A Homebuilt Solar Kiln for Hardwoods

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Drying Principles for Wood

Wood is dried in a kiln in which the temperature (T) and the relative humidity (RH) can be accurately controlled.

Green(wet) wood is dried at a **low T** and at a **high RH**
As the **wood moisture drops, T is gradually increased** and **RH is reduced**
The **wood moisture** at any drying stage **determines the T and RH** values of the kiln air. See Table 1

Table 1: A Typical hardwood drying schedule

Wood moisture content %	Relative humidity %	Temperature Deg. C
Above 35	86	37
35 to 30	83	37
30 to 25	76	43
25 to 20	62	49
20 to 15	35	54
15 to final	18	65

The **thicker** the wood, the slower will be the drying process eg.
If 25 mm thick wood uses 1 time unit, 100 mm thick wood will require 8 time units.

The higher the wood density, the longer the drying time.

High density hardwood, 200 mm thick can take up to 6 months to dry even in a commercial kiln, which explains the high cost per m^3 of thick, kiln dried wood.

Wood is **hygroscopic**, which means that it absorbs or looses moisture to the surrounding air until it is in equilibrium with the air. This equilibrium changes as the T and the RH of the air changes.

Wood **swells and shrinks** as it adsorbs and releases moisture from/to the air.

Swelling/shrink differs in the 3 anatomical directions and for different wood species [See Table 2]

Table 2: Percentage shrinkage for a change in wood moisture from 30 % to 0%

Wood species	Tangential	Radial	Longitudinal
Karri	12.1%	7.9%	0.24%
Kiaat	3.6%	2.1%	0.23%

Conclusion:

Wood drying in a conventional kiln is a complicated process that:

- Must be done carefully to avoid damage to the wood
- Requires accurate control of the drying conditions
- Requires good understanding of the process
- Requires expensive equipment
- Requires a lot of time.

Solar Kiln Drying is much less complicated and expensive and only takes about 20% longer than conventional drying!

Principles of Solar Kiln Drying

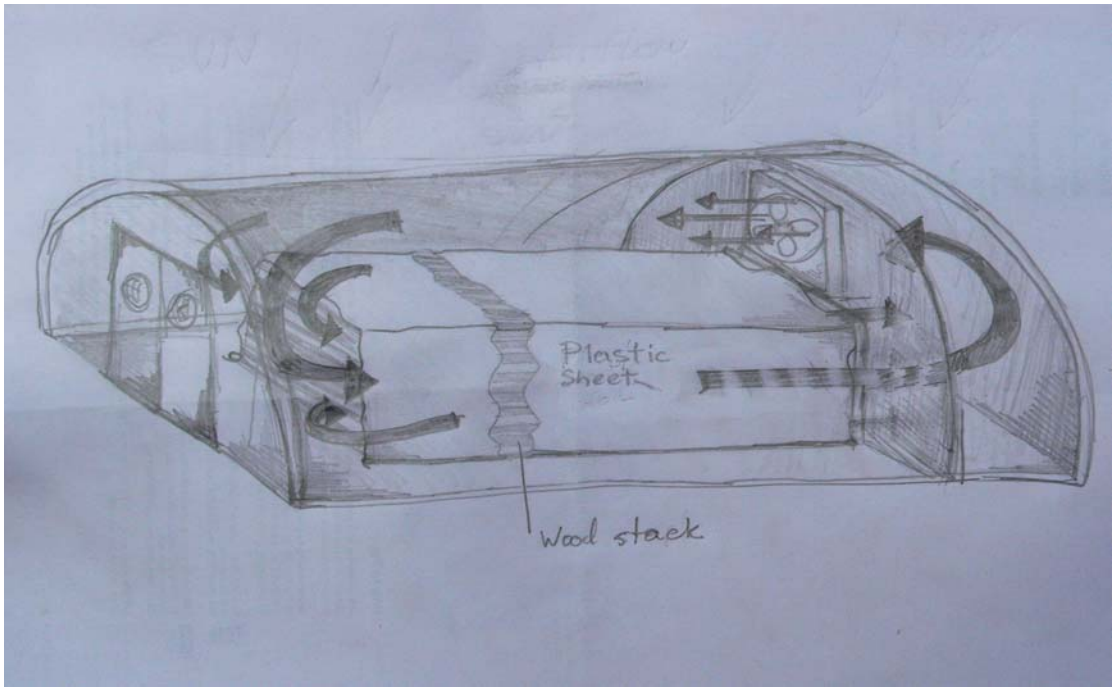


Fig. 1: Typical layout of a solar kiln showing the airflow pattern.

