

InSGeP

Investigations of Slags from Next Generation Steel Making Processes

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Beyond Recycling: Circular Strategies in Steel Production – Webinar and Workshop

InSGeP project – Overall overview

Investigations of Slags from Next Generation Steel Making Processes

- Content :
 - Data gathering about slag produced from next generation steelmaking processes and EU regulations
 - DRI-EAF slag production and characterizations
 - Impact of granulation technologies on phase formation
 - Dry and wet slag granulation
 - Definition of possible applications (Cement sector, Agriculture, 3D printing etc.)
 - Test of applications
 - Economic evaluation
 - Environmental evaluation

Partner	RTO / industrial	Country
FEhS	RTO	Germany
CRM	RTO	Belgium
Rina-CSM	RTO	Italy
K1-Met	RTO	Austria
BFI	RTO	Germany
SSSA	RTO	Italy
AMMR	Industrial	France
Voestalpine	Industrial	Austria
O.R.I. Martin	Industrial	Italy
Sidenor	Industrial	Spain
Saarstahl	Industrial	Germany
Tenova	Tech Supplier	Italy
Primetals	Tech supplier	Austria

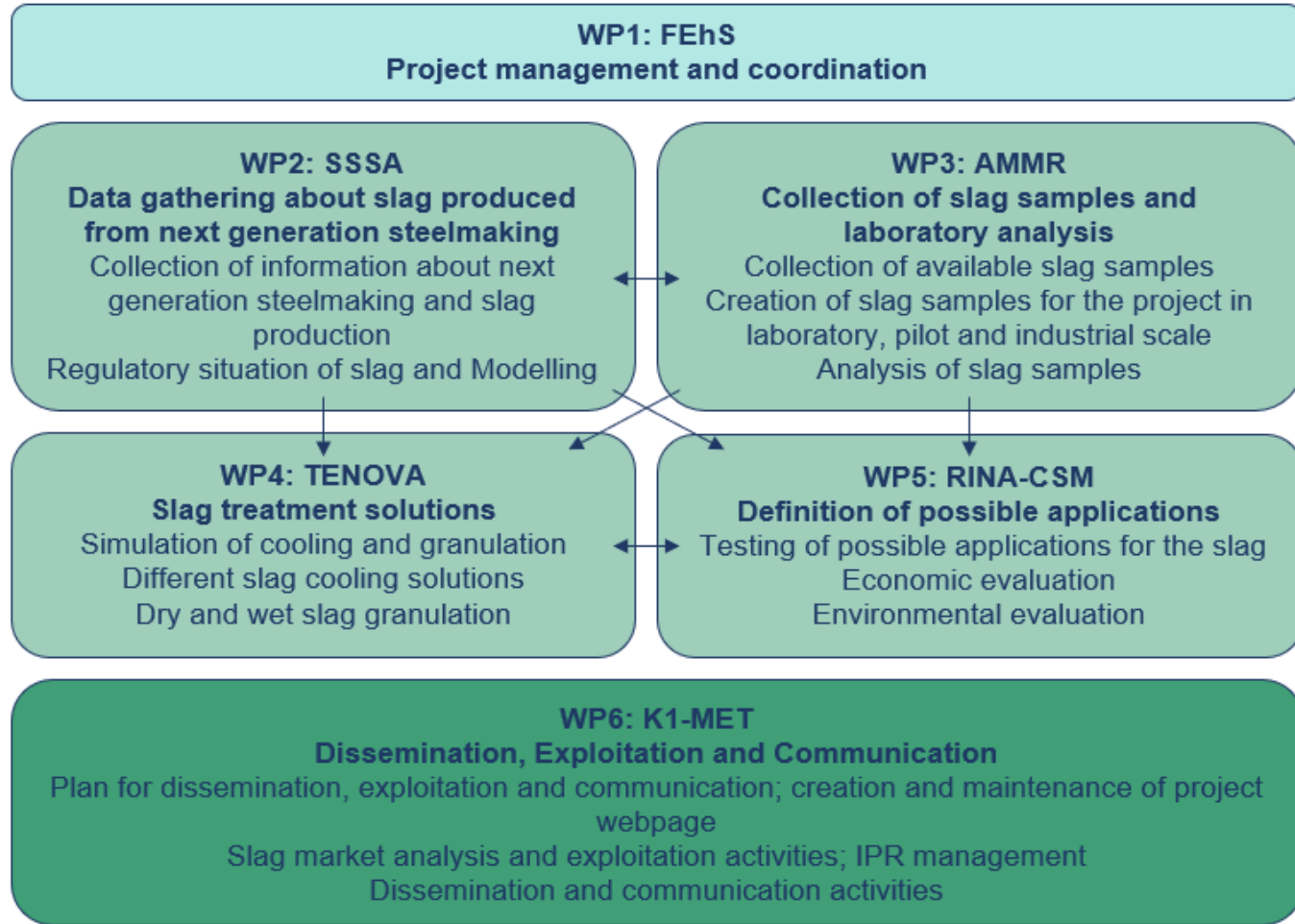
InSGeP project – WPs – CRM contributions

Modelling Tasks:

Using Available in-house EAF model codes - Predicting slag composition and properties using different DRI quality and ratio.

Using the large-scale slag from ArcelorMittal DRI melting trial

1. Modelling the slag cooling - Possible phase formation
2. Slag viscosity measurements
3. Pilot scale slag remelting and Dry granulation



1. Model validation via experimental measurements:

- using the lab furnaces to produce 5 small (100 g) size slag samples based on the future slag composition estimated by EAF model calculations in WP2.

2. Pilot scale re-melting

- DRI with different DRI ratio
- Blast furnace pellets will be reduced in two reduction degree then re-melted in Plasma furnace

Assessment of possible industrial synergies will be conducted by CRM to combine steelmaking slag with by-products from other sectors in order to recover separately metal and higher value mineral phases.

