

CnC Kilns :
A Breakthrough Technology
for
Amateur Mirror Making

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CnC kilns : breakthrough technology

What is a CnC kiln ???

A chimera of commercially produced hardware that is pressed into associated service to produce a temperature controlled volume friendly to making / annealing telescope mirrors.

kiln + computer + thermal feedback sensor +
controller + heat schedule

=

precise, repeatable thermal environment

CnC kilns : breakthrough technology

- Kiln, oven, furnace, or thermal cycling box of some kind
- Source of regulated energy :
 - 120 vac x 30 amps for small kiln
 - 240 vac x 30 to 100 amps for large kilns
 - Gas, natural or propane in very large tanks
- Digital Controller and CnC controlling program
- High amperage SSR (or other) digital controlled switches
- Type K thermal couples and type K lead wire
- Kiln shelves / kiln furniture / shelf paper
- IR thermometer (sometimes called a pyro-meter)
- Fire suppression and detection equipment

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12" (internal) hex Paragon Hi-Fire kiln (sitting on a 16" kiln) adapted for CnC operations with off the shelf components. All the individual components are available from EBAY.com

This kiln can reach 2200 degrees F (max) and will follow its program to within 2 deg F.

Care must be taken not to exceed the ramp up / down rate of the kiln.



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Kiln : Glass anneals between 900 and 1100 degrees. Slumping starts at 1100. Home made (DIY) kilns and commercial units can get this hot. Glass will foam between 2000 and 2200 F. Buy commercial if you are going that hot.



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Kilns : There are no end of new and used commercial kilns for sale on Ebay / Craigs list. Find a local one and buy it cheap.

Even if the controller or coils don't work, you can replace the coils for \$30 with aftermarket ones. You will be bypassing the controls with your CnC controller so that part of the kiln does not have to work.

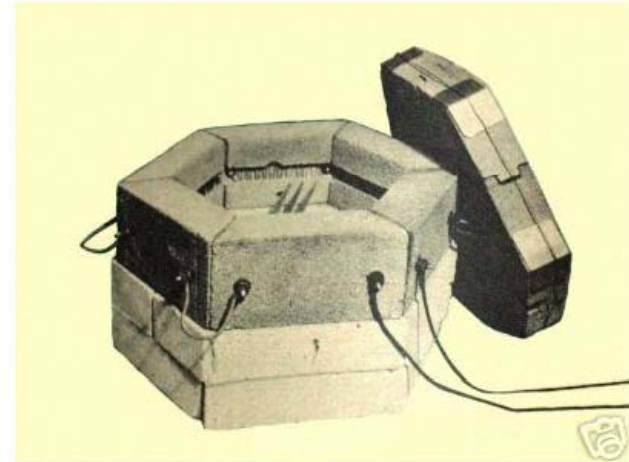
This example could be separated to make a much lower height kiln more suited for mirrors and have a spare hot section. Replacement parts : Kiln / Furnace heating element, Kanthal A1 wire, 3220W (\$15 USD)



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Kiln : It appears you can buy plans on ebay “SMALL CERAMIC KILN for home or metal clay: Plans” for about \$10.

Or you can start with kiln “extender sections” and put kiln brick under and over the section to make a single zone kiln. This is how you can make a wide and low kiln. You can use white play sand for the bottom and ceramic insulation for the top.



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Or you can build your own: The floor can be white play sand, crushed rock Mason's sand, vermiculite or Perlite but it can not contain anything combustible. The frame must be metal or block. Fired clay bricks and tiles can be used inside the kiln.

<http://www.youtube.com/watch?v=9VAU2yKKBus>



The sand above was white to start but got rust mixed in as the metal frame heated and rusted over the many times it was used. There is a bit of clay in the sand to hold it in the rough block form.

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Side walls made of washed Alumina fiber matt (2" to 4" thick. This is "not" the fiberglass stuff you see in your attic. PPG foamglas is only good to 900 deg F.

