Timbersoft Hybrid Kiln - moving towards more production orientated "eco friendly" drying

With an increased focus on global warming, and the carbon footprint left by industry, We decided in 2012 to harness our 50+ years of combined timber drying and automation experience to develop a more environmentally friendly kiln. Following intense research, we developed a unique South Africa first "production oriented" green kiln, the *Timbersoft Hybrid* Kiln (TH Kiln) – utilising a combination of solar heating, heat pump technology, dehumidification and conventional venting.

A lot of time was spend reading up on research done and solar kilns designs by numerous universities and individuals across the globe. This lead to the building of a small drier, basically resembling the Appalachian kiln, but only 1.2m wide x 1.2m long with a roof sloping at 33 Degrees with 7 x 12V DC panel fans for air circulation. This was connected a PLC with numerous probes to check and plot internal and external conditions as well as controlling powered vents for extracting moist air. The biggest lesson from this was how quickly the temperatures dropped when the sun disappeared behind the clouds. The temperature drop would be as high as 15 degrees C within minutes, and as much as 50% within 10 minutes. We also saw that surface temperatures on the black outer ceiling would go up to 98 Deg C on hot days.

We decided to look at water as an energy storage medium to try and smooth out temperature fluctuation. 16mm Irrigation pipes were used, laid flat on the outer ceiling with water circulating through it. The water reached temperatures well in excess of 80 Deg C and would only drop slowly, and by a few degrees when the sun disappeared.

A decision was made to put all gained knowledge to the test, and the full size kiln was build in Knysna, Western Cape, South Africa.

Kiln Specs and construction

The kiln's dimension is 6.1m long taking 2 x 3.0m long, 1.8m wide and 2.0m high stacks. 34 Layers boards are separated by 25mm stickers, spaced 600mm apart taking the volume up to just over 9 cubic meters .

The structure is 38 x 76mm CCA treated boards with 18mm treated plywood cladding outside and 6mm plywood cladding inside. The void is filled with normal 50mm household insulation wool (Isotherm) All the sheet joins were sealed with roof sealing strips and the building given 2 layers of roof sealer paint inside and outside.

Heating:

The solar collector is 6m x 4.8m black surface, angled at 34 Degrees facing North, with 58 x 4.6m, 16mm plack plastic irrigation pipes between 2 x 50mm diameter steel pipes headers, covered with polycarbon clear IBR roof sheets. Inside the slanted roof is a 500liter plastic container, with a 10000liter per hour, class H circulation pump that can handle fluids up to 130 Deg C. We initially had 4 x 4 kW geyser elements in the tank to try and maintain temperature at night, but abandoned the idea due to the elements not keeping up, and using a lot of electricty.

Energy transfer from water to air goes through 2 x 2.8m x 600mm industrial hot water heat exchangers

An industrial Heat pump was installed to assist at night, and when ambient temperatures dropped.

Further we installed a compressor to actuate the vents, and operate circulation valves that would direct the water flow through the solar collector ->storage tank-> heat exchanger when solar collector temperature is high enough, and change the flow to heat pump->storage tank -> heat exchangers when the solar collector cannot keep up.

