Combining Stamp Charging with the Heat Recovery Process

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Stamp charging can increase throughput of a heat recovery oven by up to 28% while maintaining high-quality coke production. Reductions in input costs can also be realized, as lower coking quality coals may be used.

Minimizing raw material costs in integrated steelworks has a high priority, as it represents the largest expense in steel production. Coking coal contributes up to 50% of the cost of hot metal (Figure 1). Therefore, it is logical that coke quality and price are key concerns for the iron and steel industry in its efforts to be competitive.

There are two primary variables that influence the price and quality of blast furnace coke—the cokemaking technology employed and selection of raw materials used in the coke plant.

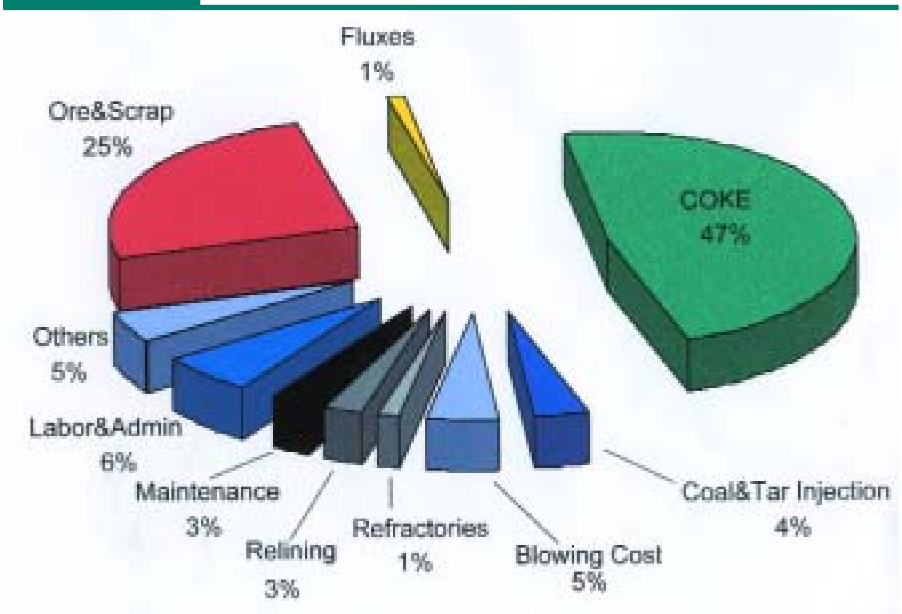
Maximum benefits are achieved by combining stamp charging with the heat recovery process. The heat recovery process offers economic and environmental advantages in coking technology. Stamp charging increases value-in-use of raw materials.

A description of pilot testing conducted is presented, along with pilot test quality and productivity results.

Pilot Oven Tests

Over two years ago, basic and comparative bench tests were conducted with a coal and coke research institute that simulated the nonrecovery process and combined it with stamp charging. The tests were performed

Figure 1



Typical breakdown of hot metal costs.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using a semiscale pilot oven and compared top charged and stamp charged oven fillings. The results were promising with regard to increased oven throughput and improved coke quality, especially in CSR, CRI, Micum 10 and coke grain size.

These results encouraged a full-scale battery of tests to be conducted at an existing commercial coke plant, and arrangements were made with Sesa Kembla to conduct such trials. Drawings for required equipment were prepared by Koch, and fabrication of the equipment was executed by Sesa Kembla. Trials began only six months after initial contact.

The trials were conducted in July 2001 in Sesa Kembla's top-charged coke plant at Amona, Goa, India. This plant has a coke production capacity of approximately 300,000 tonnes per year. Specifications for the plant are presented in Table 1.

To carry out the trials, the following conditions had to be met:

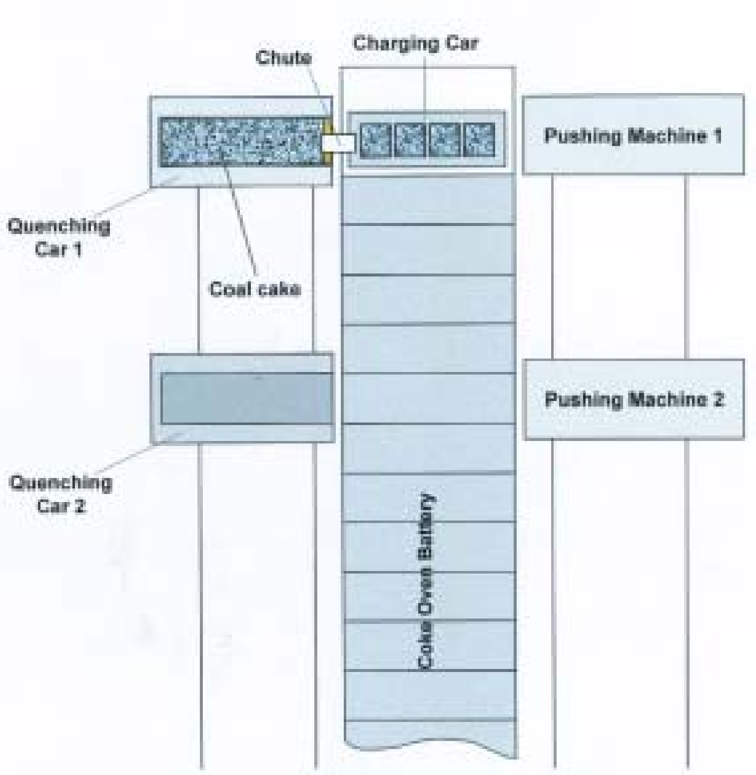
- Minimization of capital expenditures required for equipment and performance of the trials.
- Minimization of interference factors with normal plant operation.
- Avoidance of production losses.
- Development of precautions for heavy monsoon rainfalls.
- Charging of ovens within the battery only, not end ovens.

Table 1

Sesa Kembla Coke Plant Specifications

Battery type	2 CO batteries, 42 ovens each
Chamber length	10.76 m
Chamber width	2.75 m
Coal charge height	1.18 m
Coal charge per oven	26.8 tonnes
Coking time	48 hrs

Figure 2



Location of quenching car during preparation of the coal cake.

Trial Execution

An existing coke quenching car was used for preparation of the coal cake. Sesa Kembla's quenching cars are equipped with a flat steel box that corresponds to the dimensions of the oven. The quenching box also has the same elevation as the oven floor, making it appropriate for use when charging the coal cake from the coke side of the battery. This car was equipped with a charging plate and a box made of wooden planks, which were supported by the side walls of the quenching car. The charging plate was furnished with a pulling device on its front end.

Coal was transported from the coal tower to the stamping box by one of the existing charging cars on the oven top (Figure 2). This charging car was equipped with load cells to determine the exact weight of each coal charge. Coal was filled into the stamping box via a chute in layers approximately 200 mm in height, then leveled equally and compacted manually by means of pneumatic hammers. Using this method, five layers were compacted to a coal cake sized at 10.3 meters in length, 2.6 meters wide and approximately 1.0 meters high.

After compacting the coal cake, the wooden sidewalls of the stamping box were removed, and the coal cake freely rested on the charging plate.

After pushing coke from the oven for recharging, the quenching car with the coal cake was positioned at this oven. A water-cooled puller bar was inserted through the empty oven chamber from the pusher side until it reached the coke side and was connected to the charging plate (Figure 3). Both oven doors were opened to a gap of approximately 0.5 meters for this operation.

The puller bar was connected to the charging plate with a bolt. The other end of the puller bar was then linked to the pulley of a crane winch positioned on the pusher side of the battery. The coal cake was subsequently pulled into the oven chamber.

Although charging of the coal cake took quite a long time and both the oven doors were open during the charging period, only a small amount of charging gases escaped from the oven doors. Due to the slow winch speed, degasification of the coal cake began during insertion into the oven chamber. This situation would not exist during charging with a fast, commercial charging machine.

When the coal cake reached its end position inside the coke-oven chamber, the coke-side door was closed. The pusher-side door was closed until it rested on the charging plate. Then the puller bar was removed, and the charging plate was linked to the pulley of the crane winch. A load cell was installed between the winch pulley and the charging plate to monitor the pulling force required to draw the charging plate out of the oven.

