SOLAR KILN DRYING OF TIMBERS OF *EUCALYPTUS TERETICORNIS*, *ACACIA NILOTICA* AND *DALBERGIA SISSOO*

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Introduction

Freshly felled timber contains water in the form of moisture normally above its fiber saturation point. Most of this water has to be removed before making a solid wood product from it, in order to obtain satisfactory performance during its use. Seasoning of timber is essentially a drying process as nearly as possible to the moisture content warranting equilibrium with the prevailing atmospheric conditions in service. Using the freely available solar energy as a heat source for seasoning of wood caught the imagination of various workers around the world for a long time now (Chen *et al.,* 1982; Plumptre, 1967; Steinmann *et al.,* 1980, 1981; Tschernitz and Simpson, 1979). Solar kiln for timber drying has already become a useful tool for small scale wood industry. Big wood industries have also started using solar kiln as a pre dryer to steam-heated kiln for economic gain as well as time saving. Though solar drying of timber takes more time in drying the timber to desired moisture content compared to steam–heated kiln drying, the drying cost in solar kiln works out approximately one third of the cost in steam – heated kiln (Pandey *et al.,* 1992). Solar drying of timber is best suited to rural saw millers and small scale handicraft industries whose total selling capacity per month is not more than 250 cft of dried wood. In general, the quality of solar dried wood is better compared to steam-heated kiln dried wood as in solar kiln, wood gets time to release its drying stresses every night. Control on drying stresses is accomplished by conditioning treatments in steam-heated kiln. In India, solar kiln drying of different timber species has been tried by earlier workers also (Sharma *et al.,* 1972 and 1980).

Solar drying of timber is solely dependent on the ambient atmospheric conditions like available temperature and humidity. Drying of timber with same initial moisture content may take different durations during different seasons of a year to reach desired moisture content in a solar kiln. During solar kiln operations, one has control over temperature going beyond desired limit and humidity falling below the desired limit. The attained low temperature inside the solar kiln can not be increased without incorporating additional heating device. Maintaining humidity inside the kiln lower than the ambient without dehumidification pump or other appropriate device is also not possible. These aspects have been tried earlier (Pandey *et al.,* 1984) and the results were found better; however, the cost of kiln and the drying cost of wood in such kilns also increases.

During present study, drying of timber of *Eucalyptus tereticornis, Acacia nilotica* and *Dalbergia sissoo* in a solar kiln was conducted to find out rate of drying and prospective hardening effect, if any.

Material and Methods

The study was carried out using a 125 cft capacity newly developed solar seasoning kiln installed in the premises of the Wood Seasoning Discipline of the Forest Research Institute, Dehradun (Latitude 30°20'N, Longitude 78°04'E). The kiln is having single glass walls and chimney type heat vents in its south facing wall (Upreti *et al.*, 2009). Full capacity kiln runs were carried out using radial sawn 25 mm thick planks of *Eucalyptus tereticornis,* plain sawn 25 mm thick planks of *Acacia nilotica* and plain sawn 25 mm thick planks of *Dalbergia sissoo* separately in the kiln at different times during a year. *E. tereticornis* was dried in the solar kiln from 22nd May to 12th June 2007, *A. nilotica* was dried from 20th September to 8th October 2007 and *D. sissoo* from was dried from 6th November to 28th November 2007. The planks were sawn from the basal logs of the mature trees. The logs were end coated with bitumen paint to avoid end cracks in subsequent drying of planks. Wood stacks were prepared as per standard practice using 25 mm thick spacers. Four end matched kiln samples of 750 mm length were kept inside the stack for assessing the progress of drying on daily basis. During the day time the rising temperature was controlled by venting operations so that it could not rise above the recommended maximum temperature prescribed in seasoning schedules in IS:1141 of 1993 for the species studied. The relative humidity (RH) was maintained to desired levels inside the kiln using spinning disk humidifier. Prong tests and moisture distribution tests were also conducted as per IS: 1141 of 1993 for keeping control on possible drying defects. Moisture contents of kiln samples were calculated by using the method as per IS: 11215 of 1991.

