

Boost To Blast Furnace Performance: A Perspective Of Coke Cooling Practice

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Abstract

This paper reviews the importance of coke cooling method with respect to blast furnace outcome. Superior coke quality attained in dry quenching ultimately contributes in thriving blast furnace. Analysis is conducted to identify the impact on blast furnace performance. The influence of coke quenching is explored in view of specific blast furnace parameters such as coke rate, hot metal temperature and production rate. The review includes the assessment of effect of coke properties (coke moisture and CSR) on blast furnace characteristics to get better hold of the reasons for which change takes place due to use of coke dry quenching.

Index Terms- coke, coke dry quenching, coke quality, blast furnace.

To demonstrate the superiority of coke quenching method various blast furnace parameters (coke rate, hot

1. INTRODUCTION

Metallurgical coke production takes place from a blend of selected bituminous coal, called coking coal or metallurgical coal. Only certain high rank bituminous coals are classified as metallurgical coking coals. The coal blend, crushed to a desired size is poured into the ovens (through top charging or stamp charging) and heated to above 1200°C over a period of few hours. After the carbonisation process is completed, the red hot coke is pushed out of the coke ovens.

The next stage involves the cooling of the incandescent red hot coke produced prior to further processing. Variation in coke cooling techniques comprise of use of different cooling mediums or different operating processes. Most widely used technique wet quenching (which uses water as cooling media) is compared along with coke dry quenching technique which employs use of inert gas for cooling purposes.

Coke dry quenching (CDQ) technology is currently considered as a technology greatly saving energy in the coke plant, owing to its many advantages such as energy saving, pollution reduction and quality improvement. Variation arising due to their different characteristic processes and media used reflects on the coke quality attained.

metal temperature and production rate) are undertaken. The coke comprising of adequate strength and low moisture content simply enhances blast furnace performance.

2. METHODOLOGY

2.1. Evaluation of CDQ contribution

At the steel plant all the coke sources, namely wet quenched, dry quenched, and external coke sources (from outside the plant) addition takes place and after progressive screening stages the resulting coke is moved to blast furnace stock house, from where samples for coke testing are taken. Thus the coke being tested involves the mix up of different coke sources and proper consideration has to be taken care of the percentage of dry quenched coke in it.

Thus analysis may be carried out on basis of consideration of: coke oven pushings percentage or weight percentage of each source.

The coke pushings method refers to taking the percentage of coke fed to the dry quenching unit, thereby not involving the consideration of external coke. It focuses on the benefits of dry quenched coke over wet quenched coke. On other hand, analysis

carried out by consideration of weight percentage features inclusion of external coke addition.

2.2. Consideration of coke properties

For understanding the change arising in blast furnace with superior coke properties, specifically coke moisture and coke strength after reaction (CSR) have been considered. These signify the pronounced effect of CDQ in bringing out superior coke quality and thereby improving blast furnace performance.

3. RESULTS AND DISCUSSIONS

3.1. Impact on coke rate

figure 1(a). Driving off the moisture content will require an additional heat which has to be supplied by additional coke, thus directly causing an increase in coke rate and deteriorating blast furnace performance. Thus, for reducing coke rate a control on the moisture content of coke is necessary. Since the CDQ technique helps in reducing moisture content, it significantly helps in reducing the coke rate also as observed earlier.

CSR measures the potential of the coke to break into smaller size under a high temperature CO/CO₂ environment that exists throughout the lower two-thirds of the blast furnace. Thus higher chemical strength of coke enables it to provide both, mechanical support to the burden along with being efficient fuel source. Clearly decline in coke rate with increment in CSR value can be observed in figure 1(b).

