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Contribution of pilot tools @ EID
Toward lower environmental impacting processes
→ *Focus on manganese sinter*

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HEAD OF PYROMETALLURGY DEPARTMENT

METNET – PILOTING ACTIVITIES

30/11/2023

ERAMET strategic roadmap

Grow in metals for global economic development

Resilient markets

MANGANESE ORES & ALLOYS

NICKEL

MINERAL SANDS

Develop critical metals for energy transition

Fast-growing markets

LITHIUM

NICKEL/COBALT FOR BATTERIES

BATTERY RECYCLING

Manganese

Steels used for construction and transportation
Batteries, fertilizers, chemicals

Nickel

Stainless steel and nickel-based alloys

Batteries

Mineral Sands

Pigments and titanium metal

Ceramics, chemicals

Refractory materials, foundry

Lithium

Energy storage for electric vehicles

Portable electronic devices

Applications

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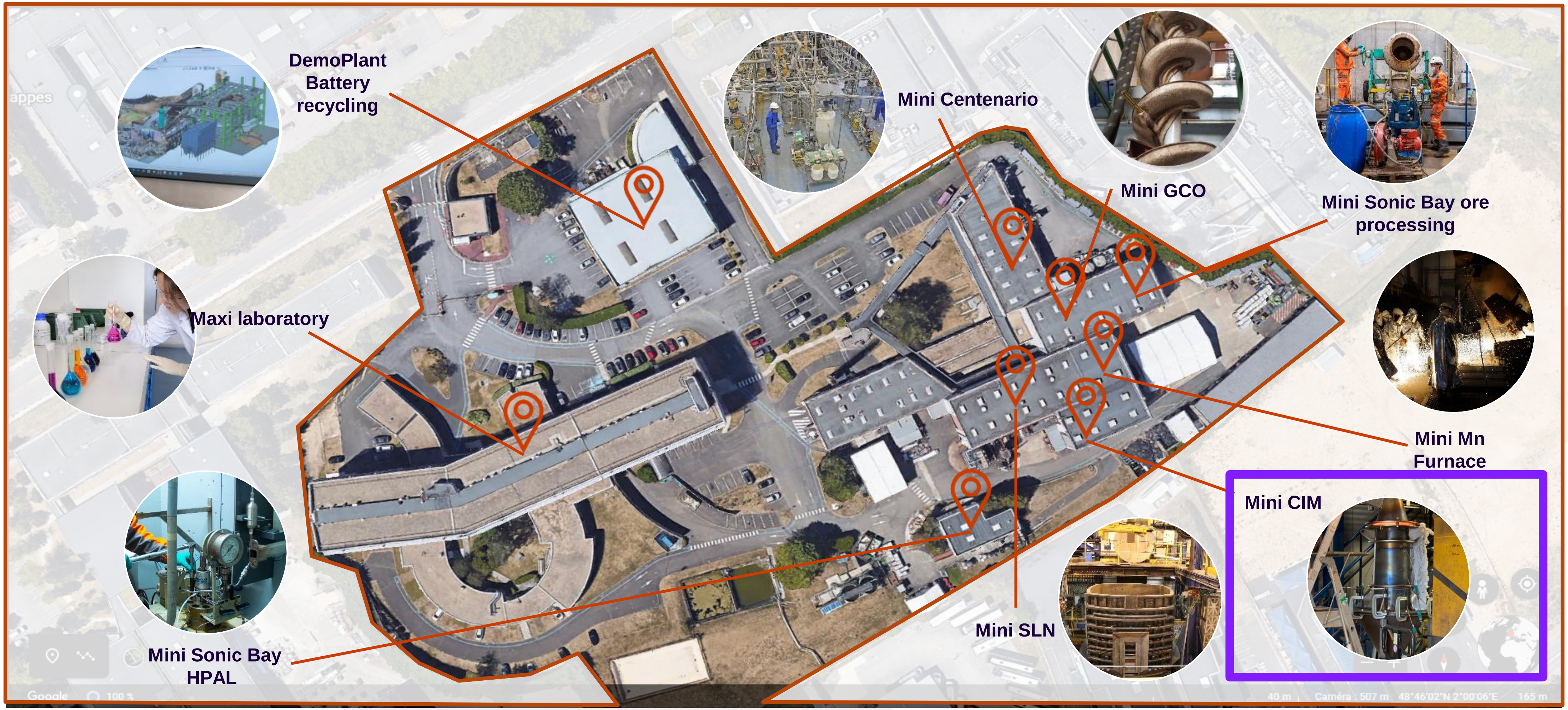
Eramet Ideas: a “mini” Eramet in France



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Mn sinter product and process

