COMPARATIVE STUDIES OF WOOD SEASONING WITH A SPECIAL *REFERENCE TO SOLAR DRYING*

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ABSTRACT

A series of charges of twenty timber species were dried employing solar drying as well as the conventional air drying and steam heated kiln drying methods. Solar and air drying were continued for three years during the entire drying seasons. The results suggest that the climatic conditions of Bangladesh are suitable for operating greenhouse type solar kilns throughout the year. Even refractory timbers of higher dimensions can be dried during the rainy season to a desired lower moisture content. The quality of the solar dried timber is found to be superior to both air and kiln dried timber. Solar drying is significantly more efficient than air drying. It is a simpler and less expensive drying technique than kiln drying. It is recommended that the solar drying technique be employed in wood based industries for effectve utilization of Bangladeshi timber.

সারসংক্ষেপ

বিশটি দেশী প্রজাতির কাঠ প্রচলিত বায়ুতে, বাষ্পচালিত চুল্লিতে ও সৌর চুল্লিতে পৃথক পৃথকভাবে শুকানো হয়েছে। সৌর চুল্লি ও বায়ুতে উক্ত প্রজাতির কাঠগুলো ক্রমাগত তিন বছর যাবত সব মৌসুমে শুকানো হয়। গবেষণালব্ধ ফলাফলে প্রতীয়মান হয় যে, বাংলাদেশের আবহাওয়ায় গ্রীণ হাউজ ধরনের সৌরচুল্লি সারা বছরই কাঠ শুকানোর কাজে উপযোগী। এ চুল্লিতে অস্বাভাবিক প্রকৃতির ও বেশ পুরু কাঠও ঈপ্সিত নিম্ন মাত্রার জলীয় অংশে শুকানো যায়। বায়ু ও প্রচলিত চুল্লিতে শুকানো কাঠ অপেক্ষা সৌর চুল্লিতে শুকানো কাষ্ঠের মানও উন্নততর। সৌর চুল্লিতে কাষ্ঠ শুষ্কিকরণ পদ্ধতি বায়ুতে শুকানোর পদ্ধতির তুলনায় অনেক বেশী কার্যকর। এটি প্রচলিত চুল্লিতে শুকানো পদ্ধতি থেকে সহজতর ও সুলভ বলে বাংলাদেশের কাঠ শিল্প প্রতিষ্ঠানে সৌর চুল্লিতে কাঠ শুকানোর জন্য সুপারিশ করা হলো।

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INTRODUCTION

Kiln drying and air-drying are two widely practised methods for seasoning of timber. Inspite of their advantages, they suffer from some limitations also. Air drying is a slow process, and in many cases, wood cannot be dried to the desired level of equilibrium moisture content. The high initial investment and operating cost coupled with a complicated technique have made the conventional steam heated kiln prohibitive for wider adoption. The growing interest in recent years is thus oriented towards finding out an alternative drying method which shlould be inexpensive and simple but comparatively rapid and effective. The use of solar energy in a suitably designed kiln has been found to be a solution (Chudnoff, Maldonado and Goytia 1966 ; Gough 1977 ; Plumptre 1967, 1973, 1979 ; Sharma 1975 ; Tschernitz and Simpson 1977).

The Bangladesh Forest Research Institute (BFRI) has been studying the feasibility of utilizing solar radiation for drying indigenous timbers since 1969 (Sattar). A solar kiln was developed and installed at BFRI (Sattar 1982a, 1982b). The basic economics of the kiln along with its return on investment were calculated. Various experimental as well as commercial charges were dried in the solar kiln. The results indicate that the solar kiln has definite advantages over other drying methods in its simplicity, effectiveness and economy (Sattar 1982a, 1982b). Recognising this fact, many wood based industries of the country have shown their interest to install the solar kilns in their plants. A number of such solar kilns have been constructed at the Chittagong and Dhaka industrial areas. The present report is the results of drying timbers in the experimental solar kiln at BFRI.

