SOME PRACTICAL CONSIDERATIONS FOR THE APPLICATION OF COAL PULVERIZATION AT COKE PLANTS

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During recent years, the United States Steel Corporation has focused increased attention on coal-pulverization practice at coke plants.[1-5]* Coal pulverization at coke plants offers two opportunities for steel-plant cost improvement. First, coal blends that are known to give cokes of good strength may yield, through pulverization, additional increases in strength, such increases resulting in increased hot-metal production at the blast furnace. Second, by pulverization of poorer coking coals the amounts of the more costly and less readily available blending coals may be reduced without a loss of coke strength.

Prior to any discussion of coal pulverization, it is important to realize that an optimum pulverization level (commonly reported in terms of % minus 1/8-inch coal) exists for each coal or coal blend and that overpulverization can be detrimental.[1,2,5-7] Optimum pulverization for a given coal or coal blend generally will give some loss of bulk density (or coke production) with a corresponding increase in coke quality (or strength). Except with dry coals, however, overpulverization results in appreciable loss of bulk density and may reduce or give little improvement in coke strength, particularly the Hardness Factor, for normally coking coals. This loss of bulk density can be substantially recovered by adjusting the moisture content or by appropriate oil addition.[8-10] Also, means for increasing the drop velocity of the coal into the coke ovens are helpful. For poor coking coals, increased coking rates are useful. The primary objective in pulverizing coals is the improvement of coke quality to give more intimate contact between the coal constituents. Thus, pulverization permits homogenous mixing and intimate contact between the various constituents.

Once the need for a coke-plant coal-pulverization system has been established and the optimum pulverization level has been determined by carbonization tests, the next objective should be to attain in a practicable manner the required level of pulverization. However, this should be achieved so as not to exceed the minimum allowable increase of fine "bug dust" (arbitrarily defined as minus 100-mesh coal) over that level present in the unpulverized coals. Attainment of this objective will minimize the amount of bug dust in the coal and the loss in bulk density. Minimizing the amount of bug dust minimizes the loss of coal during pulverization and during carbonization, with attendant improvement in plant housekeeping and safety.

Coke-plant coal-pulverization systems fall into three basic types, as illustrated in Figure 1. These are (1) single-pass systems in which all coal to be pulverized is passed only through pulverizer mills, (2) prescreening systems in which the fine (commonly, minus 1/8-inch) coal is recovered by screening and in which the screen overproduct is pulverized and mixed with the recovered screen underproduct, and (3) closed-circuit systems in which screens are used before and after pulverizers to contain all oversize coal for repulverization until the coal is fine enough to be released from the system as screen underproduct.

As these systems increase in complexity, there is a corresponding improvement in the control of pulverization level. Table I illustrates the increased pulverization that can be achieved for a given coal by progressing from the single-

* See References.

pass to the prescreening to the closed-circuit systems. However, if the single-pass system were used to bring the level of pulverization at 1/8 inch to 86 per cent, the amount of bug dust would have been considerably greater than the 12.3 per cent attained with the prescreening system. Also, by using the more elaborate closed circuit system, even greater improvements in the level of pulverization and in the control of bug dust can be realized.

In pulverizing coals for blending, the low-, medium- and high-volatile coals attain an optimum pulverization level at widely varying pulverizer-mill speeds. These mill speeds range from about 4500 feet per minute (fpm) rotor-tip velocity for certain soft and friable low-volatile coals to about 8000 fpm rotor-tip velocity for hard high-volatile coals. These mill-speed ranges were established by using impact-type coal pulverizers instead of hammermills, since the former lend themselves more readily to speed variation and give a more predictable and significant change in pulverization level for a change in mill speed. Also, for a given pulverization level, impact-type pulverizers will produce less bug dust than hammermills.

It is a popular, but perhaps obsolete, coke-plant practice to pulverize all coals by using hammermills (or hammermills with grates removed) operating at the same speed. The above conclusions, together with experience at coke plants, supoort the observation that operating pulverizer mills at a single speed will overpulverize the softer blending coals. Normally, the single-speed operation is suited for pulverizing high-volatile coals, but because of the high mill speeds used, overpulverization of the low-volatile coals results in, and is largely responsibele for, exess production of bug dust.

The detrimental effects of pulverizing a softer and a harder coal at the same mill speed (6300 fpm rotor-tip velocity) are shown in Table II. High-volatile coal was satisfactorily pulverized, but low-volatile coal was overpulverized. The amount of bug dust in the low-volatile coal was almost doulbe that in the high-volatile pulverized product. The improved pulverization that can be achieved by pulverizing softer coals at lower mill speeds (4400 fpm) and harder coals at higher mill speeds (6300 fpm) is shown in Table III. High- and low-volatile coals were pulverized to give the same amounts of bug dust.

