

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

About Thermal Technology LLC

Thermal Technology enjoys a long and well-respected history in manufacturing many forms of high temperature processing technologies. The primary product lines (Brew and Astro) date back to the 1940s and 1960s respectively, and include Laboratory Furnaces, Hot Presses, Fiber Drawing Systems, Vacuum Furnaces, Arc Furnaces, and Production Furnaces. We routinely engineer and build high quality, custom equipment to satisfy challenging applications. With our background in industrial equipment for light to heavy duty applications, all our products are built to last decades of constant operation. To date, Thermal Technology has over 3000 systems in the field with over 65% of our sales to repeat customers, which speaks volumes about our ability to maintain quality, reliability, and ongoing customer support. Our products are all proudly made in the USA.

Thermal Technology's approach to Direct Current Sintering (DCS) technology

In 2008, when Thermal Technology started building Spark Plasma Sintering (SPS aka FAST) furnace technology, it was never our intention to simply build equipment that matched current systems in the market. It was important that we provide serious ingenuity and substantial advancement to the state-of-the-art from day one. This was well-accomplished and Thermal Technology enjoyed immediate success in the SPS world market with over 50 systems currently in service, and we plan to continue this success with the Direct Current Sintering (DCS) product line. Newly designed from the ground up after extensive development of critical components to achieve peak performance in a compact package. The DCS 200 series furnace is designed from the beginning for industrial production of both large parts (>8"/200mm diameter) and high part-count tooling systems that require significant force and power.

Direct current sintering is based around a compact and powerful high current DC power supply designed to provide smooth continuous and pulsed DC power. Thermal Technology committed a great deal of time and resources on the design of our power supplies, relying on decades of experience in the resistance heating industry. A primary focus is on a durable and flexible power supply that can deliver consistent power at high current levels allowing for precise closed loop temperature control. In regards to longevity, our DCS power supplies use robust state-of-the-art electronic systems that are based on proven technologies that have been continuously operating in industry for decades.

The other primary component of the DCS process is force supplied by the hydraulic load train. In drawing on Thermal Technology's rich experience in hydraulics engineering, we have applied an advanced digital control process to our DCS technology. Precise force control benefits the DCS process in two ways. First, the DCS prioritizes force control during operation, thus, as the material expands or contracts, the target force is always maintained. Second, during processing of materials, by either diffusion bonding or sintering when accurate control over both high and low load situations is required, the DCS maintains precise control across the entire spectrum of force. To complement the advanced hydraulics, the DCS features a 4-column load frame design to ensure minimal deflection during pressing thereby providing precise and accurate alignment.

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

For system control, the DCS uses the high performance Eurotherm programmable process controllers. These controllers integrates process control using intuitive set-point programming with data recording to manage critical aspects of the machine performance. The Eurotherm manages closed-loop temperature management and controls pressure control via an integrated high-speed motion controller and system load cell. This controller setup allows the user unprecedented access to configure the automated sequencing and machine behavior, allowing complete hands off operation. Critical machine data can be displayed live and recorded data may be accessed via USB, SD card or remotely via Ethernet.

Finally, in maintaining Thermal Technology's reputation for quality and long-term reliability, we designed every aspect of our DCS product line with toughness in mind. Critical components are tested far beyond their operational limits to ensure long-term and trouble-free operation. We design our equipment with both the new user and experienced operator in mind to provide the best user experience possible. When designing the system including the frame, hydraulics, vacuum systems, controls and other components we select high quality materials and components for the application to make equipment that will last a lifetime.

Engineering and Field Support

From Thermal Technology's long history in materials processing from a myriad of processing techniques, our continuous internal SPS/DCS sample development experience, and close ties with numerous academic institutions, we offer world class applications support to our clientele. It is our intention to be our client's first resource for applications and material processing support. Our engineering team and on-site research and development lab is available to provide technical support to our customers to deliver the best possible results from their equipment.

SPECIFICATIONS

MODEL DCS 200-40

1.0 SYSTEM GENERAL SPECIFICATIONS

- 1.1 Front loading, rectangular chamber.
- 1.2 Inside chamber dimensions 26" (66cm) wide x 26" (66cm) deep x 33" (84cm) high.
- 1.3 Maximum operating temperature: 2500°C (dependent on tooling design, size, and material). Recommendation: Use Pyrometer when operating above 1000°C.
- 1.4 Ultimate Vacuum Level: 10^{-3} torr range. Pump down time ~10 min to 2×10^{-2} Torr. (Clean, dry, empty, and outgassed chamber at room temperature.)
- 1.5 Process Gasses Used:
Argon, Nitrogen, or Helium 1 psig (controlled by relief valve).
Hydrogen compatibility as an optional upgrade.
- 1.6 Maximum Pressing Capability: 250 metric tons (2,450 kN), total force.

