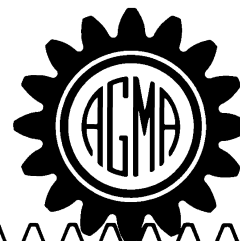


# Economic Aspects of Vacuum Carburizing

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**American Gear Manufacturers Association**



## TECHNICAL PAPER

# Economic Aspects of Vacuum Carburizing

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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

There is an increased interest in furnaces for vacuum carburizing due to the demand for products with the best overall metallurgical quality and lowest unit cost. Vacuum carburizing technology produces work with minimum distortion, the direct result of being cooled down with gas. The surface metallurgy is superior because the carburization process is carried out in a vacuum environment. Vacuum furnaces systems provide "cold to cold" (cold work going in, cold work coming out) and fully automatic operation that reduces the amount of operator involvement, thus minimizing labor costs. Considering upstream and downstream costs, vacuum carburizing provides a total reduction of processing costs and is a natural fit in a lean manufacturing cell.

An additional advantage is that vacuum furnace technology is a "green" manufacturing process with no negative impact on the environment.

This technology differs considerably from traditional gas carburizing both in the equipment used and in the process economy. This paper presents the aspects of vacuum carburizing technology that have an impact on process costs and quality improvements in the final product.

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### Vacuum Carburizing is considerably faster than gas carburizing

Vacuum carburizing is characterized by an extraordinarily high coefficient of carbon transfer at the phase interface, which results in a high carbon transfer. In the initial phase of carburizing, for example, at a temperature of 1740°F (950°C), the carbon stream directed at the charge surface reaches the rate of 250 g/m<sup>2</sup>h. This means that, in the case of thin carburization layers, the process is considerably faster than the gas carburizing process. The advantage is smaller in the case of thick layers that exceed for example, .00315 inches (0.8 mm), where the carbon transfer is much more dependant on the diffusion coefficient ( $D_C$ ).

The vacuum carburizing process may easily be carried out even at temperatures of up to 1900°F (1050°C), within the natural temperature range of a

vacuum furnace. The process temperature increases to 1700–1800°F (950–980°C), compared to traditional gas carburizing processes that typically operate within a temperature range of 1600–1700°F (880–930°C). Operating at higher temperatures results in shorter carburizing cycles due to the considerable increase of the diffusion coefficient ( $D_C$ ). Both the increased amount of carbon in the carburizing atmosphere, and faster diffusion ( $D_C$ ) are responsible for the increase in vacuum carburizing efficiency when compared to the traditional gas carburizing.



Figure 1. Single chamber vacuum carburizing furnace

### Reduction of the processing time and energy-related factors

Vacuum carburizing technology differs considerably from gas carburizing in the method of delivering the carbon stream to the charge surface, process regulation, and in the completion of the entire cycle. More differences are found in the furnace construction, the results of heat and chemical treatment, and in the consumption of energy, and therefore, the process costs. The new technology consistently reduces and/or eliminates deformations, eliminates internal oxidation, and reduces the exhaust gas emission into the atmosphere.

It is commonly believed that shortening the cycle period according to this method will reduce the process cost. But, the reduction of the process duration is higher for the same temperature, in the case of thin carburized layers than thicker layers, where