MATERIAL AND METHODS

Twenty indigenous timber species of different dimensions were used for the study. Planks of 2.5 cm x 20 cm size of ten species, viz., chapalish (*Artocarpus chaplasha*), toon (*Toona ciliata*), teak (*Tectoda grandis*), champa (*Michelia champaca*), chickrassi (*Chukrassia velutina*), koroi (*Albizia procera*), garjan (*Dipterocarpus* spp.), jam (*Syzygium grande*), jarul (*Lagerstroemia speciesa*) and gamar (*Gmelina arborea*) were selected from the species used for furniture and construction punposes. Logs of these species were produced from BFIDC timber depot at Kaptai and were converted into size at the BFRI sawmill prior to each charge of drying. Battens of 3.8 cm × 7.6 cm of five species, viz., tali (*Palaquium polyanthum*), kamdeb (*Gallophylum polyanthum*), pitraj (*Aphanamixis polystachya*), bhadi (*Lannea coromandelica*) and gutguttya (*Bursera serreta*) were selected from the species used for flushdoors. Freshly sawn battens procured from a BFIDC project at Kalurghat, Chittagong, where the battens of these species were also dried in a solar kiln. Battens of 2.0 cm x 2.0 cm of three species, viz., mango (*Mangifera* sp.), uriam (*Manifera sylvatica*) and civit (*Swintonia floribunda*) were selected from the species used for making teachest. Logs of these species were procured from the timber depot at Kaptai and were converted into size prior to drying. Blanks of 5.7 cm × 7.6 cm of two species, viz., batna (*Quercus* spp.) and babla (*Acacia nilotica*) were selected from the species used for making shuttles. Sized timber in green condition was procured from a private wood industry at Chittagong, where these planks were dried in a solar kiln for making shuttles. The blanks were submerged in a small water tank for saturation and were removed from the tank prior to drying.

All the timbers were dried in the 3.5 m^3 capacity solar kiln developed at the Institute. The solar kiln was of greenhouse type. All the walls were of 0.25 mm thick transparent polythene sheet and the roof was made of 6 mm glass. The concrete floor was covered with a layer of black polythene sheet. Six representative 2.5 cm x 20 cm planks and 3.8 cm × 7.6 cm battens, and fifty 2.0 cm × 2.0 cm battens and 5.0 cm × 7.6 cm blanks were selected as samples for each species in each charge. Two to five species of similar dimensions were dried in the same charge. Solar drying was undertaken throughout the year covering the four drying seasons. Identical batch of timber was stacked in the open yard for air drying along with the solar drying. Another batch of identical materials was dried in a compartment type steam heated kiln.

Two strips measuring 2.5 cm thick were cut from 15.0 cm apart from both ends of the samples for the determination of initial moisture content by the ovendrying method. The samples were endcoated with bituminous paint immediately after cutting the moisture sections. Based on the initial moisture content, the calculated ovendry weight of each sample was determined. The progress of drying was ascertained with the help of these estimated ovendry weights. Qualitative assessment of drying degrade was made visually at the conclusion of each drying.

RESULTS

Climatological data were recorded every day during the course of solar drying. The maximum and minimum temperatures inside and outside the solar kiln and the number of rainy days for each season are presented in Table 1.

Total drying times from green condition to 12% moisture content employing different methods were determined for each species. The percentage reductions of drying time were also calculated. These data are presented in Table 2. Qualitative assessment of drying defects developed in timbers during drying by different processes is given in Table 3. Analysis of various was employed on drying time to note the effects on species, drying period, drying process and size of timber. The summary of results is shown in Table 4. Duncan's multiple range test was used to evaluate the effect of drying periods on mean solar drying times and the results are shown in Table 5.

Table 1. Temperature inside and outside the solar kiln

Time of observation	Temperature				Number of rainy days
	Inside solar kiln		Outside solar kiln		
	Max °C	Min °C	Max °C	Min °C	
1980—81					
(a) Winter : November—March	57	18	31	11	9
(b) Postwinter : April—May	66	24	34	19	15
(c) Monsoon : June—August	66	25	34	21	46
(d) Postmonsoon : September—October	64	24	33	20	14
1981—82					
(a) Winter : November—March	59	17	31	10	6
(b) Postwinter : April—May	65	25	35	19	14
(c) Monsoon : June—August	65	26	34	22	51
(d) Postmonsoon : September—October	63	23	33	19	16
1982—83					
(a) Winter : November—March	58	17	31	11	10
(b) Postwinter : April—May	66	24	34	18	13
(c) Monsoon : June—August	65	26	34	22	44
(d) Postmonsoon : September—October	65	23	33	19	12

Table 2. Comparative drying time of different species for different drying methods
(a) During winter period - November to March