<http://www.rsifibre.com/products/ceramic-fiber-blanket.php>



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You can make the roof out of Alumina fiber. Metal framing is used to hold up the fiber. The coils can be sewn into the walls or the roof.



The heating coils can be sewn onto the roof or walls with Nichrome safety wire or quartz thread.

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It is real easy to have a bad day at 1450 deg F.

Take care to use stainless steel when ever you can to carry current near the hot box.

Copper wire's resistance goes up very fast when it gets hot.



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- Digital Controller, CnC programmable

These run \$30 to \$100 USD and often come with SSR's, TC probes and wiring as package deals. Your controlling software must be compatible with your controller.



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Example Controller capabilities :

Control : 1) PID Control (including On/Off, position PID & continuous PID) 2) Auto setting control Temperature range 32 ~ 2912 °F (0 ~1600 °C) / 752 ~ 3272 °F (400 ~ 1800 °C) - depends on input type.

Display : - Process value (PV) - Setting value (SV): -1999 ~ +1999 - Output (Out1 , Out2) - Alarm (ALM1 , ALM2) - Auto setting (AT) - Display: LED

Input : - Thermocouple (TC) - RTD

Standard current & voltage signals Accuracy : Measurement: $\pm 0.5\%$ FS

Compensation error of cold terminal: $\pm 2\%$ (amend with 0~50 °C by soft)

Resolution: 14bit

Sampling period: 0.5s

Setting range

Setting value (SV): same range with PV

Proportional band/time (P): 0 ~full range (On/Off control when set to 0)

Integration time (I): 0~3600 sec (no integral action when set to 0)

Derivative time (D): 0~3600 sec (no derivative action when set to 0)

Proportional period: 1 ~100 sec

On/Off control output hysteretic loop width: 1~100 °C (or other PV units)

Control Output

- Voltage impulse output (applicable for Solid State Relay, SSR). * Out1= SSR (heating side).

Working Power : 85 – 245V AC, 50 – 60 Hz

Other Parameters

1) Insulation resistance: $>50\text{m}\Omega$ (500V DC)

2) Insulation strength: 1500V AC/min

3) Power Consumption: $<10\text{V}$

4) Service environment: 0~50 °C, 30~85RH, no corrosive gas

Outline Dimension : 48 x 48 x 100 mm

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- High amperage SSR (or other) digital controlled switch. This is a 25 amp example. It is about \$8 (new) and would run a small kiln. You need one of these for 120 VAC or two (40 amp) for 220 VAC switching. They get hot so need heat sinks.

Load voltage	24 - 240V AC
Load current	25A
Control voltage	3-32V DC
Control current	6-25 mA

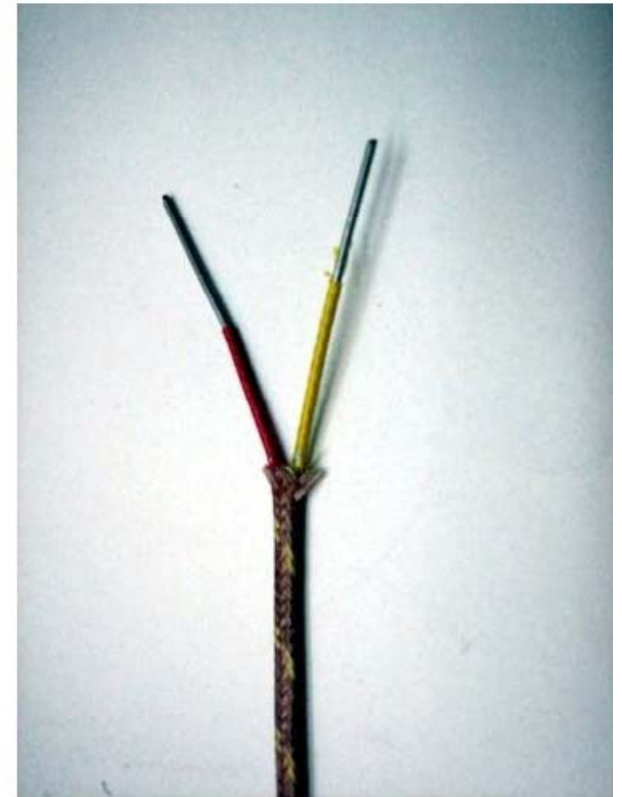


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Type K thermal couples and type K lead wire. You need the high temp ceramic shielded version : \$20 to \$60. Do not use “any old” wire to get back to the controller.