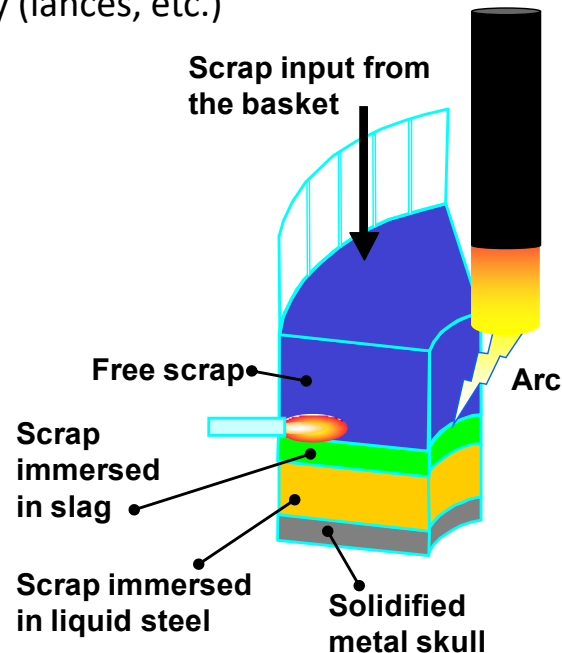
InSGeP project WP2– EAF model

DESCRIPTION

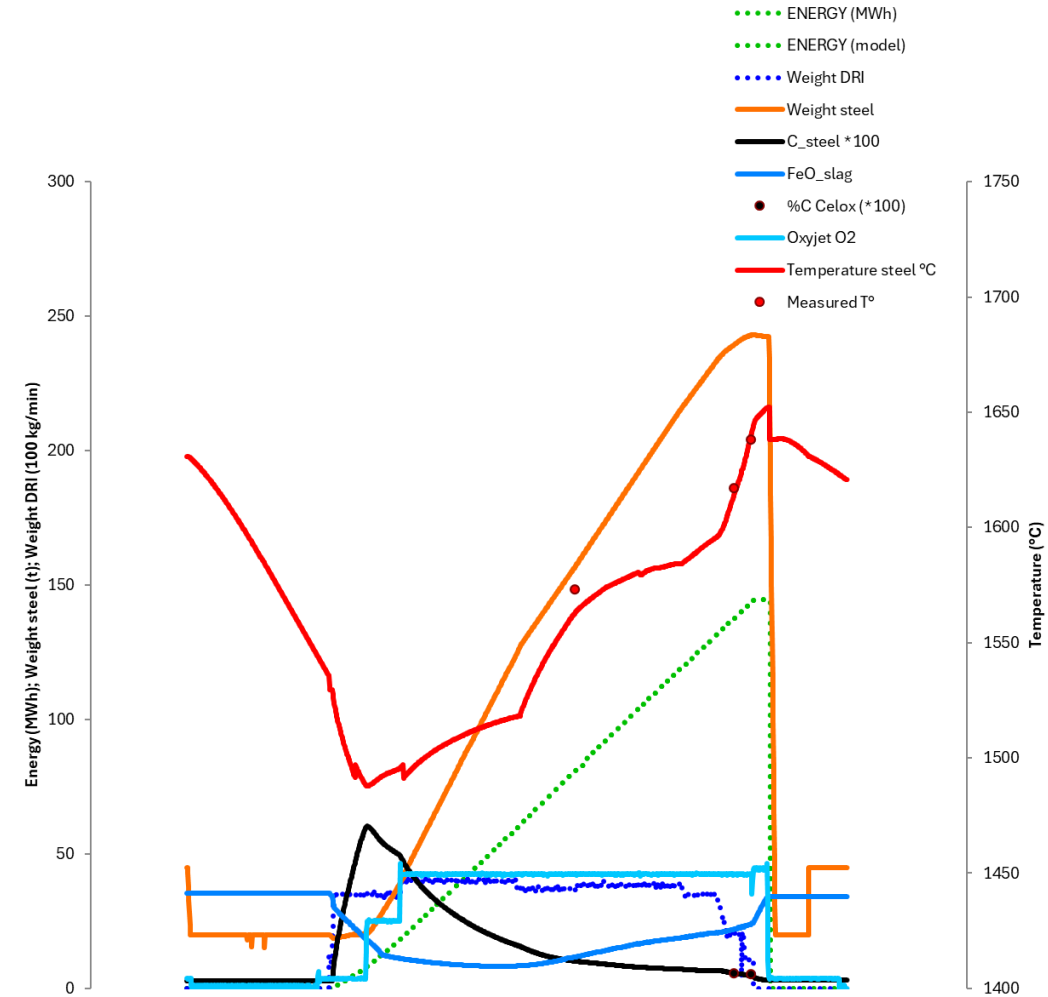
- Dynamic metallurgical model
- Continuously solves mass and thermal balances
- Calculates scrap and/or DRI melting evolution
- Based on dynamic process information

OBJECTIVES

- Assessment of the end of heating and refining point
- Scrap/DRI melting evolution
- Operating pattern optimisation
- liquid heel height control
- Furnace geometry (lances, etc.)



- 100% DRI fed EAF
- 200 tons steel
- 60 min tap to tap
- No burner
- 1 O₂ lance
- DRI:
 - 90% Fe
 - 94% metallization
 - ~2% C
- Slag compo:
 - 34% FeO
 - 15% SiO₂
 - 37% CaO
 - 10% MgO
 - 3.5% Al₂O₃
 - B2 : 2.5



InSGeP project WP3 and 4– Lab Facilities – Nabertherm Furnace

Nabertherm Furnace

- Heat up to 1800 °C
- ~2L capacity of sample
- Up to 3 crucibles per trial (3 compositions, crucible material or cooling possible)
- To be modified for gaz analyses and partially atmosphere controlled (reduced O₂ content)



Small scale water granulator

- Fast cooling in concentric water jet. : to mimic a wet granulation. PSD and cooling rate may vary.

