Machining and Handtool Properties of Mahogany *(Swietenia macrophylla)* Wood grown in Bangladesh

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Abstract

Wood is widely used in all over the world because of its excellent physical, mechanical and finishing properties. However, the machining and handtool properties of mahogany (Swietenia macrophylla) wood were ascertained for the characterization of working properties in this study. The effects of machining properties, such as- planing, shaping, boring, mortising and turning were tested on this wood species along with handtool test. The evaluation of each test was based on frequency of occurrence of defect free sample. The applications of two types of polishing materials, namely: shellac and carpa were used for the purpose of finishing property evaluation. Each sample was visually observed and classified based on five quality grades. This wood showed an excellent working performance in all properties except handtool property in planing test.

সারসংক্ষেপ

ভৌত, যান্ত্রিক ও পলিশিং গুণাগুণ থাকায় কাঠ সমগ্র বিশ্বে ব্যাপকভাবে ব্যবহৃত হয়। যাহোক, অত্র গবেষণায় ওয়ার্কিং গুণাগুণ বৈশিষ্ট্যায়িত করার জন্য মেহগনি কাঠের মেশিনিং ও হ্যান্ডটুল গুণাগুণ নিরূপণ করা হয়েছে। উক্ত কাঠের হ্যান্ডটুল ও মেশিনিং গুণাগুণ, যেমন: প্লানিং, শেপিং, বোরিং, মরটাইজিং, টার্নিং পরীক্ষাগুলির প্রভাব পর্যবেক্ষণ করা হয়েছে। প্রতিটি পরীক্ষণে ত্রুটিমুক্ত নমুনার উপর ভিত্তি করে মূল্যায়ন ও গ্রেডিং করা হয়েছে। পলিশিং গুণাগুণ নির্ণয়ে দুই ধরনের পলিশ, যথা: শেলাক ও কারপা ব্যবহার হয়েছে। নমুনাগুলোকে খালি চোখে নিরীক্ষণ করার মাধ্যমে পাঁচটি গুনাগুনের গ্রেডে ভাগ করা হয়েছে। এই কাঠ প্লানিং পরীক্ষণে হ্যান্ডটুল গুণাগুণ ছাড়া অন্যান্য কাজের গুনাগুন উন্নতমানের প্রদর্শন করেছে।

Keywords: Working properties, Planing, Boring, Mortising, Shaping, Turning.

Introduction

Mahogany (Swietenia macrophylla) tree species is native to tropical America and it is one of the most important timber species in world trade (Gillies et al, 1999).The plant mahogany commonly known as “sky fruit”, because its fruits seen to point upwards to the sky is a beautiful, lofty, evergreen large tree usually 30-40 m in height and 3-4 m in girth (Goh and Kadir 2011). The average tree is 3 to 6 feet in diameter and has a long trunk that is generally free of branches from 60 to 80 feet above the heavy buttress (Kukachka 1959). This tree has been planted in homestead and road side as timber species, and it has become popular to the people for the growing nature of it under a little bit shadow in Bangladesh.

Wood has traditionally been the basic raw material for furniture and joinery industries. One of the most important advantages of wood is its easy machine ability in contrast to metal and plastic products. However, its non-uniform characteristics within and between species plays a significant role on its efficient and effective machining. Any surface defects due to an improper machining process will also reduce the quality of the final product, resulting in an increase in the cost of the manufactured unit. Therefore, it is important to evaluate machining parameters and relate them to raw material characteristics (Sofuoglu and Kurtoglu 2014).Wood is considered as the prime material for the survival of mankind and also as the fundamental one for the enhancement of civilization (Sattar et al. 1981).

Commercial wood has excellent physical, mechanical and appearance properties and is highly used in markets all over the world (Tu et al. 2014).Variation of machining properties of different wood is influenced by their density, fiber structure, chemical and mineral contents and many other characteristics. As machining is involved in all common wood working operations, knowledge of the machine ability of different wood is helpful in selection of a particular species for a specific use. The importance of this information lies in marketing of new and inexpensive species and in their conversion for many important wood products (Qasem et al. 1981).