Use Type K thermal couple wire. It is about \$ 1 / foot.



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Kiln shelves and furniture. www.sheffield-pottery.com

CORELITE KILN SHELVES

LIGHTER:

- LESS BACK STRAIN AND FATIGUE
- LOWER FIRING COSTS
- LOWER SHIPPING COST

FLATTER:

- EACH SHELF IS GROUND TOP AND BOTTOM FOR PERFECT FLATNESS
- WARE KEEPS ITS SHAPE WHILE FIRING, ESPECIALLY TILE

STRONGER:

- LESS WARPAGE
- LESS LIKELY TO PROPAGATE CRACKS THRU CORES
- MORE FIRING CYCLES

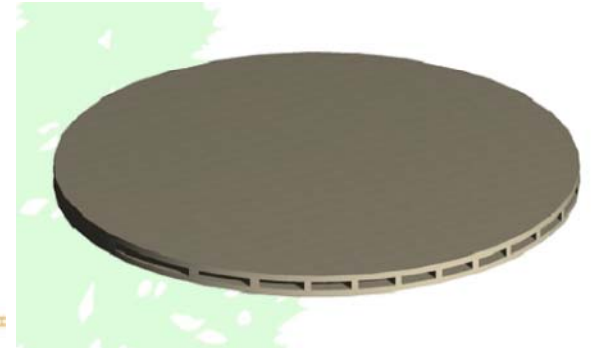


ABOVE, BOTH SHELVES ARE 3" X 10", THE SOLID SHELF IS 3/4" THICK WHILE THE HOLLOW *CORELITE* SHELF IS 7/8", YET THE *CORELITE* SHELF IS **24% LIGHTER**

LIGHTER • FLATTER • STRONGER



A general furniture assortment.



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IR thermometer (sometimes called a pyro-meter) run \$10 to \$50 on ebay. The inexpensive ones only go up to 700 F. Get one that can read to 2300 deg F if you can find it.



CnC kilns : breakthrough technology

Kiln Shelf Paper : This stuff is magic. Glass will not stick to your shelf if you use it. It turns to white dust in the heat cycle.