For most American coke plants it appears that the use of a prescreening system incorporating impact pulverizers at two mill speeds is worthy of consideration. In large pulverization installations, fixed-speed mills (or direct-drive mills) may be used provided that a lower and a higher mill-speed section is available for handling the various coals. For smaller installations where the same series of mills must be used intermittently to pulverize the different coals to be blended, variable-speed drives are recommended. This permits preselection of optimum mill speed prior to pulverization of the individual low-, medium- or high-volatile coal.

Because of its merit, the combination of prescreening with two mill speeds in coke-plant coal pulverization has been adopted by the United States Steel Corporation and is being applied at the Corporation's large, new coal-pulverization facility at Gary Steel Works, Gary, Indiana.

In coke plants where pulverization is applied, but where a complete change from the older single-pass systems is not justified, it may be desirable to equip the mills with impactor-conversion assemblies and variable-speed drives. This practice can reduce the bug-dust level and improve control of pulverization.

Generally, with these older fixed-speed, single-pass pulverization systems, control of pulverization is sought by changing the clearance between the mill rotor and impact surface. However, tests indicate that feed rate may offer a more attractive means for pulverization control. It appears that for each mill studied, increased pulverization will be accompanied by increased bug dust, but beyond a certain mill feed rate (regardless of mill speed or setting) both pulverization and bug dust decrease. The "reversal" of this trend is no doubt the result of portions of coal going through the mill unpulverized. The feed rate at which this reversal occurs (reversal-point feed rate) is at or near the manufacturer's so-called nominal rated mill capacity. Tests indicate that feeding a mill at a rate that exceeds the reversal point and approaches the mill stall point will result in an approximately equivalent percentage reduction in both the pulverization and bug-dust levels. (The stall point of most pulverizers occurs from 50 to 100 per cent above their nominal rated capacities, and at a number of plants, mills are being run at these levels.) Therefore, the attainment of a feed rate between the reversal point and the stall point, obtained by choke feeding, offers a means for reducing the amount of bug dust and increasing mill productivity, but is achieved with some reduction in level of pulverization. This reduction is not great and the new level of pulverization may be consistent with requirements. Table IV illustrates the effect on size-consist when the pulverization reversal point is exceeded.

Conclusions

From the data presented above, it may be concluded that the most effective method of using pulverizers in a single-pass system is to design the machine rotor speed to exceed that necessary to produce the desired pulverization level and then choke-feed the machine to depress pulverization back to the desired level. This practice will give both desired pulverization and significant bug-dust reduction. In those coke plants where the older fixed-speed, single-pass mills are in use, hard, high-volatile coals can be pulverized to a greater degree by feeding at a rate approaching the nominal rated capacity of the mill. Excess bug dust resulting from the soft, low-volatile coals can be reduced by increasing feed rate above the rated capacity of the mill to a value approaching the mill stall point. Therefore, by manipulating the feed rates of these older systems, pulverization and bug-dust levels of the different coals can, to a limited degree, be made to approach more closely the desired value for any given mill setting.

In this review it has been pointed out that in any of the three types of coal-pulverizing systems, mill speed and mill feed rate are the primary variables in controlling pulverization level and bug-dust production. Proper application of these concepts to any of the three systems should lead to practical improvements in pulverization within the limits of the particular system employed.

References

1. A. H. Brisse and H. E. Harris, "Some Basic Principles of Pulverization and Preparation of Coking Coal Blends," Blast Furnace and Steel Plant, 45, p. 301-307 (1956).

2. A. H. Brisse, "Determination of Coke Oven Productivity from Coal Charge Characteristics," Blast Furnace and Steel Plant, 47, p. 376-383 (1959).

3. A. H. Brisse and B. R. Kuchta, "Better Coal Preparation Through Better Crushing," AIME, Blast Furnace, Raw Materials, and Coke Oven Committee, Proceedings, Vol. 18 (1959) pp. 17-21.

4. A. H. Brisse and J. G. Price, "Explorations in Coke Making Research with a Full Scale Coke Oven Model," American Iron and Steel Institute, Chicago Regional Technical Meeting, October, 1959; Blast Furnace and Steel Plant, 47, p. 1285-1290 (1959).

5. J. G. Price and J. D. Clendenin, "Some Practical Aspects of the Degradation of Blast Furnace Coke During Handling," AIME Blast Furnace, Coke Oven and Raw Materials Committee, Proceedings, Vol. 17 (1958) pp. 79-88.

