SESSION 2: 10:10–10:30

ESTEP
European Steel Technology Platform

ESTEP workshop

SecCarb4Steel

Preparation and use of biogenic and non-biogenic secondary carbon carriers (SCC) in processes for iron and steelmaking

Practice of recycled plastics injection into a blast furnace at voestalpine Stahl GmbH

Lina Kieush[1], *Christoph Thaler*[2], *Johannes Rieger*[1]

[1] K1-MET GmbH, 4020 Linz, Austria
[2] voestalpine Stahl GmbH, 4020 Linz, Austria

Advantages of the waste plastics injection over pulverized coal into blast furnace (BF)

Lower thermal ignition temperatures

Higher burning rates

Greater calorific value

Waste plastics injection in the BF

Overview of other recent industrial-scale activities

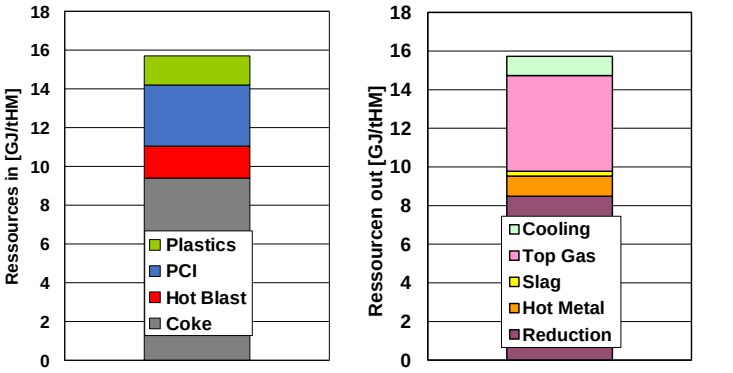
- 2008 Salzgitter: Waste plastic mixture including ASR*, max. capacity 50,000 t/y, ~5t/h injected
- 2004 East Japan Works in Kawasaki: Plastic waste from container and packaging, max. cap. 30,000 t/y
- 2000 West Japan Works in Fukuyama: Plastic waste from container and packaging, max. cap. 30,000 t/y
- 1997 ArcelorMittal Eisenhüttenstadt: Agglomerated waste plastic, max. cap. 45,000 t/y, stopped in 2001
- 1996 ThyssenKrupp Dortmund: coal-plastic blend was injected, stopped in 1997
- 1996 East Japan Works in Kawasaki: Plastic waste from container and packaging, max. cap. 40,000 t/y
- 1994 ArcelorMittal Bremen: agglomerated waste plastic (~3% PVC), max. cap. 110,000 t/y, stopped 2001
- *ASR…Automotive Shredder Residues

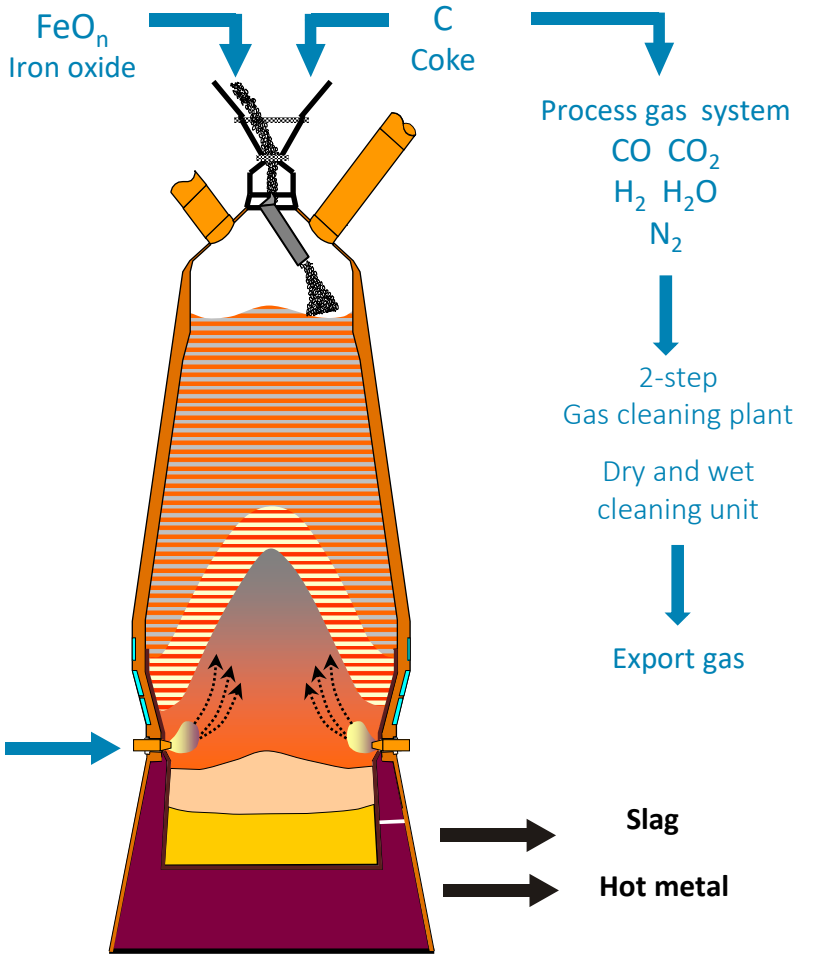
[1] Carpenter, A. M.: Injection of coal and waste plastics in blast furnaces, International Energy Agency (IEA) Clean Coal Centre, 2010

