TATA STEEL

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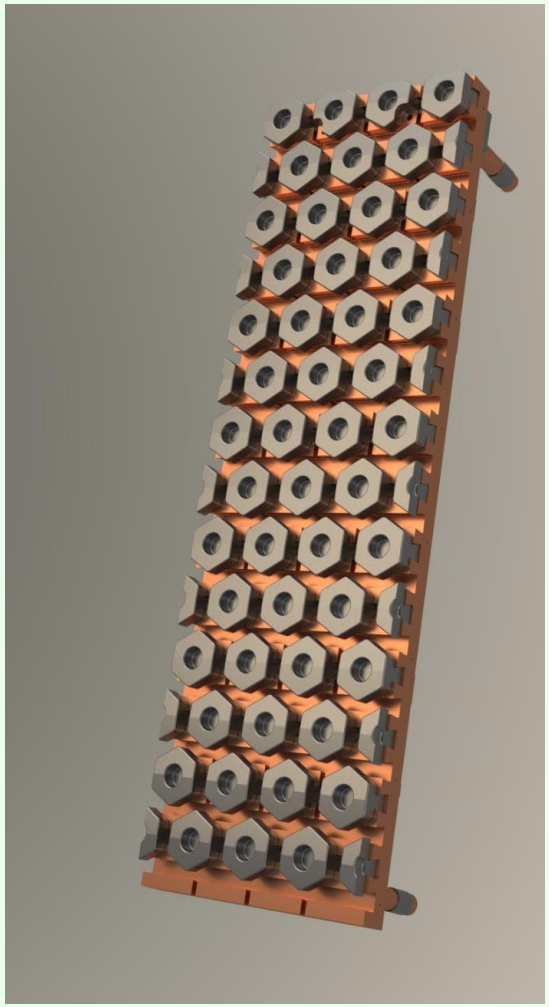
Metallurgy
Materials Engineering

