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RECLAiming valuable METals from process residues through HIsarna ironmaking (RECLAMET) - focus on pre-processing

EIT Raw Materials Upscaling project

Consortium : Tata Steel (coord.), CRM Group*, TU Delft, Nyrstar

*speaker :

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CRM Group - Belgium

Member of METNET

CRM Group in a nutshell

- 265+ researchers in Liège + Gent (B)
- 45+ industrial members covering whole value chain of steel industry and other metals + associated materials
- Pilot facilities to develop, test and scale up technologies : pre-conditioning (a.o. agglomeration) of primary/secondary raw materials, pyro-metallurgy (a.o. smelting), thermo-mechanical treatments, various coating processes, advanced manufacturing







More info : http://www.crmgroup.be

CRM agglomeration tools

Pelletising

30, 40, 100, 140 cm discs with angle adjustment

Mixing / granulation

5, 40, 400 litre Eirich intensive mixers

used in Reclamet project

200 litre horizontal ploughshare mixer

Mechanical tests

Crushing test

I-drum drop tests stickiness test

Compaction

Briquetting Press
30-40 kN/cm
50 - 450 kg/h

Lab press

used in Reclamet project

Compaction presses
(for sludges and turnings/swarfs),
with recovery of oil/water fraction

3 t/h continuous compactor for light fraction of ASR, plastic wastes, fluff

coming soon : de-airing extruder (100 l/h)

CRM (s)melting tools

Resistive furnaces	Induction furnaces	Gas-fired rotating furnace
Bottom Loading Furnace (adapted for toxic materials) 	35 and 350 kg (steel) capacity   ➔ used in Reclamet project	100 kg/h tilting furnace . 50 kW natural gas burner . under salt (e.g. for Al waste) 
Weighing furnace Max temperature 1500° C Sample weight ~250 g Weighing precision 1 g 	+ 1t steel furnace (dedicated to Continuous Casting pilot) + 2 **vacuum** induction furnaces: . 100 kg Fe . 3x30 kg Fe (incremental castings)	+ coming soon : plasma furnace 125L

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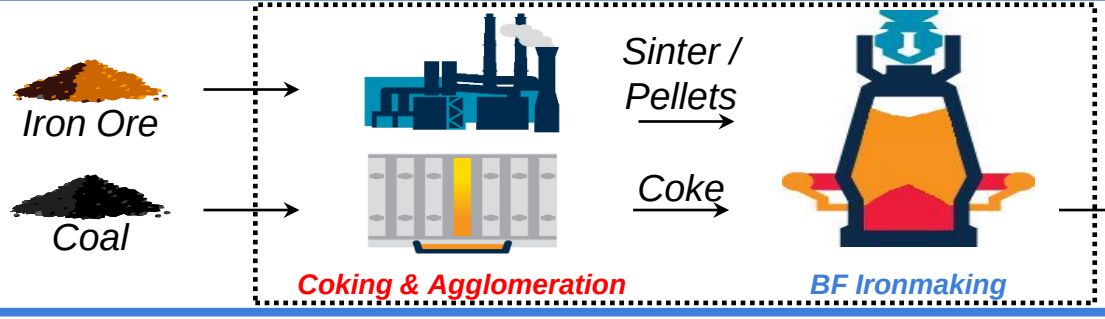
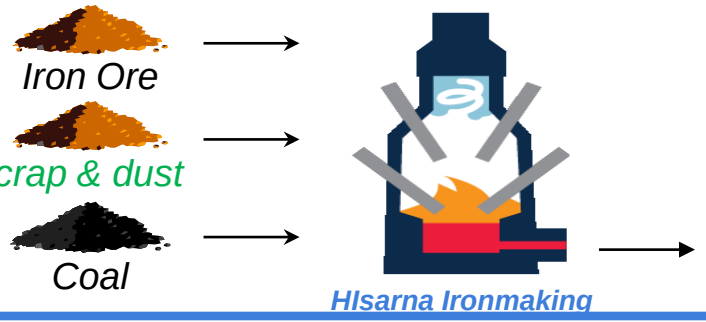
From conventional ironmaking in Blast Furnaces (BF) …



Conventional Blast Furnace (BF) Process

☹ Zinc recycling in BF is NOK !

