



RawMaterials

Connecting matters

# Recovery of V, Ti, Mn and Fe from (liquid) HIsarna slag

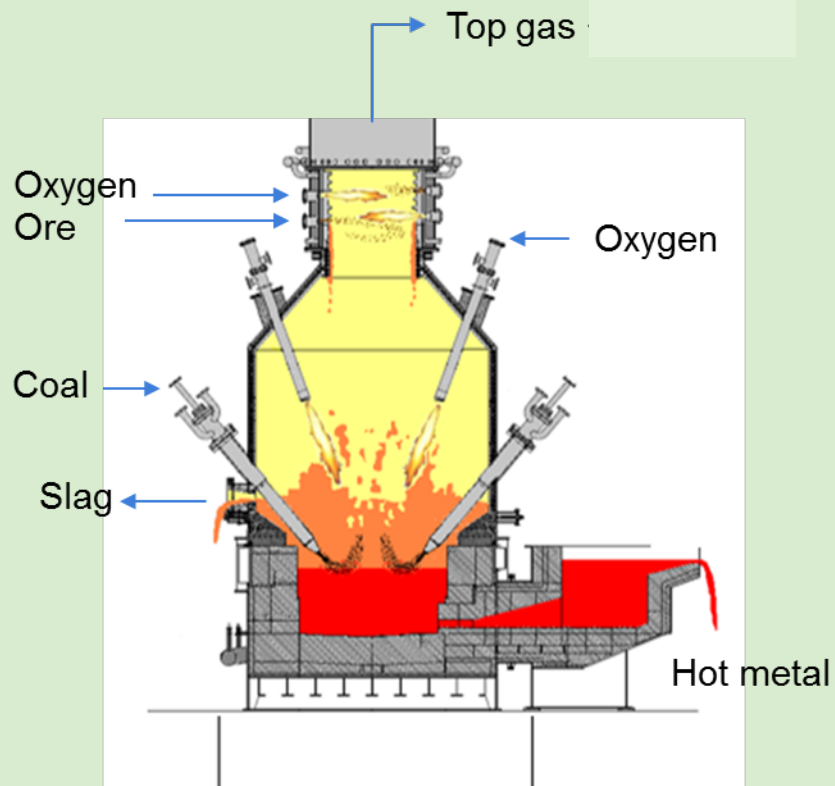
Brokerage Event & Expert Forum<sup>3</sup> | 13-14 October 2021



Co-funded by the  
European Union



# HISARNA PROCESS: MAKING HOT METAL



- Hot CO-rich gas from the smelting-reduction vessel is utilized for pre-reduction and melting.
- Molten and partly reduced iron ore drips down on the slag.
- Coal is injected in the slag layer, carburizing the hot metal bath and producing CO gas.
- The CO gas is partly combusted with oxygen, generating heat.
- Intensive heat transfer between hot gas and liquid phase due to intensive mixing.
- Hot metal is tapped continuously, slag is tapped every three hours.
- V, Ti, Mn and P report to Hisarna slag due to its slightly oxidizing conditions.

# RECOVERY OF V, P, Mn, Fe FROM LIQUID SLAG (PYRO-ROUTE)

## What?

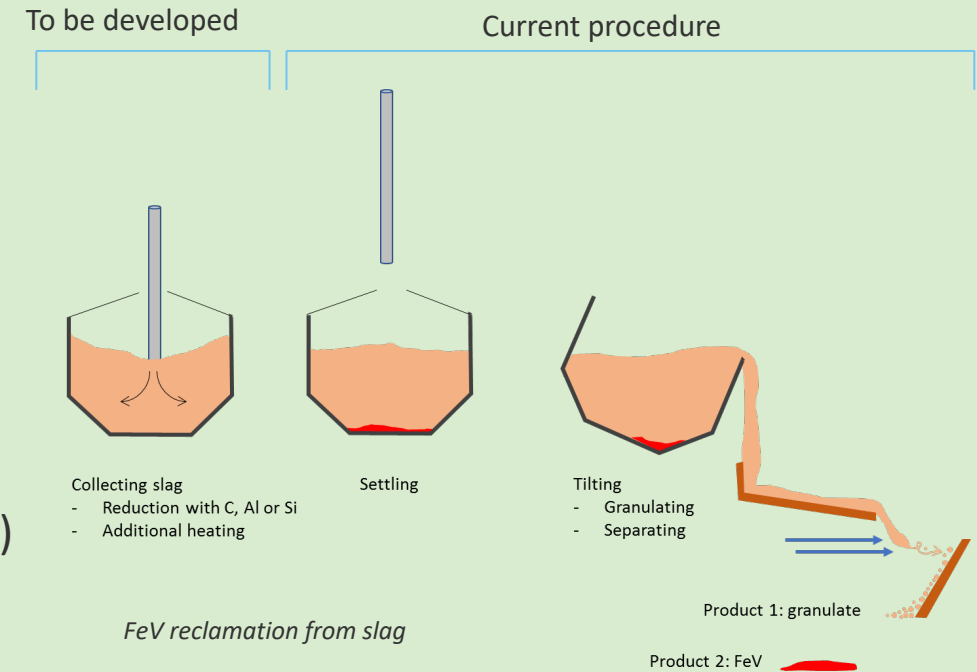
Recovery of metals by post-reduction of Hlsarna slag.

