Preparation of Coking Batch

V. P. Lyalyuk, A. D. Uchitel’, I. A. Lyakhova, D. A. Kassim, and G. L. Zaitsev
Metallurgical Faculty, Ukrainian National Metallurgical Academy, Krivoi Rog, Ukraine

e-mail: Vitaliy.Lyalyuk@arcelormittal.com
Received May 25, 2011

Abstract—With steady decline in quality of the coal available for coking, particular care must be taken in batch preparation. Correct choice of the degree of coal crushing in accordance with the actual proportions of bituminous and coke-grade coal maintains the petrographic composition of the batch and prevents a predominance of lean components.

DOI: 10.3103/S1068364X11080059

At present, the raw materials for coking are constantly changing, and the quantity of K, Zh, and OS coal with good clinkering properties is steadily falling. Accordingly, the rank composition of the batch is far from that required to produce high-quality coke. The coal concentrates sent to coke plants consist of blends of many components from various enrichment facilities. Their physicochemical properties are unstable, and the supply schedule of concentrates to coke plants is by no means optimal. Coal batch is produced from coal mined in different basins, included imported coal, without adequate verification that the clinkering and coking properties of the batch components are compatible. In these conditions, one means of regulating coke quality is careful preparation of the coking batch.

ADJUSTING THE CONTENT OF THE ≤3 mm CLASS IN THE BATCH

At Ukrainian plants, the content of the ≤3 mm class in coking batch has fallen markedly: from 90–93% in 1950 to 73–76% in the 1990s [1]. Thus, by 1973, the mean value was 79% [2]. In 1980, the figures were 75.5% at the Yasinovsk and Krivoi Rog coke plants; 75.7% at the Makeevsk plant; 75.9% at the Adeevsk plant; 71.4% at the Dneprodzerzhinsk plant; and 74.1% at the Zhdanovsk plant [1, 3].

In 1992, the crushing and quality of the coal sent for coking was significantly changed in Ukraine, Russia, and Kazakhstan: the content of G coal and other coal with diminished clinkering properties was markedly increased. At Bagleisk coke plant, up to 70% of the coking batch consisted of coal with diminished clinkering properties. The content of G coal rose from 29.5 to 56%, with decline in the content of Zh coal from 39 to 21% and K coal from 17 to 9%. The content of OS coal varied in the range 13–18%. The content of the ≤3 mm class was 78.2–80%. With increase in the content of coal with diminished clinkering properties, the coke quality declined, but timely correction of the degree of crushing maintained coke quality at acceptable levels. Thus, with 29.5% G coal, the coke strength was $M_{25} = 88.7\%$ and $M_{10} = 5.5\%$; with 56% G coal, by contrast, $M_{25} = 85.3\%$ and $M_{10} = 7.3\%$ [4].

At Russian coke plants, optimal crushing of the batch was also introduced. Thus, at OAO NLMK, it was established that the optimal content of the ≤3 mm class in the given conditions was 76.5–77.0%, rather than the initial value of 80% [5]. According to the bulletin on Russian coking-coal production and demand for January 2009 (available on the website www.met-coal.ru maintained by OOO RasMin and the Eastern Coal-Chemistry Institute), the content of the ≤3 mm class at Russian coke plants was 73.6–79.0%, with a high value of 83.7% at OAO NKMK (Novokuznetsk). The corresponding quality characteristics of the coke are as follows: $M_{25} = 84.4–89.1\%$; $M_{40} = 75.6–79.8\%$; and $M_{10} = 7.2–10.3\%$.

Extensive research with crushing of the components in the coking batch indicates that 82% of the ≤3 mm class is optimal at Karaganda metallurgical works [6]. Extensive research with crushing of the components in the coking batch indicates that 82% of the ≤3 mm class is optimal at Karaganda metallurgical works [6]. At present, the figure for AO ArcelorMittal Temirtau is 75.4–84.3%.

Examples of differential crushing at the Weirton Steel K plant (United States) were presented in [2]. At that plant, large classes (>16 mm) are preliminarily crushed, to obtain 65% of the ≤3 mm class. At the Burns Harbor plant (Bethlehem Steel, United States), coal components with high and low yields of volatiles are crushed separately, in different mills, to obtain batch with 80–85% of the ≤3 mm class. Analysis of the basic approaches to improving the effectiveness of coking in the United States indicate that the properties of individual size classes must be taken into account in coal preparation, and appropriate crushing must be employed, as well as measures to increase the packing density of the batch.
With a large content of Zh coal in the batch, it is expedient to crush the large components so as to obtain 75–80% of the ≤3 mm class [7]. Optimal crushing yields coke of the required quality and properties. To obtain coke of optimal quality, Zh and K coal must be crushed to obtain 75% of the ≤3 mm class, while G and OS coal must be crushed to obtain 80 and 85% of the ≤3 mm class, according to [8].