Results and Discussion

The conditions inside a solar kiln are not easily controllable as those inside a steam heated kiln. The temperature inside a solar kiln largely depends on that outside the kiln. The humidity, which also plays an important role in deciding the drying conditions inside the kiln, depends on the humidity outside the kiln as well as the humid conditions contributed by the wood stack inside the kiln. Keeping this in mind, the ambient conditions outside the kiln were monitored on a daily basis in terms of the maximum temperature observed on each day and Relative Humidity at 14 hrs on each day of seasoning for all the three species. The average values are given in Table 1. Figs. 1 and 2 give the actual daily maximum temperatures and RH values (measured at 14 hrs) for the three seasoning periods.

The kiln seasoning schedules recommended for *E. tereticornis* and *D. sissoo* is schedule No. IV wherein the temperature is varied from 42-55 degrees with the RH conditions lying between 39 and 80 %. A look at the Table 1 and Figs. 1 and 2 shows that the seasoning carried out in June on *E. tereticornis* perhaps had the best ambient conditions to control the parameters in the kiln among the three cases. The highest temperature regime during this period showed very little variation. The humidity also maintained low values except for a few days towards the end of the seasoning period. For *A. nilotica*, the RH conditions outside the kiln were the worst. The temperature regime outside kiln for *D. sissoo*, though was low, the humidity conditions were not as tough as during the drying of *A. nilotica*. Thus, as far as the ambient conditions are concerned, the kiln was easier to operate at the applied conditions during the drying of *E. tereticornis*. It is to note that *E. tereticornis*, being class 'A' refractory wood, develops surface cracks, warping and twisting during air-seasoning. By adopting radial sawing method these defects could considerably be reduced (Pandey *et al.*, 1984) and the same sawing technique was used in this experiment also.

By applying schedule IV, it requires about 12-15 days to season wood material from above 60 % initial moisture content (IMC) to 12 % Final Moisture Content (FMC) in a standard steam-heated kiln. In

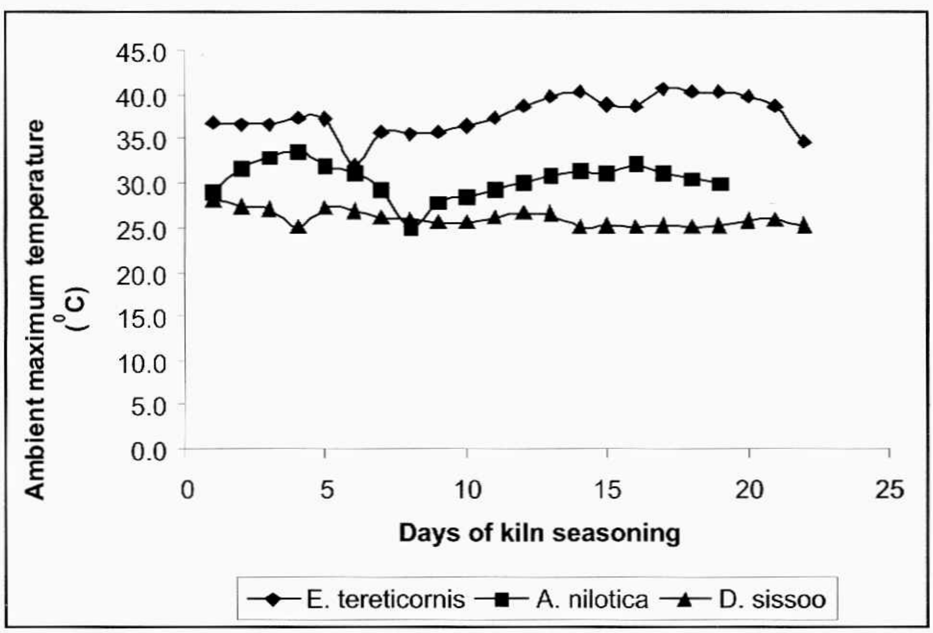
Table 1

Mean values of daily maximum temperature and Relative Humidity at 14 hrs observed on the drying days

