Partial Briquetting of Coal Batch: A Review
V. S. Vasil'ev
e-mail: vektor717@mail.ru

Abstract—Laboratory research and industrial data on the partial briquetting of coking batch by binder are analyzed. Briquetting by compacting the batch without binder is also found to be expedient.

One method of coking poorly clinkering gas and lean coal is to increase the batch density by partial briquetting. With the continuing deterioration of coal resources for coking, this technique is important in order to produce coke of the required quality [1–3].

In the 1970s, partial briquetting of coal batch was first adopted on an industrial scale in Japan, on the basis of Nippon Steel technology [4]. For the first briquet-production system built at a coke plant, the output was 33,000 t per month.

The batch was produced by crushing the individual components. About 30% of the batch was sent to the briquet department, where binder was added. The mixture was heated by live steam, and sent after mixing to a roller press of productivity 30 t/h. (The system included two such presses.)

According to Nippon Steel data, a benefit of the new technology is that the proportion of high-quality coking coal in the batch may be reduced from 70 to 55%, and up to 20% of coal previously regarded as unsuitable for coking may be employed.

For further improvement in the process, Sumitomo (Japan) collaborated with Krupp Koppers (Germany) to develop equipment of various sizes for the production of briquets at rates of 30–100 and then 120 t/h [5, 6].

A two-roller press is equipped with a distributor that ensures a uniform and continuous supply of the initial material in two parallel fluxes; a device for productivity regulation by adjusting the gap between the rollers; and a pump creating the necessary pressure and serving as a damper in the presence of foreign objects. The uniform supply of materials yields briquets with stable properties.

The rollers are fitted with high-strength steel coverings, applied while hot. The surface of the covering is subjected to electrospark machining, in accordance with the required form of the briquets. The high quality of the surface treatment prevents adhesion of the material being briquetted.

Japanese briquetting systems have been adopted in South Korea and India [6].

In Japan, besides the original roller presses (output 25–50 t/h), faster presses (84 t/h) are in use. The binder is usually coal pitch. Up to 40% of the coke is produced by this technology. Comprehensive testing in 4000-m³ blast furnaces shows that coke obtained from partially briquetted batch with binder performs well [2, 6, 7].

Detailed research on the coking of partially briquetted batch with binder at the Institute of Fossil Fuels showed that the mechanical strength of the briquets depends on the type of coal and the additives employed [8–11]. The processes in the coking of such batch were investigated.

The possibility of producing blast-furnace fuel from poorly clinkering coal was demonstrated in [8]. The formation of coke from briquetted batch was studied so as to establish the conditions of high-productivity coking.

Extensive research on the coking of briquetted coal was undertaken in [9]. Laboratory experiments showed that replacing half of the batch with fuel in which the plastic-layer thickness is reduced (briquets) does not impair the quality of the coke produced.

Semiindustrial tests were conducted on the basis of the laboratory research. A roller press was used to produce pillow-shaped briquets (50 × 40 × 35 mm, 70 g; density 1200 kg/m³). In briquetting, small quantities of BN-III petroleum bitumen or fuel oil were added. Briquetting 60% of the batch made it possible to produce coke of normal strength, rather than the friable unconditioned coke usually obtained.

In another series of experiments, with 60% of briquets made from 60% SS coal + 40% G coal with a small quantity of binder, strong blast-furnace coke was obtained, although the total content of G + SS coal in the batch was 66.8%.

Investigation of G6 and SS coal to establish how the crushability of the coal and the roller pressure affect the strength of the coke briquets was reported in [10]. The briquets were prepared by mixing crushed coal with 5% molten BN-IV petroleum bitumen, placing the mixture in a preheated (to 80–90°C) mold, and pressing at 10–30 MPa.
For G6 coal, the strength of the briquets and coke briquets increases as greater pressure is applied at the rollers. This may be attributed to the greater density of the briquets with compression of the coal grains, which, in turn, improves the clinkering properties of the coal and permits the production of conditioned coke briquets. With constant roller pressure, the strength of the briquets and coke briquets increases as the coal is ground more finely.

In bed coking, the opposite relation is observed: fine grinding of the coal reduces the coke strength and impairs the clinkering properties of the coal. However, fine grinding reduces the cracking of the coal by reducing the internal stress, as a result of the elimination of large grains, increase in thermal conductivity of the coal, and impairment of its clinkering properties.