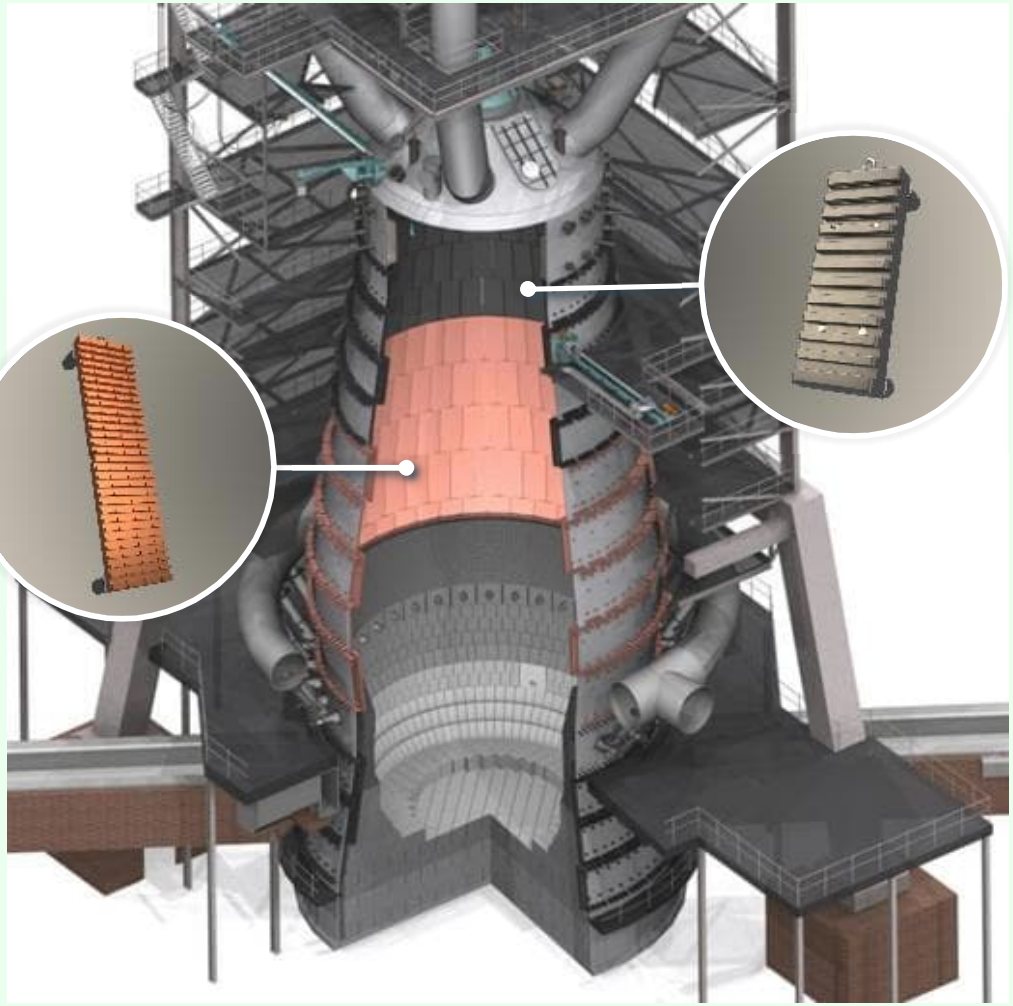
# Failure Resistant Copper Staves

January 17, 2024



# Introduction

- Cooling system is critical for a long campaign life
- Copper staves first introduced in the 1980's were based on the cast iron stave design from the 1950's
- They are used in high heat load areas due to higher heat transfer through copper than cast iron
- Primetals Technologies have extensive experience of successful copper stave installation
- Failure can mean significant loss of production
- Primetals Technologies have developed solutions for the two main failure mechanisms:
  - Stave bending
  - Stave wearing



# Consequences on $CO_2$ emissions

- While a few individual stave failures can be isolated and monitored, large scale failures require stave exchanges
- These generally require longer outages and therefore extra coke producing extra $CO_2$
- A 7000 tHM/d blast furnace (approx. 2000$m^3$ working volume) typically requires 140 tonnes of coke to recover from multiple-day outages
- If staves are replaced yearly starting from the fifth campaign year then at the end of a 15 year campaign, 1400 tonnes of coke could be attributed to outages for stave replacements
- Burning of this coke will result in an extra 4000 tonnes of $CO_2$ being produced.
- Production of this extra coke will also generate additional emissions of up to 1150 tonnes of $CO_2$

# Resisting Failures - Anti-Bending Solution

- The anti-bending solution prevents the stave from bending in at the corners but allows the stave to thermally expand and move during its operation
- Straightforward and proven design that solves the problem at the source

**References**

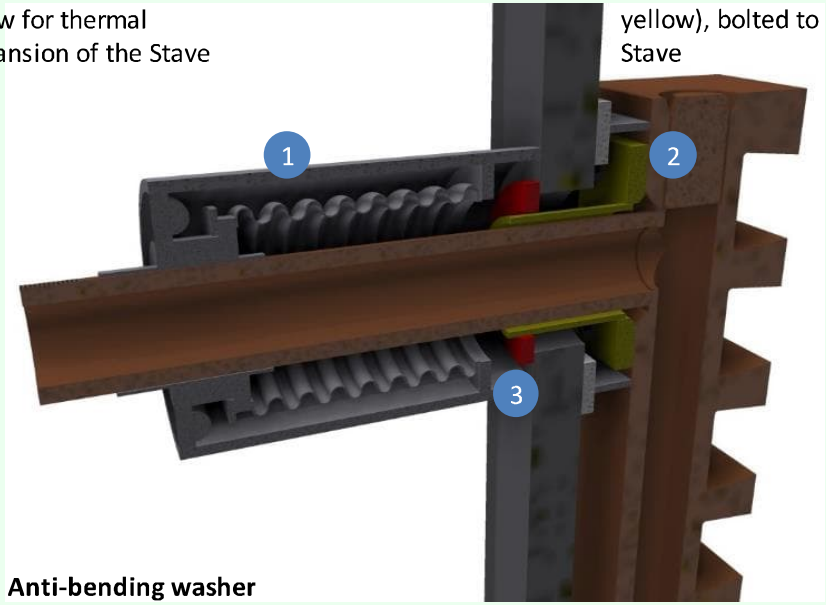
| | | |
|---|---|---|
| Voestalpine Stahl Linz | Austria | 2004 |
| SSAB Lulea | Sweden | 2015 |
| Usiminas Ipatinga | Brazil | 2018 |
| Voestalpine Stahl Linz | Austria | 2018 |
| ArcelorMittal Lázaro Cárdenas | Mexico | 2019 |
| ArcelorMittal Vanderbijlpark | S. Africa | 2019 |
| ArcelorMittal Dofasco | Canada | 2020 |
| US Steel Kosice | Slovakia | 2021 |
| ArcelorMittal Dąbrowa Górnicza | Poland | 2023 |
| ArcelorMittal Gent | Belgium | 2023 |
| Ternium Santa Cruz | Brazil | 2023 |
| Tata Steel Kalinganagar | India | 2024 |

1 **Compensator**

Compensator installed to allow for thermal expansion of the Stave

2 **Anti-bending bracket**

Anti-bending bracket (in yellow), bolted to back of Stave




3 **Anti-bending washer**

Anti-bending washer (in red), welded to bracket. The washer is not welded to the furnace shell, therefore allowing the Stave to expand and slide along the shell but preventing the Stave from bending into the furnace.

