Technology Advancements in Blast Furnace Cooling

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Keywords: blast furnace, cast iron stave, stave failure, wear, campaign life extension, finger cooler

ABSTRACT
The premature failure of staves in the lower stack and bosh is frequently the reason for an interim blast furnace repair at great
cost to the owner. Protective accretions may form on the stave hot face, but if these accretions are lost, the stave is then
exposed to abrasion from the descending burden materials, which increases cooler wear and results in cooling circuit failures.
Hatch has developed patented finger coolers as an improved alternative to traditional stave repair methods (often requiring
insulating grout) by establishing a highly-conductive metal-to-metal thermal joint. Hatch completed a pilot installation in
2016 of a pair of finger coolers in a blast furnace cast iron stave and a comparison of predictive models to site monitored
temperature data will be presented using a series of thermal finite element analyses. These models predict the installed finger
cooler performance within 2% of the measured site data, thereby demonstrating that finger coolers reduce stave body
temperatures with predictable results over a wide range of process conditions.

INTRODUCTION
Premature stave failure remains a frequent cause for costly interim blast furnace repairs. The stave is exposed to the harsh
conditions within the blast furnace, whereby descending burden materials abrade the hot face, inducing the subsequent
breaching of internal water channels and the ultimate reduction in stave cooling. At this stage, it becomes increasingly
difficult for operators to form protective accretions on the hot face as overheated staves are observed to frequently lose these
protective accretions and require more time to redevelop them compared to sufficiently cooled stave bodies. A traditional
method of stave repair implements the use of cigar coolers, grouted in place through openings drilled in the stave body. These
grouted connections have been observed to be 20 to 100 times less conductive than copper and as a result, do not allow for
the effective removal of heat from the damaged stave body.

Finger coolers were demonstrated through a series of laboratory tests to increase the rate of heat removal from surrounding
stave material. Thermally insulating grouted connections are replaced with direct metal-to-metal pressure contact, thereby
establishing a highly-conductive thermal joint. It was estimated that under typical excursion conditions, a copper stave fitted
with finger coolers experiences less than half the temperature increase than a stave fitted with the same number of cigar
coolers. By reintroducing significant cooling to damaged staves, blast furnace operators can maintain lower operating
temperatures and potentially achieve more stable operation in the face of isolated stave failure. The results of these previous
tests were compared to a series of conjugate heat transfer (CHT) simulations using computational fluid dynamics (CFD),
which combines the thermal analyses of both the fluid and solid components of the finger cooler. The CHT simulations were
validated using the experimental test data.

In 2016, Hatch completed a pilot installation at a blast furnace, installing two finger coolers in a cast iron stave located within
the furnace bosh with ongoing performance monitoring using thermocouples. The previously validated CHT simulations
were updated to account for the thermal properties of cast iron staves (i.e. versus copper) and site water flow conditions,
in order to calculate spatially-dependent convection coefficients to be used for subsequent thermal finite element analyses
(FEA) of the pilot installation configuration. Site temperature data will be used to validate this new full-scale simulation and
a comparative analysis will be presented.