HEAT RECOVERY FROM BLAST FURNACE SLAG

Graz, 14.10.2014
Overall situation:

- Blast Furnaces in Iron & Steel produce ~400 mio. tons of slag (1500°C) each year.
- The slag is generally processed to a by-product without using heat recovery (~1,8 GJ wasted energy per ton slag).
- Increasing demand in Energy Efficiency in Iron & Steel.
- The main challenges is to extract the energy from the molten slag by a dry granulation process.
What do we want from a New Slag Technology?

<table>
<thead>
<tr>
<th>New Slag Treatment Process - Overall Objectives</th>
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<tbody>
<tr>
<td><strong>PRODUCT</strong></td>
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<tr>
<td>• Cement Grade Granulate</td>
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<tr>
<td>• Even Sized High Density Granules</td>
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<td>• Dry Granules</td>
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<tr>
<td><strong>ENVIRONMENTAL IMPROVEMENTS</strong></td>
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<tr>
<td>• Sulphur Gas emissions to be reduced/removed</td>
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<tr>
<td>• No pollution from water discharge</td>
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<td>• No vapour plume</td>
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<tr>
<td><strong>SLAG HEAT ENERGY</strong></td>
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<td>• System to allow incorporation of waste heat recovery</td>
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</table>
Heat Recovery from BF Slag

Process Flow Chart

Dry BF Slag Granulation
Exemplary process values for 1 to/min BF slag
Plant design for up to 6 to/min BF slag

- BF Slag Feed: 1 to/min at 1450°C; ~30 MWth
- Rotating Cup
- Slag bed agitated by cooling air
- Motor drive
- Granulated Slag Discharge

- Hot Air Out: ~600°C, ~125,000 Nm³/h
- Recirculation Air: ~175°C

- Water Cooled Wall

- Fan: ~0,8 MWel

- Stack

Waste Heat Recovery
Example: Steam Production

- Superheated Steam: ~29 t/h at 21 bar(a), 280°C
- Boiler: ~20,5 MWth
- Customer Steam Net

- Feed Water: ~7 bar(a), 115°C
- Feed-Water Pump
- Customer Feed Water System

- Ambient Air
Heat Recovery from BF Slag

**Project Phases**

- **Phase 1:** MUL
  - Technical Plant at University of Leoben
  - 20 - 60 kg/min
  - 15 - 5 min
  - Ø ~ 2 m, h ~ 2 m
  - different slag types?
  - impact elevated temperatures?

- **Phase 2:**
  - Prototype Plant on voestalpine site
  - 1 - 2 t/min
  - Ø ~ 6 m,
  - operation close to real conditions

- **Phase 3:**
  - Full Scale Plant
  - Ø ~ 6 m
  - up to 6 t/min
  - real environment

**Timeline:**
- **CY11**
- **CY12**
- **CY13**
- **CY14**
- **CY15**
- **CY16**
- **CY17**

**Stage Indicators:**
- **GO** for Phase 2
- **STOP/GO** for Phase 3
Heat Recovery from BF Slag

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Phase 1: MUL
- CY11
- CY12
- CY13
- CY14
- CY15
- CY16
- CY17

Phase 2: on voestalpine site
- GO
- STOP/GO

Phase 3: on customer site
Heat Recovery from BF Slag Project Phase 1

Q2/2011

Q4/2011

Q2/2012

Q4/2012

TOTAL Phase 1 Budget
~ 3,0 Mio €
Project Phase 1
Successful Results from Granulation Trials

- > 95% glass content of the granulate product by high off gas temperatures !!!
- CFD Model validated for scale-up activities !!!
Heat Recovery from BF Slag

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Design / Construction
Test / Operation

GO Phase 2
STOP/GO Phase 3

Phase 3: on customer site
Heat Recovery from BF Slag
Project Phase 2

- Klima- und Energiefonds
  Programm: Energie Mission Austria (e!MISSION 2012 1.AS)
- Forschungsvorhaben zur Wärmerückgewinnung mittels Trockenschlackengranulation - „FORWÄRTS“
- Consortium
  - Siemens VAI Metals Technologies (Project Lead)
  - voestalpine Stahl
  - Montanuniversität Leoben
  - FEhS – Institut für Baustoff-Forschung
- Timeframe
  - 01.03.2013 – 28.02.2016 (3 years)
- Total Budget
  - ~ 4,8 Mio €
- Aim of the Project
  - Development, Erection and Test Operation of an Prototype Plant for Heat Recovery from Blast Furnace Slag
Heat Recovery from BF Slag

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FORWÄRTS“ Scope

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Slag droplets

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Motor drive

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Fan
~ 0,8 MWel

Ambient Air

Feed-Water Pump
Project Phase 2 - “FORWÄRTS”
Current Research Results

- Finish Prototype Plant concept and up-scale
- Conduct Prototype Plant location study
- Concept and experimental tests for liquid BF slag treatment
- Development of overall measurement and control system
- Development of liquid BF slag flow measurement
- Development of slag granulate discharging system
- Finalize basic engineering of the Prototype Plant
- Concept for WHR system integration on voestalpine site
- Conduct economic feasibility for industrial plant
Project Phase 2 - “FORWÄRTS”

Planed Research Results

- Finalize detail engineering and erection of Prototype Plant
- Successful test operation of Prototype Plant
- Positive test result regarding WHR potential
- Positive test result regarding slag product quality
- GO decision for rollout of Heat Recovery from BF Slag technology
## Heat Recovery from BF Slag

### Summary

#### Benefits
- Generate steam, electrical power or utilization of high temperature heat for other applications
- Production of dry slag granulate
- Reduced sulfur emission
- Elimination of sulfur odor
- Reduction of the “CO₂ foot print”
- No water consumption/waste water

#### Challenge
- Utilize waste heat from BF slag
- Match requirements of cement industry regarding slag product quality
- Utilize energy on high temperature level

#### Solution
- Dry granulation of BF slag with rotating cup
- Air for slag cooling
- Different waste heat recovery solutions available: Steam production, power generation & others
- Industrial scale prototype plant in planning (voestalpine Linz)

#### Features
- Recovery of ~20 MW\textsubscript{th} or ~6 MW\textsubscript{el} from a BF slag flow of 1 to/min
- Production of a dry valuable slag product
- No water consumption for granulation process
- No interferences with production process