2.0 CHAMBER ASSEMBLY

- 2.1 Front loading, rectangular shaped chamber constructed of grade 304 stainless steel with welded body and flange construction to provide a corrosion resistant chamber assembly.
- 2.2 Chamber walls are constructed with double-wall baffled design to provide efficient and thorough cooling for the chamber.
- 2.3 The chamber is vertically mounted in a four post press frame.
- 2.4 Front door is aluminum with integral water-cooling passages.
- 2.5 Door encompasses the entire front wall of the chamber and is hinged to allow a minimum 108° opening position to aid operator access for loading and unloading.
- 2.6 The door is secured with automatic hydraulic-operated clamps.
- 2.7 Exterior finish is painted light grey (RAL7035).
- 2.8 Principal elastomer seals are Viton.
- 2.9 One (1) Ø 2" (50mm) inside diameter sight window.

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

- 2.10 Single port for standard mechanical vacuum pump with roots-type blower.
- 2.11 Auxiliary port available for high vacuum pump, or additional process sensors.
- 2.12 Chamber is internally lit for easy tooling handling.

3.0 POWER SUPPLY

- 3.1 Controllable 40,000 amp 0-12 VDC compact water cooled power supply.
- 3.2 Continuous DC current output, 0 – 40,000 amps.
- 3.3 *Option: Pulsed DC with a peak applied current of 40,000A
Off time: 0-100ms
On time: 2-100ms*
- 3.4 Voltage and current data capture and display.

4.0 VACUUM SYSTEM

- 4.1 Standard: Pfeiffer Model WD 400 Roots Pump Unit, 470 m³/hr (153 cfm) volume flow rate. This dual pump system includes OKTA 500 A Roots Pump and DUO 65 Rotary Vane Pump, Oil Mist Filter, Oil Return, and Safety Valve.
- 4.2 One (1) electro-pneumatically operated roughing valve.
- 4.3 Water cooled spool pieces, O-rings, seals, supports and miscellaneous hardware.
- 4.4 Integrated vacuum leak check port and valve.
- 4.5 Available options:
High performance package: Pfeiffer Model WD 900 Pumping Station: Duo 125 rotary vane pump with Okta 1000A roots blower, 1,050 m³/hr (618 cfm) volumetric flow rate. Pump system includes Rotary Vane Pump, Roots Blower, Oil Mist Filter, and Oil Return.

Particle/vapor trap: Two stage water cooled combination vapor and particle trap consisting of water cooled stainless mesh elements and 5um particulate filters to improve pump lifetime

High vacuum package: Turbomolecular pump or diffusion pump to achieve a high vacuum processing environment.

THERMAL TECHNOLOGY

HIGH TEMPERATURE EXPERTS

5.0 PROCESS GAS SYSTEM

- 5.1 The inert gas control includes a panel-mounted flow meter, a solenoid actuated isolation valve and a compound pressure gauge. All appropriate inter-component connection plumbing is provided. (Static, purge or flowing gas).
- 5.2 Gas system valves: solenoid & relief valves are panel mounted.
- 5.3 Available options:
Combustible gas system: necessary equipment and interlocks to safely operate in a combustible gas atmosphere such as Hydrogen (H₂).

6.0 WATER DISTRIBUTION SYSTEM

- 6.1 Safety flow interlock sensors on critical water circuits – protection in low-flow and no-flow conditions in addition to over-temperature warnings.
- 6.2 Stainless Steel Water manifolds, one for supply and one for return.
- 6.3 Manual valves for isolation and flow adjustment of water circuits.
- 6.4 Blue color inlet hoses, Red Outlet water hoses.

7.0 CONTROLS AND INSTRUMENTATION

- 7.1 Main controls are mounted in a control panel to the left of the chamber and pivots for convenient viewing during tooling setup.
- 7.2 Furnace controls are all centralized for ease of operation.
- 7.3 Eurotherm based programmable process controller.
- 7.4 Ram position read out is captured, recorded, and displayed on the HMI. Position resolution <20µm.
- 7.5 Standard TC:
 - Four (4) Type K control thermocouples with protective flexible sheaths (max 1000°C). One is for control, three are available for data collection.
 - One (1) Type K over-temp thermocouple for the rams.
- 7.5 Available options:
Survey thermocouple option: Eight (8) available thermocouple channels with one being available for control. Designed for applications where simultaneous multi-channel data logging is required. Additional control channels of different thermocouple types available in addition to mixed thermocouple types.

