LO-MO Coke Quenching System

Patent Pending

ANOTHER USS INNOVATION

United States Steel announces another innovation - a new and unique coke quenching system which replaces or augments the conventional spray systems now in general use throughout the industry. Already in operation at 11 towers in 4 United States Steel Corporation plants, this breakthrough in quenching technology has demonstrated significant advantages over the spray system and has generated substantial dollar savings through reductions in coke plant and blast furnace operating costs.

DESCRIPTION OF THE SYSTEM

The LO-MO quenching system applies water to the incandescent coke as a non-symmetrical flow rather than as a uniformly distributed spray of finely divided water particles. The new method permits a quicker and more thorough penetration of water through the bed of coke in the quench car, followed by "bottom up" quenching as the water actively percolates upward and sideways through the coke.

LO-MO IS ADAPTABLE TO EXISTING TOWERS

The water flow in the LO-MO system may be arranged in any one of several ways best suited to fit the existing tower piping arrangement, a feature which permits economical replacement of present conventional sprays. The system is constructed mostly of standard pipe and fittings and, therefore, is inexpensive and simple to install in existing towers.

LO-MO REDUCES COKE MOISTURE

Where coke moisture exceeds about 4% with conventional sprays, the LO-MO system may be expected to reduce the moisture 20 to 40% (see Figure 1). The greater the moisture with sprays, the greater the reduction with the LO-MO quench.

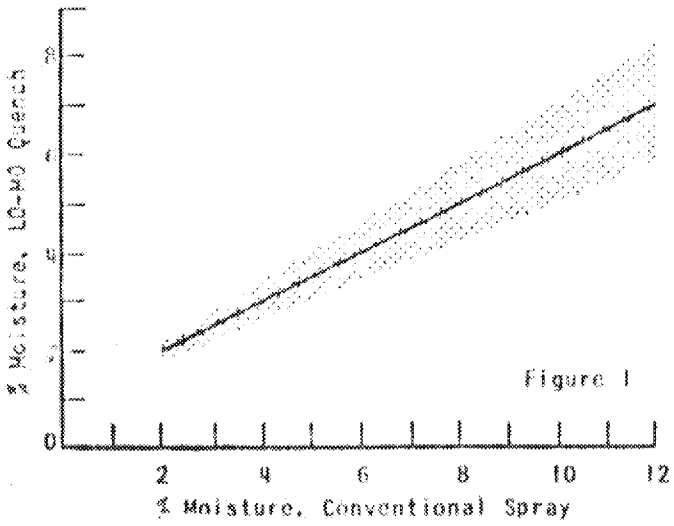

Figure 1

LO-MO REDUCES VARIABILITY IN COKE MOISTURE

Figure 2 illustrates the reduction in daily moisture *variability* which can be expected as *average* moisture decreases. More uniform and lower coke moisture means less overcharging of coke into the blast furnace, and also lower shipping costs per ton of dry coke delivered to the furnaces.

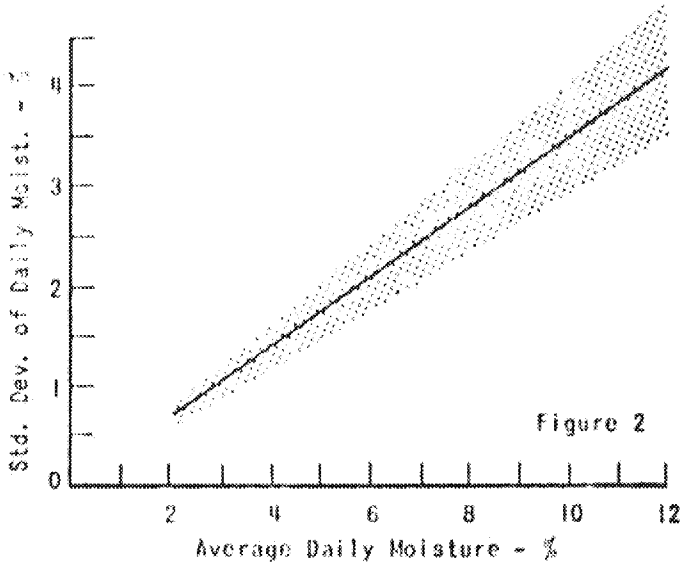

Figure 2

LO-MO DECREASES HOT SPOTS

Even at lower average coke moisture, LO-MO substantially reduces the occurrence of hot spots to almost nothing. Elimination of hot spots is a "must" for automated wharves; for this reason, LO-MO quenching is now employed at two United States Steel automated wharves and will soon be installed at the third.

