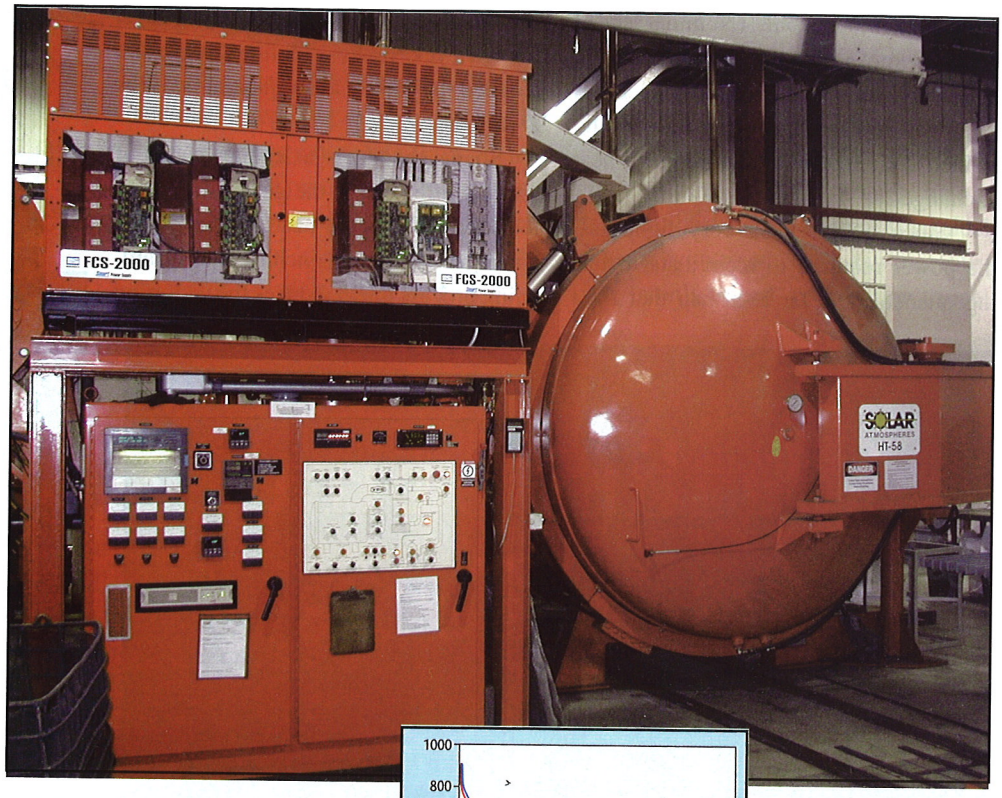
Adding High Velocity to High Pressure Gas Quenching



When gas quenching, the minimizing of heat treat distortion in gears may be a matter of high pressure *and* high velocity. That's what Solar Atmospheres thinks, that's why the heat treat company sends helium gas into its vacuum furnaces at more than 100 mph.

"The high pressure/high velocity gas quenching technology enables the gear manufacturer to finish machine gears closer to final size," says Robert Hill Jr., president of Solar Atmospheres of Western Pennsylvania, located in Hermitage. "This process has virtually eliminated post-heat treatment machining, grinding, straightening or plating to size for several types of gears, including many spiral bevel gears, worm gears, miter gears, and herringbone gears. Each of these types of gears has a propensity to severely distort during a traditional liquid quench."

Typically, gears made of low-alloy, medium-carbon steel (e.g. 4140) or of low-alloy, carburized steel (e.g. 8620) are hardened with hot oil as the quench medium. When liquid quenching is employed, three distinct phases occur. These phases produce large temperature differentials during the quenching process, so the roots, teeth, bores, shafts and webs cool at varying rates.

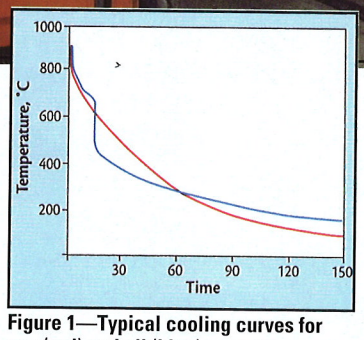


Figure 1—Typical cooling curves for gas (red) and oil (blue) quenching.

"These delta Ts cause tremendous internal stress on the gears, that will ultimately result in severe distortion," Hill says.

Instead of extracting heat by quenching in a liquid (e.g. water, salt, polymer or oil), vacuum furnace quenching uses inert gas cooling that subjects the gears to one cooling phase: convective (see Fig. 1). Since gas cooling is less abrupt and more uniform, this processing achieves acceptable hardened microstructures with considerably less distortion.

In the past, gas cooling wasn't fast enough to attain the proper metallurgical results. "Today, with increased pressure—10 bar—and increased velocity—primarily using helium, gas quenching is able to produce fully martensitic microstructures with much less distortion," Hill says. "However, there always exist certain limitations that may prevent a fully transformed phase. Therefore, for successful gas quenching, maximum cross sections and minimal percentages of elements within the alloy chemistry must be determined."

According to Hill, the use of helium for quenching is ever increasing, and improved cooling rates aren't only a function of pressure but also of gas velocity. By utilizing variable speed drives, Solar Atmospheres is now overspeeding its 300 hp blower

motors to 5,000 rpm. (Nominal speed is 3,600 rpm.) The exit gas velocity is now well over 100 mph. This quench gas impinges 360° around the workload and is then recirculated back through a heat exchanger.

"Since helium is a very light gas, the power required to recirculate it during quenching is far less than that used for nitrogen or argon," Hill says. "When cycle times—cooling times—are reduced by 40%, a substantial savings is realized."

Shape change is a leading cause of scrap and rework in the gear industry, so the value of vacuum heat treating is less spoilage. Vacuum quenching in the hardening process much reduces the distortion caused by residual stress.

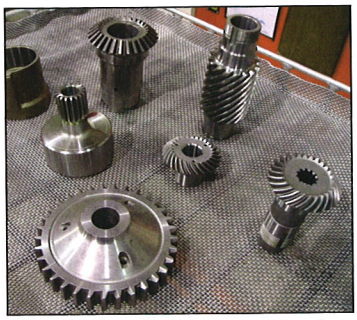


Figure 2—Sample of parts processed using Solar Atmosphere's process.

Another advantage of high pressure gas quenching is its inert atmosphere. The heat-treated gears are bright, clean and oxide-free (see Fig. 2).

"There is a tremendous added value since gears no longer need to be pickled, shot- or grit-blasted, or ground," Hill says. "The surface condition of the gears remains the same as the pre-heat treated condition."

Since high pressure gas quenching eliminates the need for liquid quenchants and the parts are processed in an inert environment, vacuum heat treating is an environmentally friendly process.

"This technique is becoming more and more popular worldwide," Hill says, "especially when combined with the advantages of vacuum carburizing."

Solar Atmospheres Inc., a commercial vacuum heat treater, is advancing this technology. "Precise temperature controls, development of vacuum furnace capabilities and the demand for manufacturing efficiency are the driving forces," Hill says.

Also located in Souderton, PA, Solar Atmospheres has more than 30 vacuum furnaces—from lab size to large production—that serve the gear industry.

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