ArcelorMittal

ArcelorMittal by-products management

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Geopolymer Camp 2011

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The world’s number one steel company

- ArcelorMittal is the world's number one steel company, with over 262,000 employees in more than 60 countries. ArcelorMittal is the leader in all major global steel markets, including automotive, construction, household appliances and packaging, with leading R&D and technology, as well as sizeable captive supplies of raw materials and outstanding distribution networks.

- An industrial presence in 20 countries exposes the company to all the key steel markets, from emerging to mature, positions it will be looking to develop in the high-growth Chinese and Indian markets.

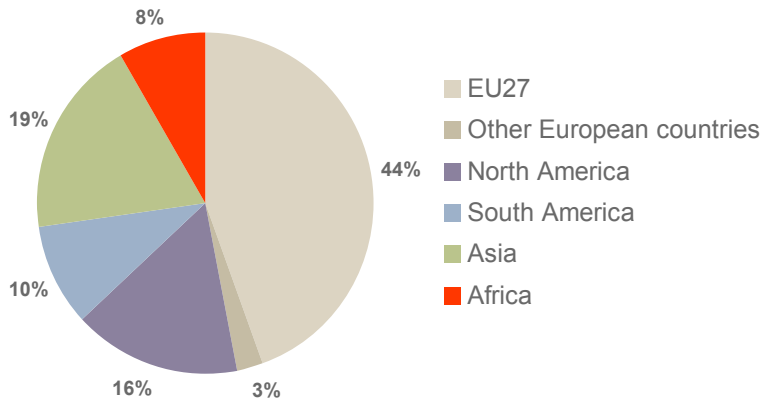
- ArcelorMittal values scale, vertical integration and product diversity. Approximately 35% of our steel is produced in the Americas, 47% in Europe and 18% in other countries such as Kazakhstan, South Africa and Ukraine.

Underpinning all our operations is a philosophy to produce Safe Sustainable Steel

ArcelorMittal 2010 key figures

	2009	2010*
Sales (US$ billion)	61.0	**78.0**
EBITDA (US$ billion)	5.6	**8.5**
Operating income/ /(loss) (US$ billion)	(1.5)	**3.6**
Net income/ (US$ billion)	0.2	**2.9**
Shipments (million tonnes)	69.6	**85.0**
Steel production (million tonnes)	71.6	**90.6**

Geographical allocation of employees in 2010



262,000 employees in more than 60 countries

An integrated leader of the metals and mining sector

*Successful spin–off of stainless steel business (Aperam) following shareholders approval on January 25, 2011. Accordingly stainless steel results have been shown as discontinued operations and all periods reported (results and operational KPI's) have been recast