Coke produced from uncompacted coal has low wear resistance—that is, low structural strength. Briquetting increases the wear resistance of the coke briquets and hence their structural strength, which is directly proportional to the roller pressure in the press. The absence of large grains in the briquets eliminates the local stress. The increased susceptibility to cracking of the coke briquets associated with their reduced thermal conductivity on account of compaction of the coal is eliminated because of their small size.

In pressing, finely ground coal has a more developed contact surface and more bonds are formed between the coal grains and binder. As a result, the density of the briquets is increased.

However, there is a limit on the grinding of the coal. Grains in the range 0–1.6 mm with 5% bitumen are associated with reduced strength of the briquets and coke briquets. This may be attributed to reduced ratio of the binder mass and the specific surface. Increasing the bitumen content in finely ground coal increases the strength of the briquets and coke briquets.

The reduced strength of the coke briquets may also be explained in that the coal becomes leaner on fine grinding, with loss of clinkering properties. To obtain strong coke briquets from coal with poor clinkering properties, finer grinding is required.

The strength of coke briquets produced from 80% G coal + 15% SS coal + 5% BN-IV bitumen increases with greater grinding of the SS coal (from 0–3 mm to 0.05 mm). Thanks to fine grinding of the SS coal, its distribution in the more fusible G coal becomes more uniform, with increase in the quantity of binder at the GG–S interface and improvement in coke strength.

Briquetting permits the production of uniform crack–free coke from more finely ground coal. The degree of grinding of the coal depends on its clinkering properties. Finer grinding is required to obtain strong coke briquets from coke with impaired clinkering properties.

Two fundamentally different technologies may be used for partial briquetting of the batch, as shown in [11]: (1) briquetting of 30–60% of the coal batch; (2) briquetting only of the poorly clinker–ing components.

Note that both approaches require separate crushing of the batch components, since high-quality briquetting depends on optimal specific surface of the briquetted grains for their metamorphic level. Separate crushing of the components also boosts coke quality.

Blast-furnace coke of satisfactory quality may be obtained from partially briquetted (by the method in [9]) Kuznets Basin coal batch containing no more than 20–40% of components with good clinkering properties. The coal produced matches the physicochemical properties, porosity, density, and appearance of regular coke.

For example, briquetting 65% of the poorly clinker–ing coal (G6, K2, and SS) markedly boosts coke quality; in regular coking without briquetting, the coke produced is of extremely poor quality; with briquetting of 35% of the coal, the coke quality is somewhat enhanced. With other batch, increasing the content of briquets from 20 to 35% also boosts coke quality.

In the design of industrial equipment, it is advisable to make provision for the partial briquetting of the whole batch and also of only the mean (poorly clinker–ing) components and also for briquetting with and without binder. Maximum productivity corresponds to the briquetting of 60% of the total coal batch.

Besides the work at the Institute of Fossil Fuels, theoretical, semiindustrial, and industrial research on the coking of partially briquetted batch has been undertaken at Eastern Coal–Chemistry Institute and the Ukrainian Coal–Chemistry Institute [12–18].

The coking of coal batch with 15% and 30% briquets was first undertaken on an industrial scale at Nizhni Tagil Metallurgical Works in some ovens within coke battery 3 (chamber volume 20 m3). The briquets increased the packing density of the batch from 750 kg/m3 to 810 and 850 kg/m3, respectively. Overall, the results of industrial coking indicated gains in coke quality [2, 12].

Long-term industrial coking of partially briquetted batch (with binder) was described in [13]; the operational efficiency of the blast furnaces was measured.

A batch of coking briquets (25000 t) was produced at the Donetskaya briquet plant. The experimental batch was used in all the coke batteries at Dnepropetrovsk coke plant. The coke was supplied to blast furnaces of capacity 1033 and 675 mm3 at Petrovskii Dnepropetrovsk Metallurgical Plant. Batch from Yasynovsk coke plant containing only 25.5% Zh and K Donets Basin coal with good clinkering properties was briquetted. The binder was BN-70/30 bitumen (7.1 wt %).

Prolonged open storage of briquets (1.5 months) had practically no influence on their performance. The briquet content in the batch was 32–35%; the content of gas coals was 40.6 wt %. In the test results,