THERMAL TECHNOLOGY

HIGH TEMPERATURE EXPERTS

NOTE: Alternative types of thermocouples are available based on specific applications, operating temperatures, atmospheres and tooling material(s); it is the buyer's responsibility to ensure proper TC selection. Alternative TCs are available at additional cost dependent upon the type and configuration required.

7.6 Data acquisition provided with Control System:

- Force
- Z-axis (ram) position
- Temperature
- Vacuum (chamber pressure)
- Voltage
- Amperage

7.7 Optical Pyrometer and Slide

- Infrared one color optical pyrometer.
- Useful range: 350°C to 2500°C
- Video output to display monitor for targeting.
- Toggle switch for vertical pyro movement to ease in tooling set-up.
- Automatic pyrometer position tracking during run.
- Window assembly with LED chamber lighting.

8.0 HYDRAULIC PRESS SYSTEM FOR 200 TON OPERATION

8.1 250 metric ton (2,450 kN), four (4) rigid-post and platen load frame.

8.2 One (1) hydraulic cylinder, top mounted 12" (30.5 cm) stroke, 30" (76.2 cm) clearance height between rams (fully retracted) with position resolution to <0.020mm and typical force control to +/- 11.4 kgf (25 lbf).

8.3 Hydraulic power supply includes pump, oil reservoir, filter, relief valve, and oil cooler.

8.4 Directional proportional valve control for programmed pressure control operation.

8.5 Pressure gauge for visually monitoring system pressure.

8.6 Water-cooled rams with user replaceable face plates.

8.7 Bellows seal on upper cold ram and static seal on lower cold ram.

9.0 DOCUMENTATION (ENGLISH)

One (1) soft copy (USB) of the Thermal Technology operating instruction manual and maintenance/replacement components manual, installation drawings and complete set of component operating manuals are supplied.

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

- 10.0 UTILITY REQUIREMENTS (customer supplies the following):
- 10.1 380-480 V, 3 Phase, 50-60 Hz, ~800kVA (1,000A @ 480V) service single point connection to system's disconnecting device. Amperage dependent on final configuration.
** CUSTOMER MUST SPECIFY VOLTAGE REQUIREMENTS AT TIME OF ORDER, STANDARD 480V 60Hz.
 - 10.2 Cooling water minimum flow 100 gpm with maximum inlet pressure of 45 psi and minimum differential pressure of 25 psi (if inlet pressure is 45 psi, outlet pressure cannot exceed 20 psi). Inlet temperature 80°F (27°C) maximum (with temperature rise of 10°F (5.6°C) at 45 psig and 100 gpm.) Water must be pre-filtered to equivalent of 20 mesh or better to minimize contamination and minerals. Water over pressure safety valve set at 50 psi is provided (customer to plumb to drain).
 - 10.3 Following are water purification recommendations for maximum equipment longevity:
 - 10.3.1 Total Hardness (as CaCO₃): 100 - 200 ppm.
 - 10.3.2 Chloride (as NaCl): 100 - 200 ppm.
 - 10.3.3 Bacteria: <500,000 colonies per culture.
 - 10.3.4 pH: 7.0 – 7.4.
 - 10.3.5 Total Dissolved Solids (TDS): 500 -1000 ppm.
 - 10.3.6 Total Suspended Solids (TSS): Minimum 20 mesh or better filter.
 - 10.4 Compressed air at 80 to 100 psig, dry filtered per ISO 8573.1 class 3.
 - 10.5 Inert Process Gases. Regulated supply to 40 psig. Max operational chamber pressure, 1 psig.
 - 10.6 Approximate required area for furnace system: 10' wide x 10' deep x 15' high (3 m x 3 m x 4.6 m) (Does not include door swings and/or clearance for access.)
 - 10.7 Customer is responsible for external exhaust ventilation including compliance with applicable codes.

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

12.0 GENERAL NOTES

1. The furnace system is factory tested to indicate no leaks with a helium mass-spectrometer measuring $<1.0 \times 10^{-8}$ atm. std. cc/second helium sensitivity at a chamber pressure of < 50 millitorr.
2. Each furnace is fully assembled and tested at the factory. Customers are welcome to visit and observe the testing results.
3. Detailed component specifications are available for any specific item or the entire assembly upon request.
4. Unless otherwise specified, Thermal Technology reserves the right to substitute items, models, or sizes of components of equal intrinsic value.
5. The customer is responsible for the installation of the equipment in accordance with the assembly and installation instructions provided by Thermal Technology.
6. It is highly recommended that the customer installs an emergency back-up water cooling system (20psi/ 50gpm).

THERMAL TECHNOLOGY

H I G H T E M P E R A T U R E E X P E R T S

