

Heaters



There are three primary energy sources for heating plastic sheet in thermoforming. Electric heat is used more than gas heat or hot fluid heat. Some common heating sources include hot air, hot water or steam, sun lamps, nichrome spiral wire or toaster wire, steel rod heaters, steel or nichrome tape, tungsten and halogen tube heaters, quartz tube heaters with nichrome or tungsten wire or tape, steel plates with embedded resistance wire, ceramic plates with embedded resistance wire, ceramic bricks with embedded resistance wire, steel plates that reradiate combustion energy from gas flame, indirect gas combustion on catalytic beds and direct gas combustion energy. Keep in mind that all hot surfaces transfer energy by conduction, convection and radiation.

Hot Fluid Heating

Recirculating hot air or forced convection ovens are used when heating times are not critical or when sheet is very thick, usually greater than 0.500 inches. There are several oven designs in use. Air is blown across metal coils and then across the sheet in indirect electric ovens. Electric panels, usually in the top of the oven, are combined with fan-circulated air in direct electric ovens. Architectural products such as commercial or industrial skylights, soaking tubs and whirlpools are frequently made using these methods of heating. Direct gas-fired heaters similar to those used in rotational molding ovens, are used to heat plastics such as polyethylene that are not easily oxidized or chemically attacked by combustion products.

Direct Contact Heating

Direct contact heating is used extensively for very thin sheet or thermally sensitive polymers. For a very short time, the sheet is brought in contact with a heated PTFE-coated metal plate. It is then quickly formed against the mold. Direct contact heating is a common heating method in form, fill and seal (FFS) machines, where the sheet may be heated sequentially on both sides, by running it against heated rolls. Oriented Pet such as Mylar (tm), oriented polystyrene (OPS), nylon 6, 66 and 11, some calendered PVC, and cast polyimide such as Kapton (tm) are heated using direct contact heating.

Electric Heaters

Electric heaters can be categorized as *round heaters*, such as wire, rod or quartz heaters, and *flat heaters* such as panel heaters. Metal rod heaters have long heat-up times, tend

to age quickly, have poor temperature control, cannot be easily zoned, but are extremely rugged and relatively inexpensive. Quartz and halogen heaters are basically nichrome or tungsten wires in quartz glass tubes. These heaters are known for their very short heat-up times, excellent temperature control, and very high temperature capability, but they are very fragile, the glass is easily etched, and they are very expensive. Panel heaters include coated metal plates that reradiate heat from nichrome wires embedded in ceramic, quartz glass and quartz cloth plates that transmit heat from similarly embedded nichrome wires. Panel heaters have moderately long heat-up times, good temperature control, and excellent longevity, but they are difficult to zone effectively. Ceramic bricks that have embedded heating wires are reasonably rugged, have moderate heat-up times, excellent temperature control and moderate longevity, but they are fragile and it is difficult to determine burn-out.

Combustion Heating

The "2000 Years of Thermoforming" cartoon on the 1996 SPE Thermoforming Division tee-shirt depicted a caveman stomping on a sheet of plastic suspended over a roaring fire. Direct gas heating using natural gas or propane rather than wood is a viable way of heating plastic. However the energy output from direct combustion is very high and sheet scorching or ignition is always a concern. Indirect catalytic heaters provide a more uniform energy source, although energy output is admittedly less than that for electric heaters, and, until recently, temperature control was "on-off." Installation cost is higher than that for electric heaters, but energy costs are as low as 20% of that for equivalent output electric heaters. Catalyst longevity was problematical early on, but fourth generation catalysts appear to have minimized loss in efficiency and formation of hot spots. High pressure indirect gas combustors known as ported surface burners are currently being tested as an alternative to the high-energy electric heaters.

Selection of the "Correct" Heater

There is no "correct" heater. Heater selection depends on many intrinsic and extrinsic factors including retrofitting, sheet geometric characteristics including thickness, polymer thermal sensitivity, day-to-day running costs, maintenance costs, initial installation cost, versatility of the heater, and the inherent design of the thermoforming machine and its surroundings.

Keywords: Electric heat, gas heat, fluid heat, direct contact heat, nichrome, tungsten, quartz, halogen, catalytic heater