- From Hlsarna slag to BF-slag (commodity)
- Reclaiming V, P (CRMs) and Mn, Fe

## How?

Post-reduction:

- Introducing reducing agents:
  - CO/H<sub>2</sub>, Coal, aluminium, solar panels, ...?
- Generating additional heat:
  - Burner in the lid (CRM)
  - EAF-approach, including induction heating (Swerim)
  - Oxy-fuel lance (...?)
- Using the concentrate, extracting metals and P



# RECOVERY OF Ti, V, P FROM SOLID SLAG (HYDRO-ROUTE)

## What?

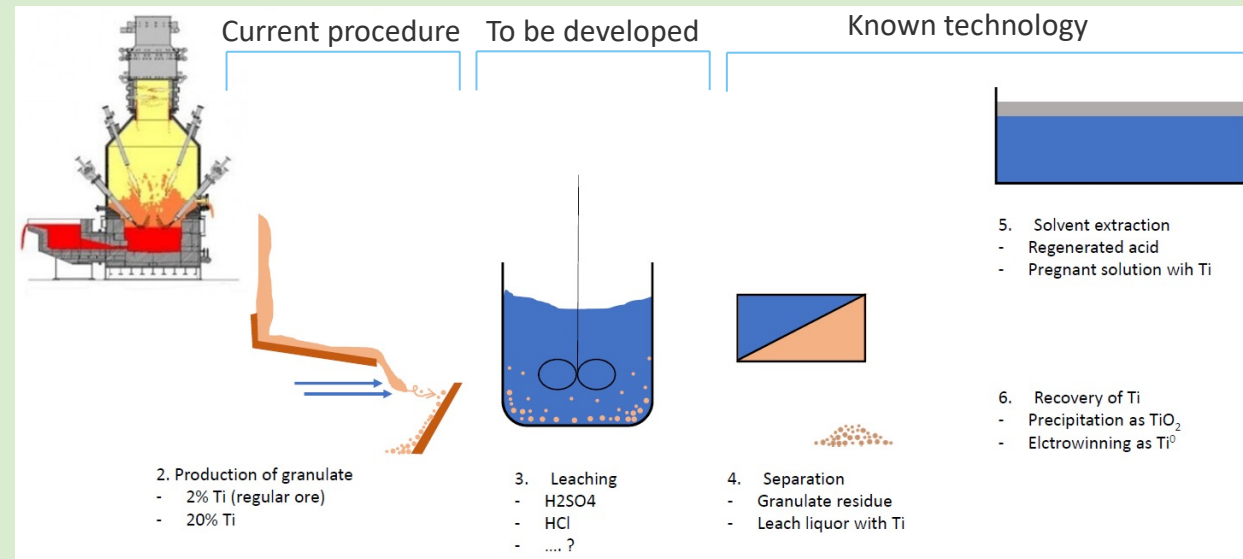
Recovery of metals by post-reduction of Hlsarna slag.

- From Hlsarna slag to BF-slag (commodity)
- Reclaiming Ti (CRM)

## How?

Selective leaching of the granulated slag:

- $H_2SO_4$
- HCL
- ...?



# POTENTIAL VOLUMES, FIRST ESTIMATES

300 kton/y Hlsarna slag:

Component	Wt%
SiO <sub>2</sub>	31
Al <sub>2</sub> O <sub>3</sub>	14
CaO	38
MgO	5
FeO	4
Others	7

40 kton/y metals concentrate and turnover:

Component	Wt%	kton/y	\$/ton	M\$/y
FeO	28	11	120 <sup>1</sup>	1.3
TiO <sub>2</sub>	28	11	3,000 <sup>2</sup>	34
V <sub>2</sub> O <sub>5</sub>	11	5	30,000 <sup>2</sup>	75
P <sub>2</sub> O <sub>5</sub>	11	5	150 <sup>3</sup>	0.7
MnO	22	9	525 <sup>1</sup>	4.6

1. TradingEconomics.com
2. Metalbulletin.com (as TiO<sub>2</sub>, V as FeV - V per kg)
3. TheGlobalEconomy.com (phosphate rock)

# THEMATIC SCOPE OF THE PROJECT PROPOSAL

Category of activity:

- Upscaling

## Link with the topics addressed in KAVA Call 9:

- Raw Materials and Circular Societies Lighthouse:
  - Recycling of end-of-life products containing Strategic Materials and/or CRMs
    - Making cement from Hlsarna slag might work, but metals will be lost
    - Converting Hlsarna slag into BF-slag by removing metals seems the way forward
  - Supply of Strategic Materials and/or CRMs
    - Amounts of CRMs depend on the selection of raw materials for Hlsarna
  - Resource and Energy efficient in metallurgical and Mineralogical processing
    - A pyro-treatment while the slag is still liquid saves energy

# CURRENT STATUS OF THE PROPOSAL

- **Current status of the proposal:**
  - Pyro route: TU-Delft (small scale), CRM (intermediate scale), Swerim (pilot scale)
  - Hydro route: TU Delft (small scale), VTT (pilot)
  - End-users: ICL for P
- **Type of expertise requested:**
  - Submerged lance technology
    - Coal injection (and others)*
    - Oxy fuel, under stoichiometric conditions*
  - Extracting and concentrating V, Mn and P from the metal concentrate
  - Extracting Ti from slag, post-processing of leach liquor
  - End-users: V, Mn, Ti

# CONTACTS

Full name: Hans Hage, Jeanne Fradet

E-mail address: [hans.hage@tatasteelurope.com](mailto:hans.hage@tatasteelurope.com), [jeanne.fradet@tatasteelurope.com](mailto:jeanne.fradet@tatasteelurope.com)