6. C. W. Stahl, "Experiments to Improve Coke Strength," American Iron and Steel Institute Yearbook (1947) pp. 355-378.

7. C. C. Russell, "The Selection of Coals for the Manufacture of Coke," Proceedings American Gas Association (1947) pp. 733-756.

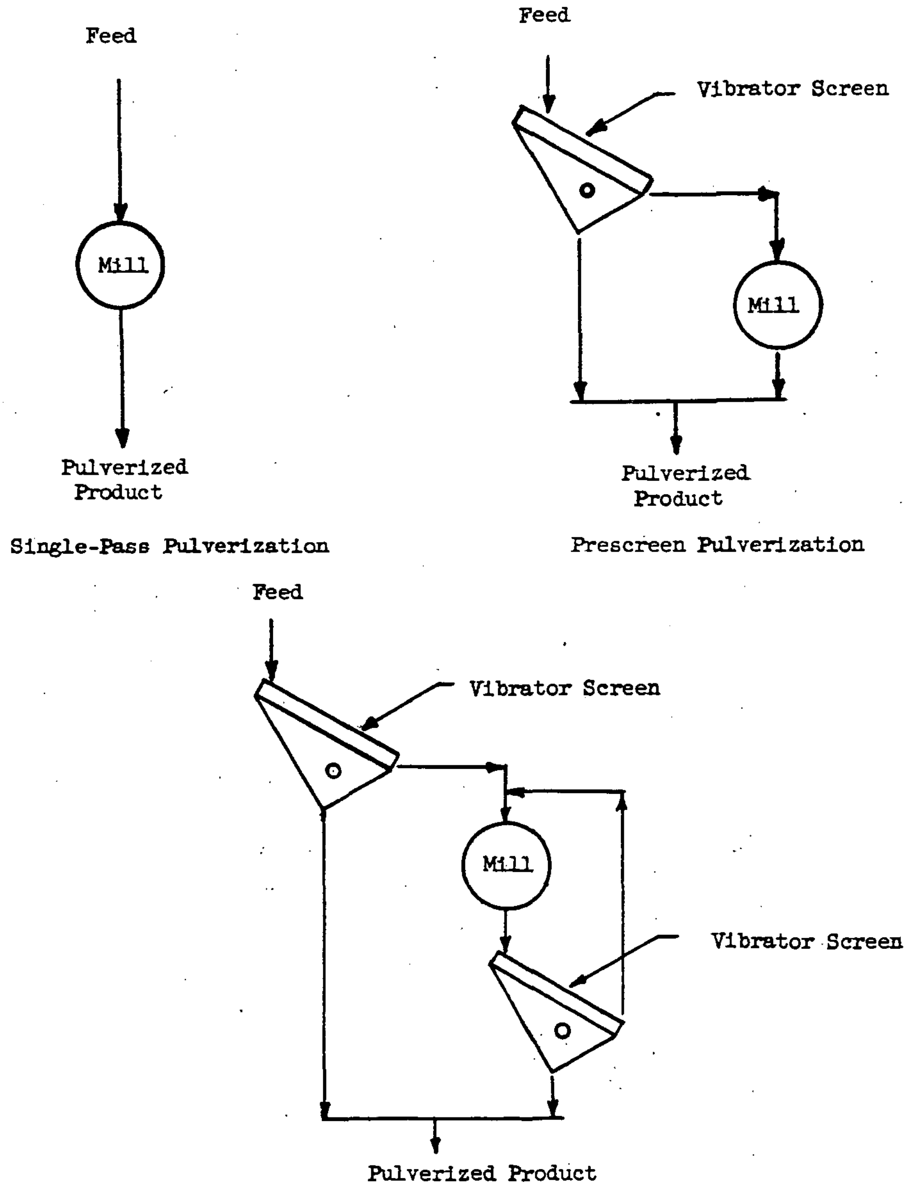
8. C. J. Ramsburg and G. V. McGurl, "Carbonization of Coal-Oil Mixtures," Proceedings American Gas Association (1940) pp. 97, 102-103.

9. W. S. Landers, L. D. Schmidt, and Wm. Seymour, "Control of Bulk Densitites in Coke Ovens: Studies on Coal Used at Three By Product-Coke Plants," U. S. Bureau of Mines Report of Investigations 3807 (1945) 22 pp.

10. Pontypridd Test Plant Committee, "A Study of Factors Influencing the Bulk Density of Coal for Carbonization," British Coke Research Assoc. (1957) May, 44 pp.

Figure 1

THREE BASIC TYPES OF COAL-PULVERIZATION SYSTEMS FOR COKE PLANTS



Closed-Circuit Pulverization