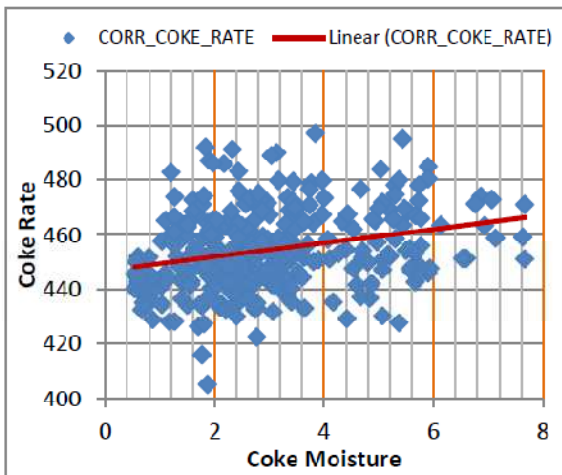
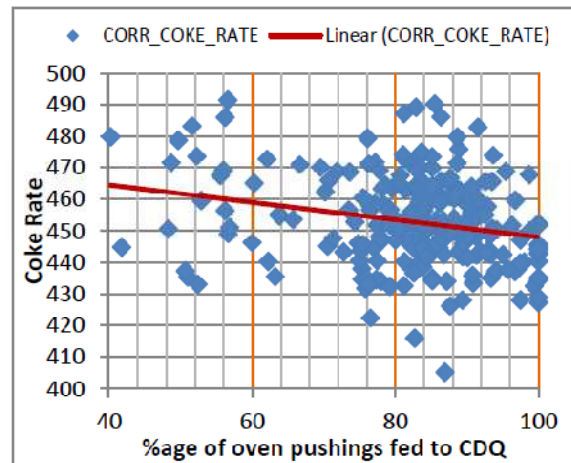


Fig 1(a) Effect of coke moisture



(a) With respect to oven pushing percentage

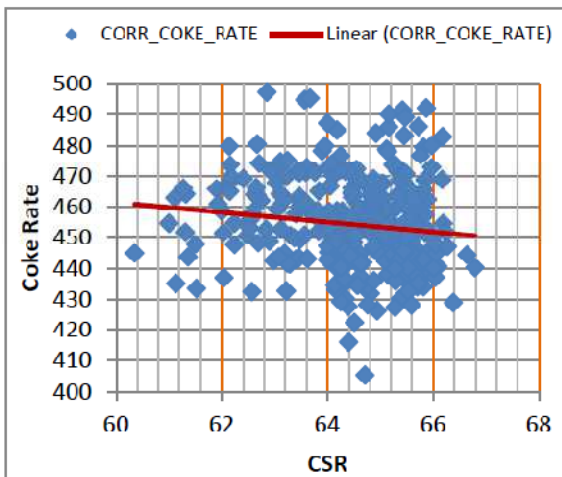
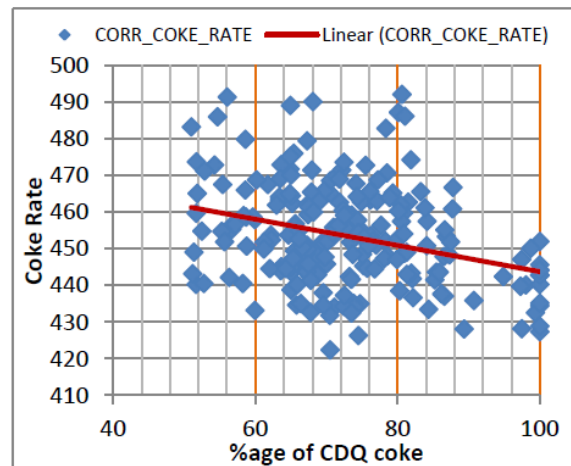


Figure 1(b) Effect of CSR



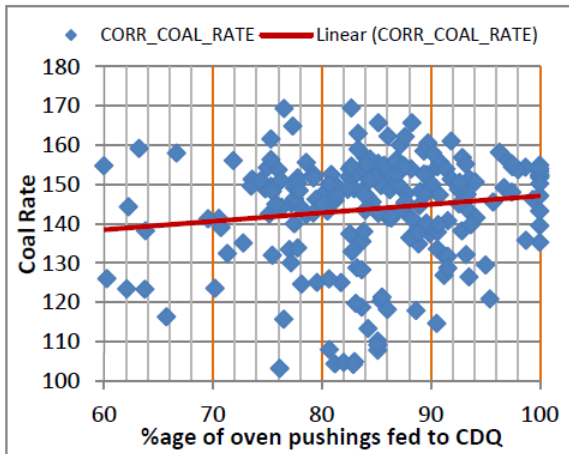
(b) With respect to weight percent of CDQ coke