Waste plastics injection plant at voestalpine Stahl, Linz

Process technology at voestalpine Stahl GmbH Blast Furnace A

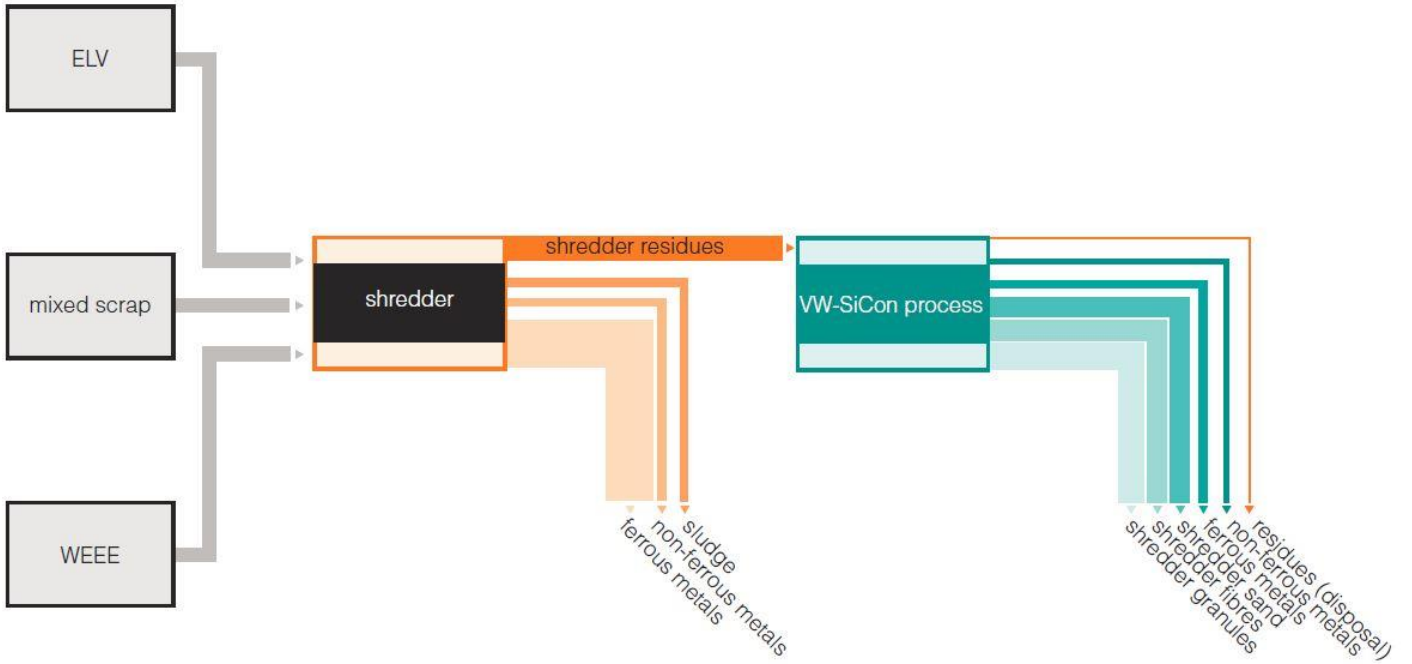
» Smelting reduction process of iron oxides:
$Fe_2O_3 + 2CO + H_2 = 2Fe + 2CO_2 + H_2O$





