AISTech 2024 — Proceedings of the Iron & Steel Technology Conference
6–9 May 2024, Columbus, Ohio., USA
DOI: 10.33313/388/017

# Spotlight on $Na_2O$ and $K_2O$ Behavior in Blast Furnace Operation

Peter Warren[1] and Maarten Geerdes[2]

[1]Binding Solutions
Eston Road, Middlesbrough, UK, TS6 6US Email: pwarren@bindingsolutions.uk

[2]Geerdes Advies
Mient 3B, 1901AB Castricum, Netherlands Email: geerdes@mgeerdes.nl

Keywords: alkali, blast furnace, plant reverts, briquettes

## INTRODUCTION

For many years blast furnace operators have been aware of the detrimental effects of alkali on blast furnace operation and its condition. Detrimental effects are the effects on refractory condition, scab formation and coke reactivity affecting BF fuel rate. Therefore operators have set standards, which are normally formulated such that the input of alkali should be below a certain level. This is generally expressed as $Na_2O + K_2O < X$ kg/thm. A typical value of X is 2.5 kg/thm. The ratios between input of potassium and sodium vary from plant to plant. European benchmark data show that potassium amounts to 50-80% of total alkali input.

Operators monitor the risk of accumulation of alkali by periodically checking the alkali balance; typically if alkali output into the slag exceeds 80% of input no accumulation is expected. Various shortcomings of this approach were discussed by Geerdes et al [1]. Such standards and checks can neglect the effect of slag volume and composition, and the accuracy of the slag chemical composition from runner samples.

Blast furnace operators generally consider that sodium and potassium have a similarly detrimental effect on a weight basis. However, more detailed analysis has already shown that circulation and accumulation of potassium is stronger than that of sodium [1]. The motivation for exploring whether there is a difference in retention between potassium and sodium is due to the need to determine whether a particular works arising reverts stream, which contains typically 0.5 to 1% sodium, can be recycled into the blast furnace at a higher rate at a given potassium loading. In addition, certain cold agglomeration technologies include sodium-containing binders in order to achieve high performance. So the question arises as to whether the total alkali loading can be increased provided that the additional alkali is in the form of sodium, due to the differences in sodium and potassium behavior. i.e., is it safe for a blast furnace operator to exceed their total alkali loading limit provided that the additional alkali is in the form of sodium?

It is normal to express sodium as $Na_2O$ and potassium as $K_2O$. In [1] it was shown that during a chilled condition, a significant increase in $K_2O$ was experienced whilst $Na_2O$ levels remained relatively consistent throughout, indicating that $K_2O$ has a greater tendency to accumulate in the process, with removal efficiency by the slag being lower for $K_2O$ than $Na_2O$. Blast furnace dissections have concluded that there is an alkali cycle: alkalis recirculate typically 3 to 10 times through the cohesive zone [2]. The majority of alkali removal, typically over 80%, is via the slag, with a small proportion being removed via the dust in the top gas. Spatzker et al [3] described how dust sampling was undertaken across the blast furnace radius using a sub burden probe; they measured 18% potassium and 2% sodium in the dust at the center, falling to 2% potassium and 0.25% sodium at 1m from the center, indicating a much lower recirculating load for sodium than for potassium.

Yang et al [4] analyzed thermodynamic differences showing that sodium silicate is more stable than potassium silicate. Experiments also demonstrated that the holding capacity for $K_2O$ fell with basicity more quickly than for $Na_2O$.

Mclean et al [5] discussed the concept of optical basicity, which originated in the glass industry, and how it applies to the design of blast furnace slags. This demonstrated that replacement of CaO by MgO (lower optical basicity) increases the alkali holding capacity.

 