Introducing SIP technology and its impact on blast furnace operation.

Nov. 2022 | Kuala Lumpur | Bartosz Smaha
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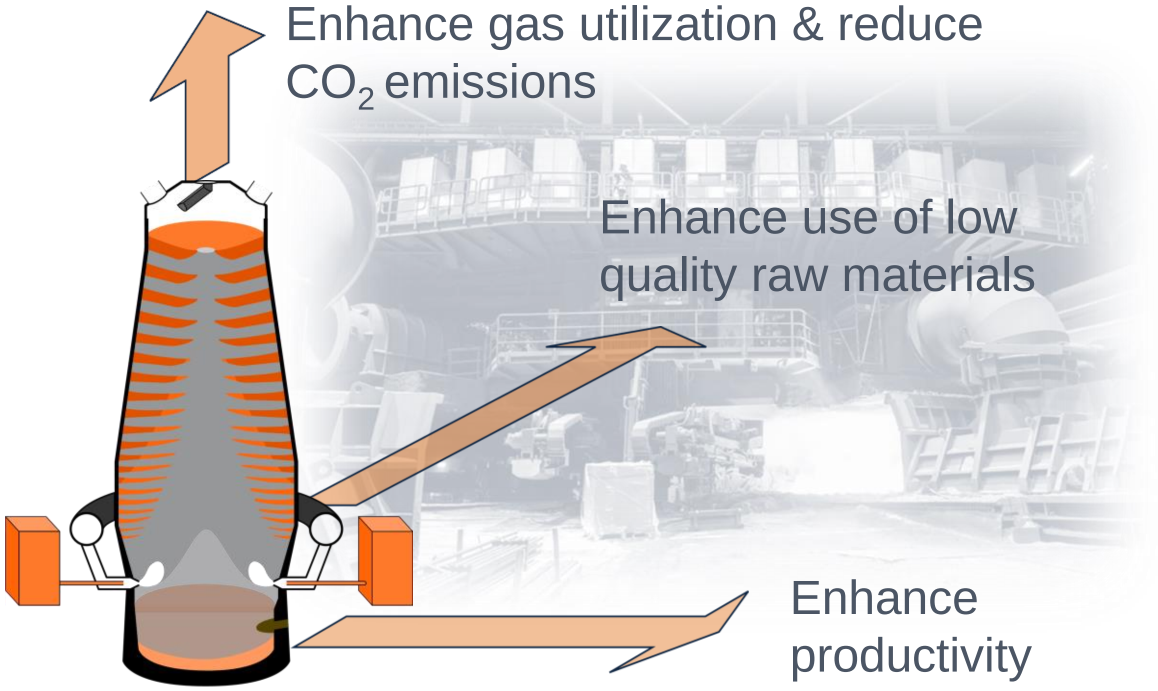
Introduction

Efficient blast furnace operation becomes only more and more challenging

- Availability of high-quality raw materials
- Low permeability, especially at high PCI rates
- Process instabilities
- Production failures and HM quality
- High fuel rates and high operation costs
- Decarbonization targets



BF with SIP Technology

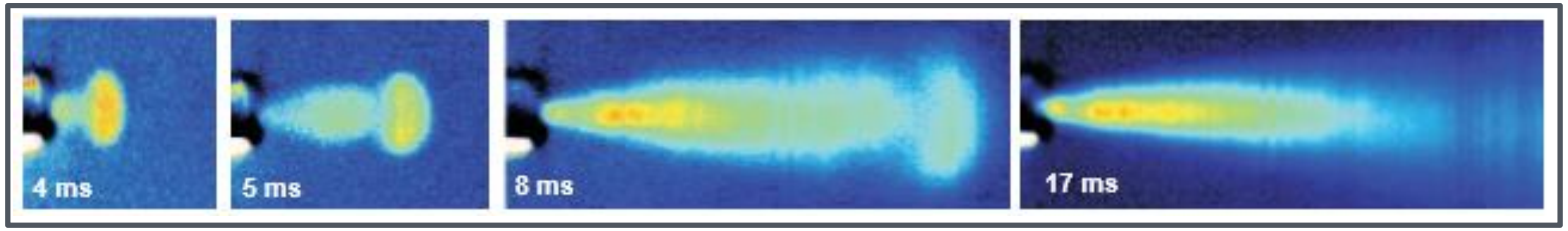
The new **Sequence Impulse Process (SIP)** Technology addresses these problems!

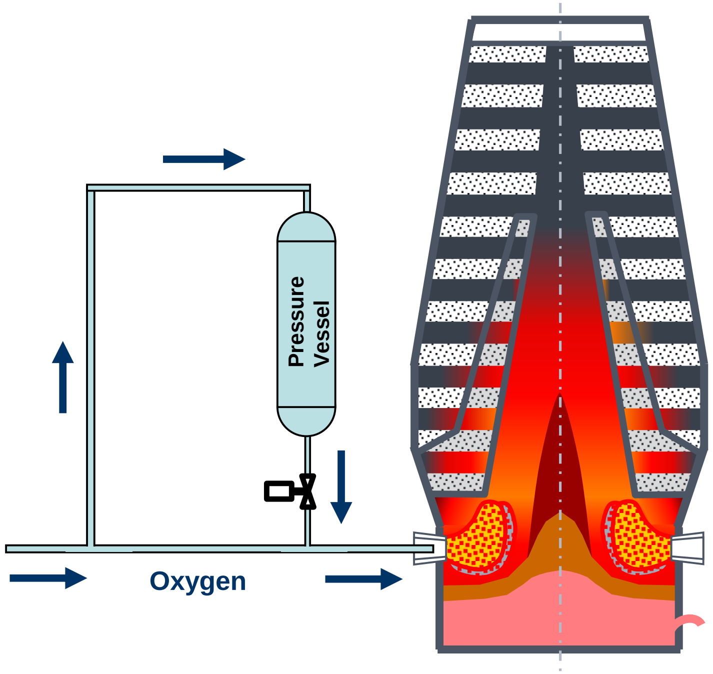
Technology Development

- SIP was developed by thyssenkrupp
- 2015 – to date, the first trials followed by the full installation on the Schwelgern BF1 of thyssenkrupp Steel Europe AG
- Operational start-up late 2020
- Today is fully adopted and incorporated into blast furnace operating practice
- Exclusive worldwide license agreement with Primetals Technologies, signed August 2021