Waste plastic preparation.
Example of automotive shredder residues (ASR)

Volkswagen-Sicon process [1]



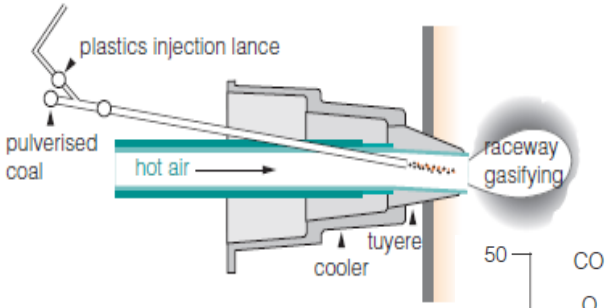
- Combination of mechanical operations
- Separation of ASR due to optical characteristics and physical properties
- 2 plastic fractions from ASR suitable for BF
  - Shredder granules
  - Shredder fibres (need to be densified before use in BF)

ELV…End of Life Vehicles
WEEE…Waste Electric and Electronic Equipment

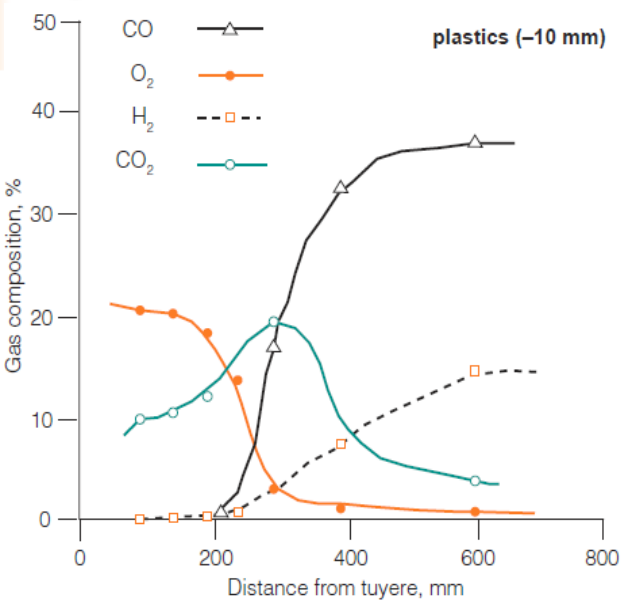
[1] Carpenter, A. M.: Injection of coal and waste plastics in blast furnaces, International Energy Agency (IEA) Clean Coal Centre, 2010

Waste plastic injection and combustion

Schematic of a BF tuyere [1]



