This article discusses important aspects of evaluating the effectiveness of different types of charging apparatuses for blast furnaces, their effect on the distribution of the charge materials in accordance with the prescribed charging program, and the use of modern instruments to monitor the distribution of these materials and the furnace gases in order to ensure efficient operation of the furnace.

Key words: bell-less charging apparatuses, distribution of charge materials and indices for its evaluation, instruments for monitoring the distribution and the movement of the charge inside the furnace.

Issues Nos. 7 and 11 of the 2009 Metallurgist published two informative articles of particular interest to blast-furnace engineers and operators. The articles were devoted to modern bell-less charging apparatuses for blast furnaces, the design features of these pieces of equipment, and their effect on the distribution of the charge materials and the overall efficiency of the furnace. The articles introduced new concepts and indicators for evaluating the charging of blast furnaces and the distribution of the charge materials in them. In light of this, we thought it would be useful here to also report on a discussion of the materials in those articles by furnace specialists and the results of the use of different designs of bell-less charging apparatuses (BCAs) to make blast furnaces more efficient as a whole.

It would be best if we first examine certain general conditions connected with the development and use of BCAs. It should be mentioned that active research into BCAs of different designs was begun in the USSR and Europe during a period of years in which the USSR had begun an intensive program to build large-volume blast furnaces. This program was undertaken at the urging of scientists at the Institute of Ferrous Metallurgy (IChM) of the Academy of Sciences of the Ukrainian SSR. The combine Krivorozhstal and the Metallurgical Plant imeni Il’icha introduced 1719-m$^3$ blast furnaces in 1958, Krivorozhstal introduced 2000-m$^3$ blast furnace No. 5 in 1960 and 2700-m$^3$ blast furnace No. 8 in 1967, and the Cherepovets Metallurgical Plant brought another 2700-m$^3$ furnace on line in 1969.

Using practical results and research findings for large-volume blast furnaces, leading scientists and specialists in the equipment and technology of blast-furnace smelting came to the understanding that the traditional standard bell-and-hopper charging apparatus is not well-suited for charging large furnaces because it does not allow flexible control of the charge distribution and makes it impossible to consistently maintain a high top-gas pressure. In addition, the components of this type of charging device have a limited service life and require extensive maintenance and repair. For these and several other reasons, work began on developing and building charging apparatuses that do not have a bell. Subsequent use of these units over many years has shown that BCAs can be used effectively on blast furnaces of almost any volume, but they are always more effective on larger furnaces than on smaller furnaces.

In 1974, Krivorozhstal introduced the first 5000-m$^3$ blast furnace in the world. Furnace No. 9 was originally equipped with a valve-bell-type charging apparatus designed by VNIIMETMASH–UZTM, but this unit was replaced by a Paul-Wurth-designed BCA in 1980 [1]. The Novolipetsk Metallurgical Combine (NLMK) introduced 3200-m$^3$ blast furnace
No. 6 in 1978, and this furnace was the first in the world to be equipped with a chute-type BCA designed by Paul Wurth. Bell-less charging apparatuses with a “hopper-slide” charge distributor designed by VNIIMETMASH–Uralmash [2] were installed on 2000-m$^3$ furnace No. 6 at the NLMK in 1982, furnace No. 4 at Krivorozhstal in 1988, 1513-m$^3$ furnace No. 5 at Zaporozhstal in 1988, and 2000-m$^3$ furnace No. 2 at the Karaganda Metallurgical Combine in 1988. Severyanka – the largest blast furnace in the CIS and one of the largest blast furnaces in the world at a volume of 5580 m$^3$ – came on line at Severstal in 1986. This furnace, No. 5 at the plant, was also equipped with a chute-type BCA made by Paul Wurth. In 1987, a chute-type BCA designed jointly by Azovstal, Azovmash, and Gipromez was installed on blast furnace N. 3 at Azovstal during its overhaul [3]. Bell-equipped charging apparatuses with a five-lobe rotary charge distributor were installed on blast furnaces Nos. 1 and 2 in 1987 at the West Siberian Metallurgical Combine (ZSMK), where the furnaces continue in successful operation today [4]. New blast furnace No. 6 at the Nizhnii Tagil Metallurgical Combine (NTMK) was equipped in 2004 with a BCA made by the company Vitkovice, and in 2005 Severstal recommenced operation of a 2830-m$^3$ furnace that was rebuilt with a Paul Wurth BCA. Blast furnace No. 5 at the NLMK was provided with a Paul Wurth BCA in 2006.

The largest project involving the retrofitting of existing blast furnaces with BCAs is now under way at the Magnitogorsk Metallurgical Combine. Although this effort is deserving of support, we believe that program would benefit from greater use of the knowledge and experience gained by Russian and Ukrainian specialists on BCAs. Doing so would be beneficial to the design and renovation of the furnaces, but it would be especially helpful in mastering the use of the new equipment being installed on them.

The following should be targeted in designing different types of charging apparatuses: ensure efficient control of the distribution of the charge materials for the given volume of production and minimize fuel consumption while maximizing furnace productivity; stabilize the furnace atmosphere while operating the furnace with a high top-gas pressure and attempting to maximize the length of the furnace campaign and the time between repairs, as well as minimize the cost and length of preventive maintenance work (class III) done with the furnace idled and minimize the total weight, cost, and number of worn parts and components that need replacement during such work. These factors – which include the prices and performance guarantees of the components of the BCA – determine which type of charging apparatus should be chosen for use.

It is an appreciably more complicated matter to make a comparative evaluation of operating blast furnaces equipped with different types of charging equipment [5, 6], since an evaluation of this nature must consider the charging conditions of the furnaces, the productivity and capacity of the equipment of the charging system, the presence and sophistication of the monitoring and control devices, the preparation and qualifications of the operating personnel, the expediency of the chosen charging programs, and the organization of the production facility. One important element in such evaluations is the use of modern monitoring equipment to obtain reliable information on the distribution of the charge materials and gases in the furnace.

The proper use of bell-less charging apparatuses with a rotary charge distributor located directly above the surface of the stock significantly improves the effectiveness with which the distribution of the charge and the gases can be controlled in the furnace, reduces coke consumption by 4–7%, and reduces atmospheric emissions of dust and gases. Rebuilding blast furnaces and equipping them with BCAs expands the possibilities for using innovative technologies in these furnaces’ operation. In connection with this, efforts to create original new designs of BCAs and make arrangements for their manufacture along with the instruments needed to monitor and control their operation are well-merited. The design, fabrication, and successful practical use of a new rotary-type bell-less charging apparatus (RBCA) by the company TOTEM is an important step in rebuilding blast furnaces and making them more efficient.

Unfortunately, the article [5] did not include the height of the RBCA or the volume of its hopper, the characteristics of the hoist for the charge materials, the diameters of the top of the furnace and the rotor, or the elevation of the rotor relative to the protective structures of the top. The lack of such information makes it difficult to evaluate the capacity of the charging equipment. In our opinion, the conclusion reached by the designers of the RBCA [5] that it will significantly increase charging rate by fully opening the charging door is unfounded, since the chute-type BCAs currently in use in the CIS do not use the charging door (CD) to control the peripheral distribution of the charge; the door is 70–75% closed when judged on the basis of the movement of the valve and is open even less when judged on the basis of the area of closed section. The effect of this factor on the capacity of the charging system is negligible, since its actual value is determined by other factors.