# Primetals Lifetime Extending Solutions

- Hexagon inserts protect the stave against wear
- Dual Arrangement:
  - Inserts act as a stone box to trap unreduced material
  - Allows liquid to flow through the stone box to the cold copper to form a protective accretion layer

| References | | |
|---|---|---|
| SSAB Raahe | Finland | 2019 |
| North America | North America | 2020 |
| South America | South America | 2020 |
| US Steel Kosice | Slovakia | 2021 |
| ArcelorMittal Gent | Belgium | 2023 |
| Ternium Brazil | Brazil | 2023 |
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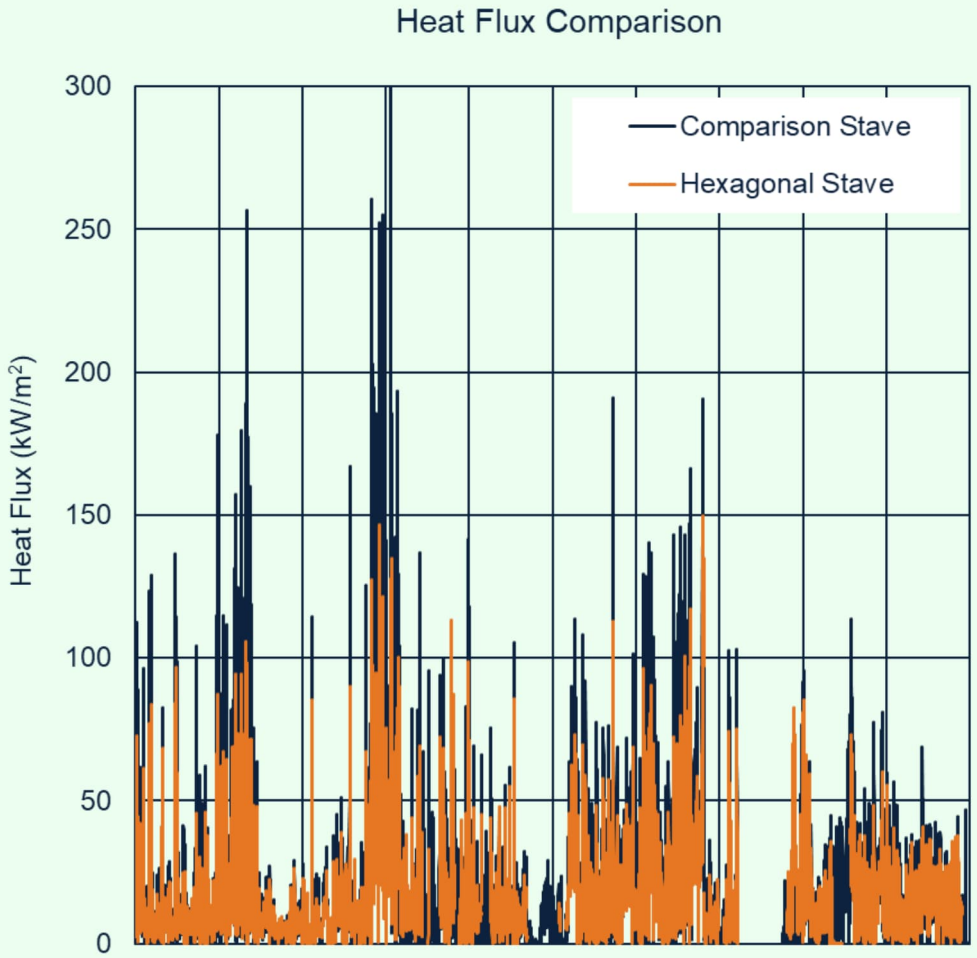
# Operating Heat Flux values from oldest reference

- Heat flux calculated from recorded water flow and temperature difference on each stave
- Wear resistant (hexagonal) stave consistently records lower heat flux than comparison stave
- Difference greatest during unstable operating periods
- Indicated heat losses to cooling system are reduced without affecting furnace stability

| Period | Stable Operation | Unstable Operation | Long Term Average |
|---|---|---|---|
| Duration (days) | 774 | 153 | 928 |
| Hexagonal Stave (GJ) | 1609 | 1011 | 2620 |
| Comparison Stave (GJ) | 1644 | 1512 | 3155 |
| Coke saving (kg/tHM) * | 1 – 2 | 3 – 7 | 2 – 4 |




* depending on coke quality, productivity, etc.

# Summary

- Adopting failure resistant staves eliminates mid campaign outages replacements to replace damaged staves
- This can reduce the amount of coke consumed to recover the BF process from longer outages
- Proven technologies exist to prevent the two main failure mechanisms
- Wear resistant inserts have also been shown to reduce process heat losses – allows a reduction in BF fuel rate

# THANK YOU

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