… to low CO_2 and more circular ironmaking through HIsarna



- 20% CO_2 reduction (without CCS)
- 80% CO_2 reduction with CCS!
- Low cost raw materials
- Recycling Zn-bearing dusts and (galva) scrap

HIsarna Smelting Reduction Process

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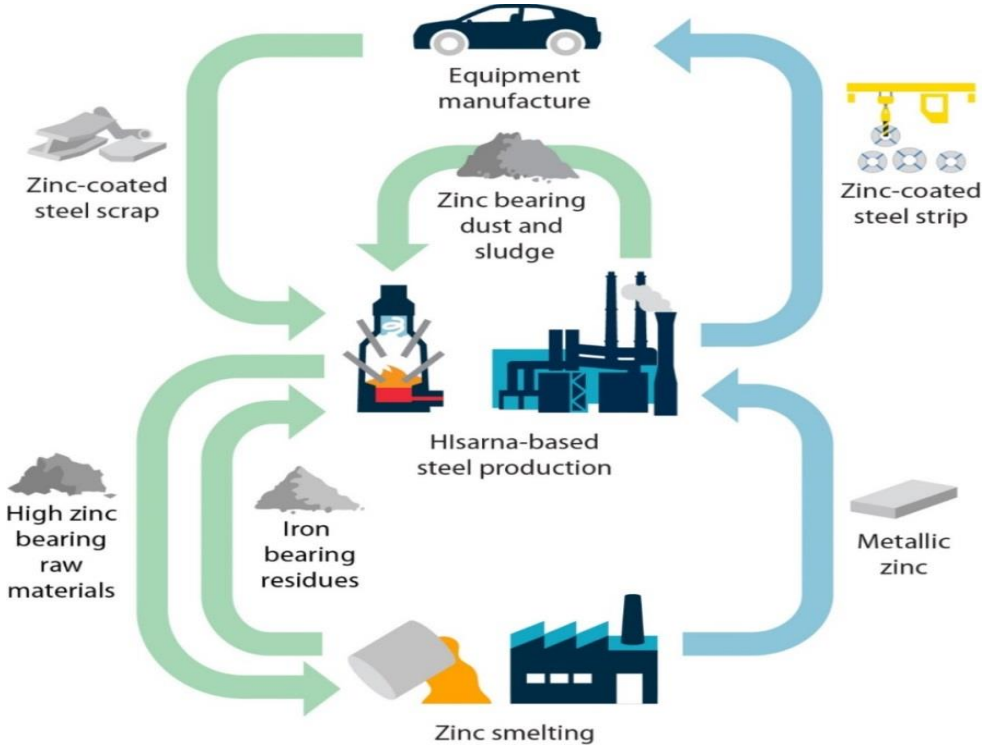
RECLAMET objective = injection of galva scrap and Zn-bearing dusts into Hisarna process, aiming at :

- Zn-coated steel recycling without downgrading
- ZERO landfilling of Zn-bearing dusts
- concentration of Zn in HIsarna offgas dust (> 50%) ➔ valuable secondary raw material for Zn producer



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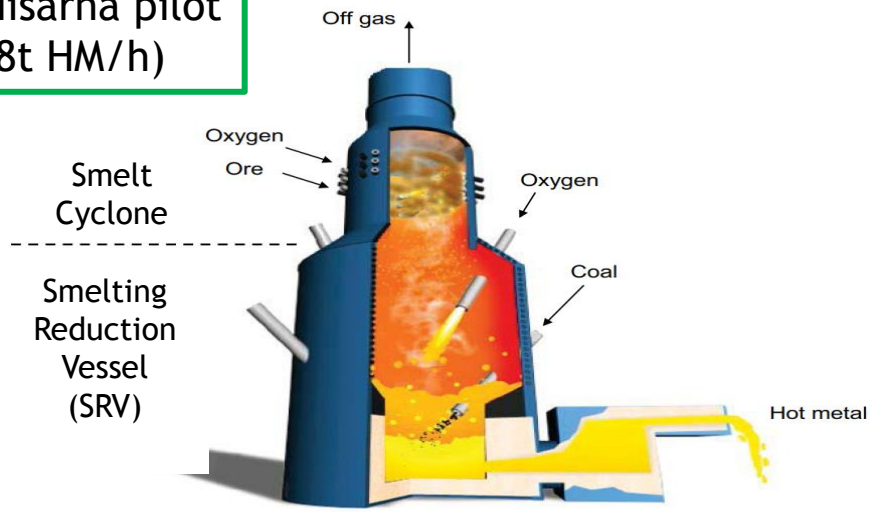
Where to inject scrap or dust ?