Species	Mean Max. temp (°C)	CV (%)	Mean RH at 14 Hrs (%)	CV (%)
E. tereticornis	37.6 (2.2)	5.8	27.5 (12.8)	46.8
A. nilotica	30.4 (2.0)	6.5	56.3 (14.6)	26.0
D. sissoo	26.0 (0.9)	3.5	45.7 (5.2)	11.4

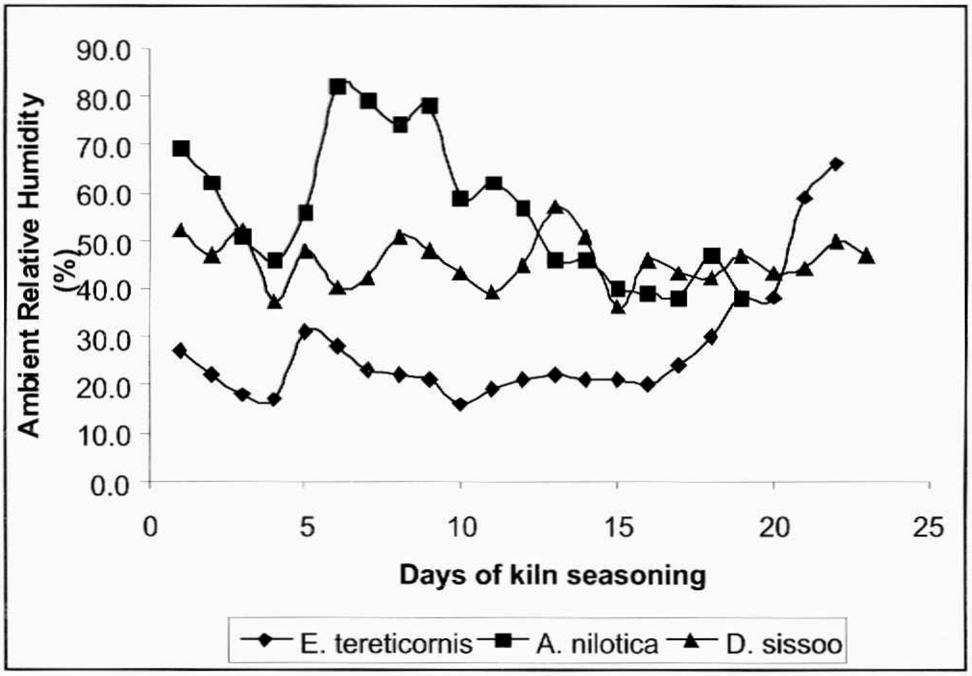
Note: values in parentheses give the standard deviation

Fig. 1



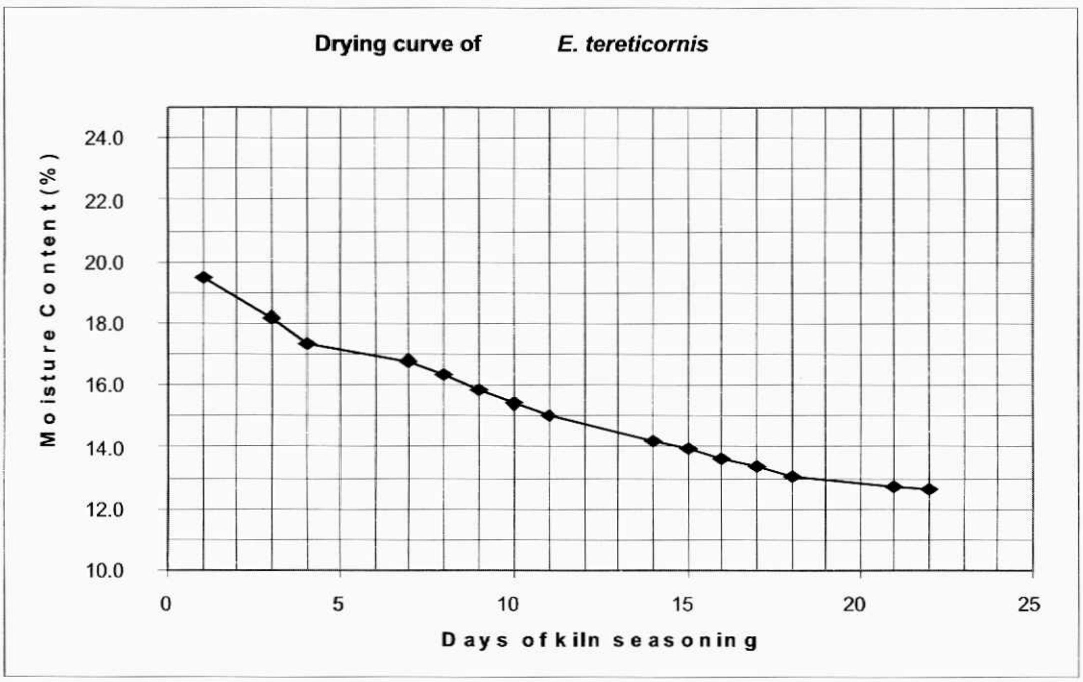
Daily maximum ambient temperatures recorded during seasoning

