

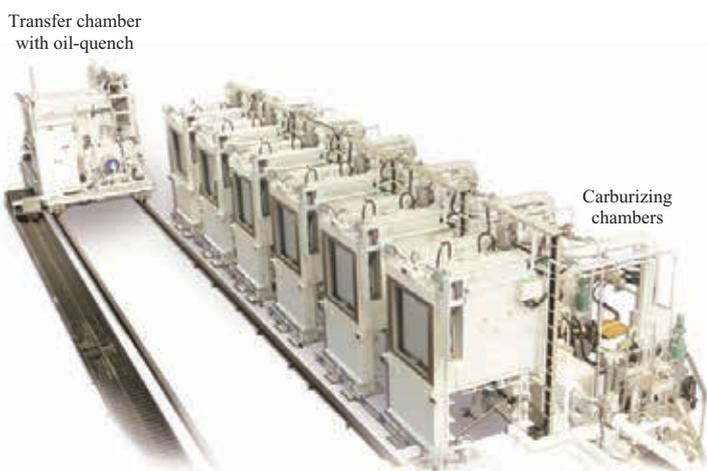
# Integrated Oil-Quench System to Boost Operations

**A line of vacuum carburizing equipment for mass-production use (V-Cell) delivers both high quality and enhanced mass productivity**

The vacuum carburizing process hardens the surface of gears, shafts, and other parts used in cars and construction equipment and improves their wear resistance. New, simplified equipment that is capable of delivering high quality and mass-production — something that has been difficult to achieve until now — have been just passing the corner.



Exterior view of batch-type vacuum carburizing equipment (VCB)



V-Cell line: carburizing chambers and a transfer chamber with oil-quench

## The vacuum carburizing process

The drive units used in the automobile and construction equipment industries consist of gears, shafts, and various other parts, and the mechanical properties, such as strength and wear resistance, of the steel components used in these units are of great importance. Vacuum carburizing is one of the processes that are used to help improve the mechanical properties of such components.

Carburizing is a heat treatment process in which carbon is diffused through the surface of a steel part before the steel is quenched to harden and improve the wear resistance of the steel surface.

In the vacuum carburizing process, the steel is heated inside the processing equipment to between 930 and 980°C under a vacuum atmosphere. And after that, acetylene gas is introduced into the equipment. The carbon generated by the thermal decomposition of acetylene gas is diffused into the steel surface (carburization). After the diffusion process, the steel is left to slowly cool to around 850°C and then placed into quenching oil for the quenching process (oil quenching), which hardens the steel surface. As it is both cleaner and

safer, vacuum carburizing is superior to gas carburizing.

Vacuum carburizing equipment forms a production line that is made up of the following: a carburizing chamber, which is used mainly for heating and slow cooling; an oil-quench chamber, which is used for oil cooling; and a washing machine for pre- and post-processing and a tempering furnace.

During the carburizing process, if the interval between the steel reaching a temperature of around 850°C and it being placed in the quenching oil is too long, the uniformity of temperature within the steel will deteriorate. Placing steel that has temperature nonuniformity into quenching oil affects the quenching quality. For this reason, reducing the time required to begin oil cooling so as to prevent temperature nonuniformity is the key to achieving quality quenching.

## Batch-type vacuum carburizing equipment (VCB)

As the inventor of an acetylene vacuum carburizing process, IHI Machinery and Furnace Co., Ltd. (IMS) is a leading manufacturer of batch-type vacuum carburizing equipment. The VCB series of products offered by IMS are used by many companies in the heat-treatment industry and by other

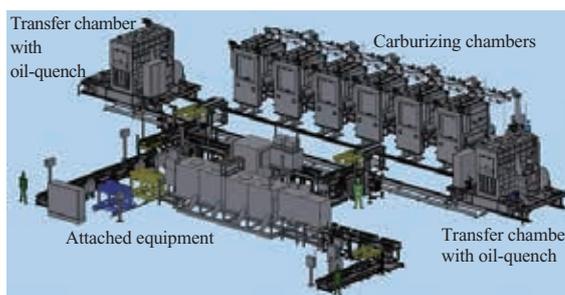
parts manufacturers. At the sites of parts manufacturers that require a large production capacity, multiple VCB products are installed in parallel.

