HOT SEAT

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Low-pressure carburizing (LPC) furnaces employ strategically positioned jets, and atmosphere furnaces must use the proper fan. However, all fans are not equally able to handle the task.

WHEN IT COMES TO CARBURIZING or protecting parts subjected to an atmosphere, fan- and gas-injection methods become the critical factor. Vacuum furnaces have air removed by vacuum pumps, but by carburizing at low-pressure carburizing (LPC) pressures, fans are ineffective because too few gas molecules to circulate. Therefore, LPC with acetylene must be introduced in a manner that will assure uniform carburizing and two primary methodologies that have been used.

Pulsed pressure is the oldest method, and it was utilized by most OEMs. It involves injecting the gas for a preconfigured time increasing the LPC pressure to some level. When that pressure is achieved, the gas injection stops, and a vacuum pump would evacuate the pressure back to a starting point where the sequence begins again until the initial case depth has been reached. Following the last pressure pulse, the vacuum pump evacuates to begin diffusion resulting in the target surface carbon and case depth.

Even though acetylene molecules (C_2H_2) will disperse throughout the entire chamber interior, only the gas contacting the parts in the hot zone will receive carbon atoms. Acetylene that is outside of the hot zone and that is between the insulation and vessel wall has no effect on the parts. As the acetylene decomposes at the parts' surface, hydrogen is formed, as well as free carbon 2C + H2. Not all of the carbon enters the steel. Some of the acetylene is cracked from temperature alone. This excess is responsible for the maintenance required. As the steel surface becomes saturated with carbon, less of it will enter the steel. The hydrogen formed will dilute and reduce the concentration of acetylene creating non-uniform carburizing. Evacuating the reacted gas and pulsing fresh acetylene will improve uniformity. Evacuation in between pulses in addition to removing spent acetylene allows carbon to diffuse into steel away from the parts surface. If the evacuation time is too short to allow enough diffusion, and if all of the unreacted acetylene is not removed, the surface carbon will be higher than anticipated by the control model resulting in excess iron carbide (Fe_3C).

To assist in distributing carburizing gas throughout the load, most LPC hot zones will have nozzles positioned around the hot zone pointing at the load. The effectiveness of nozzles can be argued since some will inevitably plug and, consequentially, disturb the nozzle jet flow. Evacuation between pulses tends to ameliorate the uniformity.

Gas pulsing eliminates evacuation between pulses and, instead, flows nitrogen between carburizing pules thereby, maintaining a constant pressure during the LPC process. The vacuum system continues to evacuate the vessel while either acetylene or nitrogen flows. The transition from high acetylene concentration to zero is much slower than with the pressure pulse technique and may never completely remove all of the diluted acetylene between pulses. The pressure is controlled by a pressure sensor in the evacuating manifold by varying the vacuum booster's RPM.

Atmosphere furnaces rely on fans to circulate the atmosphere, but the type of fan used can make a significant difference in results. Furnace fans serve two purposes—assisting in heating parts in dense loads and improving carburizing uniformity. However, not all fans are equal or provide the same fluid motion. In batch furnaces, roof-mounted radial fans provide a defined circulation path for the carburizing gas. Gas is forced radially out from the circumference of the fan to the sidewalls, down along the walls, then up through the load into the fan. Since fans operate at atmospheric pressure, case depth uniformity is good even in very dense loads. When vertical radiant tubes are employed, the gas is also heated as it passes over the hot tubes.

Since furnaces operate at high temperatures, the density of the gas is heavily reduced. Therefore, the quantity of gas moved is less than what it would be when it is cold. Nevertheless, radial fans produce higher static pressure more so than axial types and provide the critical defined flow path. Propeller-driven airplanes essentially have axial fans in the air is moved along or parallel to the axil shaft. Roof-mounted home exhaust fans are axial.

Radial fans will have straight blades that create gas flow by compressing gas as it moves along the blade length and produce a differential low pressure at the inlet and a higher pressure as the gas flies off the rotating blade tips. Axial fans slice through the atmosphere with very little compression of the gas as it slides over the fan blades. Therefore, radial fans are used where much higher system resistance is encountered requiring higher static and velocity pressures from the fan.

Either fan type will function to some degree without a plenum or directional vanes, but the radial style will outperform an axial fan in such a condition. Axial fans work much better when moving an atmosphere through a duct—even a short one—to assist in keeping the gas from sliding off the blades radially prematurely before exiting in the direction required. Axial fans with larger center hubs have a negative characteristic that will short-circuit the fluid back into the blades when no duct or plenum is used.

ABOUT THE AUTHOR: Hot Seat columnist Jack Titus has an additional column in *Thermal Processing for Gear Solutions* in which he discusses scheduled maintenance of furnaces, distortion control, and low-pressure carburizing. Jack Titus can be reached at (248) 668-4040 or jtitus@afc-holcroft.com. More information can be found online at www.afc-holcroft.com or www.ald-holcroft.com.