sanding time, feed speed and pressure), with respect to the properties of LUS, to be studied.

Generally, the results have shown that the sanding qualities of the lesser-used species studied are comparable to *Milicia excelsa* and *Triplochiton scleroxylon* (used as control species). With this promising sanding qualities therefore, the species may justify their utilization in the timber industry especially in the furniture sector where sanding to perfection is required.

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