By-products Sales, Marketing and Excellence : a worldwide team

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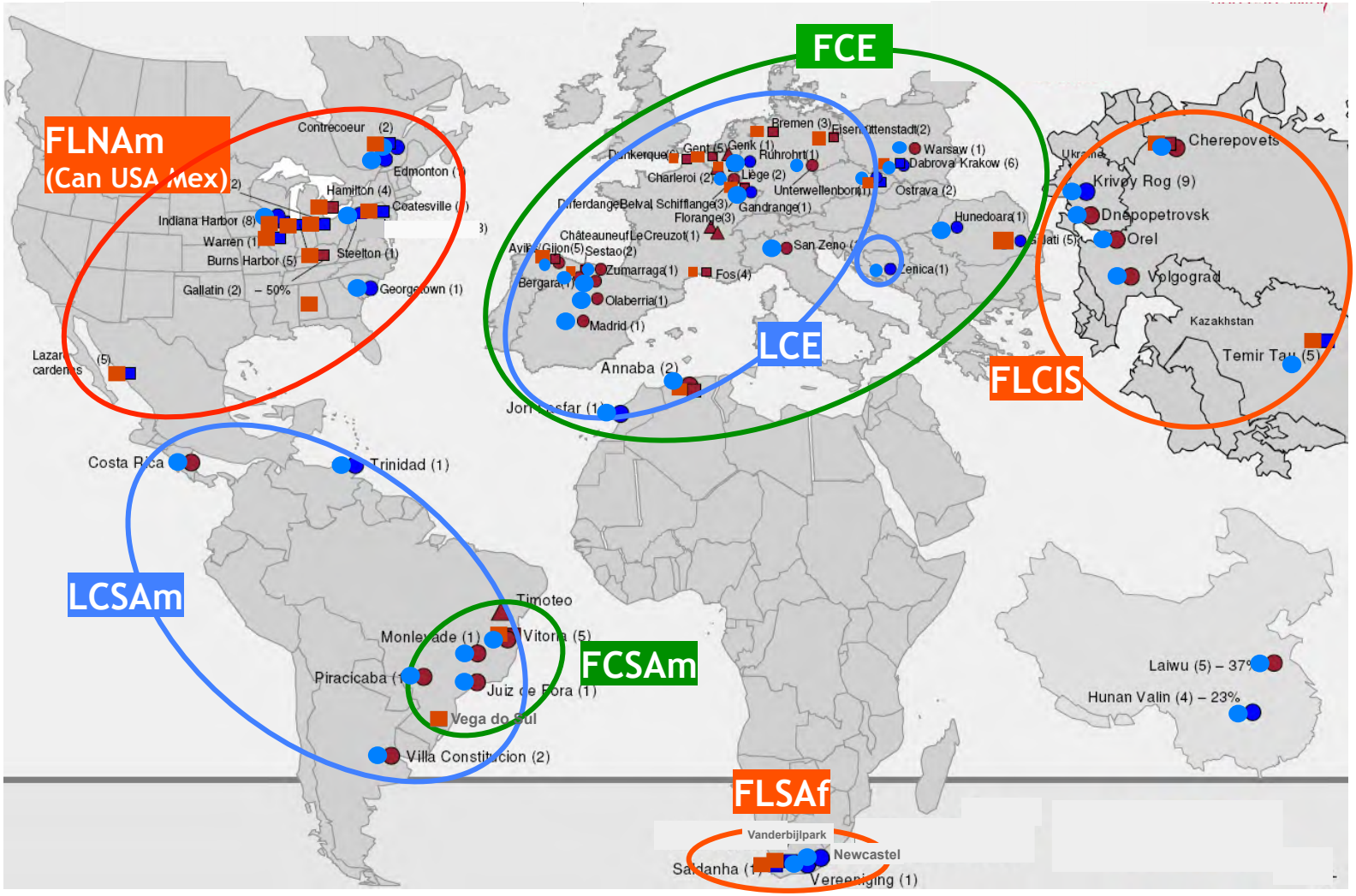
- **Objectives :**
  - Maximize the value of by-products with established market/ application
  - Develop recycling routes for by-products not yet having established market/application , external or internal