Hisarna pilot (8t HM/h)



Different options :

- Pneumatic injection of dust with ore in smelt cyclone
- chute into the SRV (scrap or briquetted dust)
- …

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Pre-processing before injection of sludge/dust

- Appropriate pre-processing (drying, agglomeration) is key for:
  - Smooth and reliable material injection (no plugging)
  - Stable HIsarna performances (heat transfer, slag foaming…) despite variable input materials
  - Maximal recovery yields (Zn evaporation and Fe reduction)
  - Limited dust carry over ➔ impact on product value (sufficient Zn enrichment of HIsarna offgas dust)
- Importance of intermediate scale experiments with representative samples and representative pre-processing facilities and operational conditions, in order (a.o.) to answer following questions :
  - most suitable pre-processing technique(s) vs type of material(s) ?
  - sensitivity of agglomerates (size, resistance) to most relevant input parameters (like moisture, size distribution, additions…) ?
    - optimal recipes and operational conditions ?
    - indications on how to react in case of variation of recycled material properties?
  - …

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Selection of agglomeration techniques

Techniques :

Micro-granulation

- ✓ Integrated mixing-granulation
- ✓ High tolerance to wet materials
- ✓ Relatively low cost
- x Low tolerance to large particles

Briquetting

- ✓ High tolerance to large particles
- x Relatively high cost
- x Lower tolerance to wet materials

Materials:

BOF sludge (wet)

+

Pelletfeed (dry)

+ Peridur®

Historical BOF dust (moist)

+

Coal (dry)

+ Molasses

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Micro-granulation study

Parameters:

- Rotation speed / time
- Sludge moisture
- Binder addition
- Pellet feed addition (for moisture control)

Specifications for micro-granules:

- ✓ Small enough for smooth injection (D90 < 3 mm)
- ✓ Large enough for limited carry over (D10 > 0.5 mm)
- ✓ Strong enough for storage, flame drying and injection (based on dedicated characterisation tests)

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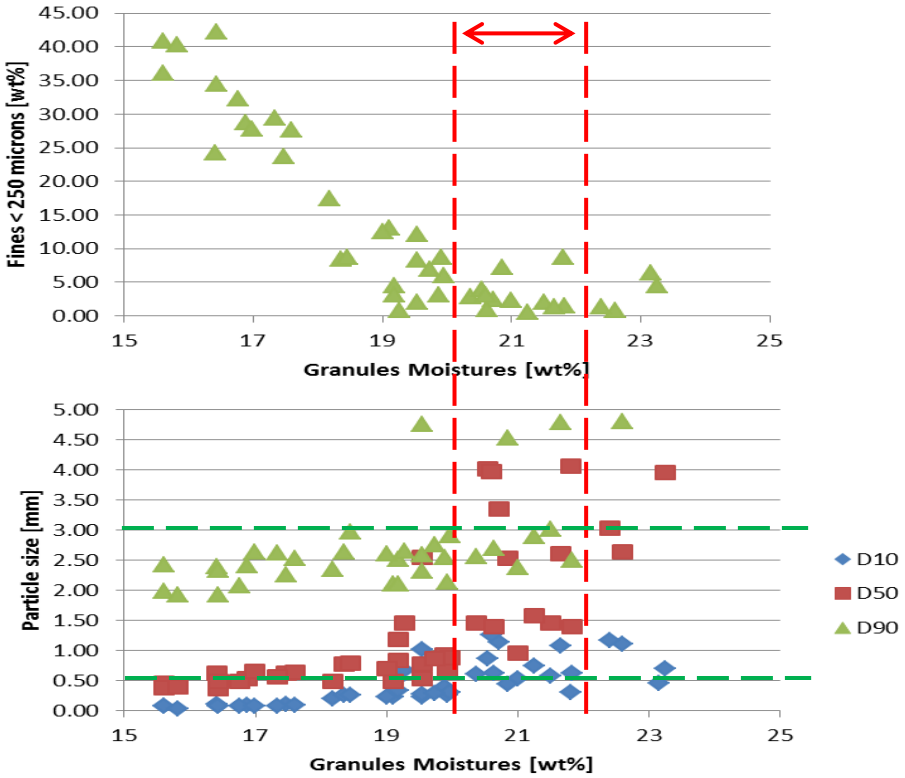
Micro-granulation study – moisture