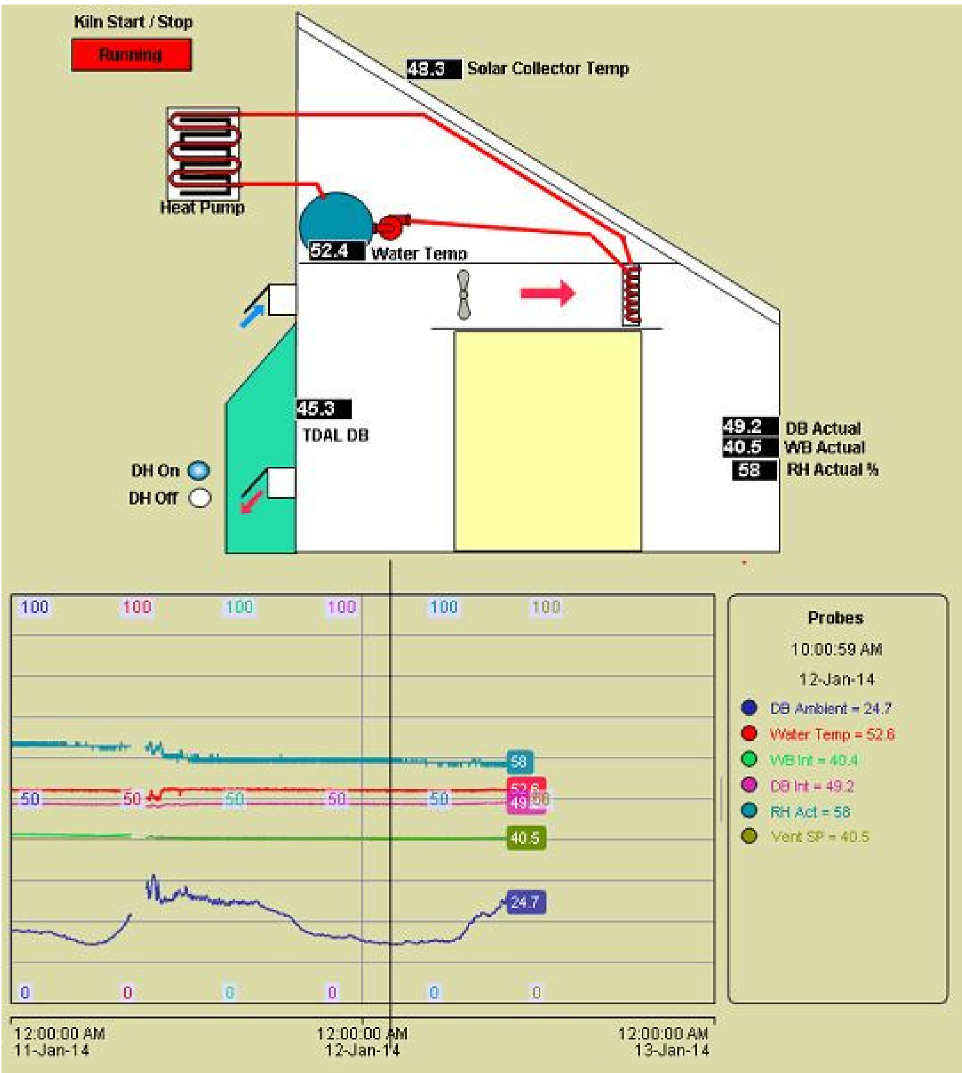
We bought a second hand Westair 180l/24hr Industrial Dehumidifier which was also installed to operate at night/bad weather days, so that energy is not lost through venting. The heating element on the DH is disabled to conserve energy.

Air circulation:

Having "green" in mind, and up to 300 hours of sunshine per month in Knysna, we thought we could harness solar electricity to run the circulation fans. We opted to use 10x 0.1 kW plate mounted circulations fans, each able to deliver 3100m^3/hr without resistance. We installed 1.3 kW of solar panels feeding a 60 amp solar regulator, charging a bank of deep cycle batteries. This in turn went through a 1.3 kW inverter to power the 220V single phase motors. Having made some calculation errors and relooking the air flow, we scrapped the whole solar power idea, as the electricity savings, vs. cost to implement vs. having used smaller fans and consequent very low air speeds…..just did not make sense.

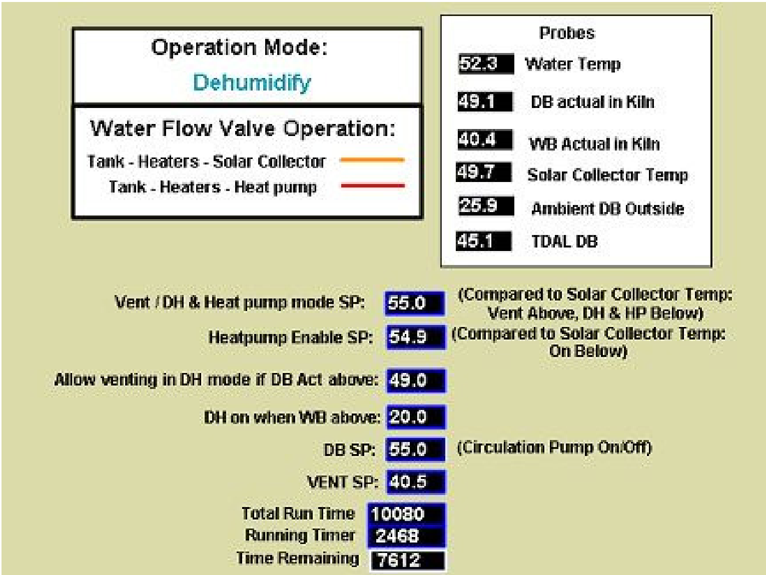
Control:

The whole process is controlled from a PLC and monitored on a SCADA system. Set points controls water circulation route, humidity control through venting or dehumidification or both and heat pump operation.

