The Staying Power of Low-Pressure Carburizing

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Open any heat treating journal today and you're certain to find multiple references (articles, technical papers and/or advertisements) promoting low-pressure carburizing (LPC). The uninformed might breeze by these references thinking it's the next flash-in-the-pan, but unlike in the past, this time the process has legs.

Commonly remembered, LPC of yesterday looked much like a tar and/or soot factory and never gained the respect it has today. For roughly 10 years, acetylene has been production proven as the carburizing gas of choice due to its high-carbon flux and its relative stability under temperature and vacuum.

LPC applications are now growing for a number of very basic reasons. First being it provides measurably and provably better results. Look at the automotive sector and you'll see lighter, smaller transmissions with significantly increased power densities. These advantages are largely attributable to LPC. Look, too, at the aerospace market where "zero defects" is a mandate for obvious reasons. The requirement is grabbing hold here and suppliers are being steered to comply. Next, the wind turbine industry has looked very seriously at this technology. The holdback here is their relative component size. The overwhelming majority of LPC furnaces are designed for high-pressure gas quenching (HPGQ), and wind generation components are just too large and of too low an alloy for adequate quenching in gas. While there are some oil quench LPC furnaces, the market is certainly not flooded with them. Finally, look at the powdered metal market where there's been success in applications for vacuum carburizing with HPGQ.

While there are many viable and successful exceptions, LPC has more-or-less been married to HPGQ. HPGQ is the primary reason post-heat treat machining can be eliminated (or at least very significantly reduced). This has made the combination very popular in the "vehicle gearing" market.

A common misconception regarding the LPC/HPGQ system seen here is increased maintenance.

There is little argument that the capital investment for LPC/HPGQ is more substantial, making the justification more challenging. The economic justification comes in pieces from a number of directions, including:

- Better quality by virtue of zero intergranular oxidation (IGO) along with more uniform case depths and hardness profiles.
- The processes can provide a significant level of piece part distortion control. This is via convection heating in conjunction with dynamic and controlled directional quenching in high-pressure gas. The combination can eliminate or at least significantly reduce post-heat treat machining needs. Heat-up is more uniform, quench intensity can be varied, wind direction can be altered and quench media can be substituted, providing a host of possibilities to control quench and therefore distortion.
- A "green" process: Emissions are extremely low. Less than five percent carbon emission can be expected for less than 10 percent of the total cycle length. Of course, cycle length depends on case depth requirements. Also, when quenching with helium, 99.5 percent of this precious gas is reclaimed and recycled on a per quench basis. When considering any possible result from the coming presidential election, this should be everyone's concern. Carbon credits are not going to stay cheap,

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they are not likely to stay voluntary and they are certainly not going away.

• Safer, cleaner working environment. The days of belching smoke and flame don't need to continue. Vacuum-based systems are clean and quiet, and you need not fear the heat or grime when leaning up against one.

• The capability of running with a higher carbon flux (near or at saturation level) can also provide faster cycle times. This is further enhanced by the ability to run at higher temperatures without fear of increasing intergranular oxidation (IGO).

A common misconception regarding large multi-chamber LPC/HPGQ systems is increased maintenance. These theories are based on performing LPC in a standard batch vacuum furnace. True, you can perform the process in these furnaces, but it comes with a high price in maintenance.

Multi-chamber systems require roughly the same amount of maintenance as a comparable atmosphere furnace system. The big difference is the type of maintenance. Instead of approaching the problem with a brick in one hand, a bucket of mortar in the other and a trowel under your arm, you're more likely to have a screwdriver, crescent wrench and an ohms meter. It takes a different temperament to work on vacuum equipment. But with proper preventive maintenance these systems run unattended and reliably for extended periods.

Using LPC and HPGQ can also eliminate post-heat treat machining. It's currently being done in mass production every day. It can be economical to make the move to LPC and HPGQ, particularly if you can eliminate downstream operations and defer the coming requirements for "carbon offsetting." It is an exceptionally green method of heat treating in batch processes.

Given the aging condition of the bulk of U.S.-based heat treat systems that will be replaced in the coming years, there is no doubt the growth of LPC will be steady.

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