Species and size of timber	Specific gravity (green volume and ovendry weight)	Drying time (days) from green condition to 12% mc for			Reduction (%)	
		solar drying	open air drying	kiln drying	in solar drying time to air drying time	in kiln drying time to solar drying time
2.5 cm x 20.0 cm planks for furniture and other uses						
Chapalish	0.48	10	22	6	55	40
Toon	0.46	12	26	7	54	42
Teek	0.55	13	28	8	45	38
Champa	0.58	15	34	9	56	40
Koroi	0.60	17	38	10	55	41
Chickrassi	0.62	17	40	10	58	41
Jarul	0.62	18	45	10	61	44
Garjan	0.65	18	48	10	61	44
Jam	0.67	21	50	12	58	43
Gamar	0.46	26	68	14	62	46
3.8 cm x 7.6 cm battens for flushdoor						
Tali	0.55	14	36	9	61	36
Kamdeb	0.55	15	44	9	66	40
Pitraj	0.57	17	48	10	65	41
Bhadi	0.62	20	52	12	62	40
Gutguttya	0.74	22	60	14	63	36
2.0 cm x 2.0 cm battens for teachest						
Mango	0.48	5	11	3	55	40
Uriam	0.50	5	12	3	58	40
Civit	0.54	6	13	4	54	33
5.7 cm x 7.6 cm blanks for shuttle						
Batna	0.60	27	68	15	60	44
Babla	0.70	32	74	18	57	44

Tablo 2. Continued

(b) During postwinter period - April to May

Species and size of timber	Drying time (days) from green condition to 12% mc for		Reduction (%)	
	solar drying	open air. drying	in solar drying time to air drying time	in kiln drying time to solar drying time
2.5 cm x 20.0 cm planks for furniture and other uses				
Chapalish	12	32	63	50
Toon	14	36	61	50
Teak	15	34	56	47
Champa	18	44	59	50
Koroi	20	48	62	50
Chickrassi	20	51	61	50
Jarul	22	60	63	55
Garjan	23	64	64	57
Jam	26	68	62	54
Gamar	30	79	62	53
3.8 cm x 7.6 cm battens for flushdoor				
Tali	17	50	66	47
Kamdeb	17	50	66	47
Pitraj	19	63	70	47
Bhadi	23	70	67	48
Gutguttya	25	72	65	44
2.0 cm x 2.0 cm battens for teachest				
Mango	6	17	65	50
Uriam	6	19	68	50
Civit	7	19	63	43
5.7 cm x 7.6 cm blanks for shuttle				
Batna	30	78	62	50
Babla	37	89	58	51

Table 2. Continued

(c) During monsoon period - June to August

Species and size of timber	Drying time (days) from green condition for		Reduction (%)	
	solar drying to 12% mc	air drying to 18-20% mc	in solar drying time to air drying time	in kiln drying time to solar drying time
2.5 cm x 20.0 cm planks for furniture and other uses				
Chapalish	18	58	69	67
Toon	20	62	68	65
Teak	21	74	71	62
Champa	27	85	68	67
Koroi	28	93	70	64
Chickrassi	29	90	68	66
Jarul	32	106	70	69
Garjan	31	110	72	68
Jam	34	114	70	65
Gamar	40	123	67	65
3.8 cm x 7.6 cm battens for flushdoor				
Tali	26	95	73	65
Kamdeb	28	98	70	68
Pitraj	32	116	72	69
Bhadi	37	130	72	68
Gutguttya	40	141	72	65
2.0 cm x 2.0 cm battens for teachest				
Mango	9	30	70	67
Uriam	10	34	71	70
Civit	10	37	73	60
5.7 cm x 7.6 cm blanks for shuttle				
Batna	40	140	71	63
Babla	52	154	65	65