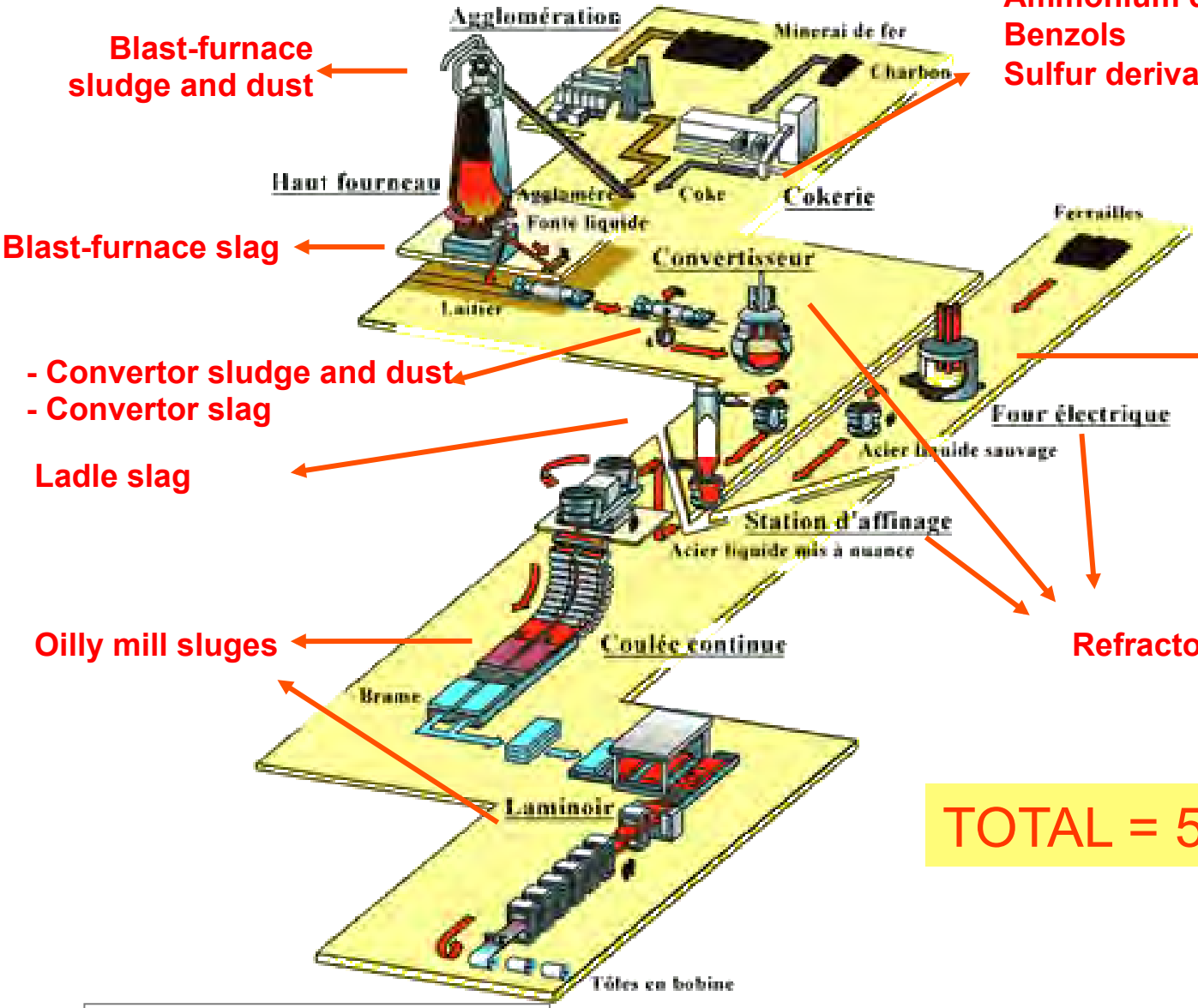
- **Missions :**
  - Define and coordinate the strategy for each segment of by-products/residues
  - Build of a multi-year plan (actions, investiments, commercial and technical)
  - Market studies and market watch
  - Technology watch
  - Coordinate Sales (one voice to the customer)
  - Steer the global R&D program
  - Organize and stimulate the exchange and diffusion of good practices
  - Report/control
  - Develop and deploy Quality management

BSME - Regions

The organisation is based on regions, with a global co-ordination.



Steelmaking by-products :