LO-MO DECREASES QUENCHING TIME AND INCREASES PUSHING RATE

Unless the present quench time with sprays is less than 80 seconds, LO-MO will reduce it. Experience at USS installations indicates a quench time in a LO-MO tower of 60 to 80 seconds for quench cars containing up to 23 tons of coke.

A reduced quenching time permits "catching up" to the scheduled number of pushes per turn after a delay. Some or all of the "lost ovens" can be recovered. And if quench car transit time limits production without delays, LO-MO quench means more tons per turn.

LO-MO USES LESS WATER

In those towers where fresh water is used and the runoff is not recycled, the 30 to 40% reduction in water possible with the LO-MO quench may represent a significant saving. The change in consumption to be expected is shown in Figure 3.

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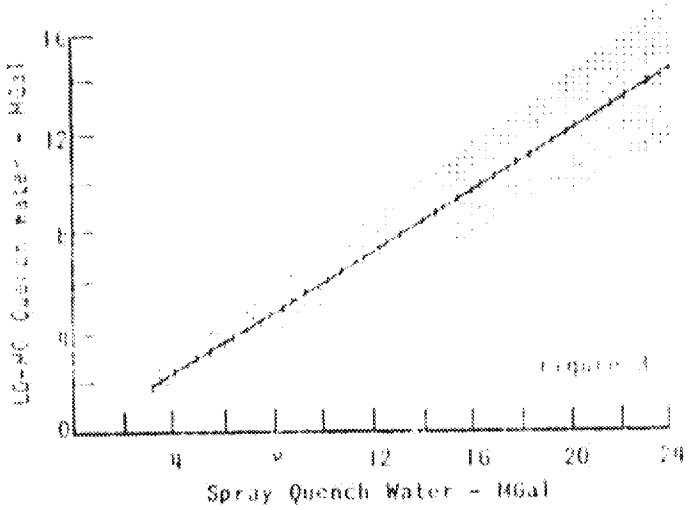

Figure 3

LO-MO REDUCES COSTS

The cost savings generated at a particular plant depend to such an extent on the specific facilities and operating practices at that plant that it is impractical to suggest a "typical" cost improvement which might result from the installation of the LO-MO quench system. However, savings can be estimated using a given set of conditions such as those for hypothetical Plant X described below. For this particular plant the conditions were chosen to illustrate the kinds of savings possible; these conditions might not exist in every plant.

OPERATING PARAMETERS FOR HYPOTHETICAL PLANT X

Plant X plans to replace its conventional spray quench at No. 1 tower with the LO-MO system. This tower serves two batteries, A and B, with 87 ovens each or a total of 174 ovens. Each oven produces 14 tons of coke at an average coking time of 17.4 hours. The batteries have produced good coke in 16 hours (a pushing rate of 87 ovens per turn), but a minimum quench car travel time of 6 minutes (including the time in the tower) limits the pushing rate to 73 ovens per turn during the average of 7 hours 18 minutes which remain in each turn after a scheduled half hour "down" period and an average 12-minute delay.

Batteries A and B produce 1,120,000 tons of coke per year at a plant cost of $19.00 per ton for shipment to the plant's blast furnaces located some distance from the coke works. The required rail transportation averages $1.00 per ton of "wet" weight, making the cost of the coke at the blast furnaces $20.00 per ton. At a coke rate of 1,200 lbs./ton (dry), the furnaces must purchase additional coke at the market price of $30.00 per ton.

Eight thousand gallons of uncontaminated industrial water at $12.00 per MM are required to quench the coke in 2.2 minutes, leaving an average of 7.0% moisture.

PLANT X ESTIMATES SAVINGS WITH LO-MO QUENCH OF ...

... $1,000,000 PER YEAR THROUGH SHORTER QUENCH TIME

Experience in USS LO-MO quench towers indicates that hot coke in any conventional quench car can be quenched in 60 to 80 seconds. Using 72 seconds (1.2 minutes) for estimating purposes, Plant X can save 1 minute in the tower and reduce the round trip transit time from 6 to 5 minutes. This 17% reduction would permit an increase in pushing rate from 73 to 87.6 pushes per turn! Only half of this improvement, say to 80 pushes per turn, represents 98 more tons per turn or 100,000 tons per year. Reducing outside purchases of coke at $10.00 over in-plant cost nets a saving of $1,000,000.