Industrial coking of batch with uncrushed concentrate containing Zh and G coal suggests the possibility of reducing the content of the ≤3 mm class from 78 to 74.5%. This does not impair coke strength and permits satisfactory blast-furnace operation [9]. The appropriate degree of crushing must be determined experimentally for each enterprise, in the light of coke quality and blast-furnace performance [10]. Optimal crushing of the batch is extremely important and will depend on the clinkering properties of the batch, the clogging with inert and poorly clinkering particles, the quality of the individual size classes, and the crushing methods. With improvement in the batch’s clinkering properties, decrease in the clogging of the large classes with inert particles, and improvement in batch preparation, less crushing should be required [11].

Optimal crushing is also important because crushing is an expensive operation, as pointed out in [12]. The power consumption per 1 t of crushed coal is 1.0–3.5 kW-h, depending on its characteristics; the energy consumption in crushing accounts for 70% of the total in batch preparation.

**EXPERIENCE IN BATCH PREPARATION AT KRIVOI ROG COKE PLANT**

In this context, it is of interest to consider experience in the preparation of coking batch at Krivoi Rog coke plant (currently the coke department at PAO ArcelorMittal Krivoi Rog). Thus, in 1972, the coking batch at Krivoi Rog coke plant contained 35.5% G coal [13]. The batch consisted of G, Zh, K, and OS coal, as well as the binary mixture G + Zh, from seven enrichment facilities. The batch was crushed to produce 74% of the ≤3 mm class. The optimal figure for the given coal at Krivoi Rog coke plant is 76–77% if the relatively fine grinding of the OS and G coal and the coarse grinding of the Zh and K coal is taken into account, as established in [13].

To optimize the granulometric composition of the batch and increase its packing density, the coal preparation was modified at Krivoi Rog coke plant. The batch then consisted of a blend of G, Zh, and K coal and binary mixtures G + Zh and OS + T, supplied by nine enrichment facilities. In the new system, the G coal and the binary mixture G + Zh were crushed to obtain no less than 80% of the ≤3 mm class; the binary mixture OS + T was crushed to obtain no less than 90% of the ≤3 mm class. The Zh and K coal, with 76–77% of the ≤3 mm class, was introduced in the batch without crushing, by means of a bypass channel. As a result of these changes, the overall content of the ≤3 mm class was reduced from 80–81 to 76–77%; the packing density was increased by 2.3% [14].

Later, specialists at Krivoi Rog coke plant noted that the rational use of the available coal entails not only improvement in the batch and the bed-coking technology but also the use of progressive coal-preparation methods [15]. Overall increase in the batch’s packing density not only increases the productivity of the coke batteries but also markedly improves the physicomechanical properties of the coke. This is especially important in the light of the ongoing decline in coal quality and in the coking properties of the batch. Thus, in the fourth quarter of 1976, the batch composition at Krivoi Rog coke plant markedly changed: increase in G coal from 29.8 to 32.3%; decrease in Zh and K coal from 34.1 to 30.8% and from 13.3 to 7.3%, respectively. The content of Kuznetsk Basin coal in the batch also increased from 7.9 to 13.2%. The initial Zh, K, and OS coal contained up to 70–80% of the ≤3 mm class and was suitable for batch mixing in terms of granulometric composition. The overall content of the ≤3 mm class in the batch was 74–75%. The irrational coal crushing at Krivoi Rog coke plant often led to excessive crushing of the component with good clinkering properties (Zh coal). As a result, the content of the lean ≤0.5 mm class in the batch increased, with decrease in the packing density and deterioration in the coking properties of the batch. This, in turn, impaired the physicomechanical properties of the coke. To eliminate these problems, a device for diverting the ≤6 mm class before crushing was installed in the crushing channel within the coal-preparation shop. This permitted the diversion of 30% of the key components and prevented excessive crushing of the Zh and K coal. As a result, $M_{35}$ increased and $M_{10}$ fell. In addition, such diversion reduced the power consumption in crushing by half [15].

Note that Kushnirov was one of the first to propose diversion of the ≤3 mm class before crushing. His research on the batch in the coal-preparation shop showed that very fine crushing has serious disadvantages and that crushing without any concomitant benefit in coke quality is inexpedient. Constant determination of the optimal batch crushing is required, with appropriate diversion of the ≤3 mm class before crushing [16].

The optimal batch crushing at Krivoi Rog coke plant was analyzed on the basis of economic considerations in [17]. In production conditions, the coke quality for batch with 65–95% of the ≤3 mm class was determined. In accordance with the group-crushing system at the coke plant, an overall content of the ≤3 mm class of 75% in the coking batch corresponded to 75–76% of the ≤3 mm class in G coal, up to 90–92% in OS coal, and up to 60–70% in Zh and K coal.