Camsizer

- Determining particle size distribution of the granulated samples (small and pilot scale)



InSGeP project WP3 and 4 – Lab Facilities – Nabertherm Furnace

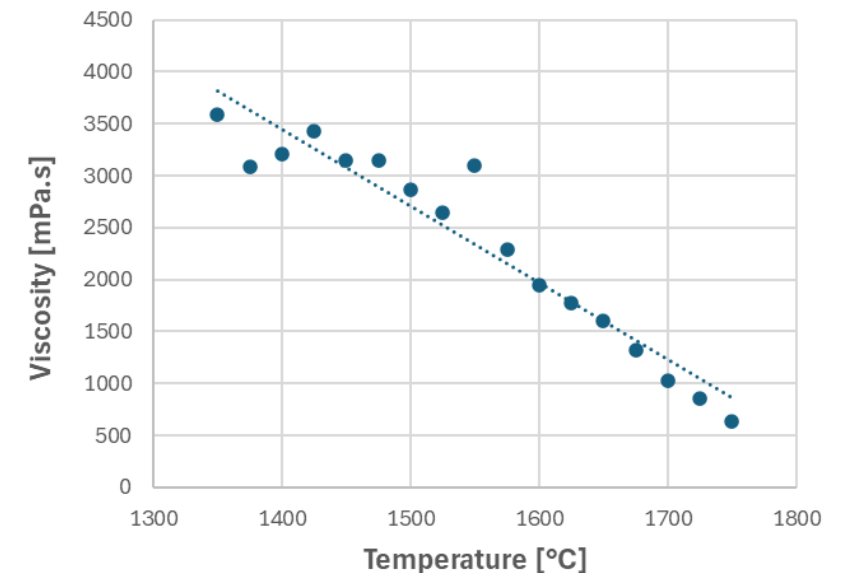
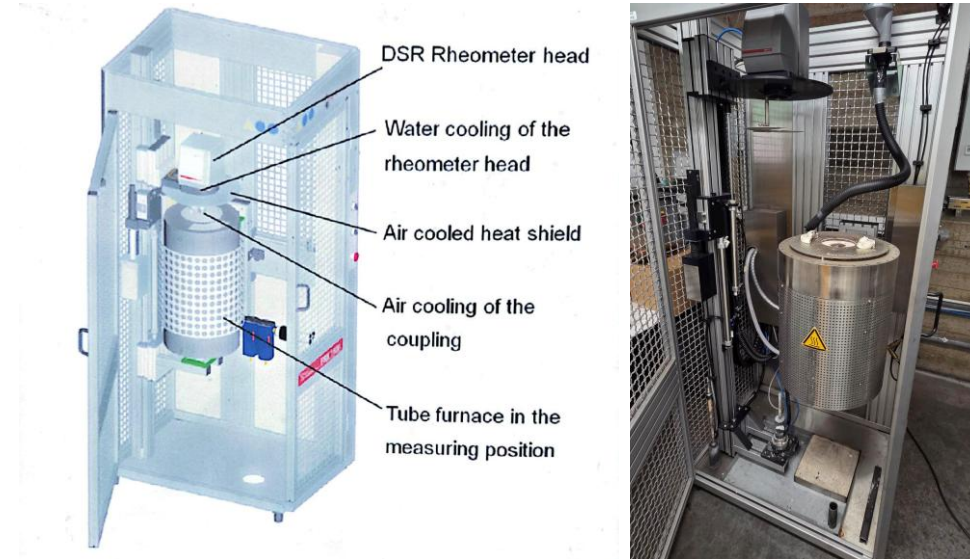
Rheometer

Main characteristics

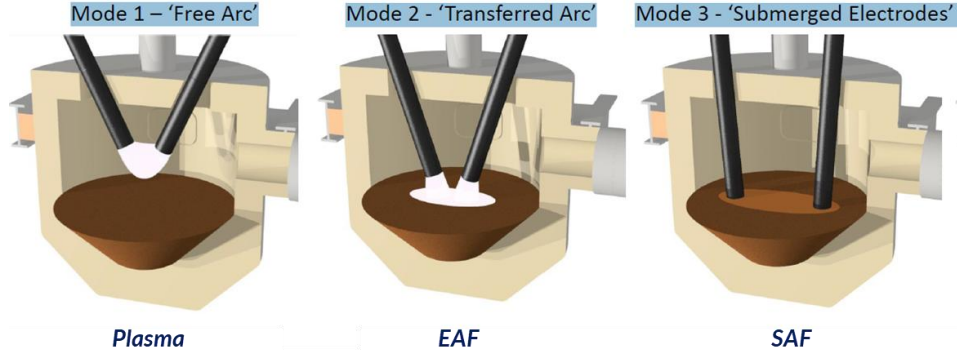
- Model: Anton Paar FRS 1800 Rheometer
- Integrated normal force sensor for measurements of density, surface tension, and melting point or softening point of materials
- Maximum sample temperature: 1650 °C
- Viscosity range: $5 \cdot 10^{-4}$ to 10^5 Pa·s
- Broad torque range (2 nNm to 200 mNm)
- different shear rates → to highlight any non-Newtonian behavior
- Oscillatory measurements → to determine visco-elastic properties of materials

Examples of intended applications

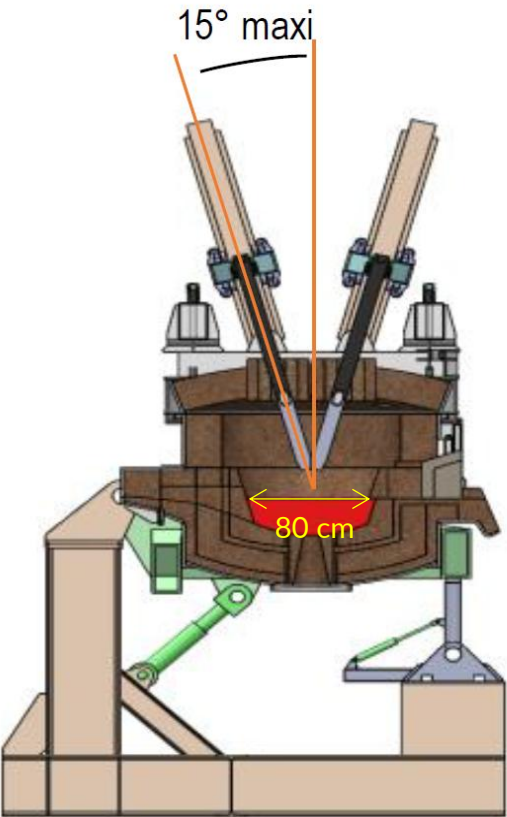
- Influence of steel slag composition on its viscosity
- Crystallization temperature of slags
- Viscosity measurements of steel (different grades, temperatures...)