... $336,000 PER YEAR BY REDUCING MOISTURE

Figure 1 indicates that the LO-MO system will reduce the moisture from the current 7.0% to 4.5%. In the efficient [illegible] furnaces at Plant X this 2.5% less moisture represents 50 lbs. less water entering the furnace per ton of iron or 36 lbs. of coke per ton which otherwise must be burned in addition to the actual 1,200 lbs. to raise that water from [illegible] at a top gas temperature of 350F. At Plant X whose blast furnaces produce more than 1,866,000 tons of iron from its own coke only, this additional fuel consumption represents 33,600 tons per year of coke which, with LO-MO, would not have to be purchased from its own coke works at $20.00 per ton. Again, even half this amount would save $336,000 per year in coke costs at the blast furnaces.

... $28,000 PER YEAR BY SHIPPING LESS WATER

The same 2.5% reduction in moisture in the coke represents 28,000 tons of water NOT shipped to the blast furnaces each year at $1.00 per ton - a saving of $28,000 in shipping costs.

... $112,000 PER YEAR BY DECREASING MOISTURE VARIABILITY

The coke charge at a blast furnace is usually weighed in order to guarantee that the amount of carbon necessary to maintain the furnace in the proper thermal state will be added. A sudden and unknown increase in moisture in the coke means less dry coke, and if the condition continues for an extended period, the lack of carbon will cause the furnace to run cold.

To avoid this, the operator not only compensates for the average moisture, but he also overcharges coke by some amount known by experience to prevent the dangerous swing to "the cold side". If each charge of coke contained the same moisture, overcharging would be unnecessary; but as the *variability* of moisture increases, the overcharging must also increase.

United States Steel experience has shown that variability (measured in terms of standard deviations) increases with increasing *average* moisture (Figure 2). Assuming that no more than 30% of the charges should contain less than the prescribed amount of dry coke (say, 1,200 lbs./ton), the amount of overcharge has been calculated to increase by about 2.4 lbs. to compensate for the increased variability associated with each increase of 1% in average moisture. In more general terms, for a change of 1% in average moisture the overcharge increases 0.002 tons of coke for each pound of coke charged per ton of hot metal.

The reduction of 2.5% in average moisture therefore reduces overcharging of Plant X's 1,200 lb./ton coke rate furnaces by 5,600 tons per year based on the annual production of 1,866,000 tons of hot metal. The saving in coke at $20.00 per ton amounts to $112,000 per year.

... $3,070 PER YEAR BY SAVING WATER

Figure 3 indicates that the LO-MO quench will cut water consumption at Plant X by 3,200 gallons per quench. Since the runoff water is not recycled, the saving of $3,070 is real although not large.

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USE THESE EQUATIONS TO ESTIMATE SAVINGS AT YOUR PLANT

(All savings in annual dollars)

A. Savings at blast furnaces from reduced moisture in coke:

$S_m = .006A(M-2)C_b$

A = annual tons of coke quenched at this tower

M = average moisture in coke using conventional sprays - percent

C_b = cost of own coke at blast furnaces in dollars per ton

B. Savings at blast furnaces from less variability in coke moisture:

$S_v = .001A(M-2)C_b$

C. Savings in shipping costs from lower moisture in coke:

$S_s = .005A(M-2)C_s$

C_s = cost of shipping coke to blast furnaces in dollars per ton

D. Savings from less water per quench:

$$S_w = \frac{0.4AWC_w}{Q}$$

W = gallons of water used in conventional spray quench

C_w = cost of water per gallon

Q = tons of coke per quench

E. Savings from increased production due to decreased quench time and greater pushing rate:

Step 1. Determine maximum pushing rate per turn, R_{ct}, as limited by desired coking time:

$$R_{ct} = \frac{8N}{T_{ct}}$$

N = number of ovens served by this tower

T_{ct} = desired coking time in *hours*

Step 2. Determine current pushing rate per turn, R_{sp}, with sprays:

$$R_{sp} = \frac{480-D}{t_t + t_s}$$

D = average delay in *minutes* per turn

t_t = average round trip transit time of quench car *less* time in tower - min.

t_s = time in tower with spray quench - in minutes

Step 3. Estimate pushing rate per turn with LO-MO quench, R_{lm}:

$$R_{lm} = \frac{480-D}{t_t + 1.2}$$

Step 4. Calculate savings resulting from decreased quench time, S_q:

$S_q = 1095\,(Z-R_{sp})Q(C_o-C_b)$

Z = R_{lm} or R_{ct}, whichever is the least

C_o = price of coke purchased from outside suppliers or as sold. If neither, let (C_o-C_b) equal reduction in coke works cost of coke due to increased production

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