Table 2. Continued

(d) During postmonsoon period—September to October

Species and size of timber	Drying time (days) from green condition to 12% mc for		Reduction (%)	
	solar drying	open air drying	in solar drying time to air drying time	in kiln drying time to solar drying time
2.5 cm x 20.0 cm planks for furniture and other uses				
Chapalish	12	36	67	50
Toon	15	38	61	53
Teak	16	40	60	50
Champa	18	46	61	50
Koroi	21	50	58	52
Chickrassi	20	53	62	50
Jarul	24	65	63	58
Garjan	24	67	64	58
Jam	27	70	61	56
Gamar	32	84	62	56
3.8 cm x 7.6 cm battens for flushdoor				
Tali	19	52	63	53
Kamdeb	17	50	66	47
Pitraj	20	61	67	50
Bhadi	25	74	66	52
Gutguttya	28	77	64	50
2.0 cm x 2.0 cm battens for teachest				
Margo	7	18	61	57
Uriam	7	20	65	57
Civit	7	20	65	43
5.7 cm x 7.6 cm blanks for shuttle				
Batna	32	81	60	53
Babla	38	93	59	53

Table 3. Drying defects developed in timbers of different drying processes

Species	Drying defects developed in timber of		
	solar drying	air drying	kiln drying
Chapalish	Nil	Minor end split and distortion	Minor end split and distortion
Toon	End check	Tendency to distortion	Tendency to distortion
Teak	Nil	End check	Nil
Champa	Nil	Severe end and surface check	End split and surface check
Koroi	Minor end and surface check	Tendency to distortion	Tendency to distortion
Chickrassi	End check	End check	End check
Garjan	Minor end and surface check	End split and distortion	End split and distortion
Jam	Minor end check	Severe end split	Severe end split
Jarul	Nil	Nil	Nil
Gamar	Nil	Nil	Nil
Tali	Nil	Minor distortion	Nil
Kamdeb	Nil	Minor end check and split	Nil
Pitraj	Minor end check	Severe end split	Severe end split
Bhadi	Nil	End split and tendency to distortion	Tendency to distortion
Gutguttya	Nil	End split	End split
Mango	Nil	Tendency to distortion	Tendency to distortion
Uriam	End check	End check	End check
Civit	Nil	Tendency to distortion	Tendency to distortion
Batna	End and surface check	End split and surface check	End split and surface check
Babla	Nil	Minor end check	Nil

Table 4. Summary of results of analysis of variance on drying times

Factor	Variance ratio	Significance
Species	87.9	*
Drying period	98.5	*
Drying process	129.7	*
Size of timber	56.8	*

**Significant at the 0.1 percent level*

Table 5. Duncan's multiple range test on solar drying times for different drying periods

Species	Drying periods			
	Winter	Postwinter	Postmonsoon	Monsoon
Chaplalish	10	12	12	18
Toon	12	14	15	20
Teak	13	15	16	21
Champa	15	18	18	27
Koroi	17	20	21	28
Chickrassi	17	20	20	29
Jarul	18	22	24	32
Garjan	18	23	24	31
Jam	21	26	27	34
Gamar	26	30	32	40
Tali	14	17	19	26
Kamdeb	15	17	17	28
Pitraj	17	19	20	32
Bhadi	20	23	25	37
Gutguttya	22	25	28	40
Mango	5	6	7	9
Uriam	5	6	7	10
Civit	6	7	7	10
Batna	27	30	32	40
Babla	32	37	38	52

** Values bracketed by the same line are not significantly different.*

DISCUSSION

The calendar year in Bangladesh may be divided into four seasons—winter, postwinter, monsoon and postmonsoon from the stand point of wood drying. The monsoon extending from the first of June to the end of August is characterised by heavy rainfall, 90 to 95% relative humidity and 28 to 34°C temperature. The postwinter from the first of April to the end of May and the postmonsoon from the first of September to the end of October are almost identical as far as the climatological conditions are concerned. Rainfall is moderate, relative humidity varies from 75 to 95% and temperature fluctuates from 24 to 35°C. The winter extending from the first of November to the end of March is characterised by very light rainfall, 50 to 75% relative humidity and 14 to 31°C temperature. Solar drying was undertaken during these four seasons of the year. The results of solar drying were thus discussed under those conditions.

Temperature

The temperature inside the solar kiln during the day time was found considerably higher than the ambient temperature. The blackened corrugated iron sheets incorporated in the solar kiln was seen useful in absorbing solar radiation. The solar kiln attained the maximum temperatures of 57 to 66°C against the ambient temperatures of 31 to 35°C during the three-year period of observation (Table 1). Even on cloudy days, the solar kiln could absorb intermittent sunlight and diffuse radiation, and thus its temperature was found to exceed the atmospheric temperature. In a similar study in India, Sharma (1975) also observed that in cloudy weather the solar kiln could make use of the available intermittent sunlight and diffuse skylight to trap requisite amount of heat for maintaining 5 to 7°C higher temperature than the ambient. In the present study, the minimum temperatures of 17 to 26°C were recorded in the solar kiln during the night against the ambient temperatures of 10 to 22°C. The solar kiln thus kept 4 to 7°C higher temperature than the atmosphere even during the night.

