HOTSEAT

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With 91 percent of survey respondents saying they dunk quench in oil, why does LPC continue to be conducted in graphite lined furnaces?

TWELVE YEARS AGO I COMMISSIONED A STUDY TO IDENTIFY trends in the heat treating industry where part of that survey involved three processes: traditional endo carburizing, low pressure carburizing [LPC] and quenching; high pressure gas quenching [HPGQ], oil and salt. Of the 27% who responded to the survey, a very high return rate, 91% of them said they dunk quenched in oil; 24% used gas quenching [vacuum furnaces] of which most used one to two bar nitrogen; followed by three to six bar and a few seven to 10 bar nitrogen. No one at that time was using pressures above 10-bar and 21% press quenched in oil; 18% dunk quenched in salt. Seventy percent of the respondents used atmosphere batch furnaces; 21% continuous and 9% batch vacuum. I believe it's a fair statement that the majority of parts processed were gears.

In earlier columns I've discussed the evolution of the vacuum furnace, vacuum carburizing and gas quenching. Having the benefit of witnessing the evolution of carburizing and quenching from the 60's through to today's technologies, I'm struck by why LPC continues to be conducted in graphite lined vacuum furnaces. No question that the furnace must be designed to accommodate the vacuum purge to remove air [oxygen] but essentially that's all.

Why therefore is graphite insulation required when the carburizing process is rarely performed above 1800°F, and for sure not more than 1850°F? And those few are conducted in an R&D setting. For me the answer is obvious: Purchasers of vacuum furnaces first wanted to process very clean parts in addition to high speed tools, perhaps copper brazing or solution annealing stainless steel, only as an afterthought did they purchase the LPC option; but wait… you can only case harden a very few high alloy gear steels in a single chamber vacuum furnace even at 20-bar helium, and there are very few of those. So what can the owner of a graphite-lined vacuum furnace harden? How about micro alloyed steels? But wait again; micro alloyed steels have no more hardenability than conventional steels – they're just designed to allow carburizing at temperatures above 1750°F [954°C].

Most vacuum hardening furnaces are designed for heating to 2400°F [1315°C], and since traditional insulation like ceramic fiber can't withstand such temperatures graphite ridged felt is the most economical option. And in typical furnace construction if the furnace was a hot wall style like an integral quench batch furnace, the graphite would have to be 24 inches thick to reduce the wall temperature to 150°F [66°C], and that would be impossibly expensive. The alternative is design for two or three inches of graphite felt, and then add a water-cooled jacket because the insulation cold face will be about 400°F [204°C]. With that design comes the cold space between the graphite insulation and the water jacket.

Many LPC furnace suppliers will hype their efficient use of acetylene although not much is required anyway, but none-the-less it's a sales pitch. However, that cold space is also filled with acetylene that once was heated to carburizing temperature and began the process of cracking to methane and carbon because only a small portion is actually absorbed into the steel parts. Granted the steel surface acts as a catalyst but first the acetylene must contact the steel and what portion of the carbon really does enter the steel? No one really knows. In fact at the ALD-Holcroft symposium held at the Michigan State University Management Education Center in late May, a paper was presented outlining early research to develop an LPC sensor in an attempt to identify the quantity of carbon entering the steel, but unfortunately any reliable device is a long way off.

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So why fight Mother Nature? To heck with graphite; who needs it anyway since we're only heating to 1900°F [1038°]? And at that temperature the warm wall furnace without a water jacket can easily be designed to accommodate a vacuum purged LPC system and that brings with it a true heat treater's furnace – one a hammer mechanic can repair.

I believe the industry has forgotten that heat-treating furnaces are self-destructive devices and any attempt to treat them otherwise is just asking for a lot of heartburn and unnecessary expense. Because remember the survey said 91% of all carburizing is dunk quenched in oil.

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