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Vacuum Carburizing Large Gears

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

Vacuum carburizing of gears has typically been limited to parts with relatively small cross-sections. Most alloys currently in use require oil quenching to achieve adequate surface hardness and core properties in large gear applications. Pit or large batch IQ furnaces with endothermic atmospheres are often used to process this type of gear. The majority of vacuum carburizing equipment is designed for processing smaller parts with a high pressure gas quench.

Recent equipment and process developments allow vacuum carburizing and oil quenching of very large gears and pinions – up to 70" diameter and 7,000 lbs. Fixture design and careful process control help minimize distortion, while providing the case uniformity and surface integrity that is unique to vacuum carburizing.

This paper will discuss specific case studies involving large gears and pinions. Distortion, case hardness profiles and microstructures from conventional gas carburizing and vacuum carburizing will be examined and compared.

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Manufacturing large, high precision gears requires an investment of machine time, materials and design. Throughout the machining process, great care is taken to achieve and maintain critical dimensions. The gears are then handed over for heat treatment. Exposing the parts to a high temperature environment, changing the material chemistry, and rapidly cooling in oil to harden is necessary to produce the high strength and long wear life expected in large gears. Heat treating, while critical to gear performance, is a step that puts an enormous amount of stress on the part and must be done correctly to produce an acceptable part.

One of the most frequently asked questions is “How much will this distort?” This is very difficult to answer completely. Factors like material chemistry, prior thermal and machining history, geometry, fixturing, case uniformity and quenching process all play a role in determining how much the gear moves. The heat treater can control the last three variables, and help minimize the size change of the part. Vacuum carburizing can effectively address these.

Vacuum Carburizing is a solid alternative to conventional endothermic gas carburizing in an integral quench or pit furnace. Stack Metallurgical Services uses a Seco Warwick two chamber, vacuum carburizing, oil quench furnace to process large gears (see Figure 1). The furnace is capable of running parts up to 70” diameter, 80” long and 8,000 lbs.

A key component of successful distortion management is fixture design. In Stack’s vacuum carburizing furnace, the load is suspended from an overhead trolley (see Figure 2). This gives an opportunity for innovative fixture design. There is no grid assembly, so the parts contact the oil without any interference or turbulence. The heat removal is very symmetrical, which helps reduce the distortion. Parts are arranged and supported to minimize movement or creep during the heat treating cycle, and provide efficient load densities that allow rapid cooling.



Figure 1. Vacuum carburizing furnace