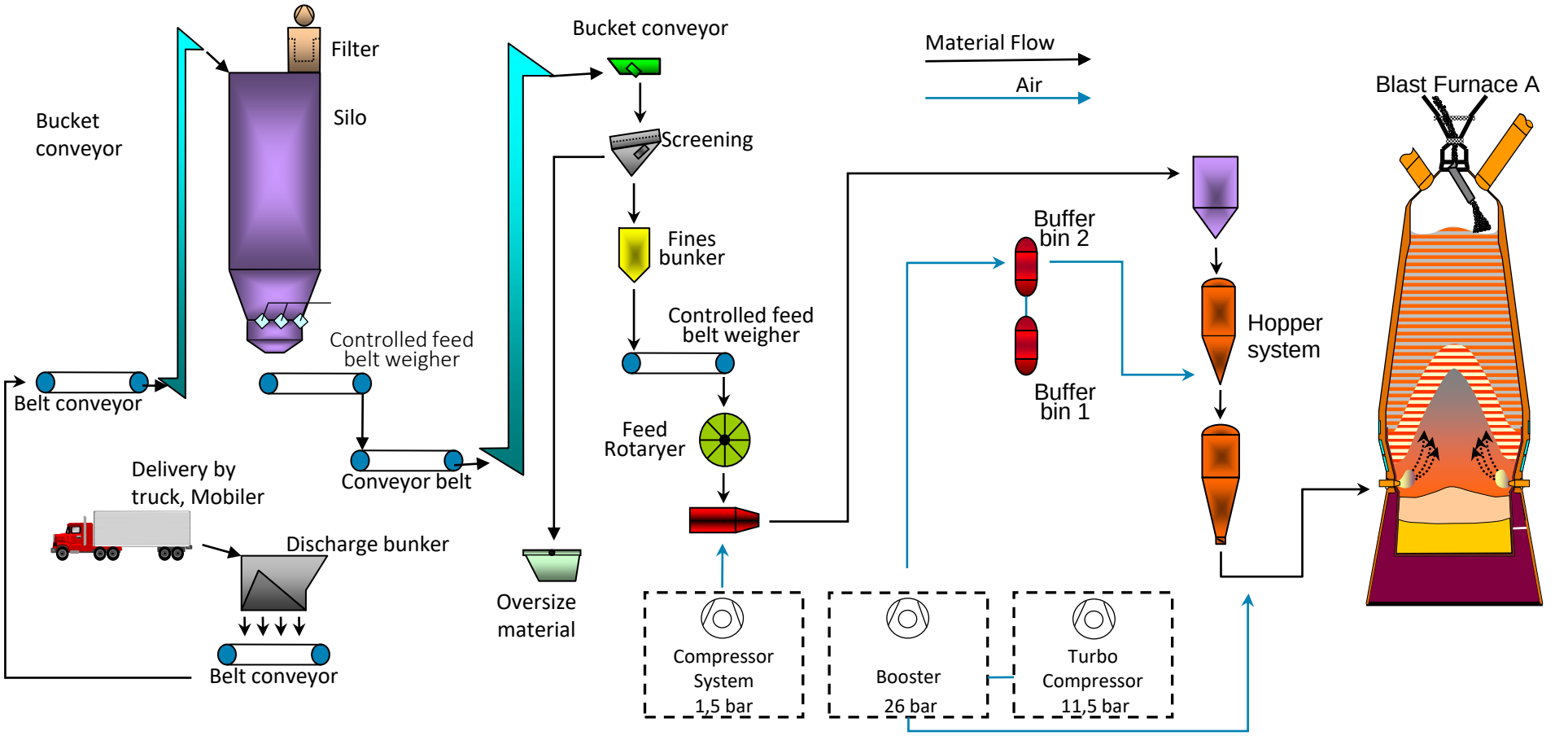
Simulated gas composition in the raceway during plastic injection [1]



- Pneumatic injection via tuyere
  - Lance design influences conversion efficiency and blockage events
  - Different lance systems possible
    - Coaxial lances, high dispersive lances, swirl lances...
- Transformation of waste plastics to CO and H_2 in the high temperature zone
  - In general: $2C + 2H + O_2 = 2CO + H_2$
  - E.g.: $½C_2H_4 + CO_2 = 2CO + H_2$

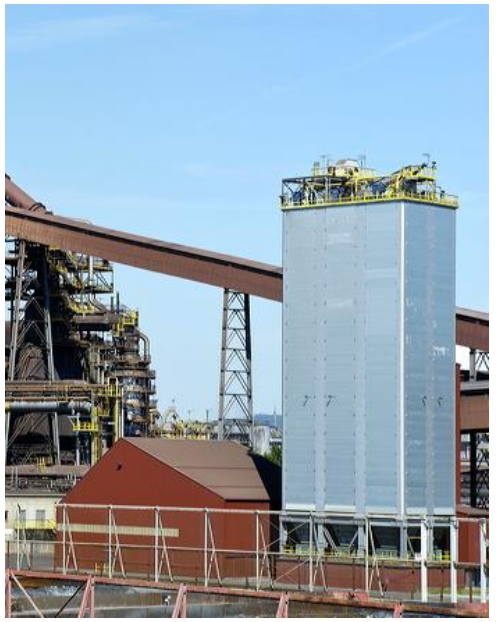
[1] Carpenter, A. M.: Injection of coal and waste plastics in blast furnaces, International Energy Agency (IEA) Clean Coal Centre, 2010

Flowchart of the plastics injection plant



Plastics injection Blast Furnace A

Material handling and storage



Process air compression and injection tower

Pressure hopper and material distribution

Injection tower and material distribution for 32 injection positions (6 bar abs. 25 mm diameter) developed by E.S.C.H. GmbH, Germany

Plastics as reducing agents for BF

Plastic materials injected at BF A:

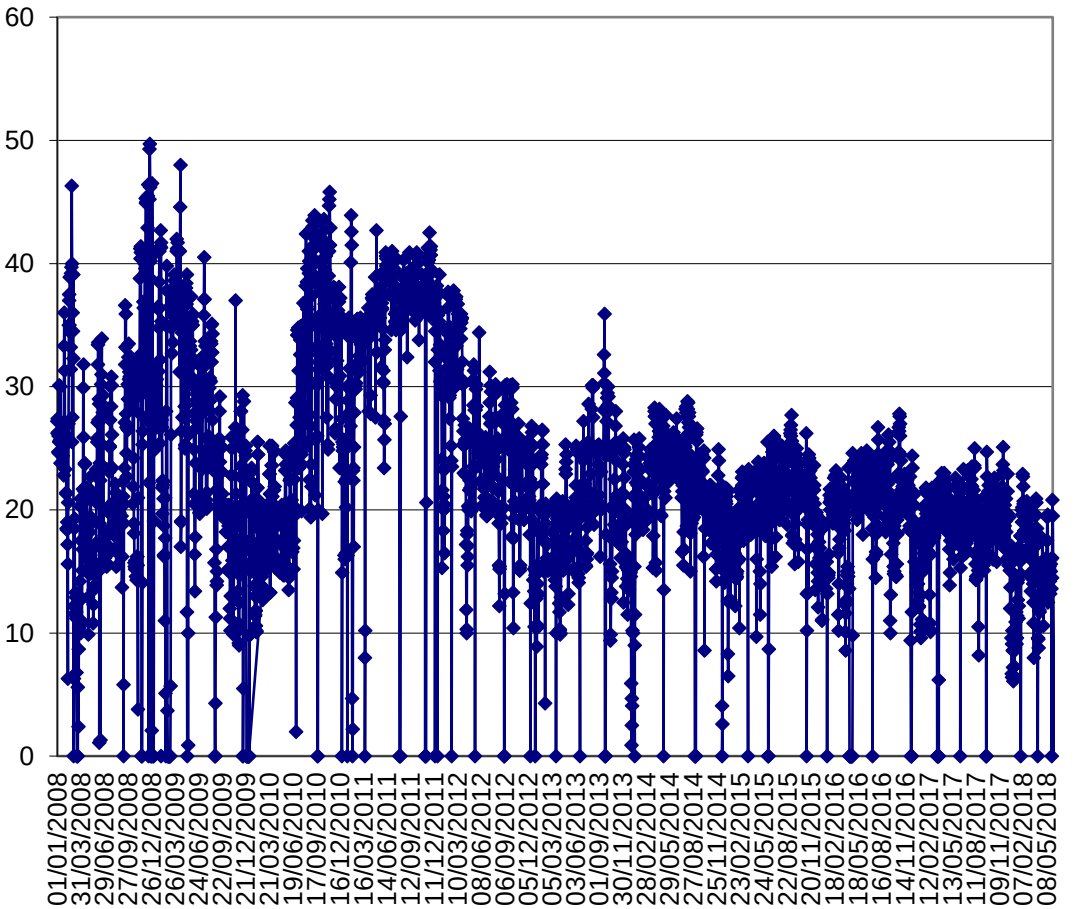
- Pellets;
- Agglomerate;
- Granulate (product of shredder residue treatment process).