Tar
Ammonium derivatives
Benzols
Sulfur derivatives

Blast-furnace sludge and dust

Blast-furnace slag

- Convertor sludge and dust
- Convertor slag

Ladle slag

- Electric arc furnace dust
- Electric arc furnace slag

Refractories

Oilly mill sluges

TOTAL = 560 kg/t steel

Cold rolling mills

Waste pickling liquors, iron oxides, Zn,Sn rich sludges

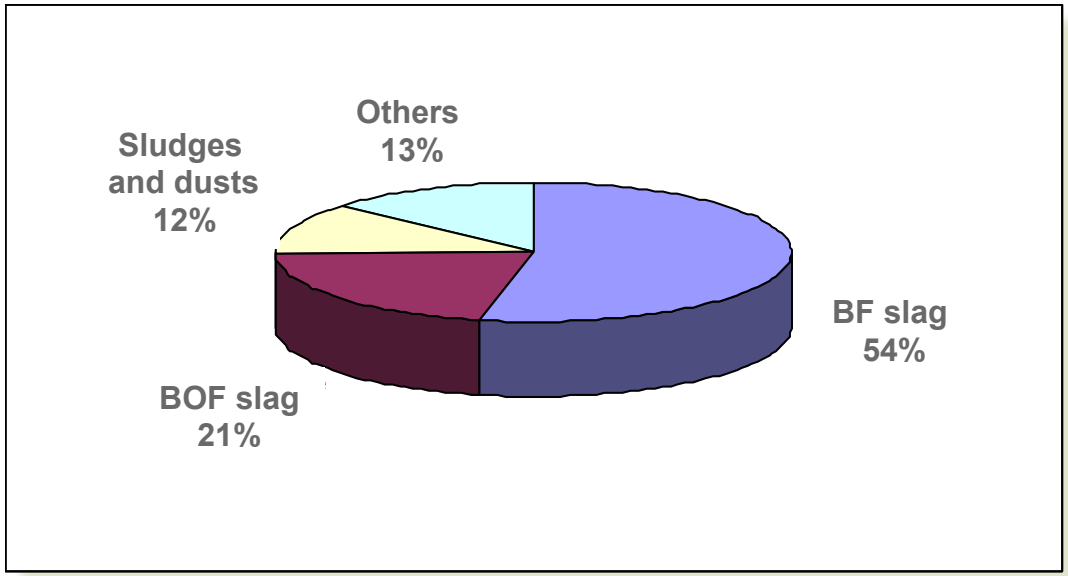
Key figures for 1 ton of steel (integrated plant)

300 kg BF slag

100 kg BOF slag

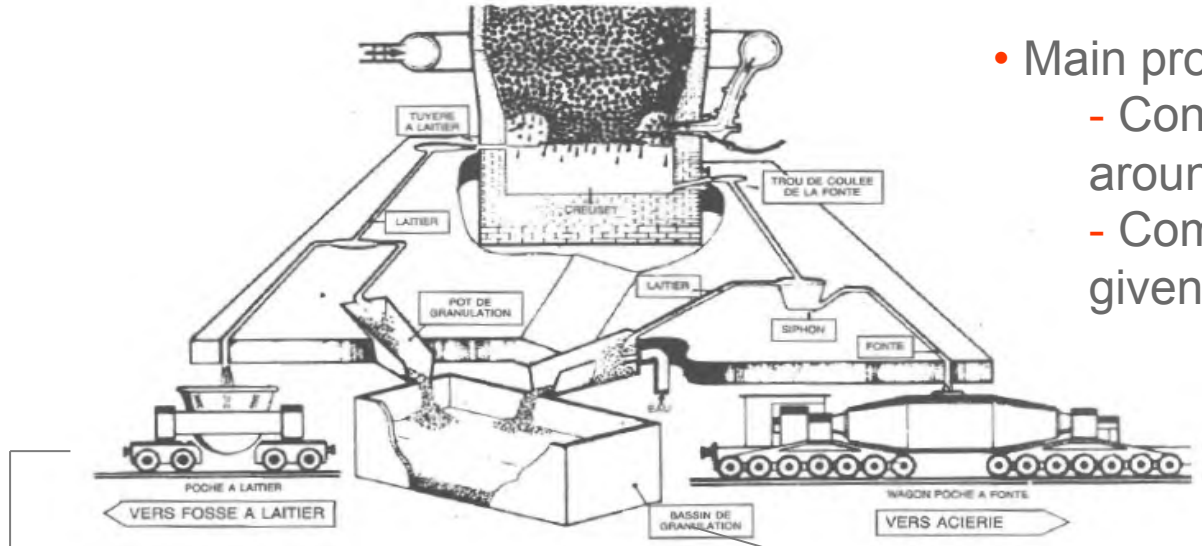
70 kg sludges and dusts

80 kg other byproducts



In 2010, 81% of the worldwide tonnage of byproduct (46.3 Mt) was recycled or externally sold. By-products sales turnover was 600 M$.

