SOLAR DRYING OF URUGUAYAN RED GUM

Andrés Ono[1], Alejandro Venturino
Forest Products Department
Laboratorio Tecnológico del Uruguay, LATU

Abstract

The use of solar energy as an alternative to non-renewable energy sources has been widely researched in the last decades. Compared to air drying, solar drying kilns can better control the drying process, resulting in a higher quality of the dry wood and lower final wood moisture content values. Investment and running costs for a solar drying kiln are lower than those of a conventional kiln. Moreover, the solar drying process can be advantageous for drying hardwoods which are traditionally considered difficult to dry such as eucalyptus wood of medium and high density (Red gums, known in Spanish as "Eucaliptos colorados"). The solar drying kiln naturally incorporates a daily high relative humidity period that can be similar to a conditioning or steaming step, although at a lower temperature. This results in fewer defects due to the drying process.

A pilot scale 2.5 m3 semi-greenhouse type solar wood drying kiln was constructed at LATU (Uruguay Technological Laboratory) in Montevideo, Uruguay. The operating conditions and the results from two drying runs are presented. Two species of red gum (*Eucalyptus tereticornis* Sm., ADD 870 kg/m3, and *Eucalyptus camaldulensis* Dehnh., ADD 800 kg/m3) were dried from initial average moisture contents (WMC) of around 60% down to 10.0% and 12.7% in 108 days and 76 days, respectively. Boards were provided by the Grupo Forestal San Gregorio from trees harvested at Tacuarembo and Paysandu Departments from cattle shelter forests 60 and 70 years old.

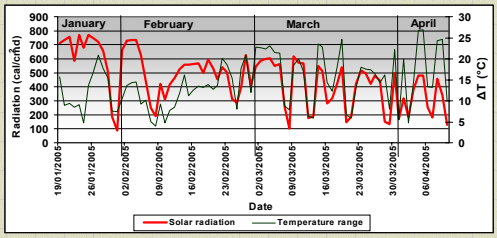
Mean volume shrinkage was 18% for E. tereticornis, and 16% for E. camaldulensis, and the level of defects was moderate. Residual stresses and moisture content gradients were observed for both species. Final moisture content values were similar compared to those obtained in conventional drying kilns but with longer drying periods and lower operating costs. This would make the solar drying process attractive to small and medium sized forest products industries in a small country like Uruguay.

Materials & Methods

- Solar kiln characteristics
  - –Location: 34°54'43" S, 56°04'28" W, 26.7 m o.s.l.
  - –Semi-greenhouse type kiln with PS foam insulation
  - –Clear polycarbonate roofing 24 m^2
  - –2 blowers, ½ HP ea., 60 cm dia
  - –Capacity: 2.5 m^3 of lumber
  - –Collector area to lumber volume ratio: 9.6 m^2/m^3
- Wood stacks
  - *Eucalyptus tereticornis* Sm. ADD 870 kg/m^3
  - *Eucalyptus camaldulensis* Dehn. ADD 800 kg/m^3
  - Cattle shelter forests without management.
  - 140 boards 3.1 m x 125 mm x 40 mm
  - Total weight over stack was 1800 kg (663 kg/m^2)
  - Air velocity was kept below 1 m/s for both runs.

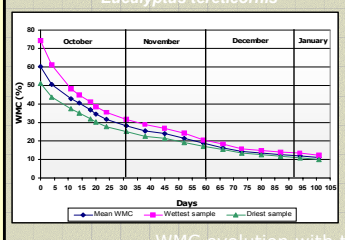
Plantation data

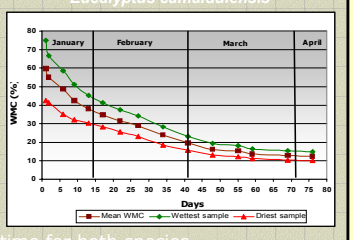
	Eucalyptus tereticornis	*Eucalyptus camaldulensis*
Location	Tacuarembo, Uruguay	Paysandu, Uruguay
Age	60 yrs	70 yrs
Original plantation density	300 trees/ha	300 trees/ha
Total height	25 m	25 m
Processing height	4-6 m	4-6 m
Top dia (w/bark)	45 cm	51 cm
Bottom dia (w/bark)	57 cm	59 cm



Results

Eucalyptus tereticornis *Eucalyptus camaldulensis*





WMC evolution with time for both species

	Mean (°C)		Max. (°C)	
Period	Outdoors	Kiln	Outdoors	Kiln
Eucalyptus tereticornis				
october	15.3	25.1	27.4	33.5
november	17.5	28.5	29.9	47
december	21.2	35.9	32.6	50.9
jan/01-17	24.6	38.7	36.1	54.9
Total period	19.7	32.1	36.1	54.9
Eucalyptus camaldulensis				
jan/17-31	21.3	29.5	36.4	45.0
february	21.5	33.6	31.4	49.6
march	19.4	32.3	33.5	53.0
april/01-11	17.5	29.3	25.8	48.0
Total period	19.9	31.2	36.4	53.0

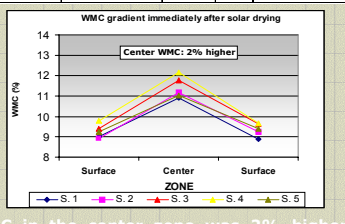
Mean temp. was 12 °C higher inside kiln compared to outdoors.

Time in days required for different values of target WMC

Period	Oct-Jan	Jan-Apr
	Eucalyptus tereticornis	*Eucalyptus camaldulensis*
WMC	Time (days)	
20 %	52	40
15 %	73	58
12 %	90	76
10 %	108	--

DRYING RESULTS

		Startup	End	Vol. shrinkage
Eucalyptus tereticornis	Mean WMC (%)	60.2	9.9	18%
	Std. dev.	7.2	0.5	
	V. coeff. (%)	12	5.1	
	n	7	7	
Eucalyptus camaldulensis	Mean WMC (%)	61.7	13	16%
	Std. dev.	10.9	1.0	
	V. coeff. (%)	17.7	8.1	
	n	8	8	

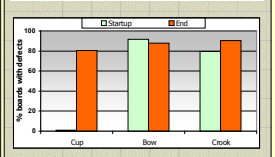


WMC in the center zone was 2% higher than that of the surface.

SUMMARY OF DEFECTS

Eucalyptus tereticornis	Mean defects (mm)	
	Start-up	End
Cup	1.5	1.7
Bow	7.6	6.1
Crook	5.5	7.0
Twist	-	4.8

Eucalyptus camaldulensis	Mean defects (mm)	
	Start-up	End
Cup	1.5	2.8
Bow	7.0	5.9
Crook	7.5	7.5
Twist	3.0	5.4



Boards with defects: E. Tereticornis

Conclusions

- The solar drying kiln was suitable for both species of red gum. Final WMC values were between 10 and 13%. Lower values are limited by the time required.
- Summertime conditions are optimal for this type of drying kiln. Other conditions may require longer drying periods.
- Residual stresses and internal WMC gradients were observed. Conventional drying kiln conditioning steps would be required for an immediate processing of the boards.
- Mean volume contraction values were 18% and 16% for E. tereticornis and E. camaldulensis respectively. Defects levels were moderate.
- Investment and running costs were lower compared to conventional drying kilns. This would make the solar drying process attractive to small and medium sized forest products industries in a small country like Uruguay. Since drying is considered as the bottleneck in capacity, solar drying kilns could be used to supplement wood drying capacity.

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1 aono@latu.org.uy, www.latu.org.uy
Avda. Italia 6201, Montevideo, 11200, URUGUAY