Fig. 2



Daily RH recorded at 14 Hrs during seasoning

Fig. 3



The solar kiln drying curve of E. tereticornis

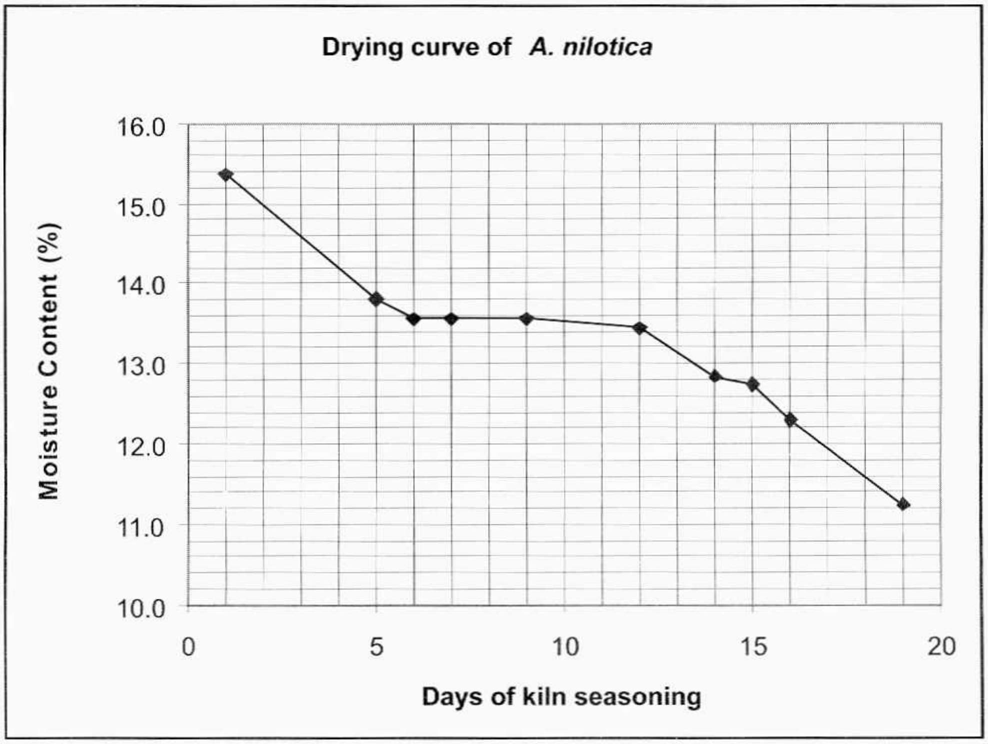
the present study, *E. tereticornis* took nearly 22 days to reach 12 % MC though it started from only 19.5 % MC (Fig. 3). Thus the whole of the drying took place below the Fiber Saturation Point (FSP) which is in the range of 21-25 % for this species found in Punjab and Haryana (Rajput *et al.*, 1992).

However, *D. sissoo* dried from about 40 % IMC to 12 % FMC in 24 days itself in the solar kiln despite having a low temperature profile outside the kiln during the experimental days (Fig. 4).