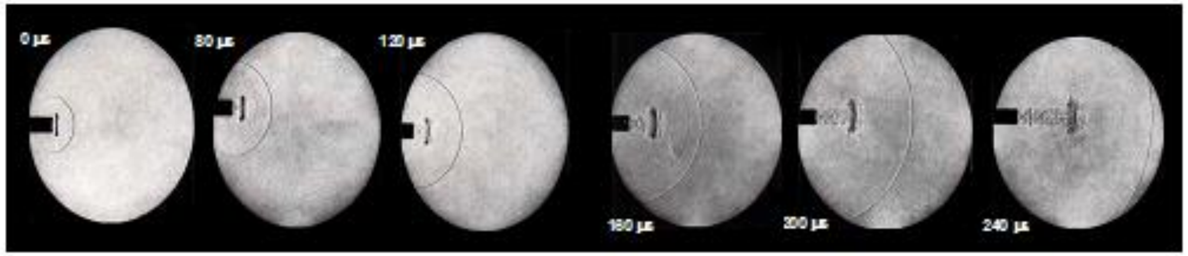
Sequence Impulse Process (SIP) Principle

- A shockwave is generated by the fast opening of a pulse valve and the release of oxygen at high pressure. The shockwave precedes the following oxygen flow of the free jet, at supersonic speed
- Typical propagation pattern of a transient gas flow with its vortex formations:



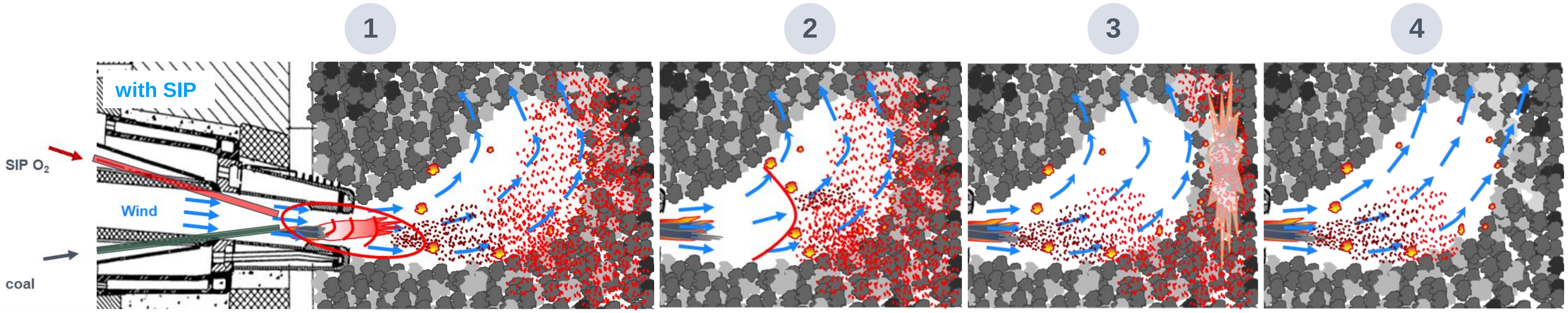


- Conditions beneficial by influencing and intensifying the local manifestation of turbulence in the raceway
- Due to the sequencing, in a short time period, a large amount of oxygen can be released
    - a multiple of the stoichiometric oxygen necessary for a reaction of the injected coal



Sequence Impulse Process (SIP) Principle

- SIP seeks to address problems associated with the formation of char deposits (particularly at high PCI rates) and fine coke particles generated from circulation and degradation in the lower blast furnace that can accumulate and block the raceway
- SIP enables oxygen to reach the coke bed behind the raceway, consuming fine particles → more ideal gas distributions and temperature profiles towards the center
- **The improved permeability and raceway length, lay the foundation for improved blast furnace operation**