Blast-furnace slag



Représentation schématique du plancher de coulée d'un haut fourneau

- Main properties :
  - Continuous production of around 300 kg/t pig iron.
  - Composition quite stable for a given BF:

CaO	40 - 50%
SiO_2	30 - 40%
Al_2O_3	5 - 15%
MgO	5 - 10%
S	0,5 - 1%

Crystallized / Air cooled BF slag

Vitrified / Granulated BF slag

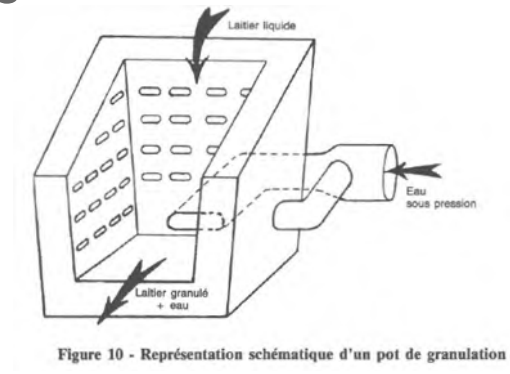


Figure 10 - Représentation schématique d'un pot de granulation

ArcelorMittal and geopolymers

Granulated BF slag is known to be a excellent component for a geopolymer formulation, but its access was limited due to supremacy of cement companies on this ressource.

However, 10 years ago, AM decided to reinforce its role in BF slag direct marketing and sales.

Granulated BF slag is now available in sand grain size (0/5 mm) in limited tonnages from all integrated ArcelorMittal plants.

Ground granulated BF slag is now available in larger tonnages from ArcelorMittal plant of Fos s/mer.

ArcelorMittal and geopolymers

Still, ArcelorMittal has other byproducts which could be of interest for the geopolymer industries, especially other steel slags.

Some papers already exists on this field:

- Cementitious materials including stainless steel slag and geopolymers. (D.C. Comrie, US Patent 2005/0160946)
- Geopolymeric repair material made with steel slag. (Hu and all, Cement&Concrete Composites, 2008)

But steel slags are complex materials, and links between steel process and slag quality are not always clear.

→ ArcelorMittal has the knowledge and the tools to understand and control slags qualities, and can provide information and materials in suitable conditions.

Steel slags are diverse and variable

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Desulfuration slag (5 kg/t steel)

Fe	15 to 30	%
Al2O3	1 to 3	%
SiO2	10 to 15	%
CaO	30 to 50	%
P2O5	0.5 to 1	%
S	0.5	%
MnO	0.5 to 1	%
C	3 to 8	%
MgO	3 to 4	%

Basic Oxygen Furnace slag (80-120 kg/t steel)

Fe	15 to 25	%
Al	1 to 3	%
SiO2	10 to 15	%
CaO	40 to 55	%
P2O5	1 to 2.5	%
Cr2O3	0.1 to 0.3	%
S	0.05	%
MnO	3 to 5	%
MgO	2 to 7	%

Steel slags are **diverse** and **variable**

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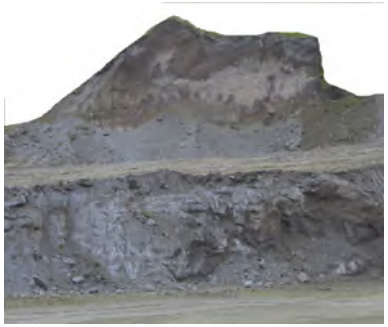
Electric Arc Furnace slag (80-120 kg/t steel)

Fe	20 to 30	%
Al2O3	2 to 6	%
SiO2	10 to 20	%
CaO	32 to 50	%
P2O5	0.5 to 1.5	%
Cr2O3	0.1 to 0.2	%
S	<0.2	%
MnO	2 to 7	%
MgO	2 to 7	%

Secondary metallurgy slag (10 kg/t steel)



Fe	0 to 15	%
Al2O3	10 to 30	%
SiO2	8 to 16	%
CaO	40 to 55	%
Cr2O3	0 to 1	%
MnO	0 to 1	%
MgO	4 to 9	%

Chemistry is not enough, what about mineralogy ?

- Existance of glassy phases ?

Nearly impossible for BOF slag (too low SiO_2). May be difficult for EAF slag. Never tested for other slags.

- Main minerals ?