With increasing moisture content in the coke, coke rate also follows an increasing trend as can be seen in

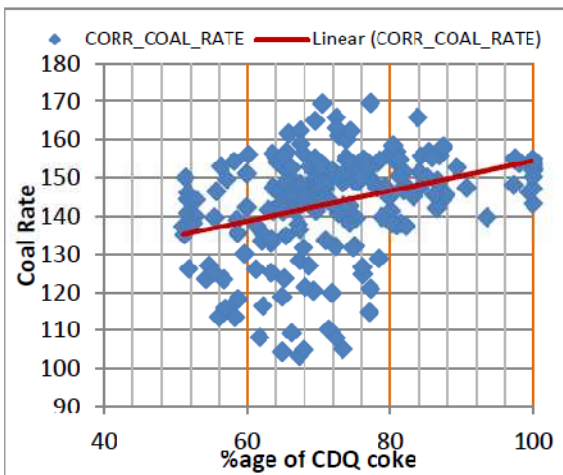
Figure 2 Dependence of coke rate on CDQ

Clearly, increasing CDQ pushing helps a lot in decreasing the coke rate in the blast furnace thus straightaway reducing the coke expenses. Decline in coke rate with CDQ coke use arises from the superior coke quality attained in case of dry quenched coke.

3.2. Impact on coal rate



(a) With respect to oven pushing percentage



(b) With respect to weight percent of CDQ coke

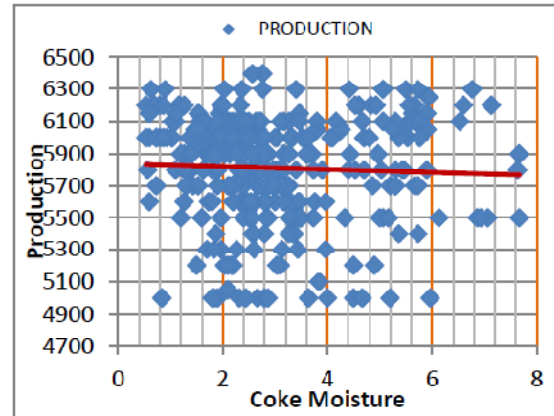
Figure 3 Dependence of coal rate on CDQ

Clearly with increasing CDQ coke use, an increasing coal rate can be observed from figure 3 (a) and figure 3 (b), thus signifying that the coke produced from the CDQ allows an additional use of coal bearing to its better coke quality. The overall effect being the efficient decrease in coke requirement as can be observed with the decline in coke rate with corresponding increasing share of CDQ coke.

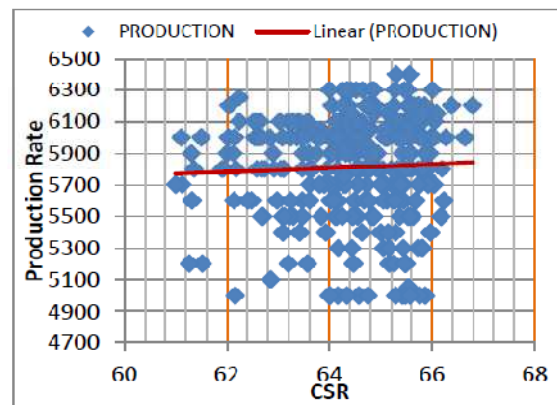
Increasing coal rate helps in cutting down the costs of its coke conversion besides catering to the pollution

aspect arising from the coke oven plants. Owing to the reduced coke rate, the coal rate jump can be observed with increased use of dry quenched coke.