Pellets

Agglomerate

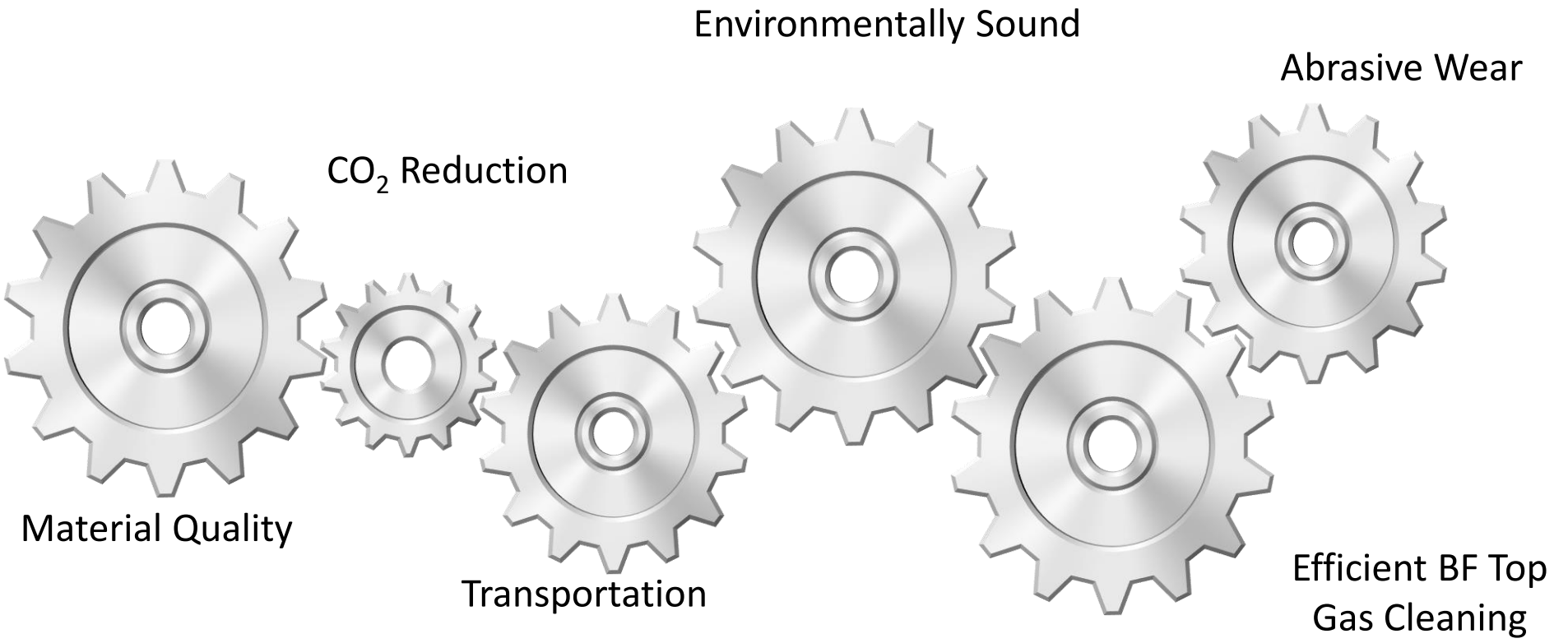
Granulate

Plastic-usage in kg/t HM



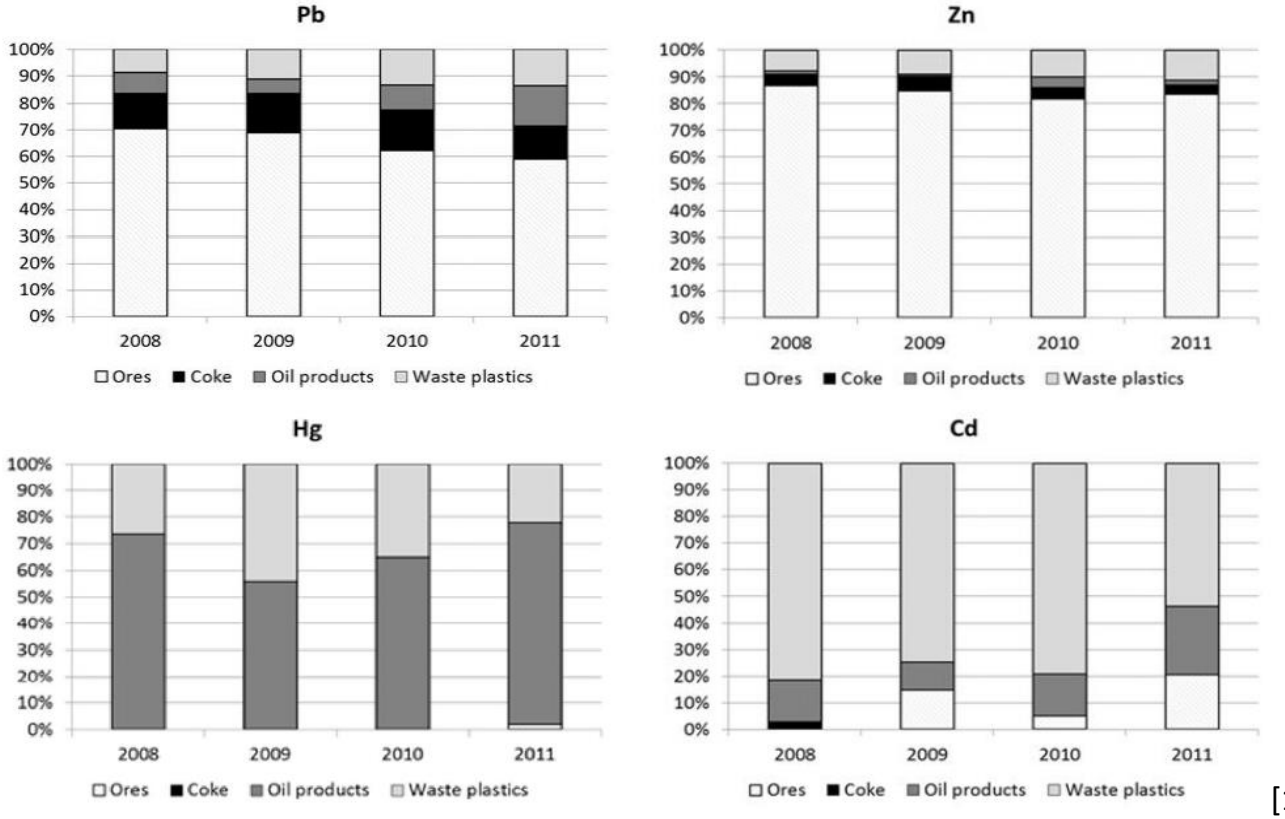
The average injection rate was 20 kg/t HM