InSGeP project WP3 and 4 – Pilot scale Facilities – Plasma Furnace



Max. temp.c	1800 °C
Capacity	125 L / 1 ton
Heating mode	Plasma / EAF / (SAF/ESR)
Max power	DC 700 kW
Atmosphere	Air, N ₂ , Ar
Loading	Automatic, batch
Fully integrated off-gas system (designed for material fuming) Thermal oxidizer, bag-house & absolute filters, sorbent dosing system, sampling system	

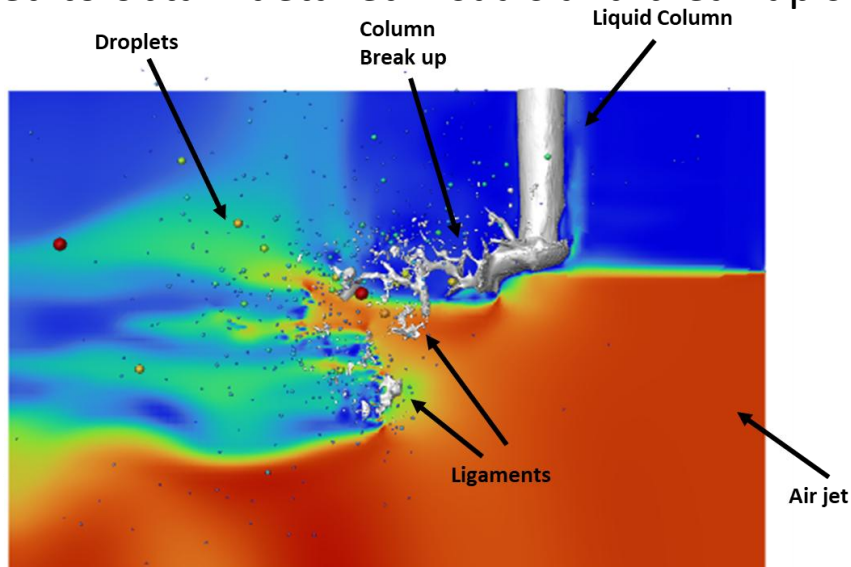


InSGeP project WP3 and 4 – Pilot scale Facilities – Dry slag granulator

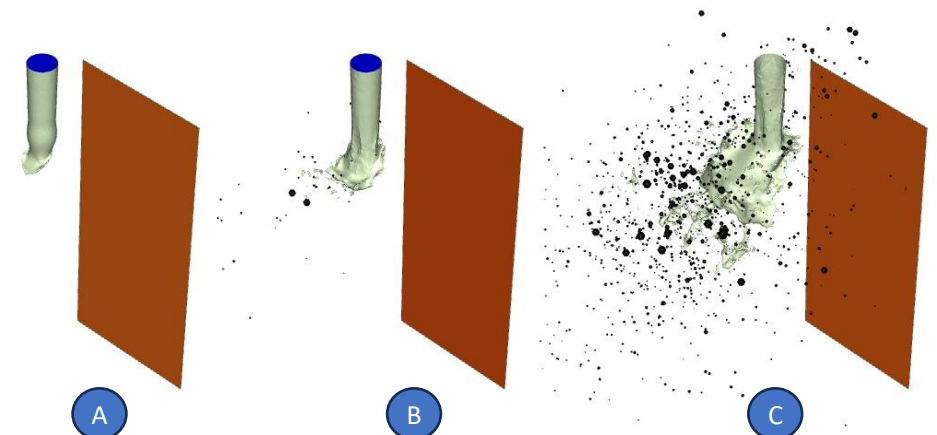
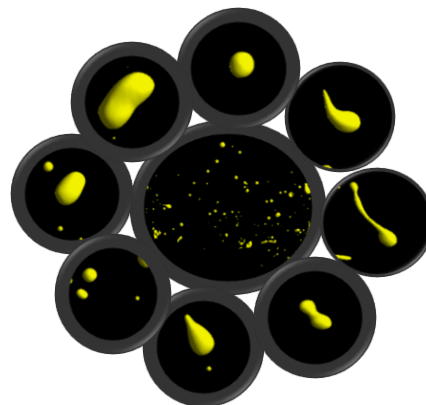
Promote valorisation of slags thanks to dry granulation & increased amorphous grade



The design of the CRM granulator was developed based on Computational Fluid Dynamics (CFD). This has been used to obtain detailed visuals and break up sequences with high accuracy.