3.3. Impact on production rate



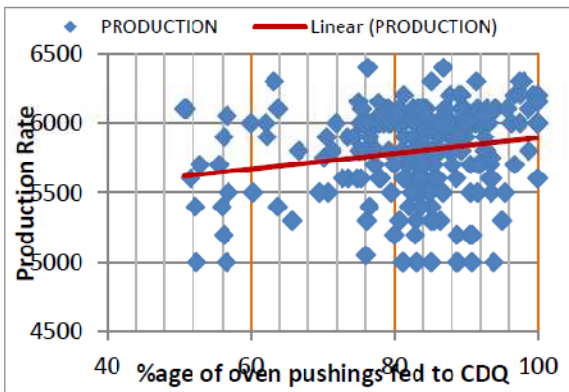
(a) Effect of coke moisture



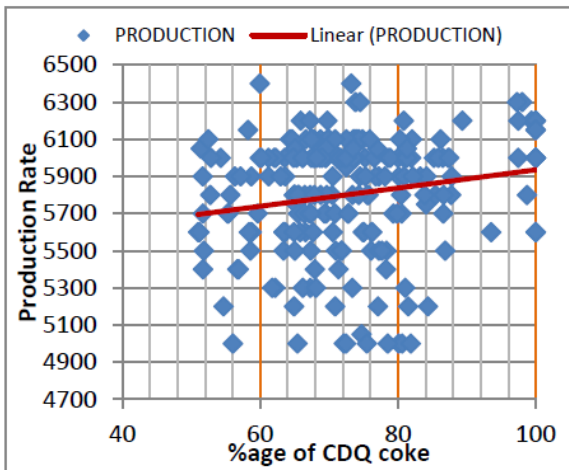
(b) Effect of CSR

Figure 4: Effect of coke properties on iron production level

Low production rate and productivity index with increasing moisture is due to extra coke requirement for the additional moisture content, thus raising ash load on blast furnace and lowering down the overall production rate.



(a) With respect to oven pushing percentage



(b) With respect to weight percent of CDQ coke

Figure 5 Dependence of production rate on CDQ

Since the productivity can be represented as the ratio of coke burned to that of coke consumed, thus an increase in productivity with the increasing percentage of CDQ coke (figure 5 (a) & (b)) can be attributed primarily to reduction in coke rate with the CDQ coke in blast furnace. Reduction in coke rate leads to reduced ash load in the furnace thus reducing the corresponding flux requirement, thus bringing down the slag percentage and ultimately increasing production rate due to increased hot metal output. Thus CDQ technique helps in increasing the overall productivity of the blast furnace.

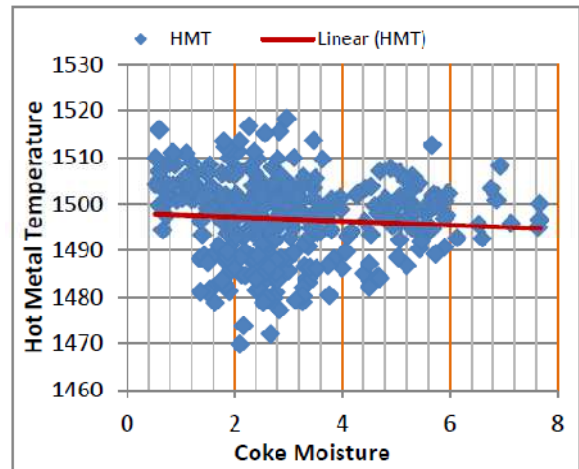


Figure 6(a) Effect of coke moisture

A slight decline in hot metal temperature takes place at higher moisture as observed in figure 6(a).