The quality of commercial timber varies according to local conditions, and the variations encountered are no greater over its entire range than those which might be found within the confined geographic area. These variations chiefly effect the weight, hardness, and color of the wood (Kukachka, 1959). Knowledge of machining properties of wood is required specially for fabrication of furniture and cabinet work (Hossain et al. 1978). Now-a-days, mahogany wood is being widely used for the purpose of making furniture, cabinet, interior and construction works in Bangladesh. But it is unknown to the users of its working properties. The study was thus carried out to ascertain the machining and handtool properties along with finishing properties which wood help to regulate the proper use of the species.

Materials and methods

Mahogany (Swietenia macrophylla) wood aged about 27 years was procured in the log form from Chattogram. This log was converted into different sizes by plane sawing. The sawing quality of this wood was determined by manual feeding of logs to the saw blade. The sawn timber was seasoned to less than 15 percent moisture content (Table-1). The seasoned timber was dressed and 20 samples of 20 mm × 126 mm × 1224 mm in size were prepared according to ASTM standard. All the test samples were sound and free from all defects including knots, stain, incipient decay, end splits and surface checks. For different experimental conditions, each sample was cut into three parts which are 20 mm × 106 mm × 915 mm, 20 mm × 20 mm × 153 mm and 20 mm × 78 mm × 307 mm in size. First sized were used for the tests of planning and finishing properties, and second were used for turning property tests. The third sized samples were used for the tests of boring, mortising and shaping properties.

Table 1: Moisture content, age and specific gravity of mahogany wood species.

Parameter	Quantity	Unit
Moisture content of wood	14	Percentage
Age of the tree	27	Year
*Specific gravity	0.58	No unit

* Sattar, et al 1999.

Ten samples were tested with machines and ten samples with hand tool but twenty samples were tested for the purpose of planing and finishing tests. After the completion of machining tests, the samples were visually examined for sorting out the defect free ones immediately. The occurrence of defects, namely- fuzzy grain, torn grain, raised grain, chipped grain, broken corner, tear out and roughness was recorded. The percentages of defect-free samples based on total samples were determined and these percentages were considered to be the measure of their machining qualities. Then, each sample was visually examined and classified based on five quality grades which are shown in Table 2.

Table 2: Quality grades of different property tests

Quality grade	Performance	Defects
1	Excellent	No defect
2	Good	Few slight defects
3	Fair	Lots of slight defects
4	Poor	Serious defects
5	Very poor	Very serious defects

The performance criteria and suitable pieces for different test samples used for the tests are presented in Table 3. The machining tests were carried out according to American Society for Testing and Materials standard test method - "Conducting Machining Tests of Wood and Wood-Based Products (ASTM D 1666-64 Standard International, 2004)". Similar tests were carried out using carpenter's handtool.

Table 3: Qualified grade and performance criteria based on different test along with dimension of different test samples

Tests	Dimension (mm)	Qualified grade	Criteria of performance
Planing	20 x 106 x 915	1 and 2	Excellent and good
Shaping	20 x 78 x 307	1 and 2	Excellent and good
Boring	20 x 78 x 307	1 and 2	Excellent and good
Mortising	20 x 78 x 307	1,2 and 3	Excellent, good and fair
Turning	20 x 20 x 153	1 and 2	Excellent and good
Finishing	20 x 106 x 915	1	Excellent

Planing

The planing test was carried out in a single surface planer with a cutter head speed of 3000 rotation per minute. The depth of cut for all the runs was 1.59 mm. The machine was equipped with a variable feed rate of 154 mm to 2540 mm per minute and the feed rate was adjusted to 636 mm per minute so that the target numbers of knife mark were 40 per 2.54 cm. The run was made with a cutting angle of 25 degrees and sharpness angle of 30 degrees. The test samples were fed into the machine one by one to complete a full rotation of test. Each of the samples was carefully examined visually for planing defects after each run. The test samples of the species were tested in a group separately. The same number of samples were tested with the carpenter's hand planner and similar procedure of testing was applied.

