MACHINE DESIGN

Lean, green heating machines

Induction systems give instant-on heat for lean soldering and brazing operations.

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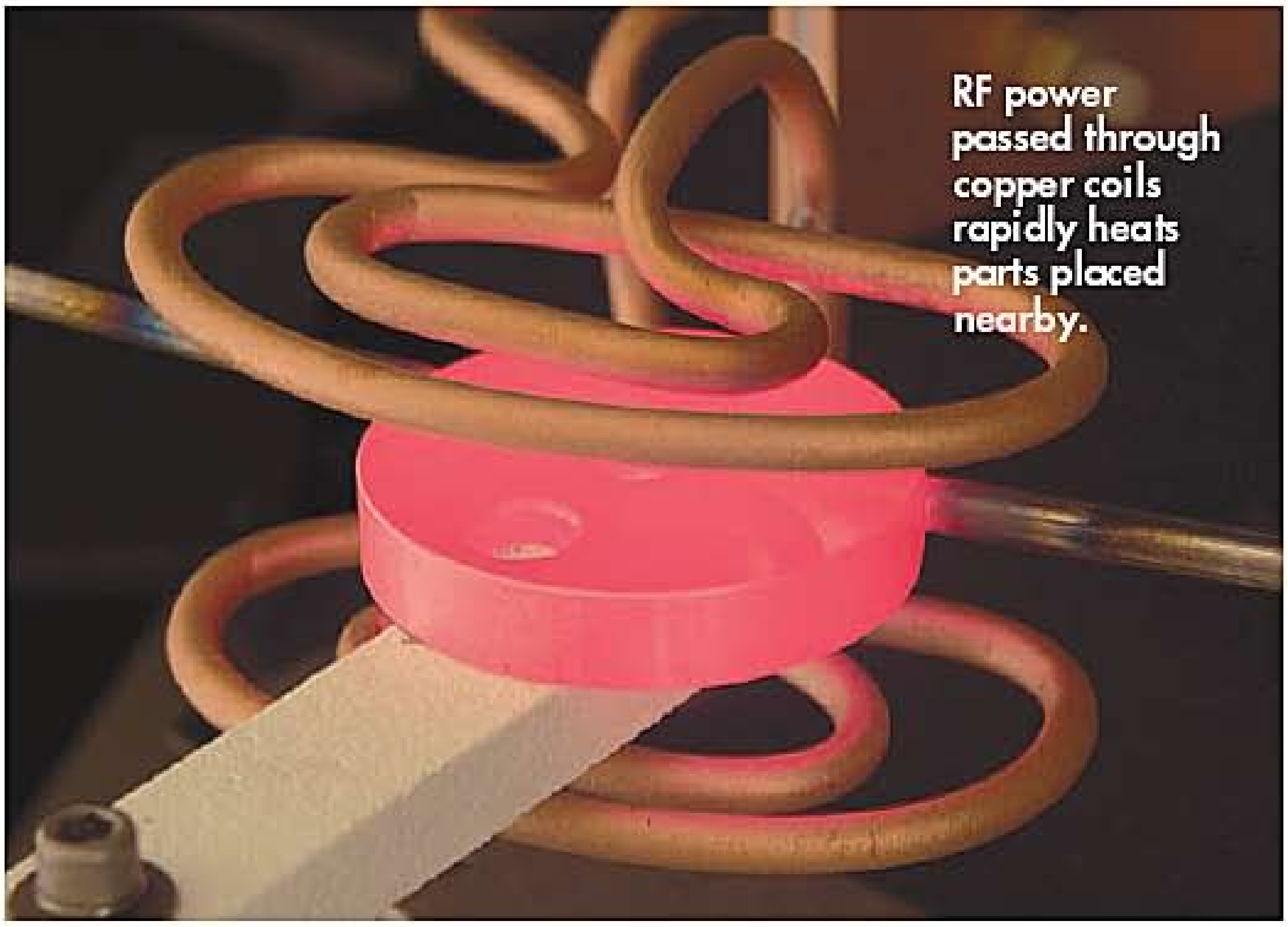

RF power passed through copper coils rapidly heats parts placed nearby.

Furnace brazing and soldering typically takes place in batch or continuous-belt processes. But these processes don't mesh with lean manufacturing operations that group production machinery into cells and dedicate it to making similar items or parts families. Most cells simply lack floor space for the large-sized furnaces. Further, such furnaces rely on relatively slow convection and radiation mechanisms to heat parts, which may disrupt lean, continuous workflow.

Induction systems, in contrast, can heat parts to temperatures of 2,000°F in less than 1 sec. A footprint as small as 2 × 4 ft lets the equipment reside in cells near cold or hot-forming machines, eliminating remote furnaces. Closed-loop control of temperature permits ramp-up, hold, and ramp-down rates on a part-by-part basis. And process data can be recorded for each part, options not possible in batch processing.

Energy efficiency is another advantage of induction heating. Traditional continuous-belt furnaces are about 45% efficient, provided they run 24/7, even when not processing parts. Batch furnaces when filled to capacity are more efficient but take a long time to heat and cool. Induction-heating systems, for comparison, are about 90% energy efficient and may be turned off when idle, which saves power and better matches lean "pull" processes.

One company, **Magnum Shielding**, Pittsford, N.Y., switched to induction heating when continuous-belt furnace technology could not meet a part surface finish spec. The induction process also saved a considerable amount of energy. The continuous-belt furnace (to braze one set of parts) consumed 1.41-kW-hr, while sets done by induction heating consumed just 0.035 kW-hr, a savings of 1.375-kW-hr/set. The potential for energy savings made the companies eligible for research-project support from the New York State Energy Research and Development Authority, which supplemented R&D related to the induction-heating system.

In another case, a company needed to solder heat-exchanger plates for fuel cells. Induction Atmospheres built a system comprised of a specially shaped induction coil, programmable sled, and a turntable. Significant energy savings were realized here as well. The original continuous-belt furnace consumed about 8.36 kW-hr to solder one electrode set; induction-heating technology consumed only 0.049 kW-hr/electrode set. Part of the energy savings came from the use of ceramic fixtures that hold the parts together during heating. This let the induction field directly heat the parts, rather than the fixture. The system is capable of processing 2 million parts annually. ■

Induction heating basics

Induction heaters use an RF power supply to send ac current through a water-cooled, copper-tube coil surrounding but not touching a part to be heated. The coil serves as a transformer primary and the part becomes a short-circuit secondary.

Circulating eddy currents induced within the part produce localized heat for bonding, hardening, or annealing/softening of metals or other conductive materials. Placement of parts closer to the coil boosts current flow and heating rate, a relationship referred to as coupling efficiency. Low-resistivity metals such as copper, brass, and aluminum heat more slowly than steels. Resistivity rises with temperature so heated steel is more receptive to induction heating than cold.

About 80% of heating in conductive materials happens on the part surface. Frequencies of 100 to 400 kHz quickly heat small parts or the surface/skin of larger parts. Long heating cycles at frequencies between 5 and 30 kHz deeply penetrate large parts, while frequencies to 60 MHz are used to heat microscopic-sized parts. Power depends on unit size and ranges from 1 to 500 kW.