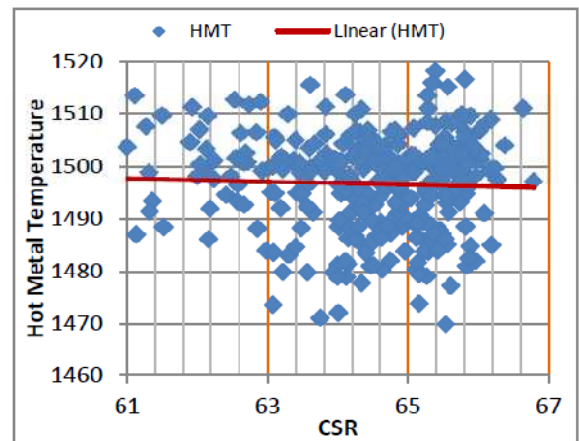
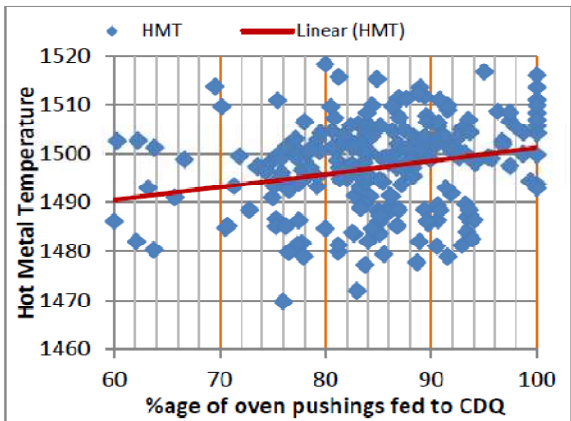
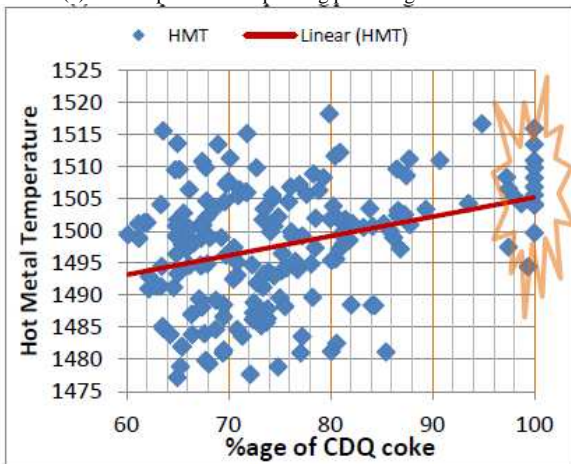


Figure 6(b) Effect of CSR

On the other side, figure (b) depicts that CSR coke value has no significant impact on hot metal temperature.



(a) With respect to oven pushing percentage



(b) With respect to weight percent of CDQ coke

Figure 7 Dependence of hot metal temperature on CDQ

Increase in hot metal temperature occurs with increasing CDQ coke percent (figure 7 (a) & (b)). Besides, it can be seen that the variation in hot metal temperature is largely reduced at higher CDQ operating levels which will help in achieving better control.

4. CONCLUSIONS

The positive impact on blast performance can be observed with the use of CDQ by improvement in coke rate and fuel rate. Besides, with CDQ an increase in production rate and productivity index also takes place. Low coke rate as seen with dry quenching technique allows an increased use of coal instead of coke thus allowing flexibility accordingly with production level despite cutting down coal treatment costs. Moreover, dry quenched coke allows a rise in the hot metal temperature.

Importance of coke quality can be described on the basis of blast furnace performance, with improvement

in coke properties having a direct impact on performance characteristics of the furnace.

Improvement in coke properties such as moisture, chemical strength efficiently leads to reduction in coke rate besides increasing the productivity of the blast furnace. Through volatile matter has no such direct impact on coke rate, but it is still targeted to be as low as possible in order to avoid operational problems. Coke properties thus improved by application of CDQ technique reveals the cause for the improvement in blast furnace performance by the dry quenching technique.

5. FUTURE SCOPE

In order to gain benefit of the superior coke quality (moisture, strength) of CDQ and catering to its judicious use coke management is of utmost importance. Its need arises in order to have a control over the variations arising due to different coke sources, thus improving the blast furnace performance.

With different coke sources variations in coke properties is bound to be there, but with suitable management of the system these variations can be significantly reduced. An optimized distribution in accordance with the resulting properties of each coke source will serve the purpose of obtaining consistent product quality with better control and regulation. Minimizing variations in coke quality prove to be a great boom for blast furnace operation and therefore it is of utmost importance.

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