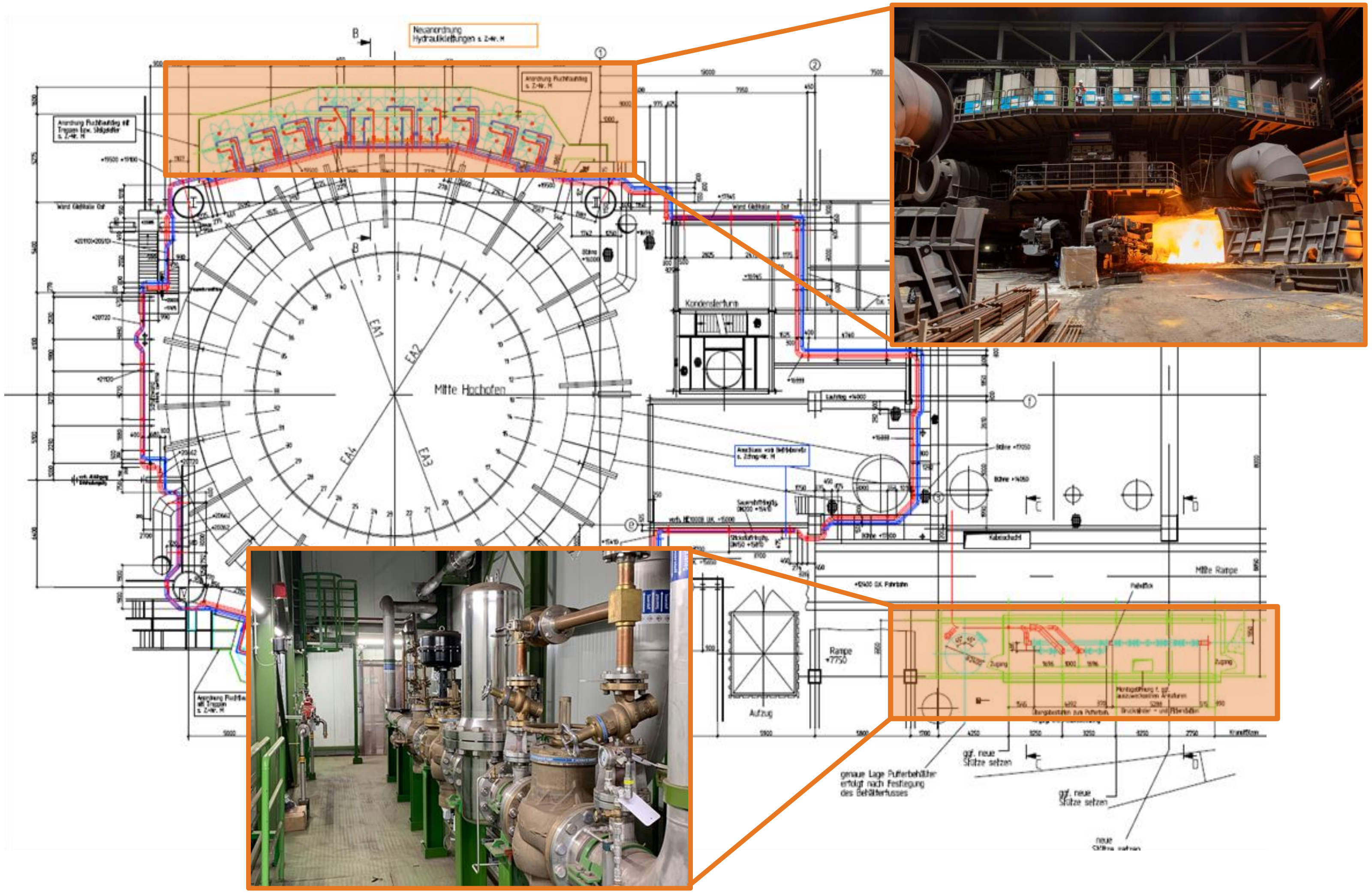


Plant Description

Nitrogen Supply
- Filter Station
- Ring main around BF 1

Oxygen Supply (25,000 Nm3/h)
- Pressure Control Station incl. filter
- 50 m³ Buffer vessel (pulsation dumper)
- Ring main around BF 1

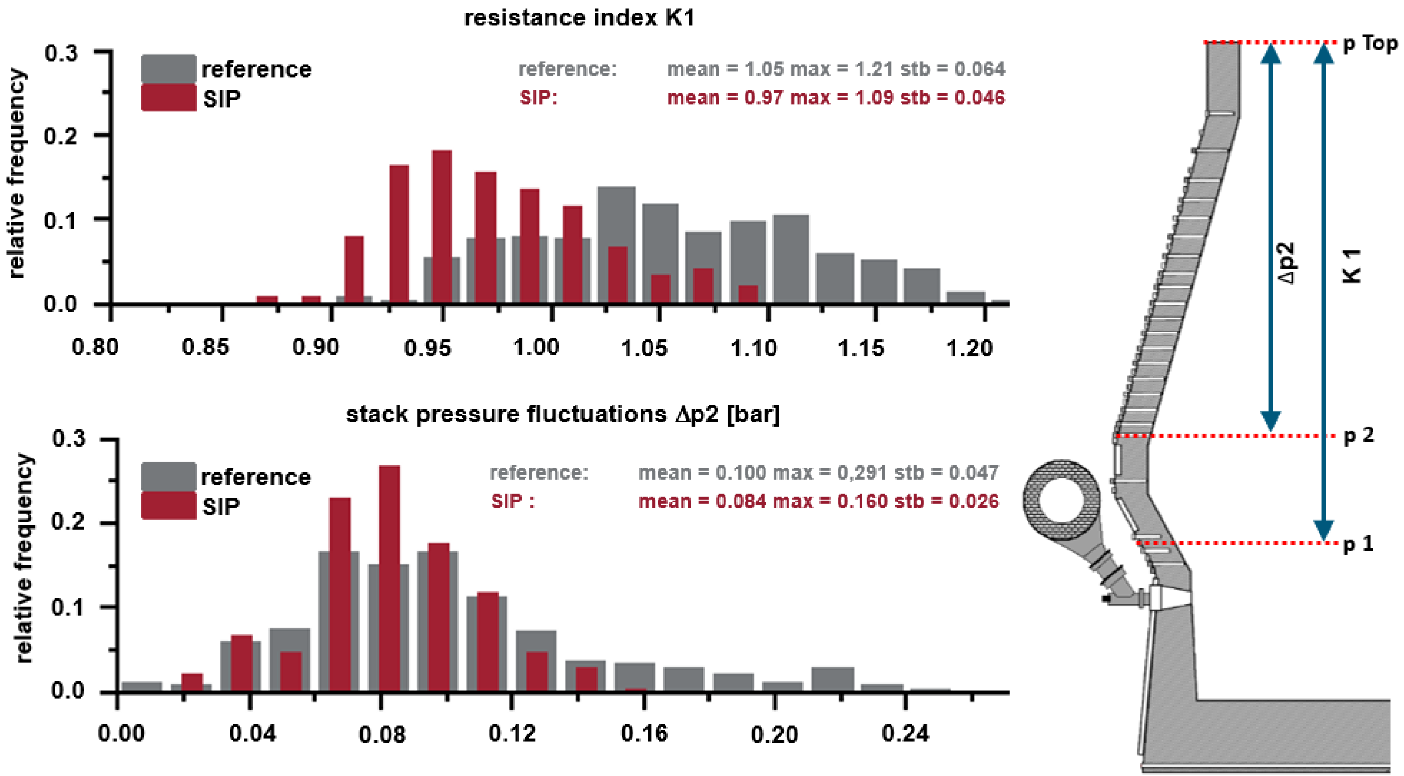
SIP Boxes (pulse generators)
- One for each tuyere
- Incl. connection pipes to the SIP-lances