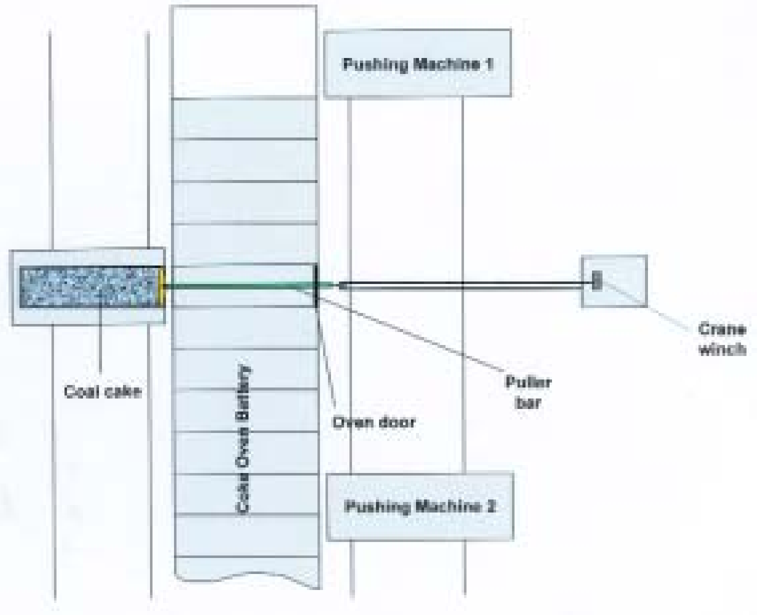
During withdrawal of the charging plate, the coal cake was held in place using the pusher-side oven door. This practice required blocking and supporting the door via steel beams installed between the door and the steel construction of the two pusher machines (Figure 4).

Upon its extraction, the charging plate was cleaned of coal, coke and tar residuals and used again for the next charging cycle.

The carbonization time of the stamp charged coal cakes was approximately 48 hours. This took the same amount of time as top charging due to better heat transfer in the compacted oven charge.

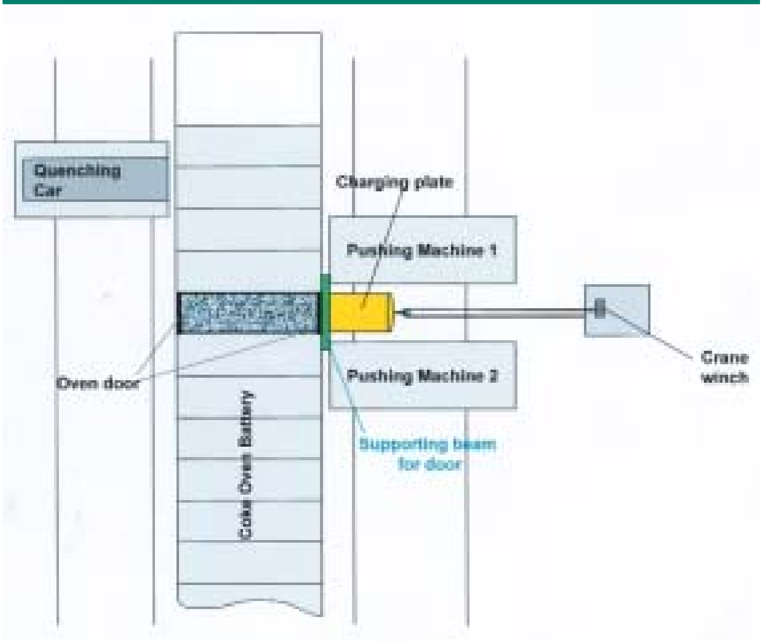
Views of the above-described operations are provided in Figures 5 through 11.

Figure 3



The coke cake was pulled into the oven with a puller bar attached to a slow speed crane winch.

Figure 4



While the charging plate was pulled out by the crane winch, the coal cake was held in place by the pusher-side door, which was reinforced by a steel beam braced against both pushing machines.

Figure 5

The coal cake was manually compacted under cover to guard against heavy monsoon rainfalls.

Figure 6

The covered quench car was located on the coke side of the oven for charging of the coal cake.

Figure 7

The puller bar was inserted through the oven from the pusher side.

Figure 8

Degasification of the coal cake occurred during its insertion, as viewed from the pusher side.

Figure 9

When the puller bar exited the oven, the door was closed onto the charging plate.