➔ Moisture has a significant impact on micro-granulation

➔ Optimal moisture of the final recipe : 20 - 22 wt%

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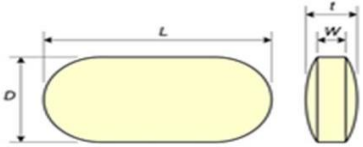
Briquetting study

- Recipe screening through pastilles
- Parameters :
  - Moisture (by addition of dried HOKS, SA dust, coal)
  - Binder % and type : molasses, hydrated lime, starch, Peridur,…
- Briquettes production with most promising recipes ➔ drop tests,…

Pastilles

Briquettes



L = 30 mm
D = 20 mm
t = 10 mm
W = 1 mm

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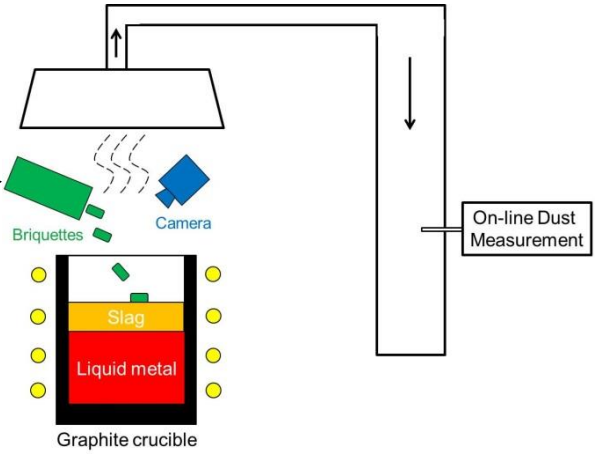
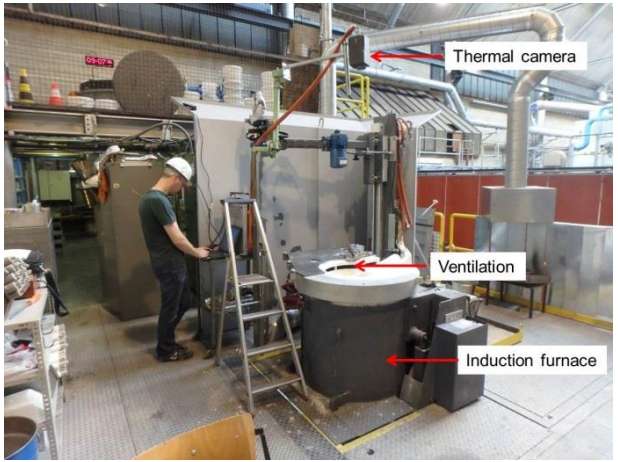
Melting tests on briquettes

- Objectives : assess briquettes dissolution and Zn fuming kinetics
- Experimental set up :
  - 350 kg induction furnace
  - Hot heel : remelting of 160 kg HIsarna iron and 5 kg HIsarna slag
  - Monitoring by thermal camera and optical PM counter-sizer ➔ most (fine) PM emissions assumed to originate from Zn fuming
  - 200, 500 & 1000g batches





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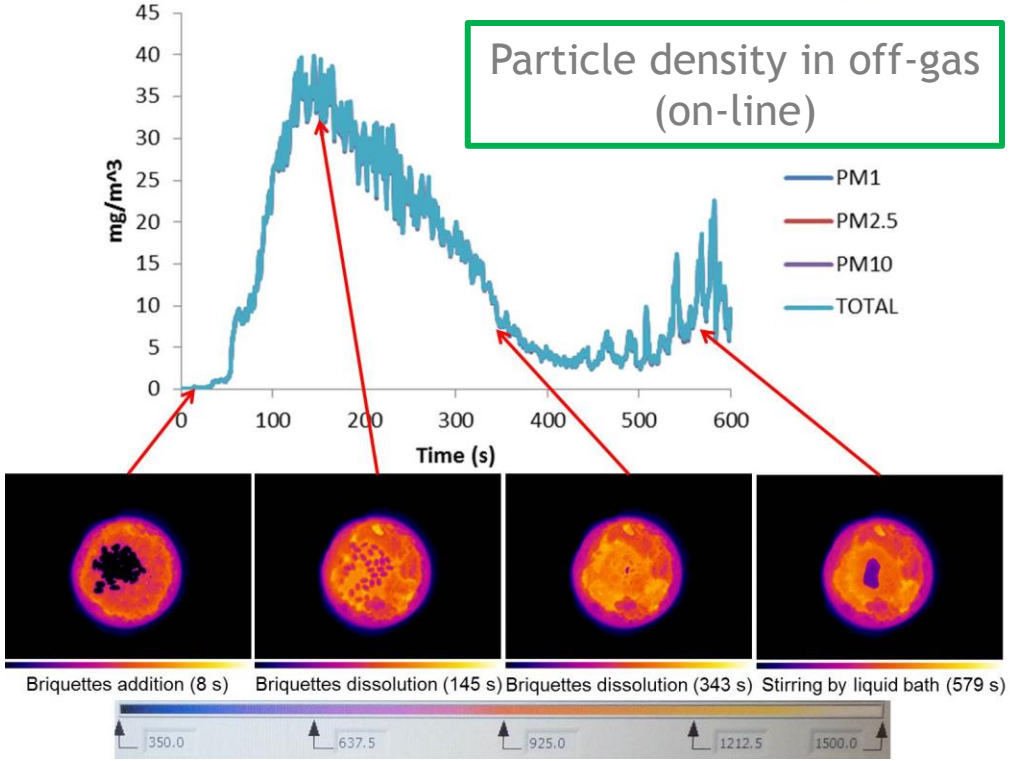
Example of briquettes melting results