Boring

The boring test was carried out in a 508 mm single spindle hand feed drill press. Two thorough holes were bored on each sample. A one-inch single twist solid center bred point type of wood boring bit was used for the test. The drill was adjusted to maintain a spindle speed of 2850 rpm. In hand tool test, boring was done by a carpenter's hand drill. A one-inch single twist solid center screwed point type wood boring auger bit was used for the test. Solid hardboard was used as backing underneath in order to avoid the tearing and splintering of samples at the bottom during boring both for machining and handtool test.

Mortising

The samples used for boring test by machine and hand tool were also used for carrying out the mortising test by machine and handtool respectively. Two thorough mortises were cut on each sample extending through into a hard board backing. Each mortise was cut with two sides parallel and two sides perpendicular to the grain. The tests in machining were carried out in a foot feed vertical square hollow chisel mortiser. The spindle speed of 3600 rpm and the chisel of 12.7 mm were used for mortising test.

Shaping

The test samples used for boring and mortising were also used for shaping test. In machine, the test was carried out in a special jig to shape the sample to a curved pattern. A hand feed single spindle shaper with two high speed steel knives having a spindle speed of 6500 rpm was used. The cutter used to obtain a quarter round pattern had a radius of curvature of 12.70 mm and the cutting angle was set 25°. In hand tool test, ripping of the sample was done by carpenter handsaw to obtain the quarter round pattern. The shaping was carried out by carpenter’s chisel of half-round type.

Turning

The turning test was carried out in a variable speed wood lathe at 2400 rpm. A single high speed steel cutter was used to give head and cove for having different turning features as well as the ability to cut at different angles with the grain.

Finishing

The planing test samples were used for the finishing test after completing all planing tests. In finishing test, two types of polish, viz.: shellac and carpa were applied and performance was recorded on the basis of the surface finish and physical appearances. Gum copal finish is locally known as 'carpa' or 'chandra' polish. The polish is prepared by dissolving gum copal in denatured alcohol. The standard mixture is 70% denatured alcohol and 30% gum copal. The method of applications is the same as that of shellac polish (Qasem 1987).

Results and Discussion

Mahogany wood was moderately hard and heavy according to the variation of its density, grain orientation and the load applied to the saw blade, and it indicated medium sawing quality.

The results of planning, shaping, boring, mortising, turning and finishing properties for mahogany wood species are presented in Table 4.

Table 4: Property wise grade percentage of different properties for mahogany wood

Properties		Grade of different properties (%)					
Name	Type	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Qualified grade
Planing	Machining	70	25	5	0	0	95
	Handtools	85	15	0	0	0	100
Shaping	Machining	100	0	0	0	0	100
	Handtools	100	0	0	0	0	100
Boring	Machining	100	0	0	0	0	100
	Handtools	100	0	0	0	0	100
Mortising	Machining	90	10	0	0	0	100
	Handtools	90	10	0	0	0	100
Turning	Machining	100	0	0	0	0	100
Finishing		100	0	0	0	0	100

The qualified grades of planing, shaping, boring, mortising and turning properties were assumed the summation of grade 1 and grade 2. Among these operations, shaping, boring and turning showed only grade 1 that referred 100% qualified grade. On the other hand, machining and handtool properties of planing tests resulted three grade (grade 1, 2 & 3) and two grade (grade 1 & 2) respectively. In terms of planing test, machining property indicated 70 % grade 1, and it rated only 95 % qualified grade where as hand tool property indicated 100 % qualified grade. In case of this test, handtool property showed 85 % grade 1 which is higher than that of machining.

In terms of mortising tests for both machining and hand tool properties, the qualified grades were considered the sum of grade 1, 2 and 3. In this case, both machining and handtool properties showed 90% grade 1 and 10 % grade 2, and these properties indicated 100 % qualified grade. In the finishing operation, qualified grade was assumed only grade 1, and it scored 100 % qualified grade.

The defect free samples for mahogany wood in different tests are shown in Fig.1. In case of machining properties, this wood showed excellent shaping, boring, mortising and turning results, but planning operation indicated good quality. In terms of hand tool properties, all showed excellent qualities.