This is due to the lower refractoriness of this species (Class B) compared to the high refractoriness of *E. tereticornis* (Class A).

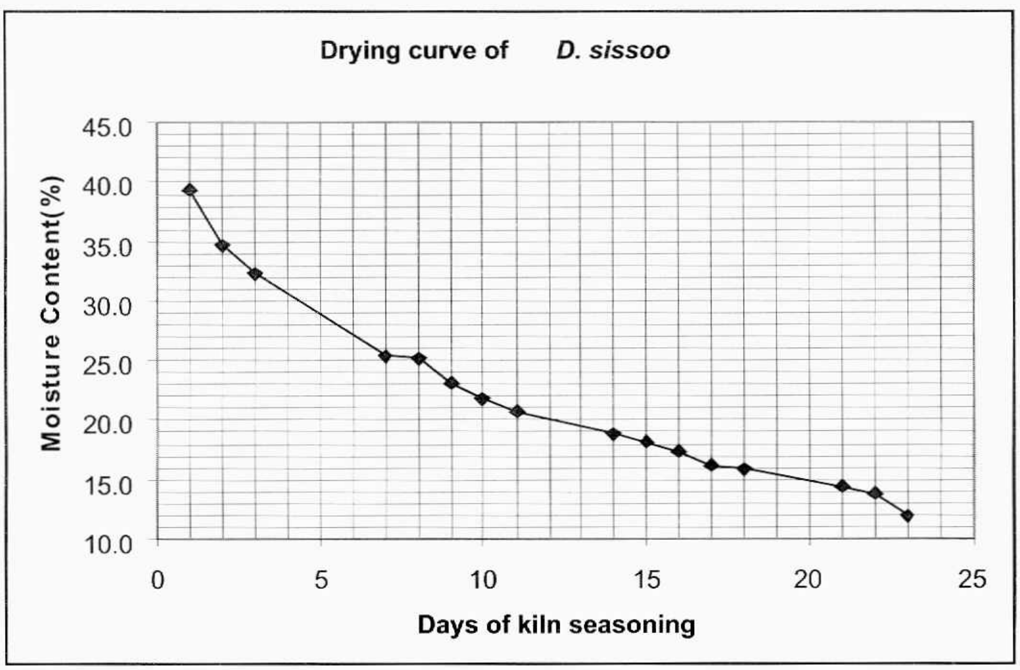
A. nilotica, though a Class B refractory species,

Fig. 4



The solar kiln drying curve of *A. nilotica*

Fig. 5



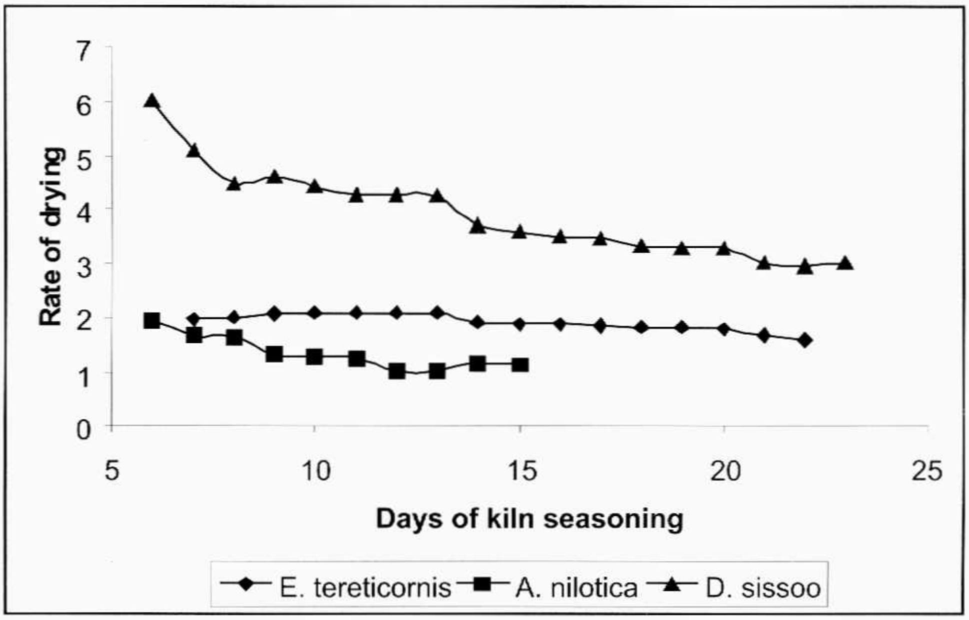
The solar kiln drying curve of *D. sissoo*