Operational Results

The permeability of the blast furnace improved with SIP. More stable BF operation was achieved.

- Resistance index K1 and Δp2 shift significantly to lower values
- More uniformly distributed gas pressure over the furnace cross-section
- SIP effect is reproducible

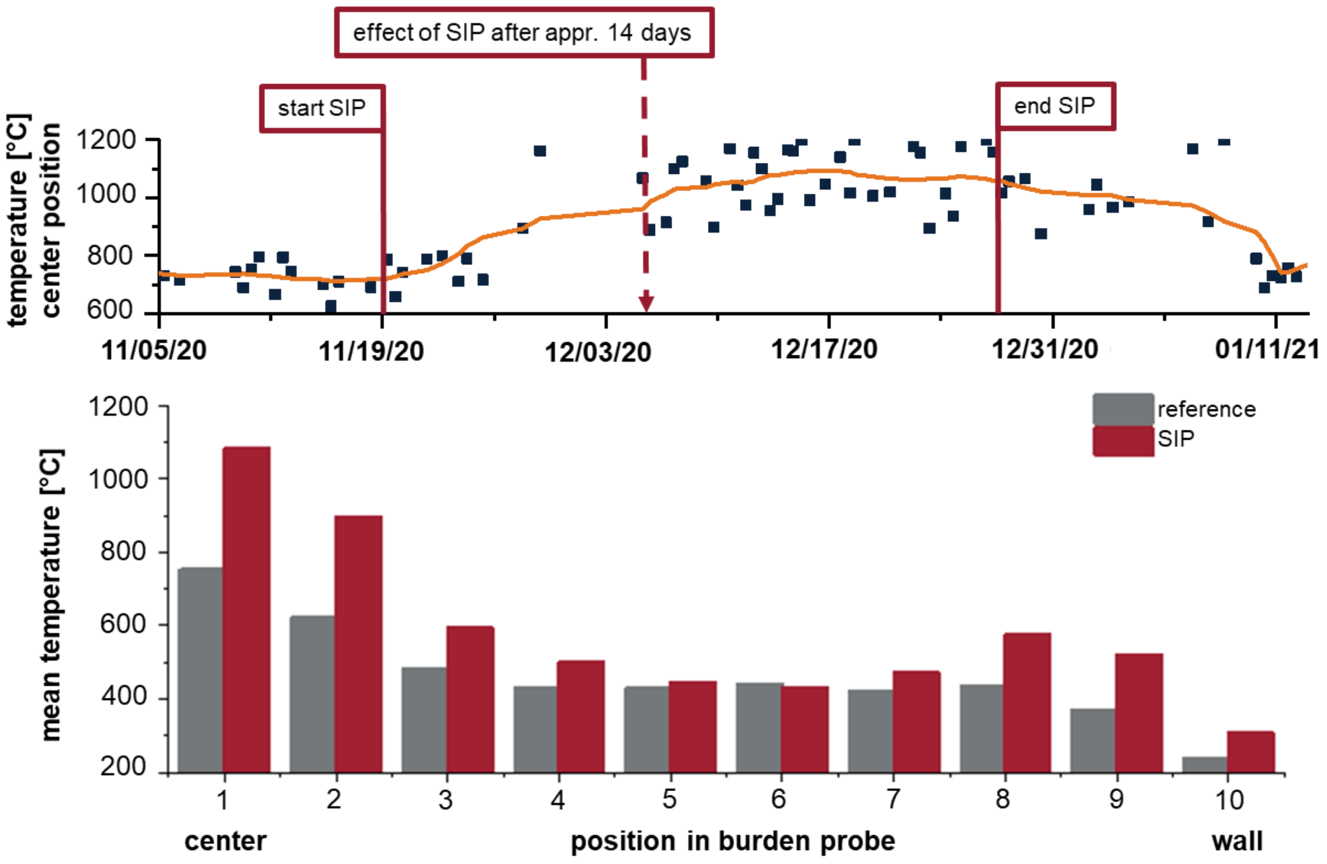


Operational Results

The injected SIP oxygen influences the gas flow profile and thus the temperature profile moves significantly away from the sidewalls, toward the center.

in-burden probe - center temperature

- without SIP: Temperature range 600 – 800 °C
- SIP in operation: Temperature range 900 – 1100 °C
- changes fully pronounced after approximately 14 days and could be observed in all selected evaluation periods