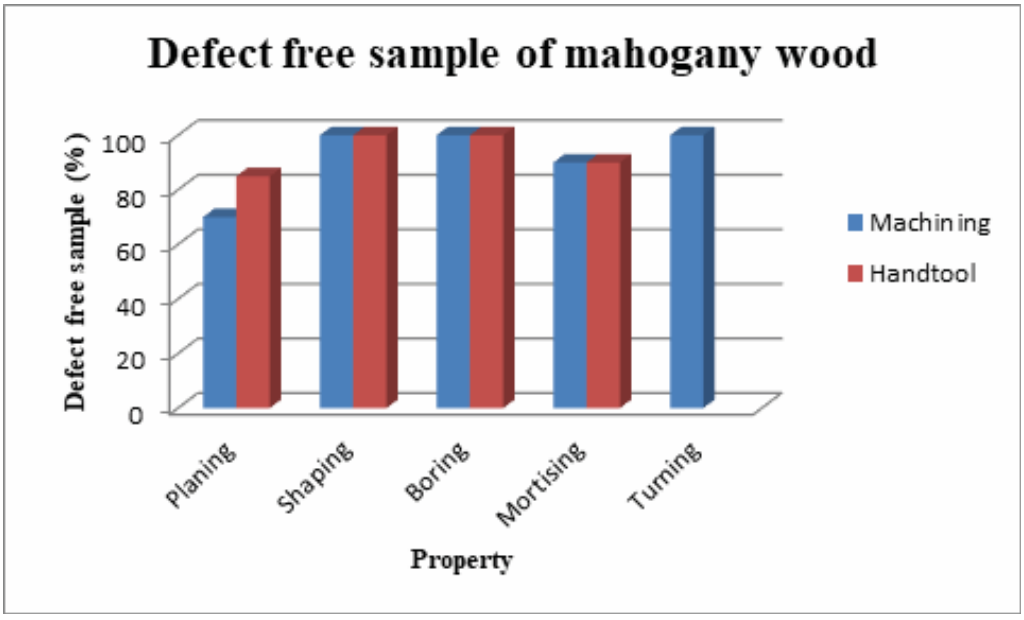

Figure 1: Comparison of the defect free samples among different tests

Defects of planing and mortising operations along with average percentage of defects are presented in Table 5. Defects typically observed for mahogany wood species were fuzzy grain for both machining and handtool properties in planing operations. A few tear out and crushing out were present on the transverse side of the hole for machining and handtool properties respectively in mortising tests.

Table 5: Defects of planing and mortising tests for machining and hand tool properties

Test name	Property	No. of defected sample	Defects	Average %
Planing	Machining	06	Fuzzy grain	21.67
	Handtool	03	Fuzzy grain	20
Mortising	Machining	01	Tear out	20
	Handtool	01	Crushing out	20

For good machining quality, the cutters used in the machine should be maintained properly. Generally, deep cuts should not be made. The number of blade traces in unit distance should be high. High feed speed can cause a poor surface. The defects may be caused by feed speed. The feed speed of planing test should be slow, but capacity should also be considered.

The evaluation of machining defects was based on visual inspection. But it was not possible to quantify them properly. In the defective samples, particularly in planing and turning test, the degree and frequency of incidence of defects were negligible and the defects could easily be removed by adequate sanding.

Because of the limitation of available equipments, extensive investigation of the machining tests could not be carried out. For optimum results, further research work is still needed.

Conclusion

This experiment was carried out to ascertain the behaviour of mahogany wood species for the characterization of different important machining, handtool and finishing properties generating some essential information on the suitability of various utilizations. These evaluated properties indicated that this wood species should have potential suitability in different purposes. Mahogany wood could be suitable for quality furniture, cabinet, fixture, music instrument, door, paneling and turnery works along with interior designs and construction purposes. By using this wood commercially, it may reduce the pressure on the traditional timber species and people of our country could fulfill their quality furniture demand. However, the result of this study is an indicative value and may be used when and where a particular property or a group of properties are to require in the selection of this species for specific use.

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