Drying time

It is evident that solar drying was effective throughout the year (Table 2). Timber of different enduse species and dimensions were found to dry from green condition to 12% moisture content. The most favourable season was the winter when solar drying was most rapid. The postwinter and the postmonsoon offered moderate solar drying conditions and thus solar drying was moderately rapid. The unfavourable season was the monsoon when solar drying was significantly slowest among the other seasons (Table 4). Duncan's multiple range tests reveal that solar drying time of the postmonsoon did not differ significantly with those of the postwinter period (Table 5). The reason for the differences in drying times may be directly attributed to the differences in climatological conditions. The winter experienced only 6 to 10 rainy days during the entire period of five months while the monsoon had 44 to 51 rainy days in three months. The high temperature attained during the monsoon could not affect the solar drying time appreciably due to occurrence of fewer number of sunny days. The climatological conditions of the other two seasons were almost identical (Table 1). This is why no significant difference in drying time was noticed between these seasons.

It is apparent from Tables 2 and 4 that solar drying was significantly faster than that of air drying. During the most favourable season, it was observed that 2.5 cm planks took 10 to 26 days in solar drying against the air drying period of 22 to 68 days. The reduction of solar drying time over air drying for this batch of timber was 54 to 62%. During the unfavourable season, the saving of solar drying time over air drying time was even more. It varied between 67 and 71% for 2.5 cm planks and for timbers of other dimensions, it ranged from 65 to 73%. Timber of different dimensions could be solar dried to the desired lower moisture content level during the monsoon while the moisture content below 18% could not be attained in air dried timber even in 154 days. During the postwinter and the post-monsoon seasons, solar drying was 56 to 70% faster than that of air drying.

Conventional steam heated kiln drying was, however, faster than solar drying. The reduction of drying time was recorded to be 33 to 70%. These three drying processes affected drying times significantly (Table 4).

Drying defect

No objectionable drying defect was noticed in any batch of solar dried timber (Table 3). Drying defects like endsplits, surface checks and distortion were observed in severe form in some kiln and air dried timber. The quality of solar dried timber was thus found to be superior to both air and kiln dried timber. This may be due to the fact that during solar drying, timber receives a mild reconditioning treatment every night due to rehumidification (Plumptre 1979). The stresses formed in timber are reduced and thus there is less chance of development of drying degrade. This aspect, however, needs indepth study.

Economic aspects

Solar drying cannot be expected to be as efficient as conventional steam heated kiln drying. But when economic aspects are considered, solar drying seems to be a better technique for seasoning timber in Bangladesh.

The total cost of erection for a 3.5 m^3 capacity solar kiln developed at BFRI is estimated at about Tk 25,000. Conventional imported kilns cost about 40 to 50 times higher than solar kilns. The operating cost of solar kilns is also very low. No constant attendance of skilled operators is needed in solar drying, whereas they are indispensable for a conventional kiln. A considerable amount of energy involving a huge expenditure is required for the supply of steam to the conventional kiln. On the other hand, the solar kiln needs power for running only a motor (186 to 746 w) to drive a fan for 10 hours a day. Taking all these aspects into consideration seasoning cost of timber in a solar kiln is estimated to be Tk 250 per m^3 compared to Tk 1,000 per m^3 in a steam-heated kiln.

CONCLUSIONS

The following conclusions may be drawn from this study :

(i) The climatic conditions of Bangladesh are suitable for operating solar kilns throughout the year. Timber of different dimensions can be dried to a desired lower moisture content level even during the rainy season.

(ii) Solar drying is significantly faster than air drying. The saving of solar drying time is quite appreciable. Conventional kiln drying is, however, faster than solar drying.

(iii) The quality of the solar dried timber is superior to both air and kiln dried timber. The solar dried timber is generally free from any serious drying degrade. This aspect needs, however, investivation.

(iv) Solar drying is more efficient than air drying ; it is a simpler and cheaper drying technique than kiln drying. Thus, solar drying can conveniently be employed for seasoning timber in Bangladesh.

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