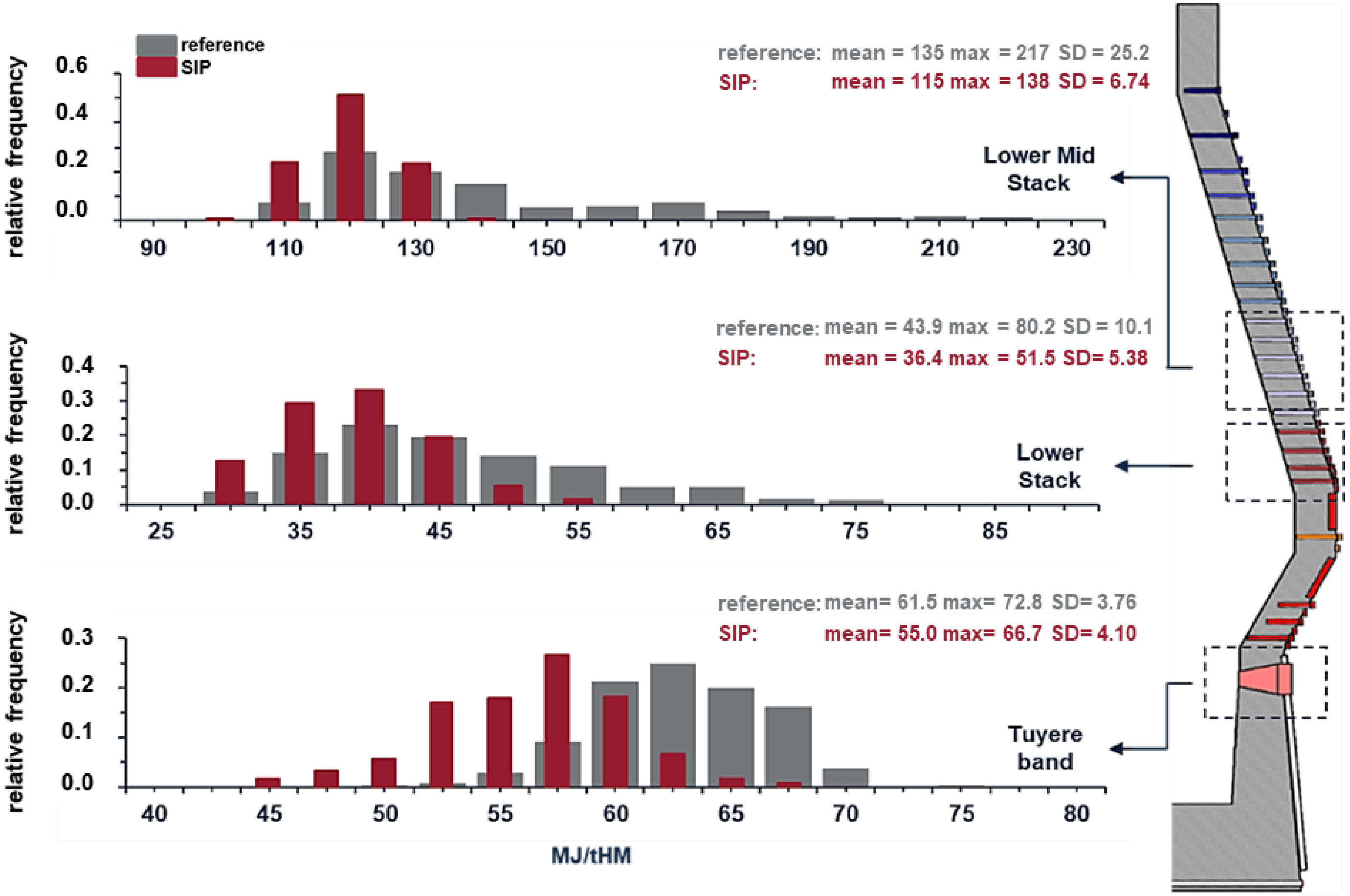


Operational Results

An improved central gas flow also implies a lower gas flow at the blast furnace wall, thus also an effect on temperatures at the blast furnace wall and the resulting thermal load.

- Area around lower mid and lower stack in average with reduced thermal loads
  - fluctuation range was significantly lower during SIP operation
- Tuyere band with a noticeable shift in values towards lower heat loads