Wood is stacked in a **double skinned** solar kiln with **transparent** roof and walls

The **wood is covered** to protect it from direct sunshine (**Fig. 1**)

The **sun heats** the inside of the kiln and the air

The warm kiln air is **circulated** by a fan through the **wood stack** to heat it. (**Fig. 2**)

Fig. 2: Fan mounted in (transparent) fan wall above wood stacks

The wood **releases its moisture** into the kiln air

A small blower blows **this moist air** into the space between the two skins and back into the kiln via vent holes in the inner skin. (**Fig. 3**)

Fig. 3 Interior of a solar kiln during loading. The small blower (top left) and a feed back vent hole under table can be seen.

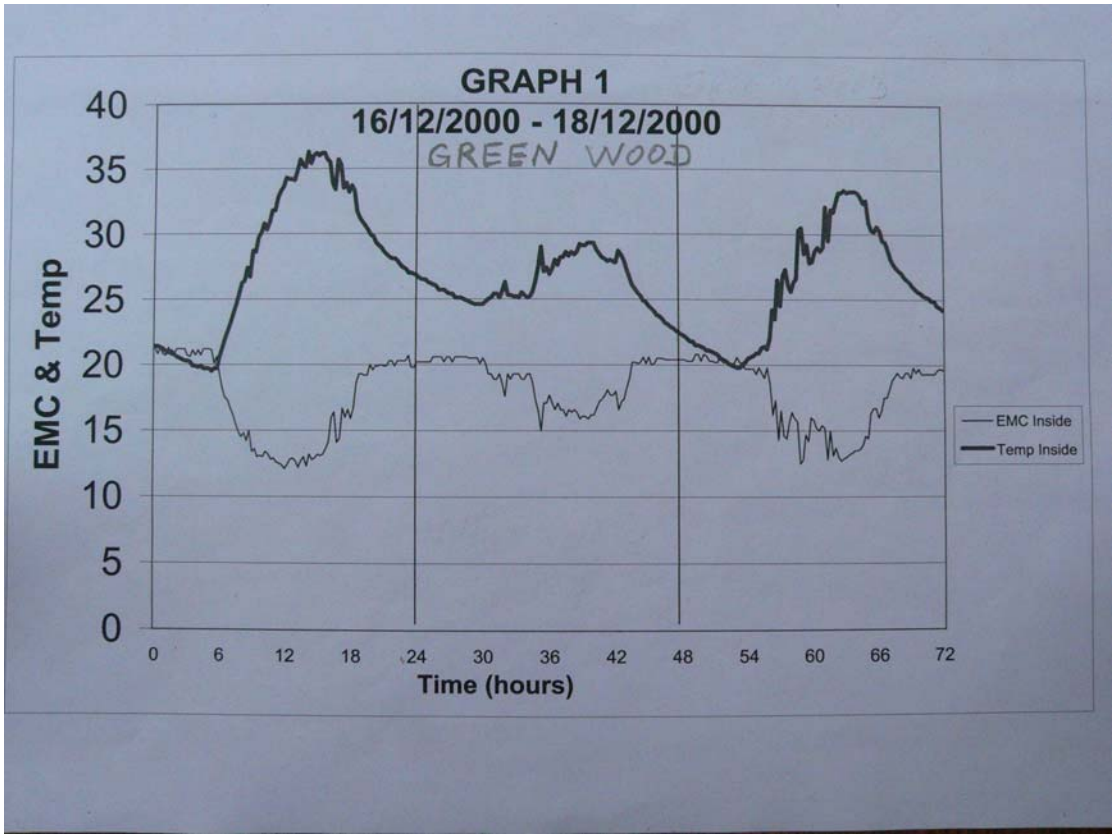
When the temperature outside the kiln drops below the **dew point** of the kiln air, the **moisture condenses** on the inside of the outer skin

This **condensate collects** between the skins and is drained through **weep holes** to the outside of the kiln.