However, although the process performed in the carburizing chamber takes 6 to 7 hours for example, the one performed in the oil-quench chamber only takes about 30 minutes for a single carburizing process. If a VCB composed of one carburizing chamber and one oil-quench chamber is used, the utilization rate for the oil-quench chamber is too low. The challenge is how to improve its utilization rate.

### Development of vacuum carburizing equipment for mass-production use (V-Cell)

Recently, a proposal was made concerning the concept of matching multiple carburizing chambers to a single oil-quench chamber in order to improve the utilization rate for mass-production use, especially the oil-quench chamber. This concept also requires the use of a transfer facility (i.e., a heating transfer chamber) to carry products from the carburizing chambers to the oil-quench chamber while maintaining their temperature. The configuration is shown in the top figure below.

As stated above, temperature uniformity from the carburizing process through to the quenching process is the key to achieving quality quenching. The configuration developed based on the concept described above requires attention to be paid to temperature uniformity control. The reason for this is that the configuration increases the transfer of workpieces through the carburizing chamber, the heating transfer chamber, and the oil-quench chamber, which may lead to temperature ununiformity and increase the amount of time that elapses from the carburizing process through to the quenching process. Given this, IMS considered other configurations based on doubts



V-Cell line configuration

about whether the proposed configuration would be able to replicate the same level of quenching quality as that of the conventional VCB.

In its consideration of this matter, IMS focused on the following: ① ensuring the highest level of quenching quality in oil cooling; ② improving mass productivity by balancing the utilization of components; ③ reducing the startup time for customers by maintaining the conventional batch-type system configuration so that the same processing conditions could be used; and ④ improving maintenance through the adoption of a (patented) function for removing the soot generated by carburizing automatically during the carburizing process by burning it.

In light of the above, IMS developed the concept of transferring the oil-quench chamber so that the carburizing chambers and the oil-quench chamber are separated (bottom figure on the left).

In addition to ensuring the same level of quenching quality, our concept allows the amount of quenching oil that is held to be reduced significantly from 42 000 l to 8 500 l when compared with a conventional line that is made up of six pieces of batch-type equipment. This helps to simplify hazardous material management in accordance with the Fire Service Act.

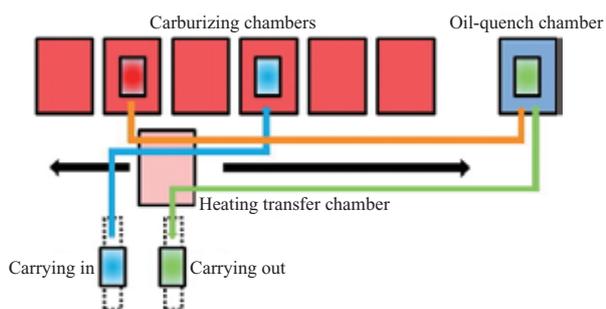
### Present situation and future prospects

The first model has been installed on-site and it is currently undergoing a test operation.

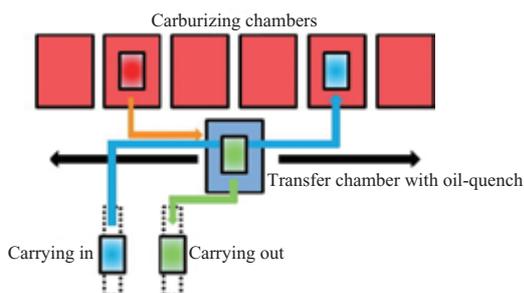
Recently, in consideration of the environment, demand has been growing for the gas carburizing method to be replaced by a vacuum carburizing method, which emits less carbon dioxide. By supplying new equipment that offers higher productivity at a lower cost than conventional vacuum carburizing equipment, IMS expects to be able to contribute to society. Moreover, by combining remote monitoring based on IoT (Internet of Things) technologies and new approaches such as preventive maintenance, IMS will strive to continue providing equipment that contributes to greater efficiency in the activities of our customers in world wide.

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Example configuration of vacuum carburizing equipment for mass-production use



IMS equipment configuration