Thinfire Kiln Shelf Paper

16 - 5" x 5" pieces BULLSEYE THINFIRE KILN SHELF PAPER

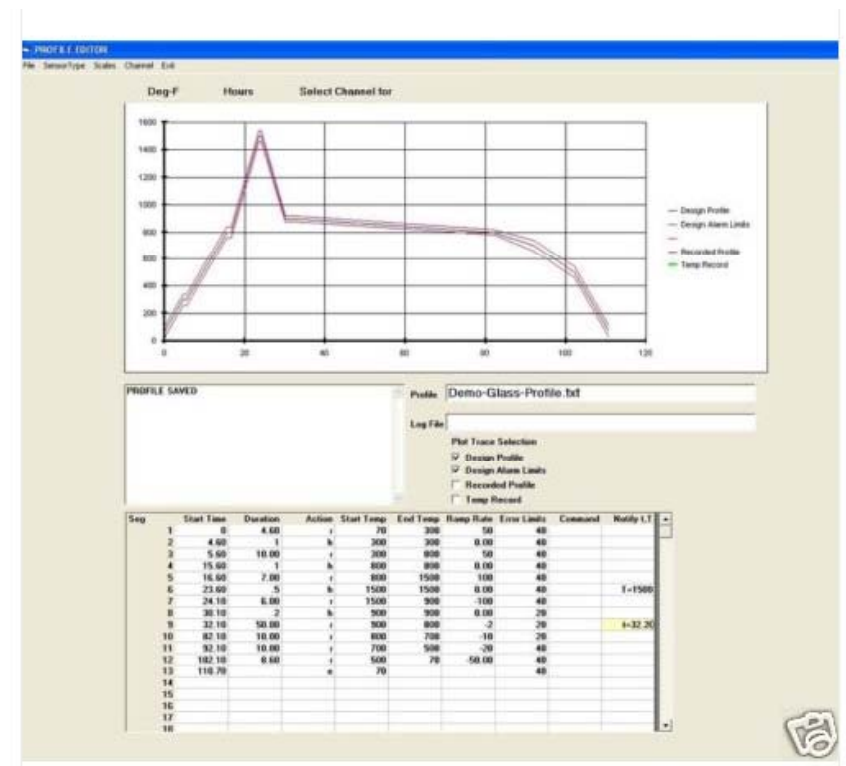
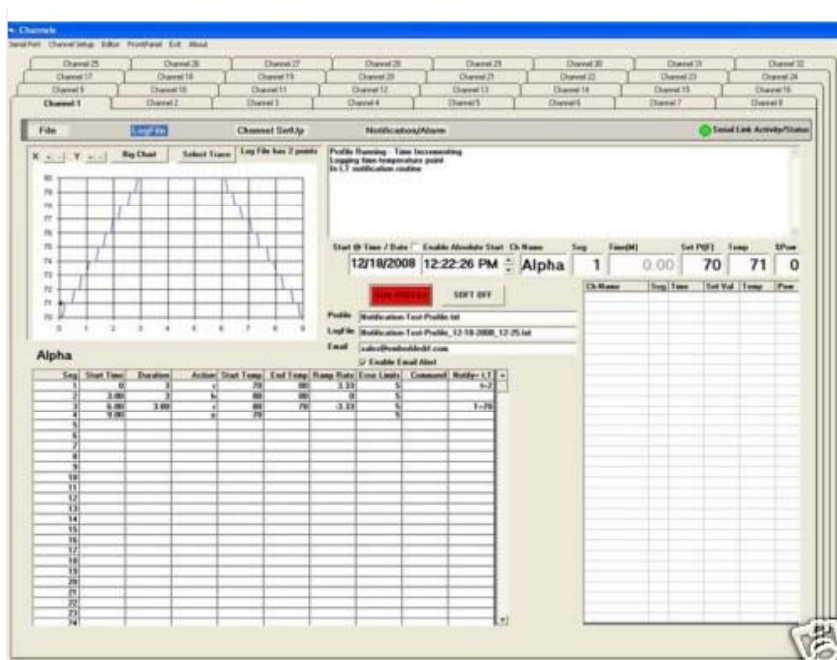
A heat-resistant light weight ceramic impregnated paper. Thin Fire shelf paper provides excellent separation between kiln shelf and glass in kiln firing applications up to 1,600 degrees. When compared to more conventional ceramic fiber materials: glossier finish on the shelf side of your finished project, less binder burnout odor, and lighter weight for easier handling and storage. Compared to kiln washes, ThinFire reduces shelf preparation time and improves surface release qualities. On firing, ThinFire disintegrates to a dusty tissue. Wear a respirator during disposal. If possible, clean shelves with a HEPA vacuum.



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Controlling program : Commercial versions available.

<http://www.embeddedrf.com/> A few years ago the single input system was \$125. This program is very good at controlling a one zone kiln.



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Controlling program : <http://www.embeddedrf.com/>

It appears that Fred now offers a full (multi zone) kit for kiln automation on ebay for around \$425. This is a very good option for kiln conversion to CnC mode.



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Microwave powered Kilns : This could be the future
No clue on how you would control this.