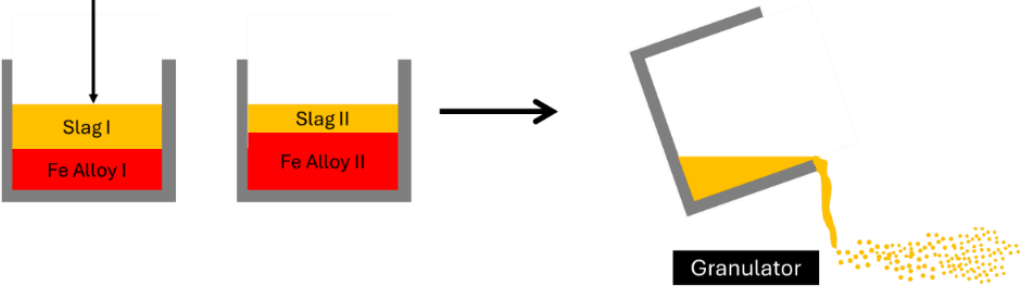


Predicted granulated shapes



InSGeP project WP3 and 4 – FactSage calculations

- Reductant
- Flux



6 g Carbon
10 g SiO₂

Slag	
Temperature [°C]	1600
Amount [g]	100
Composition	wt.%
CaO	38.9
FeO	32.2
CaO	29.9
SiO ₂	18.4
MgO	9.8
Al ₂ O ₃	5.4
MnO	1.7
TiO ₂	1.80
Cr ₂ O ₃	0.57
P ₂ O ₅	0.20
V ₂ O ₅	0.04163

Gas	
T [°C]	1600
Amount [NL]	10.8
Composition	Vol%
CO	99.8%
CO ₂	0.13%

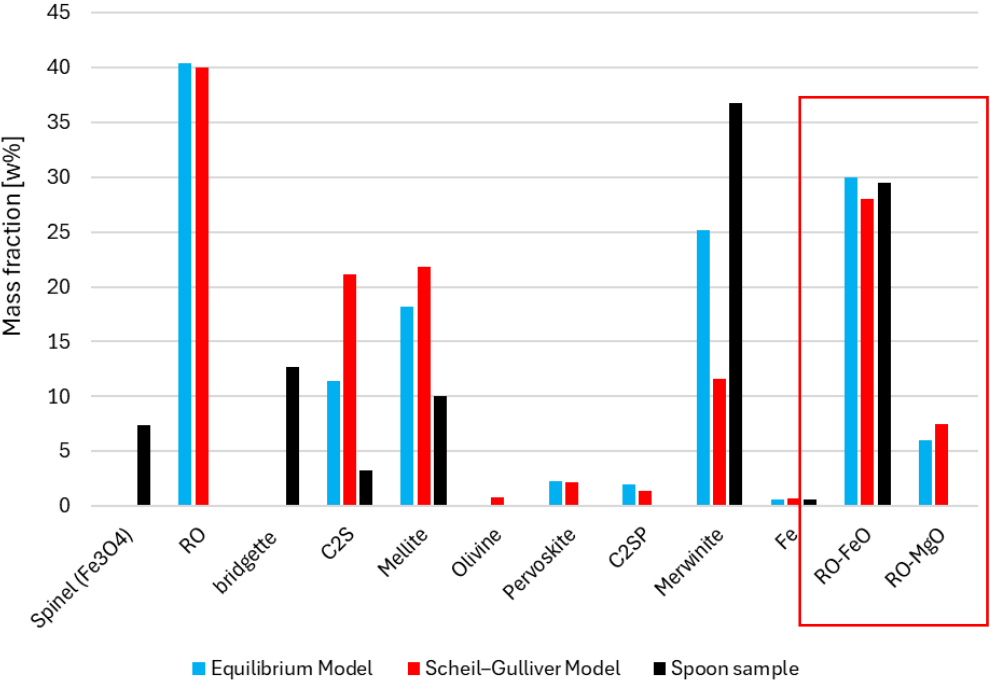
Slag	
Temperature [°C]	1600
Amount [g]	76.43
Composition	wt.%
CaO	38.9
SiO ₂	36.9
MgO	12.7
Al ₂ O ₃	7.1
MnO	1.9
TiO ₂	1.4
Ti ₂ O ₃	0.8
FeO	0.2
CrO	0.12
VO	0.05
V ₂ O ₃	0.02
Cr ₂ O ₃	0.01
Fe ₂ O ₃	0.001

Fe Alloy	
Temperature [°C]	1600
Amount [g]	26.1
Composition	w%
Fe	96.6
Cr	1.3
C	0.9
Mn	0.7
P	0.3
Si	0.13
V	0.06

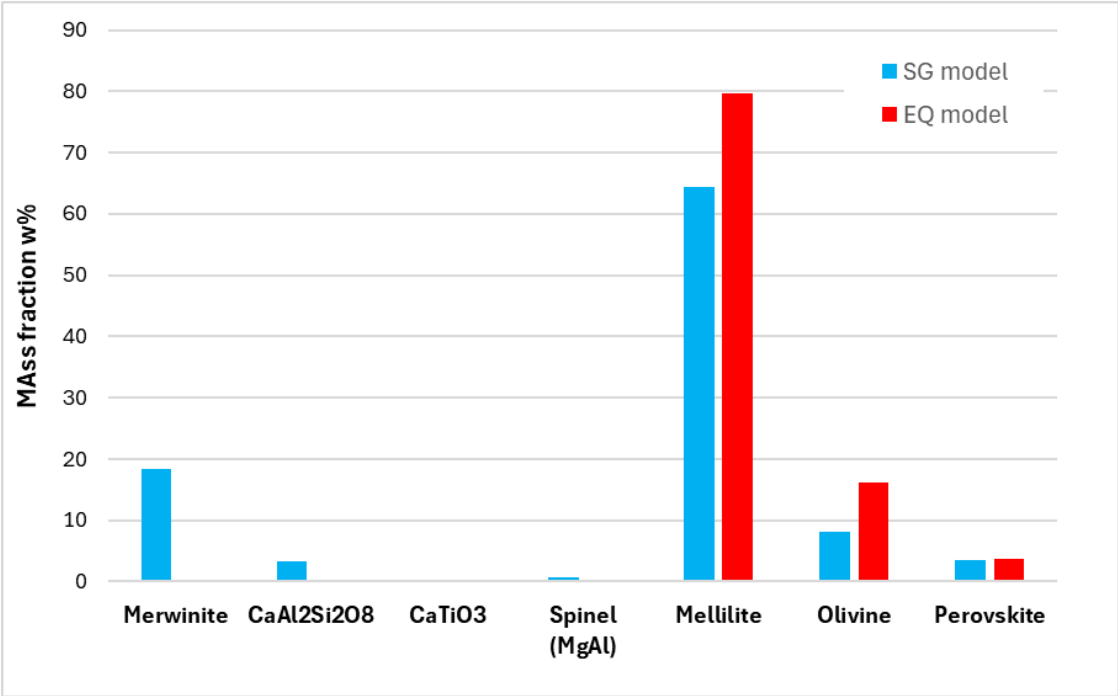
InSGeP project WP3 and 4 – FactSage calculations