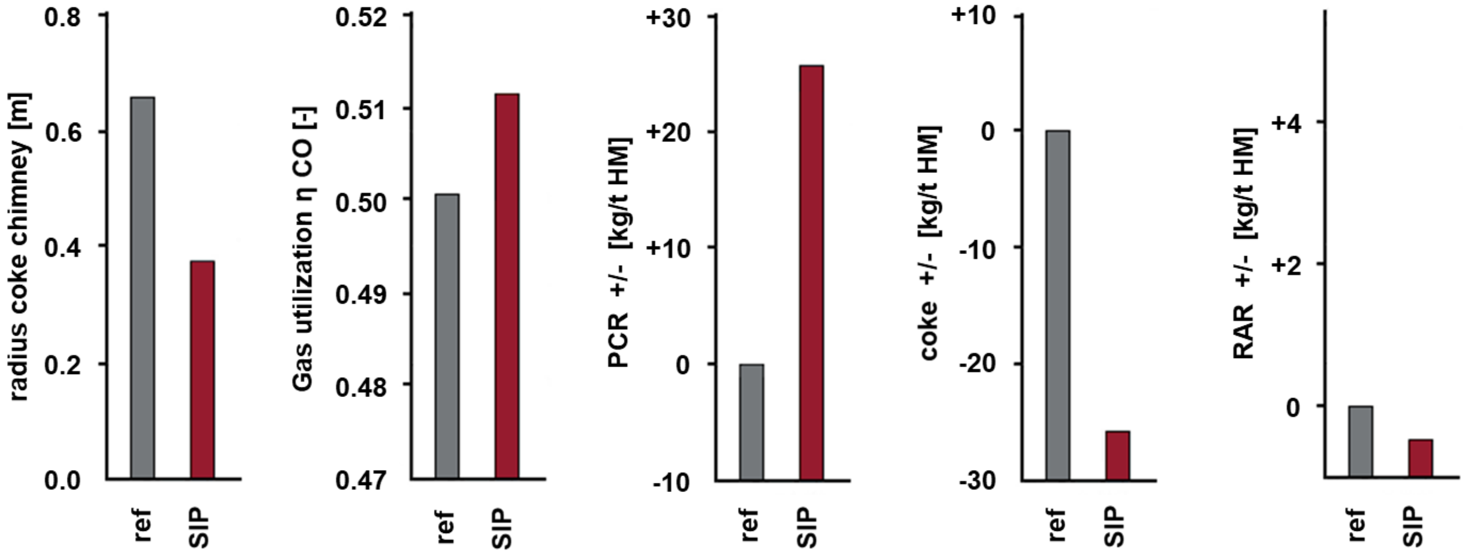
Herewith an indirect confirmation of the improved centre gassing



Operational Results

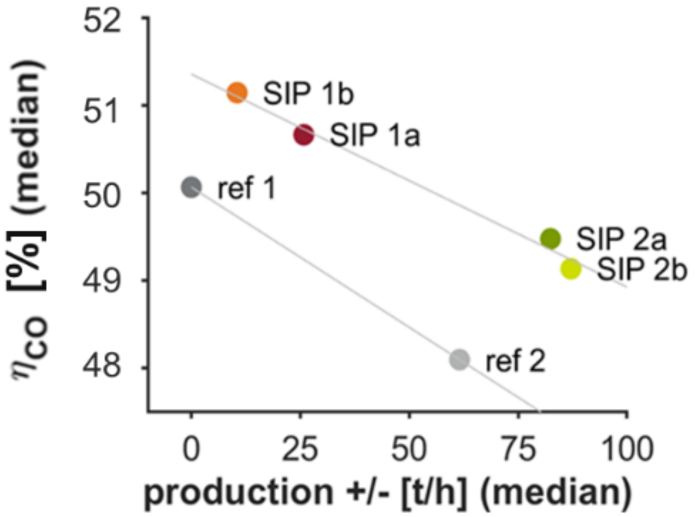
Adjustment of the proportion of central coke possible through improved gas flow.

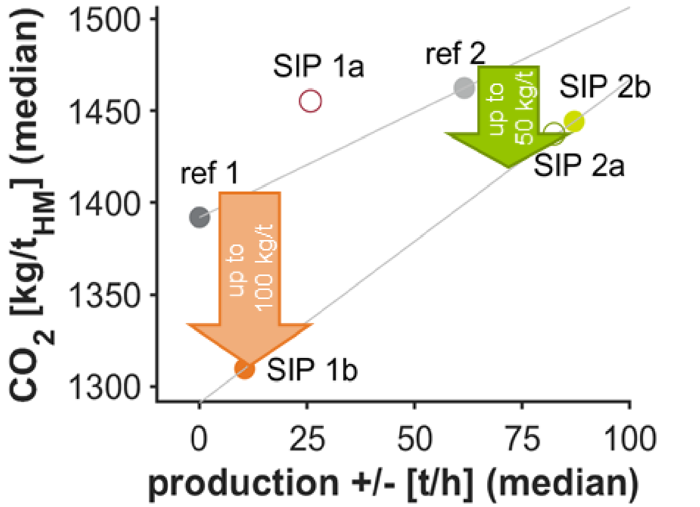
- reduced central coke chimney
- increased gas utilization
- significantly increased PCI rate
- consequently, reduced coke consumption
- coke replacement ratio of around 1



Operational Results

- SIP substantially changes the gas flow paths in the blast furnace and therefore the location of process reaction zones
- influence on the total blast furnace gas utilization (ηCO) and therefore directly on the efficiency of how the supplied reducing agent is utilized in the process
  - each SIP evaluation period with a higher ηCO than the corresponding reference period -
  - consequently, reduced carbon footprint
    - SIP 1b vs. ref 1 → up to 100 kg/tHM less CO_2
    - SIP 2b vs. ref 2 → up to 50 kg /tHM less CO_2