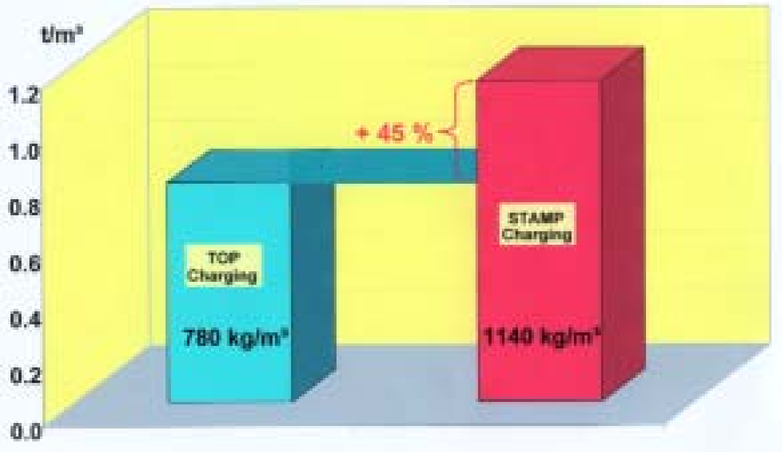
Figure 10

The oven door was blocked and reinforced with a steel beam braced against both pusher machines, while the crane winch was connected directly to the charging plate.

Figure 11

View of the charging plate being extracted from the oven.

Figure 12



Bulk density of the charge was increased by 45% with stamp charging.

Trial Results

Bulk Density — The bulk density of the coal charge at Sesa Kembla during normal top charging operations was approximately 780 kg/m^3 (wet). Water content is normally approximately 6 to 8%.

During stamp charging, water content serves as a binder. In the case of heat recovery ovens, the coal cake design has a flat shape and its stability is of minor importance. Water content can thus be maintained at the same level as in top charging. The density of a stamp charged coal cake, however, is approximately 1140 kg/m^3 (wet), an increase of 45% in bulk density (Figure 12).

Oven Throughput — With a coking time of 48 hours, the actual throughput in the Sesa Kembla plant is 26.8 tonnes per oven.

When applying stamp charging in these ovens with a coal cake height of 950 mm, oven throughput increased by more than 21%. This height was used during the trials; coking time was maintained at 48 hours.

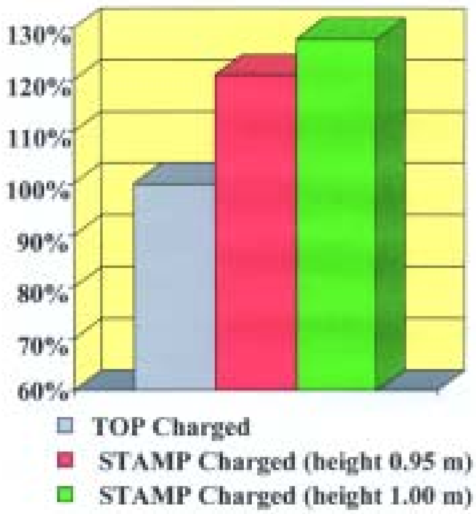
However, as only provisional equipment was used during the trial to produce the coal cake and charge it into the oven chamber, the lengthy charging time resulted in serious heat losses in the oven chamber. From these trials, it was evident that a coal cake with the height of 1.00 meter would be carbonized in the same time period when using commercial stamping and charging equipment enabling coal cake to be charged within one minute and avoiding significant oven heat losses.

At a coal cake height of 1.00 meter, throughput would be increased 28% over that obtained during top charging operations (Figure 13).

With improvements in oven throughput, a corresponding reduction in the number of ovens required for the same coke production level can be realized when using stamp charging (Figure 14).

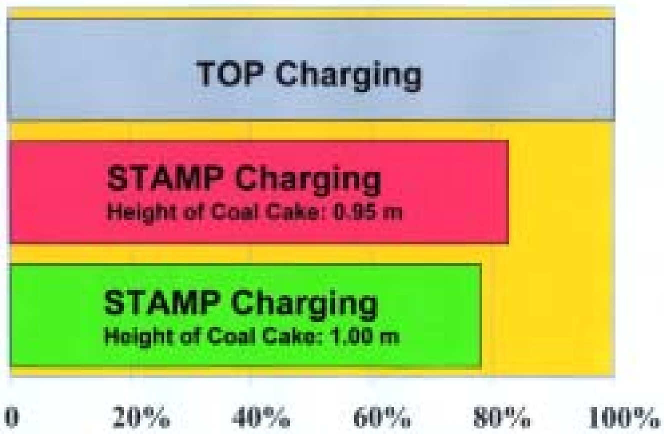
Coke Quality — The coal blend used for stamp charging normally consists of inferior coal grades, but low-grade coals were not available in the Sesa Kembla coal yard. Consequently, the coal blend used for stamp charging was the same as that for top charging. Grain size and coal moisture were also kept the same.

Figure 13



Throughput of 121.3% was obtained during the stamp charging trials with a coal cake 950 mm in height. With a coal cake height of 1000 mm and commercial stamping and charging equipment, a throughput level of 128% could be achieved.

