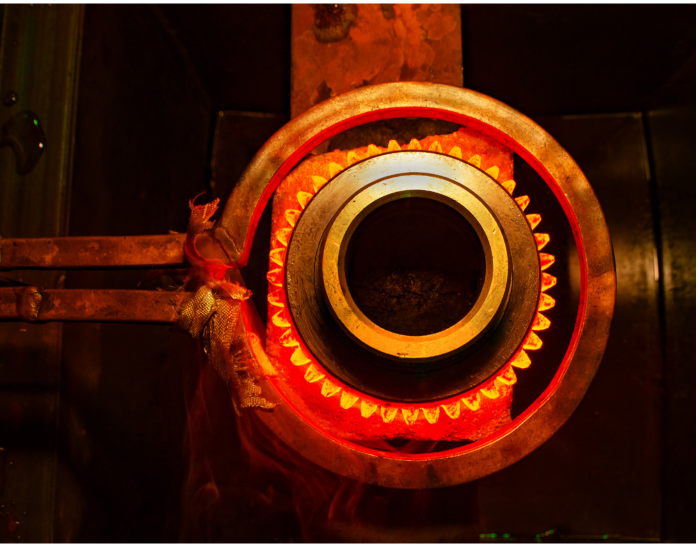
ELECTRIC POWER
RESEARCH INSTITUTE

INDUCTION HEATING OF METALS



Surface heat treating of metals is a common manufacturing process that produces a hard, durable surface on a softer, ductile metal part. In general, hardening allows lower grade materials to meet more stringent hardness and durability standards. Induction surface heat treating can provide a cost-effective alternative to other hardening methods. In addition to surface hardening, induction heating is used in tempering, brazing, bonding, welding, curing, annealing, forging, straightening, coating, and engraving.

DID YOU KNOW?

Induction heat treating is a proven technology that works very well for large production runs where high precision, high energy efficiency, low emissions, and high throughput are important.

HOW IT WORKS

During heat treatment, the surface of a part can be heated quickly to avoid affecting the underlying layer of metal. Continued induction heating can raise the temperature of the entire part if needed. Exposing a conductive metal part to high-powered alternating electromagnetic fields heats it by induction. With inductive heating, the power and frequency of the fields can be adjusted to regulate the depth and temperature of surface heating, giving more precise control of the process. Moreover, induction heats the surface more quickly than does direct heat transfer.

APPLICATIONS

Applications of induction surface heat treating and through heating of metals include, but not limited, to the following:

- Steel product and fabricated metal manufacturing
- Foundries
- Machinery manufacturing
- Appliance, electrical equipment, and component manufacturing
- Transportation equipment manufacturing
- Furniture manufacturing

BENEFITS

Increased energy efficiency. Dwell periods are practically eliminated because energy is directed only where needed, whereas a natural gas furnace heats the entire part, part trays, furnace refractory, furnace structure and shell. There are significant thermal losses through exhaust stack gases as well in the case of a natural gas furnace.

Improved precision and process control. Very precise control is maintained over the output energy level and where the electromagnetic field is applied on the part. Detailed heating system and performance data are easily captured and stored for product traceability requirements.

Higher production rates. Rapid heating speeds product throughput and results in higher productivity. Typically, induction heating is 10 times faster than conventional direct heat methods.

Single-piece workflow and lean manufacturing. Induction heating lends itself to single-piece workflow processing and lean manufacturing principles. Induction heating is fast, and there is no furnace or refractory heat-up and cool-down time, so single parts can be processed as needed. In addition, many automotive suppliers must now provide documentation and processing history for every single part. Meeting these requirements with batch processes is more difficult than with single-piece workflow.

Production cell technology. Induction heating is a clean and operator friendly technology that allows heat treatment to occur within a single process cell, achieving lean production goals.

Zero site emissions. Atmospheric processes and vacuum processes require large amounts of gases for carburizing and purging, in addition to heating. Induction produces no emissions at the point of use.

LIMITATIONS

Short production runs. Induction heat treating is usually the most cost-effective method for high-volume production of identical parts; induction coils are designed specifically for a single part shape and powered to achieve the desired hardened depth. For short production runs on differing parts, the cost of induction heating may prove prohibitive because each part may require a different coil design.

Diffusion processes. Induction heating usually occurs in an ambient atmosphere and temperature. Under these conditions, diffusion processes for altering surface metallurgy cannot be used. However, proper coil design and material handling can ensure quick heating and quenching. Additionally, new methods that combine induction with direct heat such as vacuum furnaces can also help to overcome this limitation.

Complex part geometry. Because induction coils must be near the metal to be effective, some complex parts are not suited to induction heating. This can be overcome, in most applications, by using scanning surface induction coils.

Up-front cost. Expensive material-handling systems may be required before the advantages of higher throughput promised by inductive heating can be realized. Acquiring an inventory of induction coils may also be expensive.

Trained operators. While fewer person-hours may be required per part when compared to direct heat methods, induction heating operators need knowledge that requires specific training.

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