How to Carburize a Finished Gear

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Precise heat treatment plays an essential role in the production of quality carburized gears. Seemingly minor changes in the heat treating process can have significant effects on the quality, expense and production time of a gear, as we will demonstrate using a case study from one of our customer's gears.

The gear we looked at was a 20-inch, 98-tooth spur gear with a 1/2-inch web used in a construction drill head. The gears were made from normalized 8620 steel with minimum hardenability of HRC 28 at J6 quench rate. The customer called for carburizing with an effective case of .030–.040" to HRC 50, minimum surface hardness of HRC 58 and minimum non-carburized web hardness of HRC 28. A 3/4-inch coupon of the same alloy was heat treated and quenched in the same load to verify both effective case depth and microstructure.

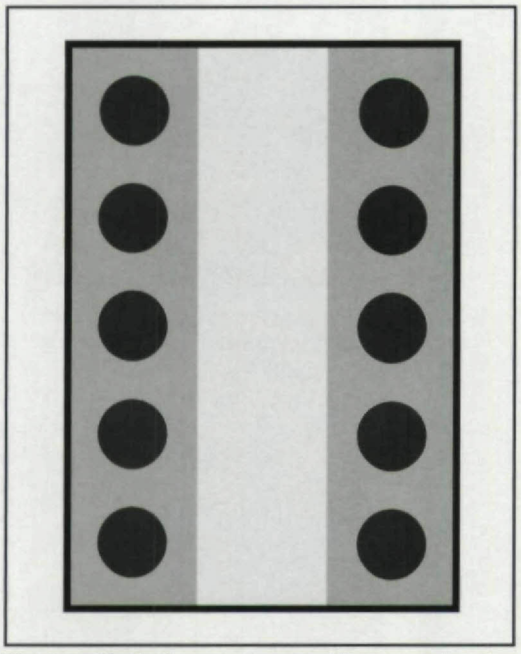

Fig. 1 — Typical arrangement of burner tubes in a carburizing furnace.

Initial test and production run results showed nicks on the teeth, an egg-type shape and an unacceptable lead, profile and composite roll check, according to our gear specialists. Using standard carburizing procedures, the gears came out of the furnace with a quality of AGMA Q6 or Q7. Because the gear print called for an AGMA Q8 gear, the parts required additional gear tooth grinding after being heat treated to compensate for distortion. To reduce the cost of the part to our customer, we examined ways of increasing the quality level to AGMA Q8 and eliminating the need for post-heat treatment gear tooth grinding.

To produce a higher quality gear, it is important to follow some important guidelines during the heat treating process. To begin, the gear should be routinely washed, rinsed and dried prior to heat treatment. This is done to ensure that contaminants are neither allowed on the heat treated surface of the gear nor introduced into the furnace during loading. Any contaminant, including dirt and oil, may adversely affect the desired heat treatment result.

Following the cleaning process, any excess oil should be "burned off" the surface of the gear by heating it and holding the temperature of the gear at an appropriate level for a short period of time. This is common procedure if carbon-resistant paint (for example, Condursal Stop-off) is to be used. The paint is most often applied in select areas, normally on or around the inner diameter, to provide a softer post-heat treatment material for further machining. Once the gear is cleaned and carbon-resistant paint has been applied and allowed to dry, the gear load is ready to be arranged on trays, baskets or other fixtures for carburizing.

Load arrangement has a significant effect on the outcome of direct quenched gears. Small, light weight, more intricate gears should be loosely hung on carburizing rods, mounted on special carburizing fixtures or laid flat on their faces. Larger and heavier gears should either rest vertically on their teeth with overhead wiring for added stability or lie flat on their faces.

During our first efforts with the 20" spur gear, we rested the parts in a basket on their outside diameters. However, because the high temperature in the furnace caused the parts to rattle, the gears came out with nicked teeth. The nicks could be ground out in finishing operations, but since we were trying to reduce post-heat treatment finishing, we sought another option. Instead of resting the gears on the flat surface of the basket, we introduced a curved stainless steel pad that conformed to the shape of the outside diameter of the gear. The steel pads eliminated the problem with nicked gear teeth, yet they still allowed for the free flow of oil necessary during the quench.

Another factor to consider when arranging a load for heat treatment is the distortion caused by the burner tubes in the furnace (Fig. 1). Regardless of the way your heat treater presently arranges a gear load, it may be necessary to experiment in order to find the method best suited to the gear in question.

At first, we arranged the gears as shown in Fig. 2. However, we found that the webs of gears numbered 1 through 5 and 14 warped excessively, while those numbered 6 through 13 did not. After removing those gears in the arrangement that were severely warped, we were able to better control the quality and consistency of the load. Although this increased the amount of time it took to process an entire order of gears, we considered it worthwhile because of the gain in quality.

Another important aspect of gear heat treatment is preheating the gear before carburizing. It is usually advisable to preheat the gear prior to loading into a furnace. This is generally done in a draw furnace. A temperature of between 600 and 800 degrees is common, depending on the material being used. Pre-heat treatment is a common technique used to help control the distortion that results from introducing the gear from room temperature directly to a furnace temperature exceeding 1400 degrees. Pre-heat treatment also reduces the time required to reach the desired furnace temperature and thus saves on furnace costs.

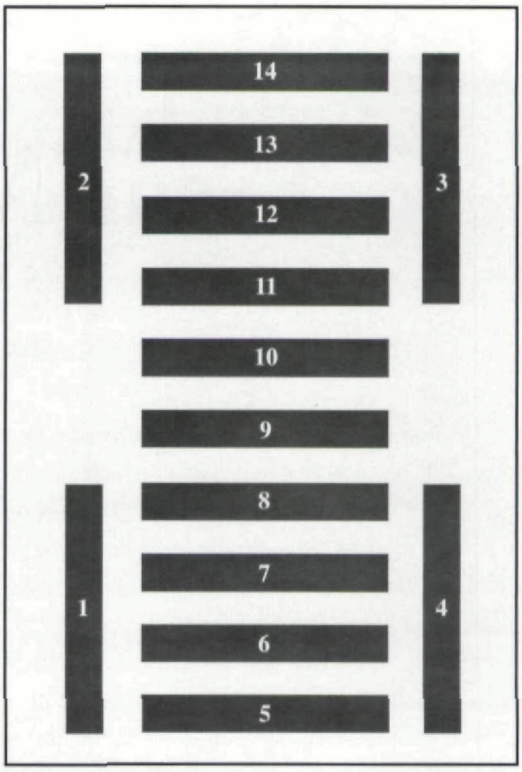

Fig. 2 — Arrangement of 20" spur gears in carburizing furnace.

After making these adjustments and following the guidelines mentioned in this article, the gear we were able to produce came out of the furnaces at a quality level of AGMA Q8B. The only post-heat treatment operation was superficial turning of the non-carburized area of the face and minimal boring.

This example demonstrates some of the ways in which gear heat treatment professionals can affect the quality of your gears. In addition, significant cost savings can result from eliminating post-heat treatment operations such as finish grinding of the gear teeth. For a gear such as the one we examined here, the savings can be as much as $100 per part in gear grinding alone. While this is only a small example of the success attainable through proper heat treatment, it should give gear engineers some understanding of the ways the process can be modified to help them produce a better product. ○

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