Figure 14



Number of ovens required when stamp charging to maintain top charging production levels.

Coke produced by top charging at Sesa Kembla has a CSR in the range of +70 and Micum 40 above 80. Coke produced during the trial by stamp charging showed only slightly better quality parameters, as the coal blend used for top charging (also used in the stamp charging trials) had optimal coking characteristics (Figure 15).

Although the coke quality of the top charged coke is high due to its superior coal blend, the Micum 10 values of the stamp charged coke exhibited an outstanding range (Figure 16). A Micum 10 between 3.8 and 5.2 was found in the laboratory, while in top charging operations it typically is 6.0. CRI parameters ranged between 16.0 and 17.5.

When compared to top charged coke, that produced during stamp charging had a larger mean coke size and a lower amount of undersized coke and coke breeze. Both characteristics are favorable and will result in a higher amount of blast furnace coke yield.

Summary

By improving charge bulk density by 45% with stamp charging and maintaining a coking time consistent with that obtained during top charging, throughput increases of up to 28% can be realized. Furthermore, coke quality was maintained and actually increased in terms of Micum 10 values.

With increased throughput, a reduction of the number of ovens required can be achieved, reducing investment costs and required area for coke-oven layouts and servicing machines.

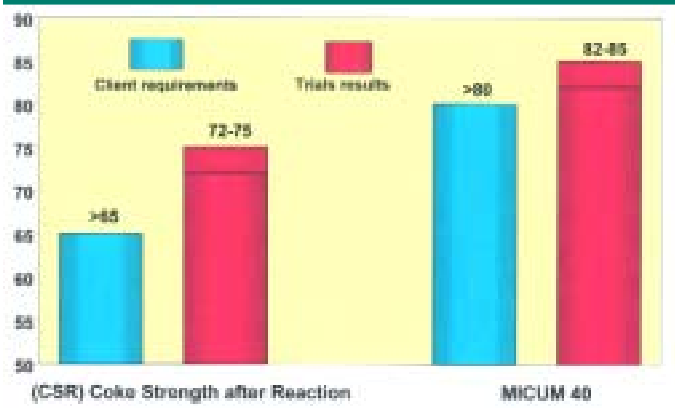
The machinery for stamp charging and pushing operations would be relatively simple with regards to control as these machines must only execute a few basic actions. This situation makes it possible to furnish such machines with a high level of automation, achieving virtually man-less operation and providing further opportunities to lower operational costs.

The range of suitable coals would be further enlarged with stamp charging, as its use in the heat recovery process generates no restrictions concerning coal expansion and wall pressure, unlike stamp charging in slot ovens. In slot ovens, careful attention must be paid to the coal blend, as a blend with high expansion will lead to high oven wall pressure and cause serious wall damage. In heat recovery ovens, coal is allowed to expand without any negative impact to oven construction.

High- or low-volatile coal may be used with stamp charging, depending on the benefits resulting from power generation. Coke production and cogeneration can thus be optimized case to case to achieve the lowest coke and energy costs.

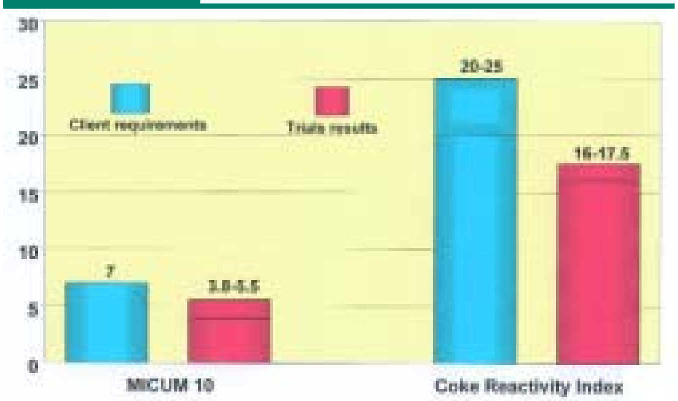
In conclusion, the application of stamp charging to heat recovery cokemaking technology is economically and ecologically feasible for the heat recovery process. By operating heat recovery ovens with a compacted oven charge, advantages are gained in investment cost, operational costs, input material costs, coke quality and ecology. *AISE*

Figure 15



CSR and Micum 40 values achieved during the stamp charging trials.

Figure 16



Micum 10 and CRI values achieved during the stamp charging trials.