Original Slag

Excluding Bridgite phase



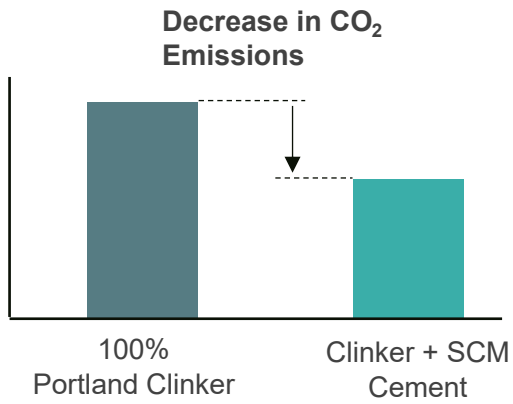
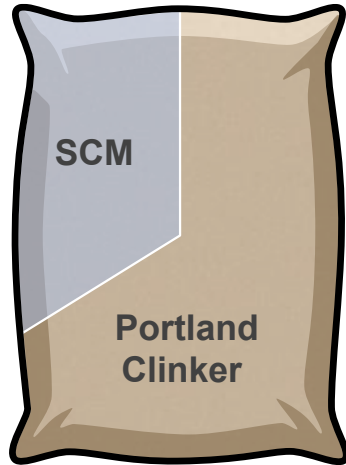
Modified Slag



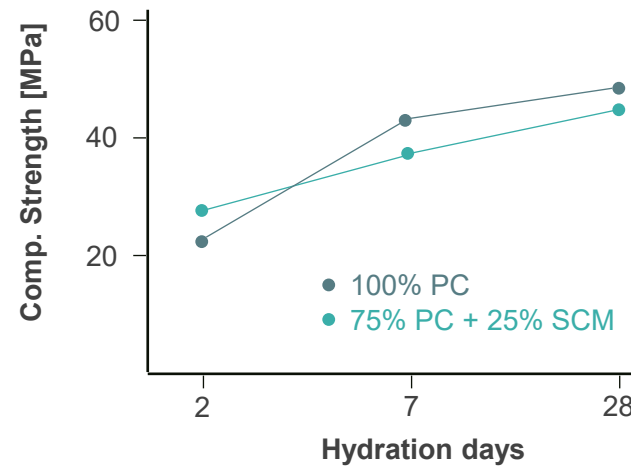
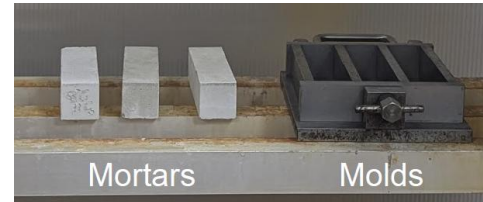
Spinel and RO phase is difficult to quench and make it amorphous
 C reduction reduces Fe content of the slag make it easier for amorphous phase formation

What is an SCM (Supplementary Cementitious Material)

- SCMs substitute part of Portland clinker in the cement mix

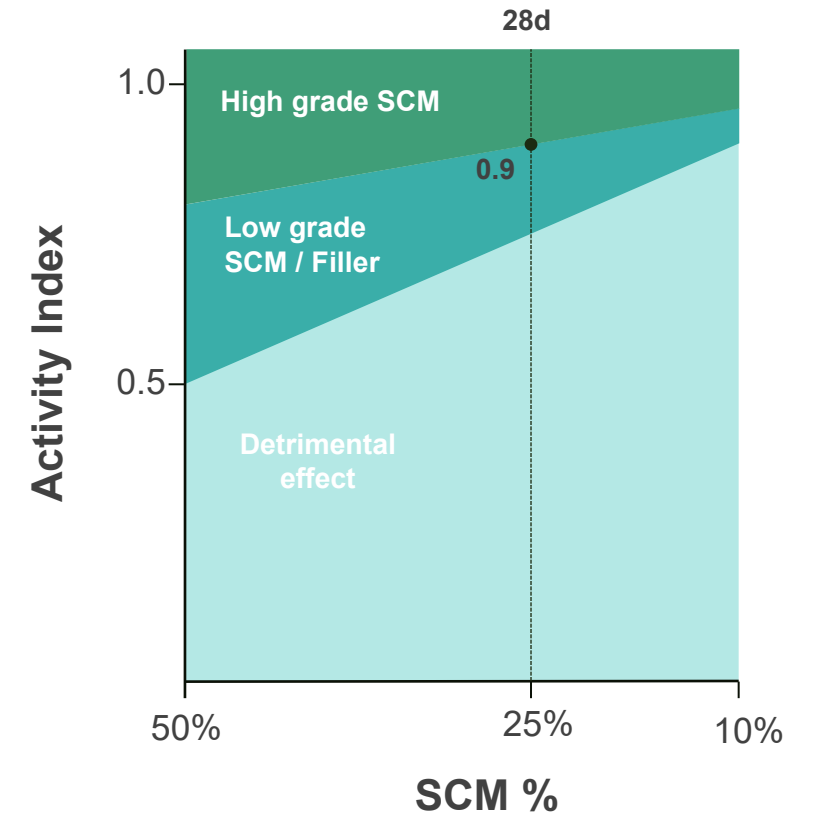


- The cement strength is measured as a function of his hydration time
- The compressive strength of standard mortars (16*4*4 cm) is measured at 2, 7, 28 days



