PRODUCT PROFILE: Transparent Tube Furnace

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Users can visually check how their process is reacting at operating temperatures through the use of a transparent tube furnace.

In the fall of 2001, Thermcraft acquired technology enabling the development of a transparent tube furnace that allows users to visually check how their process is reacting while at operating temperatures. From initial limited sizes, Thermcraft has developed this technology into the Trans Temp product line, with sizes ranging up to 8 in. (inside diameter) by 40 in. (long) heated lengths.

Innovative Design

The furnace consists of three glass tubes and a coaxially mounted, specially designed heating coil. The outer tube is Pyrex that has been coated with a non-toxic material. The coating is transparent to certain visible light wavelengths, allowing them to pass through while acting as a mirror and reflecting a high percentage of generated infrared energy back into the process chamber. The efficiency of this coating allows for high process temperatures (up to 1100°C) with relatively low outer tube temperatures. Other than hard refractory end plates that support the tubes, the furnace contains no insulation.

The second tube, which serves to protect the mirror coating from contamination, is quartz and is transparent to both visible wavelengths and infrared energy. The third tube, also quartz, is the actual process tube and serves to isolate the heater coils from the product being heated. Like the second tube, this process tube (or muffle) is also transparent to both visual and infrared wavelengths and typically extends some distance beyond the refractory end plates to facilitate loading of the product.

Benefits

In a conventionally insulated furnace employing either packed or porous insulation, temperature uniformity is generally limited to the central third of the heated chamber. Outside this area, the temperature drops off rapidly due to heat being lost out of the ends of the process tube. In the Trans Temp design, repeated reflection of infrared energy by the mirror occurs across the entire length of the heated chamber. The mirror coating is applied in accordance with exacting standards of thickness, yielding very uniform radial heat losses. With a properly designed heater coil and plugged ends, a Trans Temp furnace can produce a temperature uniformity of ±1°C over the center 60% of the heated chamber under steady state conditions.

The furnace's heating element consists of an insulated metallic heating alloy formed into a series of fixed coils. The coil lengths, which include spacing between the coils coupled with turn-to-turn spacing of the various coils, determine the temperature uniformity of the heating chamber and can also be used to provide a thermal gradient. Due to the nature of the furnace's construction and its theory of operation, programmed thermal gradients can be rather difficult to obtain, mainly due to the uniformity of the reflected infrared energy.

Zoning can be approximated through heater coil spacing and design. If true independent zoning and control is required, individual furnaces with common end plate supports and a common process tube can be used. This joining of individual furnaces has been successful when applications have required process tube lengths greater than those that are commercially available, or when unsupported span restrictions come into play.

The furnace design also features a low thermal mass, which allows for rapid heat up and cool down of the heating chamber. A typical design with a center process tube inner diameter of 2.5 in. with a heated chamber of about 20 in. long can be expected to reach 1000°C in about 15 minutes and will cool to 600°C in approximately 10 minutes. (Process tube loading, the material being heated and the efficiency of the end cap seals can have a bearing on these numbers.)

A frequently overlooked benefit of this style of furnace, in comparison to a conventionally insulated furnace, is its inherent cleanliness. The hard refractory material of the tube support end plates is non-dusting in nature, which leaves the client-supplied or specified end caps (if required) as the sole source of refractory dust during operation. Subsequently, the furnace is well suited for use in clean room applications and requires very little, if any, modification for fairly stringent part per million (ppm) contamination requirements.

Operation

The furnace can be operated either in a vertical or horizontal orientation (mounting direction is specified prior to delivery). An integral mounting plate is provided as part of the furnace to allow the unit to be bolted to the user's fixtures. If desired, custom mounting and support structures can also be provided.

Temperature measurement for the Trans Temp furnace is achieved either by use of an optical pyrometer or a standard thermocouple inserted from one of the process tube ends. When using optical pyrometers, it may be necessary to run calibration tests to allow for any offset between the heater coil temperature and the actual sample temperature. Due to the stable resistance characteristics of the heating alloy used to manufacture the coils, a simple power supply that uses a phase angle fired SCR can be used and is typically mounted remotely from the furnace.

Various inert atmospheres, including nitrogen or argon, can be introduced into the center process tube through the use of specially designed end caps. (When using other atmospheres, such as forming gases, the customer should contact the factory for additional information.) Since the center process tube is generally quartz, care must be taken to insure that the gases do not interact with the glass and cause etching or the formation of an opaque coating. Similarly, in applications where volatiles may be present, some venting is required since any condensation forming on the process tube will interfere with the proper transfer of infrared energy. Either condition will have an adverse effect on the operation of the furnace and could hamper visual inspection of the process.

Increasing Applications

When originally developed, the Trans Temp line was mainly used as a research tool for university laboratories and corporate research centers. It is still widely used in these fields for applications including ceramics, crystal growth, glass development, gas analysis, environmental product development and metallurgy. With the larger sizes now available, the product line has branched out into production applications, such as wire

annealing. Fiber conditioning is another application currently being investigated.

For more information about the transparent tube furnace, contact Thermcraft Inc., P.O. Box 12037, 3950 Overdale Rd., Winston-Salem, N.C. 27117; (336) 784-4800; fax (336) 784-0634; e-mail info@thermcraftinc.com ; or visit http://www.thermcraft.com .