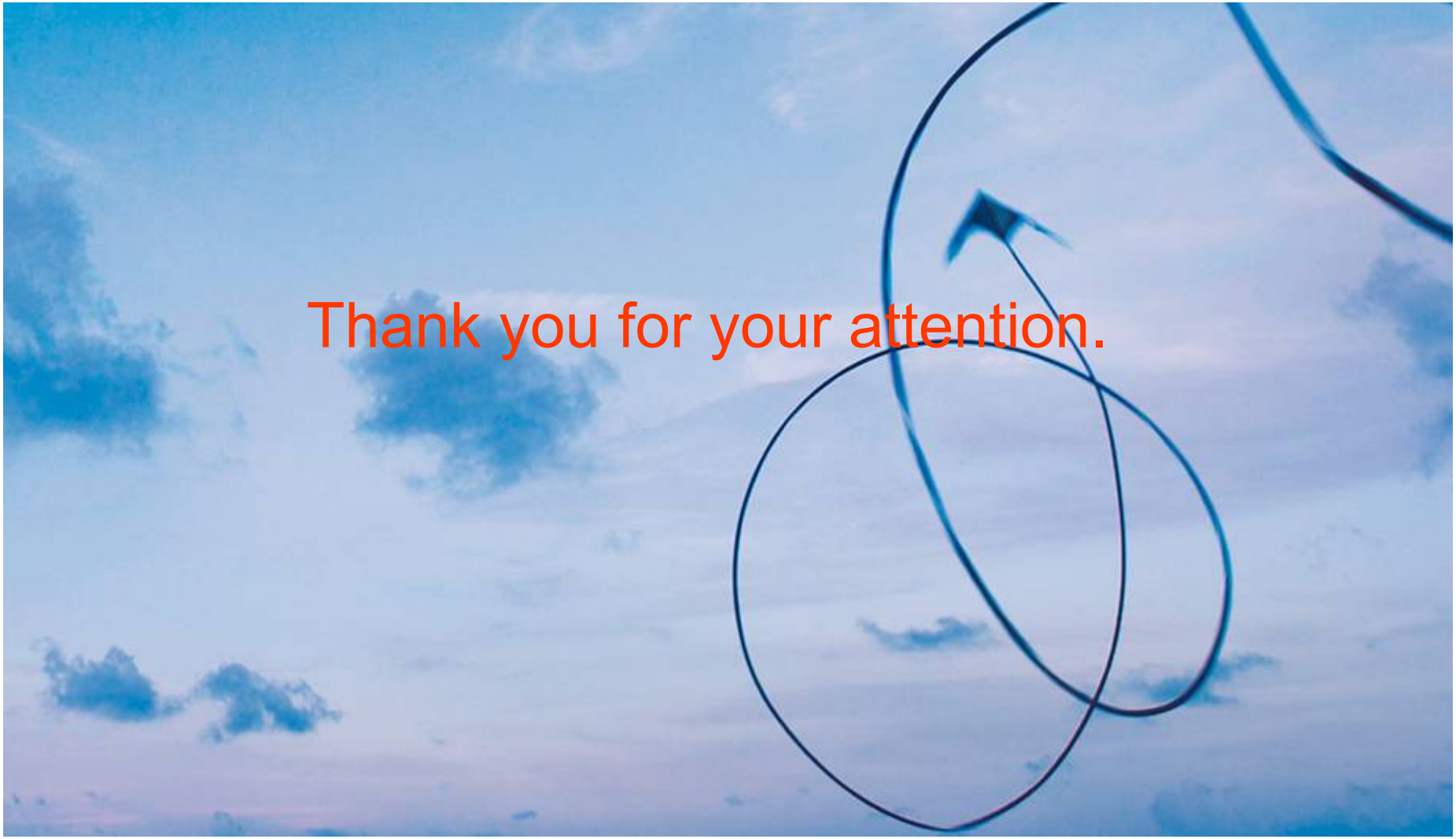
Dicalcium silicate (C2S) is always present. A slag contains a minimum of 4-5 main minerals (C2F, C3A, free CaO, FeO-MgO, …), in very various proportions, even between two successive tapping for the same furnace. However, prediction and sorting at molten state, depending on chemcial analysis, is possible (practiced in Dunkirk).

→ Steel slags have first to be studied on a local point of vue.

Granulated BF slag is available for industrials projects.

Developments for other steel slags have started.

What are your ideas ?


Thank you for your attention.