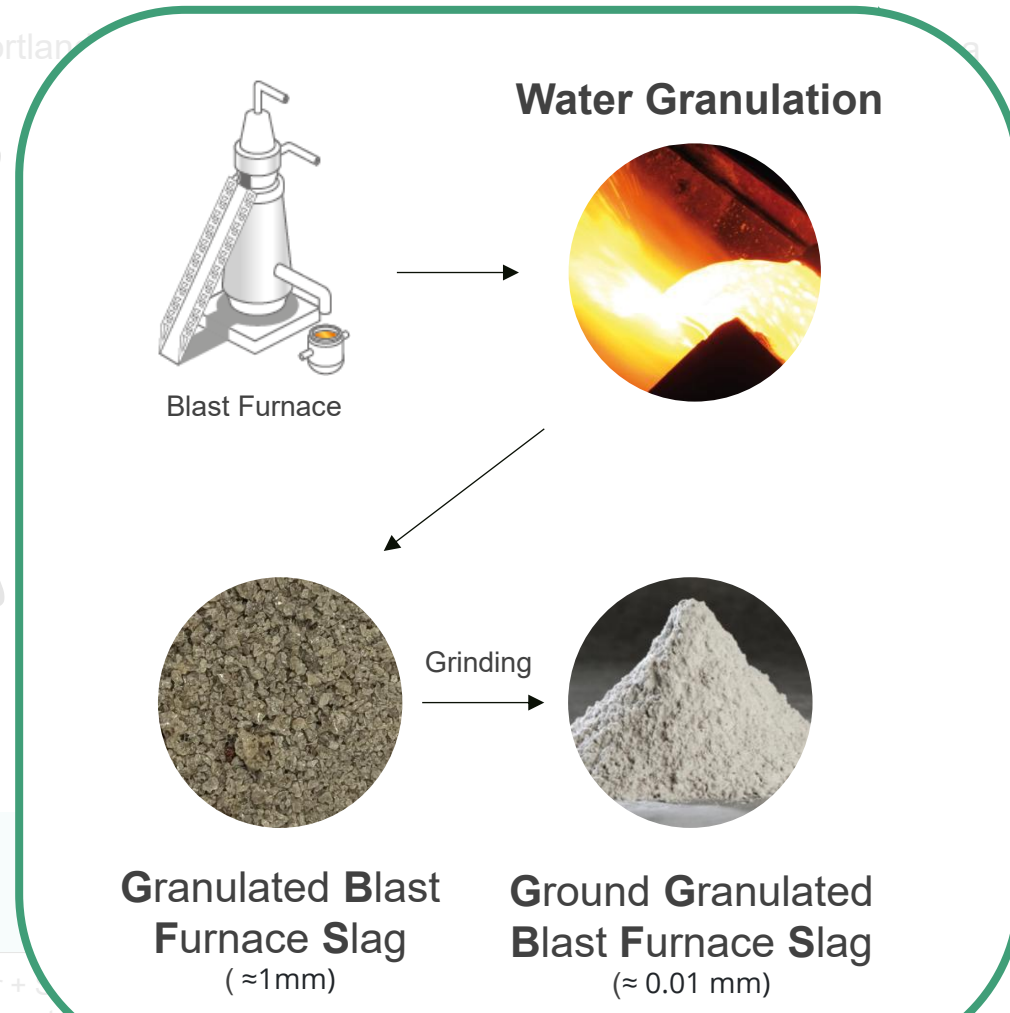
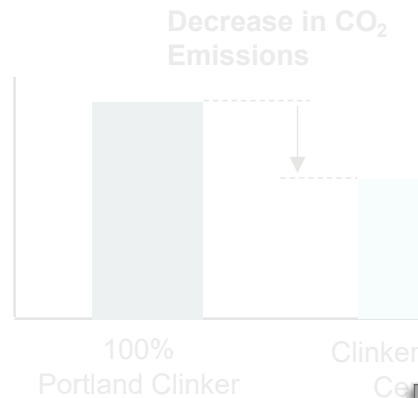
- To compare performances, we use the Activity Index (AI) measured as:

$$A.I. = \frac{Comp. Strength_{PC+SCM}}{Comp. Strength_{PC}}$$



What is an SCM (Supplementary Cementitious Material)

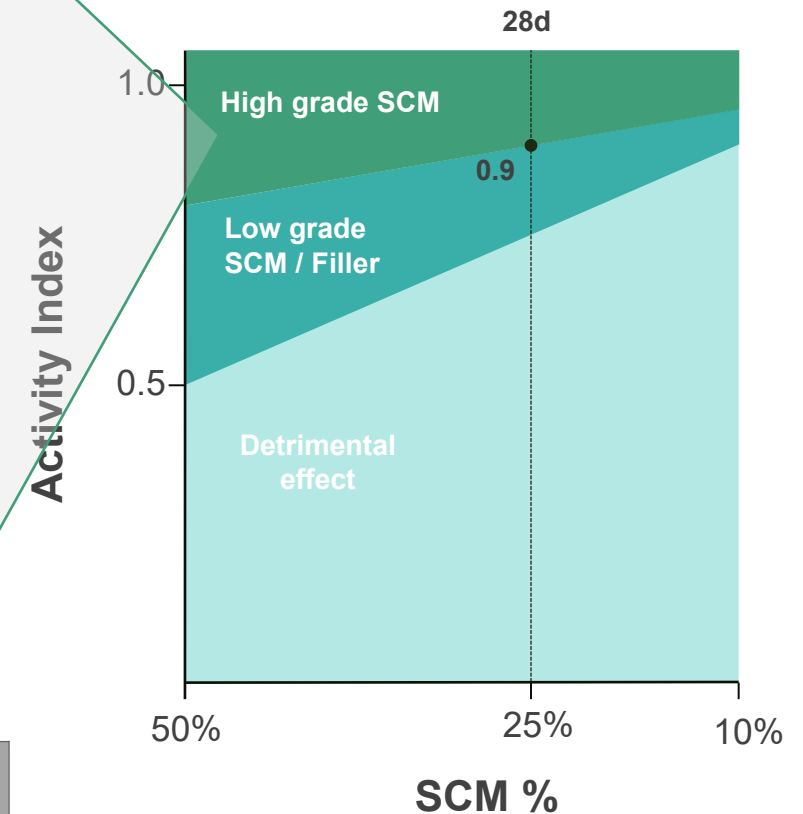
- SCMs substitute part of Portland clinker in the cement mix