Experience with waste plastic injection



Environmental aspects.
Heavy metal input into the BF by waste plastic

Share of heavy metal input (Pb, Cd, Hg, Zn) from 2008 to 2011



- Waste plastic contributes to…
  - 60-80% of total Cd input
  - ~30% of total Hg input
  - ~15% of total Pb and Zn input

[1] Trinkel, V., Rechberger, H., Kieberger, N. et al.: Heavy metal flows induced by waste plastic in blast furnace process, DepoTech Conference, Leoben (Austria), 2014

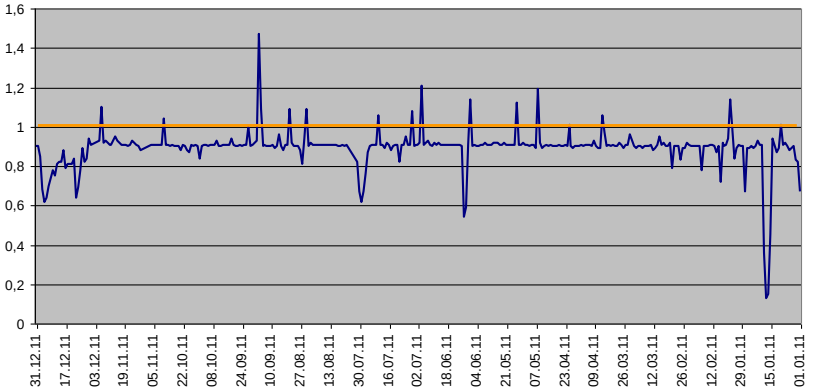
Top gas cleaning at BF process

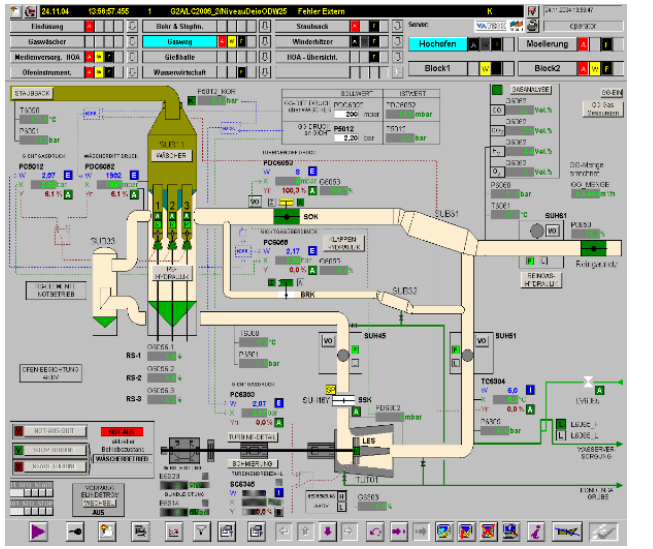
Worldwide unique dust limit of **1 mg/Nm³** as daily average in the BF top gas

(BAT Documents ISP: Dust < 10 mg/Nm³)
BF top gas cleaning with gravity seperation of coarse dust in the dust cyclone and fine dedusting by wet scrubbing in the spray tower/cone scrubber system.

BF top gas is used for steam production (steam turbines for process air compressors), hot stoves heating, coal pyrolysis and electricity production.