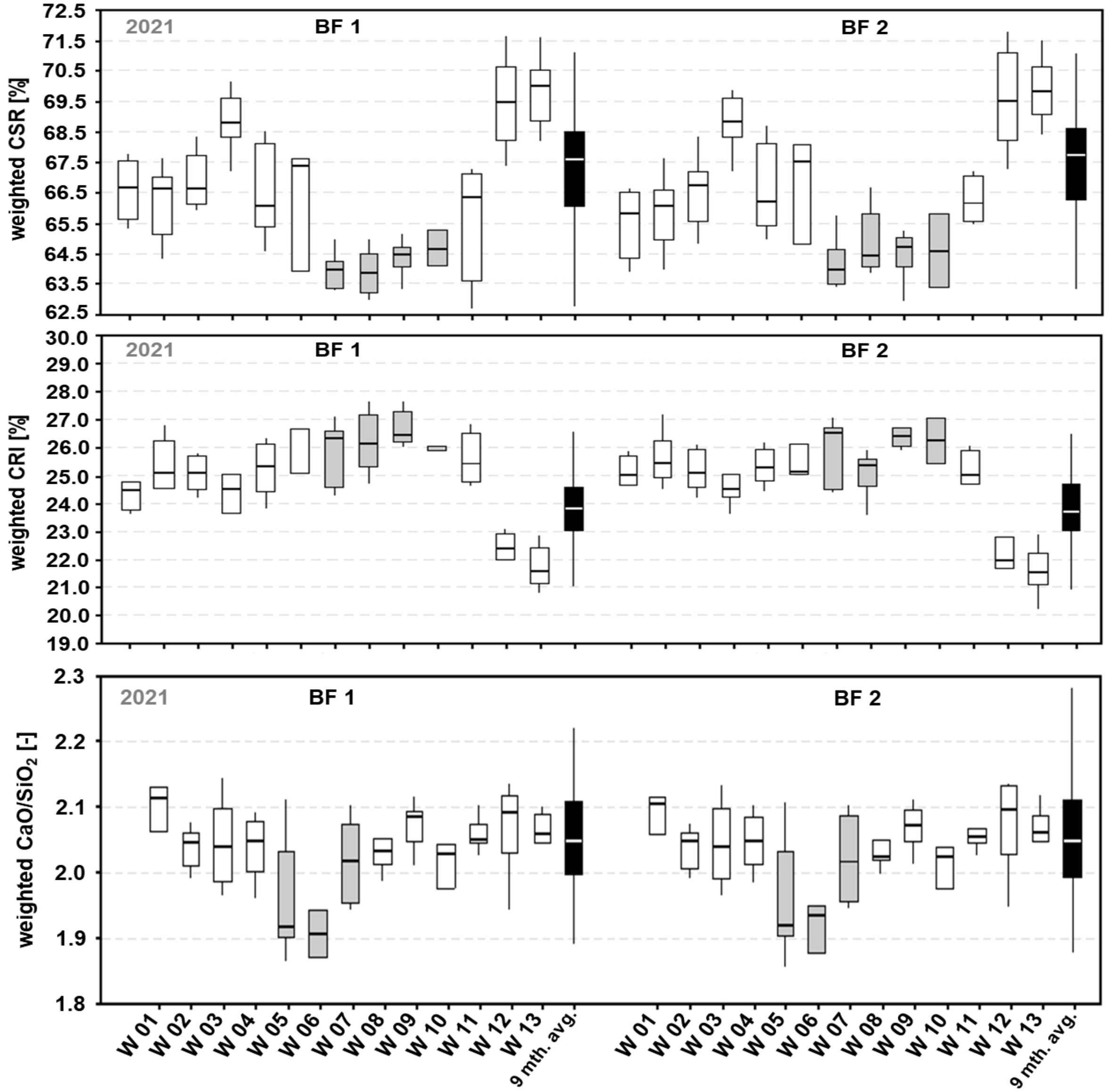


Operational Results - reduced raw material qualities

Challenging fluctuations in raw material qualities within a period of around 6 weeks:

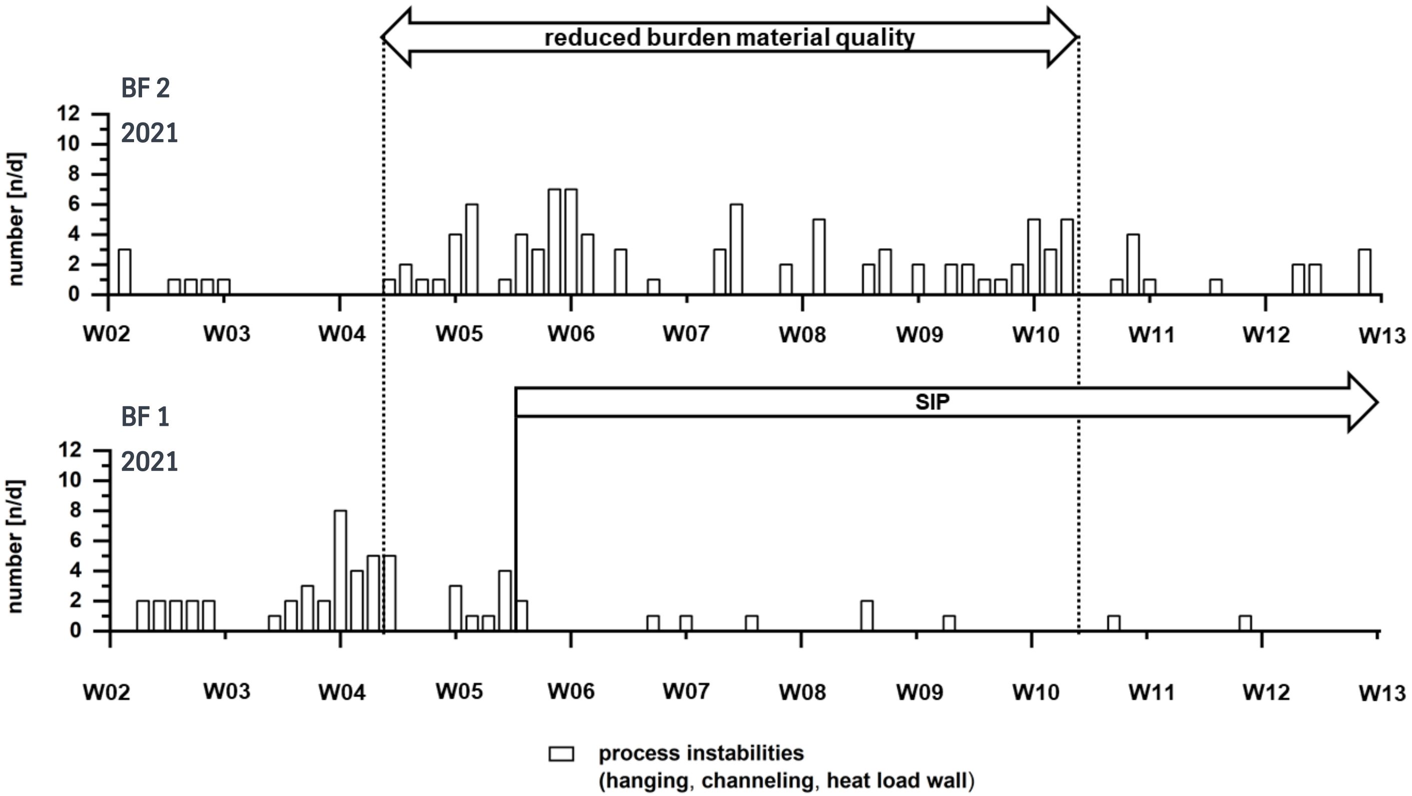
- remarkable decrease in coke quality → week 7 until week 10
- very strongly fluctuating basicity values → weeks 5 until week 7
- Qualities recorded above and beyond this:

Raw Material Quality BF 1 and BF 2		
Coke	mean size	low
	I 40	low
	I 10	high
Sinter	mean size	low
	fines	high
	strength	low
	RDI	high
lump ore	type	change often
pellets	type	change often



Operational Results - reduced raw material qualities

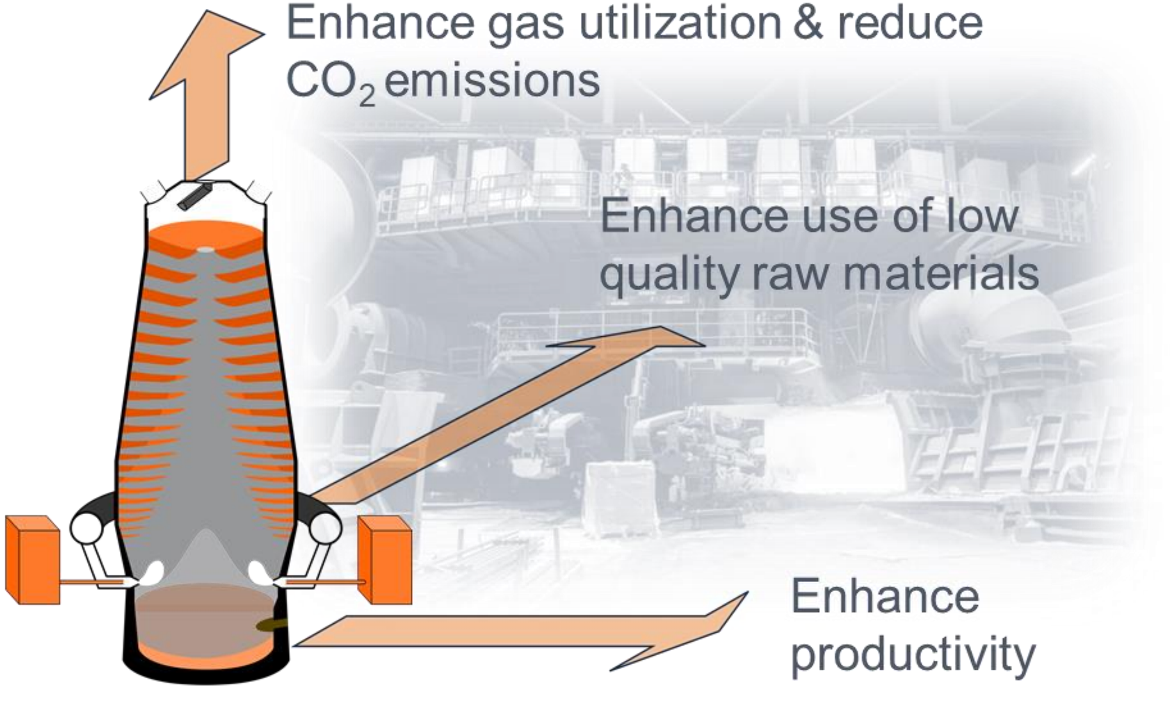
- Significant differences in the occurrence of process instabilities between BF 2 without SIP and BF 1 with SIP
- BF1 was able to reach its **maximum production level**
- in contrast, it was **not possible to achieve a normal production** level at Blast Furnace 2, even with effort.
- Process-critical parameters were in a **markedly** better **cost-effective** range at **BF 1 with SIP** than at BF 2 without SIP



parameter	production	blast volume	PCR	RAR [kg/t HM]	gas utilisation [%]	wall heat load	permeability	HM analysis
BF 2	85 %	low	low	up to 533	→ 46.6	high	low, unstable	aim failed & unstable
BF 1 with SIP	100 %	high	typical	up to 503	→ 50.0	low	good, stable	typical level

Summary & Conclusions

- The world's first SIP plant for blast furnace application has been operating at Schwelgern BF1 since late 2020
- Fully adopted and incorporated into blast furnace operating practice, it shows its contribution to:
  - reduce the carbon footprint
  - positive influence on process stability, enables a significantly smoother furnace operation
  - increase productivity & optimize operating costs



BF with SIP Technology

Thank you for your attention

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