MODERN SMALL-CAPACITY UNIT FOR THE VACUUM-OXYGEN REFINING OF STEEL

S. E. Malkov, I. Yu. Zinurov, and A. M. Shumakov

A vacuum-oxygen refining unit has been installed in the pouring and furnace bays of electric steelmaking shop No. 2 at the Zlatoust Metallurgical Plant. The shop specializes in the production and casting of stainless, chromium-nickel, and complex-alloyed steels, alloyed high-speed and tool steels, and nickel alloys. The unit can be used to perform both vacuum degassing and vacuum oxygen refining.

The Zlatoust Metallurgical Plant has installed a vacuum-oxygen refining unit in the pouring and furnace bays of its electric steelmaking shop No. 2. The shop specializes in the production and casting of chromium-nickel and complex-alloyed stainless steels, alloyed high-speed and tool steels, and nickel alloys.

The equipment in shop No. 2 includes three 10-ton arc steelmaking furnaces, one 5-ton arc furnace, and a ladle-furnace unit (model AKP-12). The steel is cast into ingots molds installed on carts to obtain ingots weighing 0.8–3.6 tons.

The equipment of the refining unit (Fig. 1) includes a vacuum chamber for the installation of a metal-filled ladle that is positioned at the 2300-mm level. The unit also has a vacuum-tight cover suspended from a cart, as well as mechanisms and devices to monitor and control the process. A TV camera is mounted on the cover to allow observation of the behavior of the metal in the ladle, and special sluices are used to measure temperature, take samples of the steel, and introduce ferroalloys and slag-forming materials without having to depressurize the vacuum chamber.

The unit has its own hydraulic power system to operate the mechanism that raises the cover of the vacuum chamber and operate the drives of the covers of sluice-batcher. A vacuum line connects the vacuum chamber with a steam-jet ejector.

A conveyer transfers ferroalloys and slag-forming materials to the sluice-batcher from the hoppers of the batching system of the AKP-12.

The steam-jet ejector used to evacuate the chamber of the refining unit is of model AVPN 80×0.5/11-30 and was designed and built by the company Ékvaks (in Kazan).

The automatic control system of the unit controls the drives, records and stores the necessary data, and documents the progress of the refining operation.

The vacuum chamber is a strong welded structure in the form of a cylinder 3600 mm in diameter and 3900 mm high. The cylinder has vacuum-tight welds. A water-cooled flange with a vulcanized rubber rim is installed on the top part of the vacuum chamber. When the cover is off the chamber, the rim is covered by a layer of water roughly 10 mm deep to keep the rubber from igniting when the protective shield passes over the chamber. An emergency vessel lined with fireclay brick is installed on the bottom of the chamber. A water-cooled pipe 800 mm in diameter is welded to the cylindrical part of the chamber and is provided with a flange to connect the chamber to the vacuum line.

The cover of the vacuum chamber is designed to hermetically seal the chamber and house various pieces of equipment used in the refining operation. The caisson-type cover is dome-shaped and cooled with water. A 3980-mm-diam. flange is installed in the lower part of the cover. The flange is mated with the flange on the vacuum chamber and ensures that the
Joint is air-tight. Installed on the cover are equipment to measure temperature and sample the steel, a device to inject oxygen, the sluice-batcher, and the TV camera. A ceramic shield with a water-cooled ring is suspended from the bottom of the cover to provide protection against heat radiation. The mechanism that lifts the cover is mounted on the cart and is connected to the cover by rigging screws. The mechanism consists of two hydraulic cylinders, a lever, a tie, a synchronizing shaft, and supports. The synchronizing shaft makes it possible to raise and lower the cover while keeping it level. The cart serves as the supporting structure for the cover-lifting mechanism, various process equipment, a hydraulic power system, and platforms. The cart is a framed structure with an electromechanical drive.

The hydraulic power system, provided with distribution and control devices, is designed to control the hydraulic cylinders that hoist the cover of the vacuum chamber, the cover of the sluice-batcher, and the slide of the device that measures temperature and takes samples. The system consists of two vane pumps with a combined capacity of 90 liters/min.

The sluice-batcher is designed to feed ferroalloys and slag-forming materials into the ladle during the refining operation without having to depressurize the chamber or remove the vacuum. The sluice-batcher is installed on the cover of the vacuum chamber and is connected with the cover’s interior space by an inlet pipe.

The sluice-batcher is a vacuum-tight hopper which has a capacity of 0.4 m$^3$ and is equipped with top and bottom doors. The drives of the doors are hydraulic. Two electromagnetic valves are installed on the sluice-batcher. One valve connects the internal cavity of the sluice with the interior space of the vacuum chamber before the bottom door is opened, while the other valve connects the sluice cavity with the atmosphere before the top door is opened.

The device that injects oxygen consists of a vertical column installed on the cover, a roller-equipped carriage that travels along the column, a water-cooled lance secured in the carriage, a drive, and a seal for the lance. The electromechanical drive employs a cable. The lance is moved within the interior space of the vacuum chamber as the metal is being blown with oxygen.

The device that measures temperature and takes samples is a hermetically sealed sluice chamber installed on a flange on the pipe fitted into the cover of the vacuum chamber. The device houses a rod with a block containing a replaceable thermocouple or a sampler. The electromechanical drive of the rod also employs a cable. The sluice chamber has a door.

Fig. 1. Vacuum-oxygen refining unit: 1) vacuum chamber; 2) cover of vacuum chamber; 3) cart; 4) protective shield; 5) TV camera; 6) hydraulic system; 7) thermoprobes; 8) sluice-batcher.