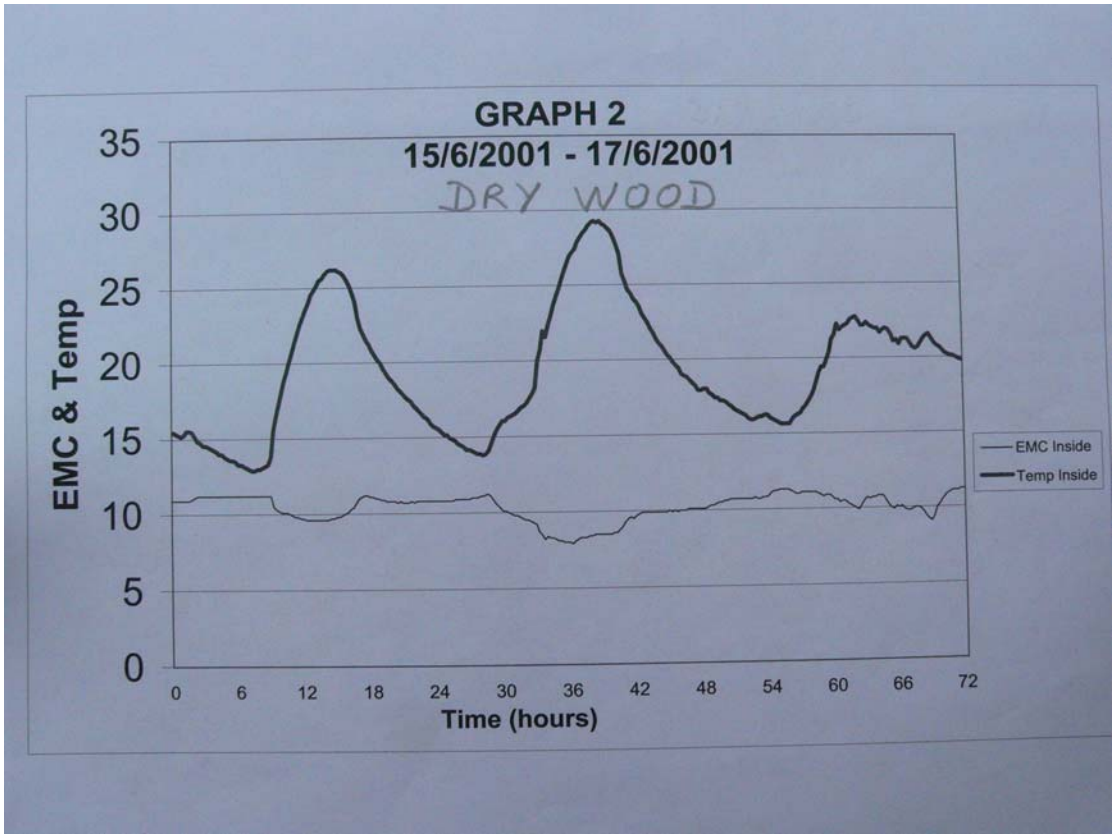
The above process removes the water from the wood and releases it outside the kiln

This process repeats itself in **day/night cycles.**

As the wood dries, the **drying process slows down and** the rate of moisture loss from the wood decreases and therefore the **RH in the kiln decreases.**
At the same time less energy is used to evaporate the water and the kiln **temperature increases. These conditions agree with the drying schedule in Table 1.**
(Compare Graphs 1 and 2)
Note that Graph 1 was recorded for a *green* load of wood in *summer* and Graph 2 for the same load of dry wood in *winter.*
The lower, thinner line. marked as EMC represents the moisture content of the kiln air. The average EMC of 10 % in Graph 2 means that the wood in the kiln can dry to as low as 10% moisture content under these circumstances if given enough time.