Briquettes addition (500 g):

- Dissolution and reduction occurred at the same time (gradual particle release over 10 min)
- The reduction was controlled by carbon transfer in later stage (sharp peaks after boiling of metal)
- No detectable increase of %Zn in hot metal

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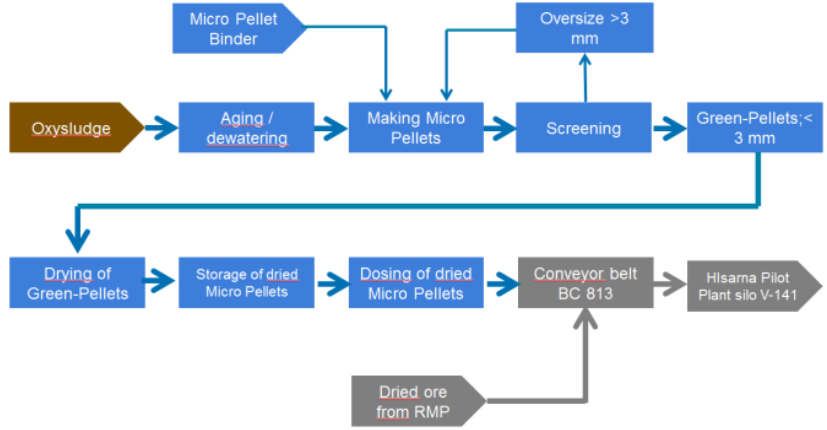
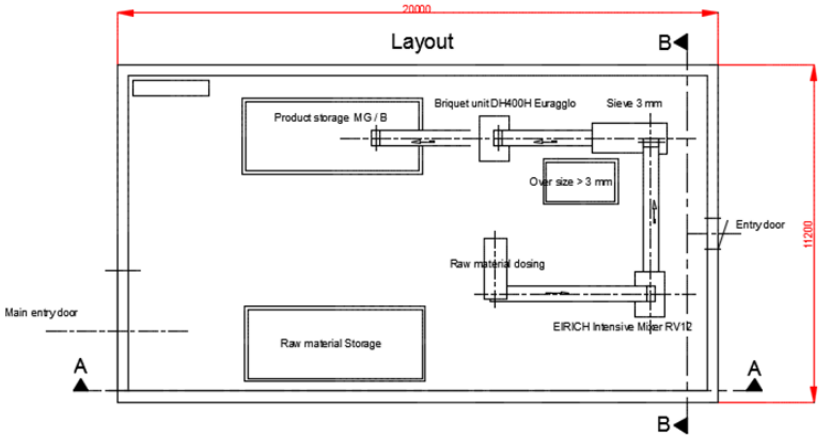
Conclusions and outlook

- Agglomeration and melting tests at CRM have been useful to orient and de-risk the Upscaling towards industrial trials with dust and scrap injection into the Hisarna pilot plant. In particular :
  - Suitable agglomeration techniques and recipes have been defined for different types of 'secondary raw materials'.
  - The optical counter-sizer has proved to give relevant information about the Zn fuming process ➔ a more robust prototype to be used at Blast Furnaces and at the HIsarna plant is under construction in the frame of another European project funded by RFCS (Research Fund for Coal and Steel).
- Tata Steel has meanwhile defined the full RECLAMET pre-processing block diagram and selected the equipment for on site trials (planned in 2020).





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