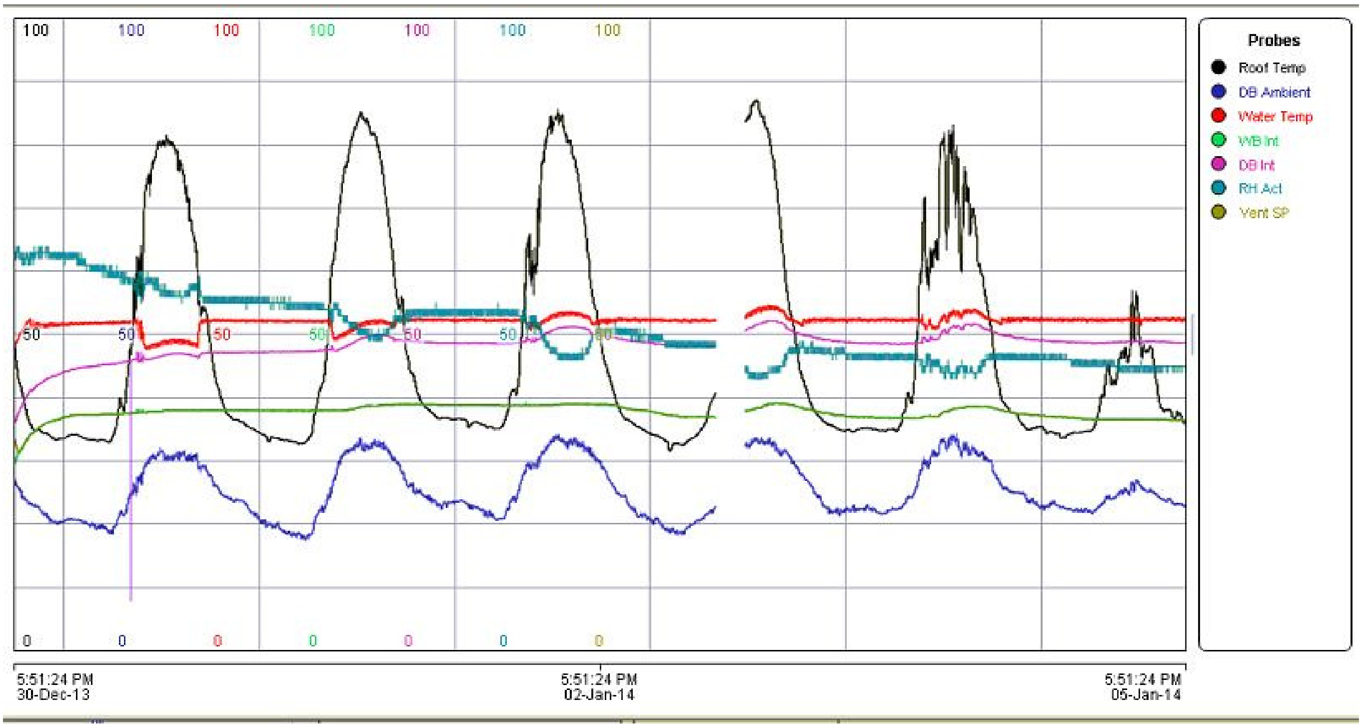


Basic view of control interface

The drying schedule is self adjusting, with the depression being increased by 0.1 deg C increments as the timber gets drier.



Operation Mode, All probe temperatures and Set points



Graph showing 6 days logged data. Note how RH% constantly decreases (light blue line) When RH % is constantly below 40%, we start checking the MC to see if timber is dry

Electricity Consumption:

With only 1.3kW of power being drawn on a 24/7 basis, and the Heat pump and DH units only effectively running approximately 8 hours a day, actual consumption varies around 40-50 kW hours per day

Drying results:

We are currently on the 6th batch, and still implement changes and improvements as we go along. The first batch we dried was Eucalyptus diversicolor, and took 17 days to dry. We are currently down to 9 days on the E.diversicolor and 7 days on Acacia melanoxylon. Notable is that the quality of the timber coming out the kiln is very good.

The test and figures, done on E.diversicolor was not obtained very scientifically, and should not be seen in that light. We will be re-doing the test with the help of Wood technology students from the Nelson Mandela Metropolitan University early 2014.

On the very first batch we measured and weighed 18 sample boards, marked and measured all defects before and after drying.The sample boards were placed, 9 on each stack, 4 on each side of the stack at even intervals from the second layer at the bottom, to the second layer from the top. The ninth board was in the centre of each stack. Moisture content averaged wet, 73% with wettest 111% and driest 43 %(calculated from initial weight, end weight and average final moisture content at 6 intervals along the length of each board) Dry average was 6%, with the driest not moving the needle on the moisture meter and the wettest 12%.

66 Existing splits and checks were measured on the sample boards before drying. Of these 66 splits, only 17 increased in size, the rest remained unchanged. The average size increase for the split/check was 12.3mm or 8.1%. 7 of the sample boards developed isolated surface checks and only one developed a new end split

On boards containing pith, cell collapse occurred. None of the boards were cross cut to check for honey combing.

The feedback from the client, who manufactures school desks were: “The wood is very stable when ripping and planing. No pinching the blades or opening when ripping (stress inside the planks). No problems like immediate resin built-up on blades or shaving extraction built-up in pipes when planing through the thicknesser and moulder”

We learned a lot form the first kiln, with the second kiln already on the drawing board with a lot of improvements planned.