Graph 1: Temperature and equilibrium moisture content (EMC) inside a kiln just after loading with green wood in summer



Graph 2: Temperature and equilibrium moisture content (EMC) inside the kiln with the same load after 6 months of drying in winter.

Conclusion

A solar kiln will automatically create safe drying conditions without a control system or a drying schedule! The drying process is controlled by the moisture left in the wood at any time.

Note
The initial drying temperatures for thick hardwoods should be kept below **35 deg. C** until the wood moisture has dropped below 30%. Use **shade cloth** to reduce the solar radiation on the kiln during this period.

The construction of a Solar Kiln

The kiln floor should be level, sturdy and dry even during the rainy season. Drain water away from the kiln. Use a sheet of plastic as a moisture barrier against ground moisture and use a layer of bricks to lift the floor 50 to 100 mm above ground level.

Framework of wood or pipe is made to a suitable **size** to accommodate the stack of wood you intend to dry and allow for air circulation.
[See Fig 1 for a typical kiln layout]

A **tunnel shape** is recommended for easy construction.

Cover both ends of the tunnel with any material. Allow for a **door** to load the kiln.

Cover top and sides with a **double layer** of ultra violet stabelized transparent plastic sheet **sealed** all around its 4 edges

Ensure that the kiln air can **not leak** out of the kiln**!!**

Stack the wood in the kiln in such a way that an electric fan can blow the kiln air through the stack. **Baffle the stack** to the fan to ensure that no air by-passes the stack. An air speed through the stack of **1,5 m/sec** is sufficient.

Fit a **small blower** fan (50- 150 watt) to the inside of the kiln structure and use a suitable air duct to blow the air between the two skins of the kiln at a point near the top of the kiln and about halfway along its length. (Fig 3)

Cut **vent holes** through the **inner skin** of the kiln, about 200 mm above ground level and at 2 metre spacing all along both sides of the kiln. These vent holes are required to feed the air from the small blower back into the kiln.
NB Make these holes small enough to allow a slight pressure build-up between the two skins to keep them apart when the blower is running.

Drying wood in the kiln

1 Stack the wood in the kiln allowing for uniform airflow around each piece of wood.

2 Use stickers/spacers of uniform thickness to separate boards

3 Cover the top and two sides of the stack with a heavy tarpaulin or black plastic sheet and extend the sheet to form a tunnel into which the fan can blow to force all its air through the stack

Fig. 4 Tarpaulin over stack with ends of stack open to allow airflow. Fan just visible above stack

4 Close the kiln and start the fan and blower.

5 Use a maximum/minimum thermometer to measure the max/min temperatures in the kiln during the first 24 hour periods. If temperatures rise above 35 degrees C, cover the kiln with a suitable shade cloth to reduce the maximum temperature to below 35 deg. C for as long as the wood is still above 30 % moisture content (mc). A suspended shade cloth not lying on the kiln cover will be more effective than one thrown over the kiln.

As soon as all the wood is below 30% mc (moisture meter), the shade cloth can be removed to allow higher kiln temperatures. The wood is now able to handle these temperatures.

Do NOT vent the kiln to reduce temperatures as this will upset the kiln climate!!

6 During those times of the day/night that condensation can be detected between the two skins of the kiln, the blower **must** be running (if not running continuously).

7 A day or two after starting a new kiln for the first time, check where the condensate is collecting between the two skins. At these points puncture the OUTER skin only with a sharp pencil to create a “weeping” hole that will drain the condensate away from the kiln.

8 Remove the wood when dry and put a new load in. Repeat the above 6 steps.

Notes

Drying time ?? You need a wood moisture meter to measure the moisture content of the wood and determine if it is dry.
As a very rough guide: 38 mm thick ironwood boards required 4 months at Stormsriver to reach 12% moisture content.

Mixing of wood species is allowed. "Over drying" is very unlikely but the less dense pieces will take a shorter time to dry, so it is better to have a moisture meter to check when these pieces are ready to use.

Adding "green" wood to a partially dried load will retard the drying of the partially dried load and may expose the "green" wood to too high temperatures and too low humidities at that stage. This practice is not recommended.

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