CaO	SiO ₂	Al ₂ O ₃	MgO	FeO
35-45%	30-35%	10-15%	5-10%	<1%

- To compare performances, we use the Activity Index (AI) measured as:

$$A.I. = \frac{Comp. Strength_{PC+SCM}}{Comp. Strength_{PC}}$$



EAF Granulation



- Trying to replicate GGBFS technology to EAF slag
- Can be coupled with chemical adjustments to improve performances and to recover Fe and other metals → Maximize resource utilization

CaO	SiO ₂	Al ₂ O ₃	MgO	FeO
20-35%	10-20% ↓	5-10%	10-15%	20-35% ↑

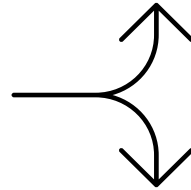
EAF Granulation – 6Ton Pilot Trials



Slag is generated in our 6-ton pilot
(≈300/400 kg of slag)

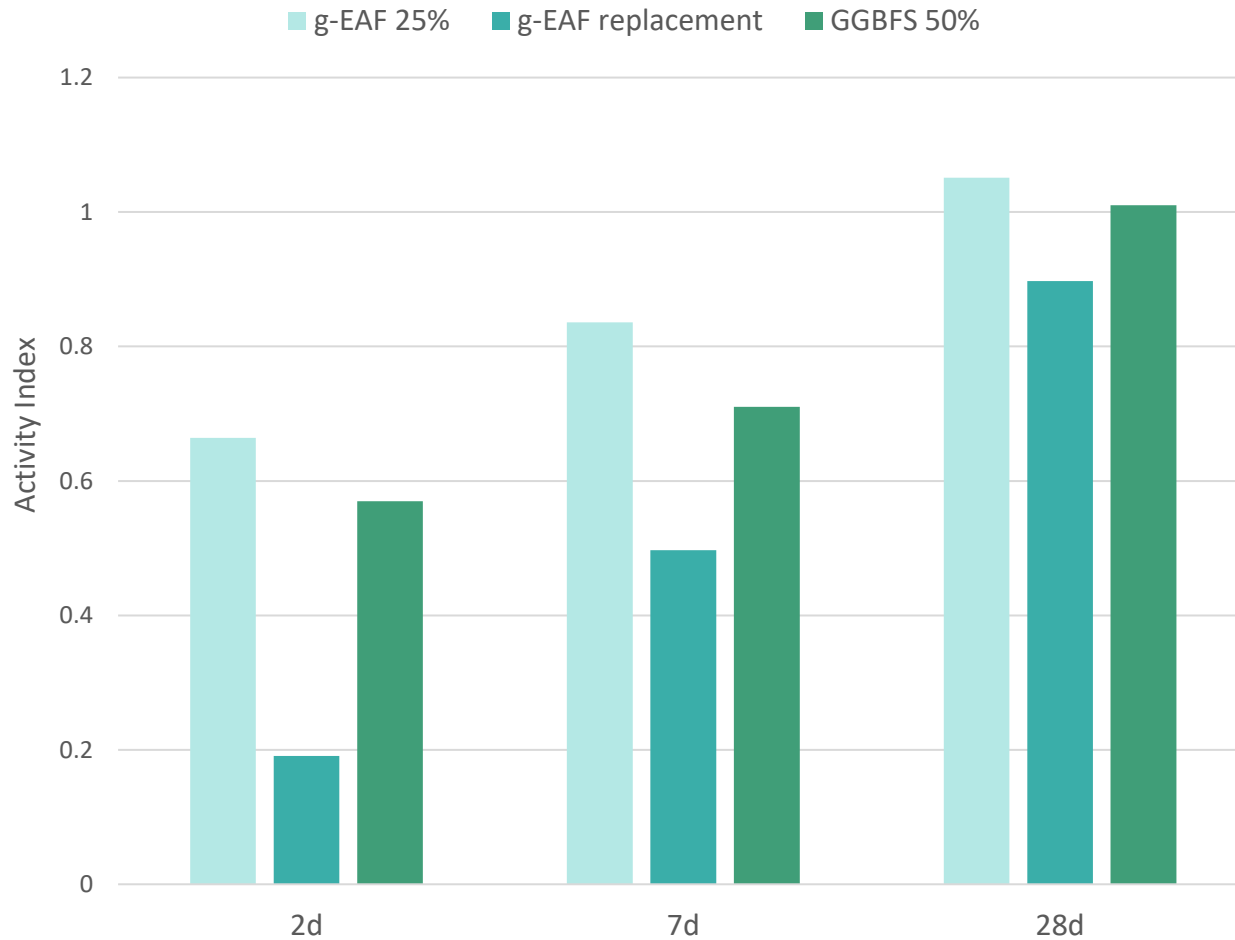


Slag is water granulated during the trial
(≈50 kg of slag)



Remaining slag is poured into a ladle,
let solidify and sent to CRM for Air
Granulation
(≈200 kg of slag)

EAF Granulation – 6Ton Pilot Trials



Chemical composition 1st trial

CaO	SiO ₂	Al ₂ O ₃	MgO	FeO
29%	19%	5%	10%	25%

- 2 Trials have been conducted (Nov '25, Apr '26)
- 200-300 kg per trial
- Custom slag composition to fit cementitious needs
- Also conducting lab trials to acquire fundamental knowledge on slag properties (ongoing)

InSGeP

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