is recommended a much slower drying under schedule VI as where it is expected to dry from above 60 % MC to 12 % FMC in about 16 to 20 days in a standard steam-heated kiln. In the present case, it dried from a very low IMC of 15 % to 11.25 % in about 19 days (Fig. 5).

It is to note that both class B species in this study were subjected to seasoning below their FSPs requiring higher energy to release the bound water.

One of the tools to look at the capability of any drying method is to look at the drying rates achieved by the drying stack. Fig. 6 gives the drying rates

Fig. 6



Drying rates

calculated for the three species.

In the present study the drying rates were calculated as percentage reduction in MC compared to the IMC per days of drying. It was seen that the *D. sissoo* samples which started from 40% were losing MC at the rate of 5.9% (compared to IMC) per day after one week of seasoning. Thereafter, this value steadily dropped and approached 3.1 towards the end of seasoning. The other two species, which were already below the FSP, lost moisture at much slower rates. The values were 2.3% and 2% per day respectively for *E. tereticornis* and *A. nilotica* compared to their respective IMCs. These values dropped to 1.7% and 1.3% per day respectively towards the end of their seasoning.

The prong test revealed no visible casehardening for all the three species at the end of the drying experiment. The defects were also under control due to slow drying in the solar kiln as well as the timber gets time to release its drying stresses during every night in a solar kiln.

Conclusion

The study reveals that, even refractory species like *E. tereticornis* could be seasoned below its FSP in a solar kiln. The fact, that no significant degrades were observed, makes this a useful tool in seasoning of refractory and moderately refractory species studied here. Of the three species studied, the moderately refractory wood of *D. sissoo* dried much faster than wood of *E. tereticornis* and *A. nilotica*. The cost of seasoning is obviously going to be much lower compared to the traditional steam heated method in absence of various expensive paraphernalia of the kiln.

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SUMMARY

Solar drying of wood of *Eucalyptus tereticornis, Acacia nilotica* and *Dalbergia sissoo* has been tried in a single glass-walled solar kiln. Of the three species studied, the moderately refractory wood of *D. sissoo* dried much faster than wood of *E. tereticornis* and *A. nilotica*. All the three species dried at the rate of 2-3% per day below their respective fiber saturation points. No visible case hardening could be detected after solar drying in any of the species.

***Key words*:** *Acacia nilotica, Dalbergia sissoo*, Drying rate, *Eucalyptus tereticornis*, solar kiln drying, fibre saturation point.

यूकेलिप्टस टेरेटिकार्निस, अकेसिया नीलोटिका और *डलबर्गिया सिस्सू* की लकड़ियों का सौर अत्पाक में सुखाना

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सारांश

प्रस्तुत अध्ययन में *युकेलिप्टस टेरेटिकार्निस, अकेसिया नीलोटीका* और *डलबर्गिया सिस्सू* की लकड़ियों को एकल कांच-भित्ति वाले सौर आत्पाक में परीक्षाणार्थ सौर सुखई करके देखा गया है। अधीत तीनों वृक्ष जातियों में मध्यम प्रतिरोधी *ड. सिस्सू* की लकड़ी *यु. टेरेटिकार्निस* और *अ. नीलोटिका* की लकड़ियों की तुलना में ज्यादा तेजी से सुखी। इन सभी प्रकाष्ठ जातियों को उनके सम्बन्धित रेशा-संतृप्ति बिन्दुओं से 2-3% प्रतिदिन कम की दरों पर सुखाया गया। इनमें से किसी भी प्रकाष्ठ जाति में सौर सुखाई के बाद ऊपरी स्तर कड़ा हो जाना नहीं दिखाई पड़ा।

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