BAT= Best Available Technique, http://eippcb.jrc.ec.europa.eu/reference/



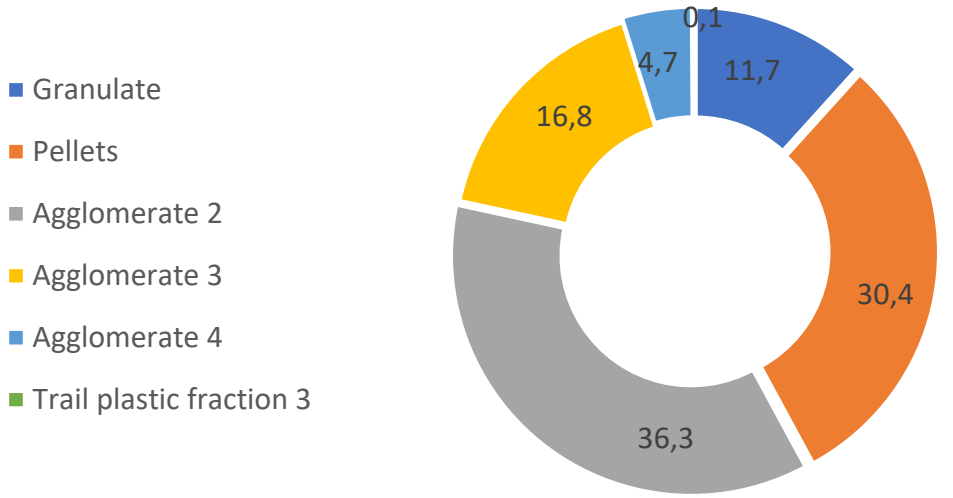


Material transport

- Minimizing the risk of traffic accidents due to rail transport system
- CO_2-reduction (> 5.800 t/a) due to change of transport system
- More flexible material handling on weekends

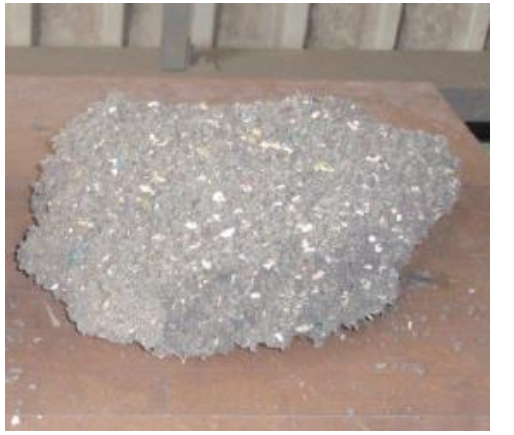
Material quality is essential

- Calorific value to ensure stable BF operation;
- Grain size distribution: <10mm;
- Chemical composition;
- Moisture content < 1.5%.



Plastic input distribution within 2012-2016

The oversized material



Big agglomerated „piece“ of plastic due to the moisture

Selected characteristics of plastic pellets, agglomerates and granulates

Moisture	max.	%	1.5
Ash	max.	% dry	10
Net Calorific Value [1)]	min.	MJ/kg dry	35(33) [1)]
Bulk Density	min.	kg/m³	300
Particle Diameter	max.	mm	6
Particle Length	max.	mm	10
Fines <4mm	max.	%	5
[1)] Target Value (Limit Value)			

Remarks

- The application of plastics for injection aims to recycle industrial and municipal plastic waste.
- Recycled plastics with a sufficient heat value of about 33.000 kJ/kg offer a viable option to replace conventional fossil carbon sources in BF processes, contributing to lower CO_2 emissions.
- Injecting recycled plastics through the tuyere system, with a maximum injection rate of up to 40 kg per ton of hot metal (kg/tHM), has been successfully implemented in several countries.
- Recycled plastics generally can contain higher levels of trace elements than conventional BF feedstock materials, and these amounts should be controlled.
- Partially unburned recycled plastics may be present at the end of the raceway due to the larger grain size.

Thank you for your attention

Lina Kieush, K1-MET GmbH, 4020 Linz, Austria; lina.kieush@k1-met.com

Christoph Thaler, voestalpine Stahl GmbH, 4020 Linz, Austria; christoph.thaler@voestalpine.com

Johannes Rieger, K1-MET GmbH, 4020 Linz, Austria; johannes.rieger@k1-met.com