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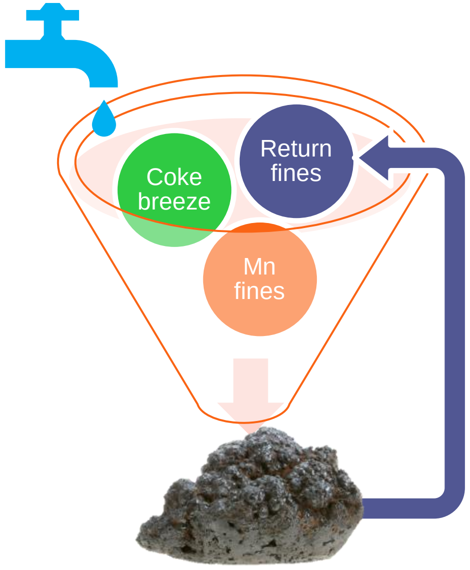
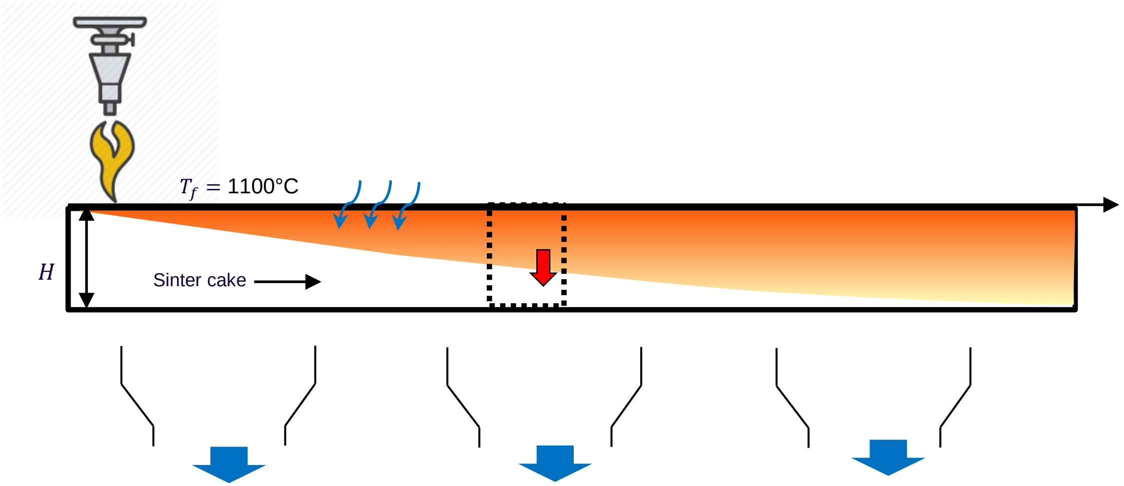
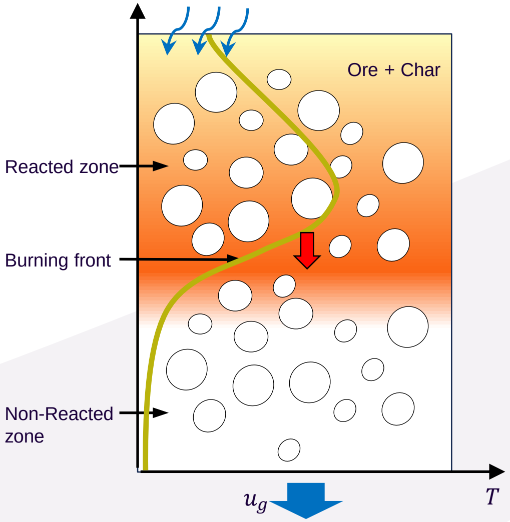
Mn fines valorization → Sinter-making process



Sinter
(SINTEC, SINTER F2)





PROCESS

Quality / productivity

- **Fed materials properties**
  Chemistry (bounding phases) and moisture %
  Granulometry, UF → Permeability
- **Operating conditions**
  T°, gas flow rate, coke combustion kinetics

PRODUCT

Mn sinter, fed material inside SAF → Permeability, stability

- **Hardness index : % > 6.3 mm** → To be maximized
- **Abrasion index : % < 500 µm** → To be minimized
- **Chemistry : %Mn, %P, %K** → In specifications

Eramet Ideas sinter-making pilot

A flexible sinter-making pilot setup

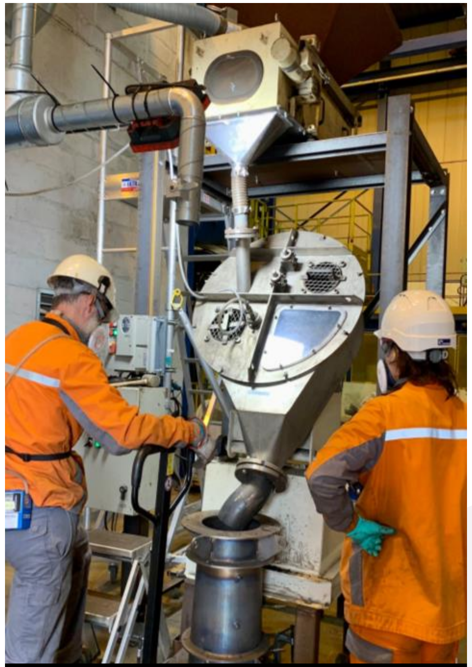
Quality
- Return fines generation (<5 mm)
- **Hardness index (>6.3 mm)** after aging
- **Abrasion index (<0.5 mm)** after aging

Analysis
- Chemistry (%Mn, %P, …)
- Temperature profiles
- Gas analysis

Productivity
- Speed of the flame front

High Intensity Eirich mixer

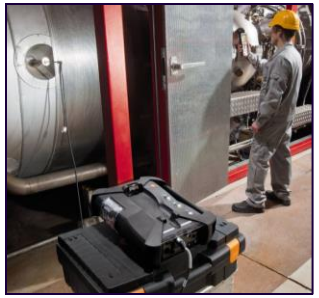
Mixer



Mixing plate

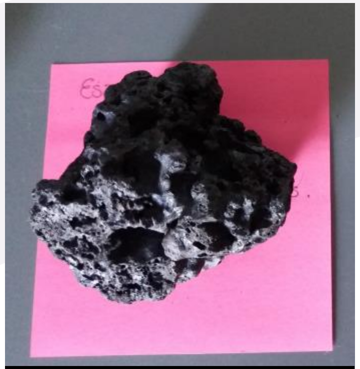
Sintering pot

20+ pilot campaigns in Trappes since 2002



Testo 350 mobile gas analyzer
O_2, CO, CO_2, NO, NO_2, SO_2, H_2, C_xH_y

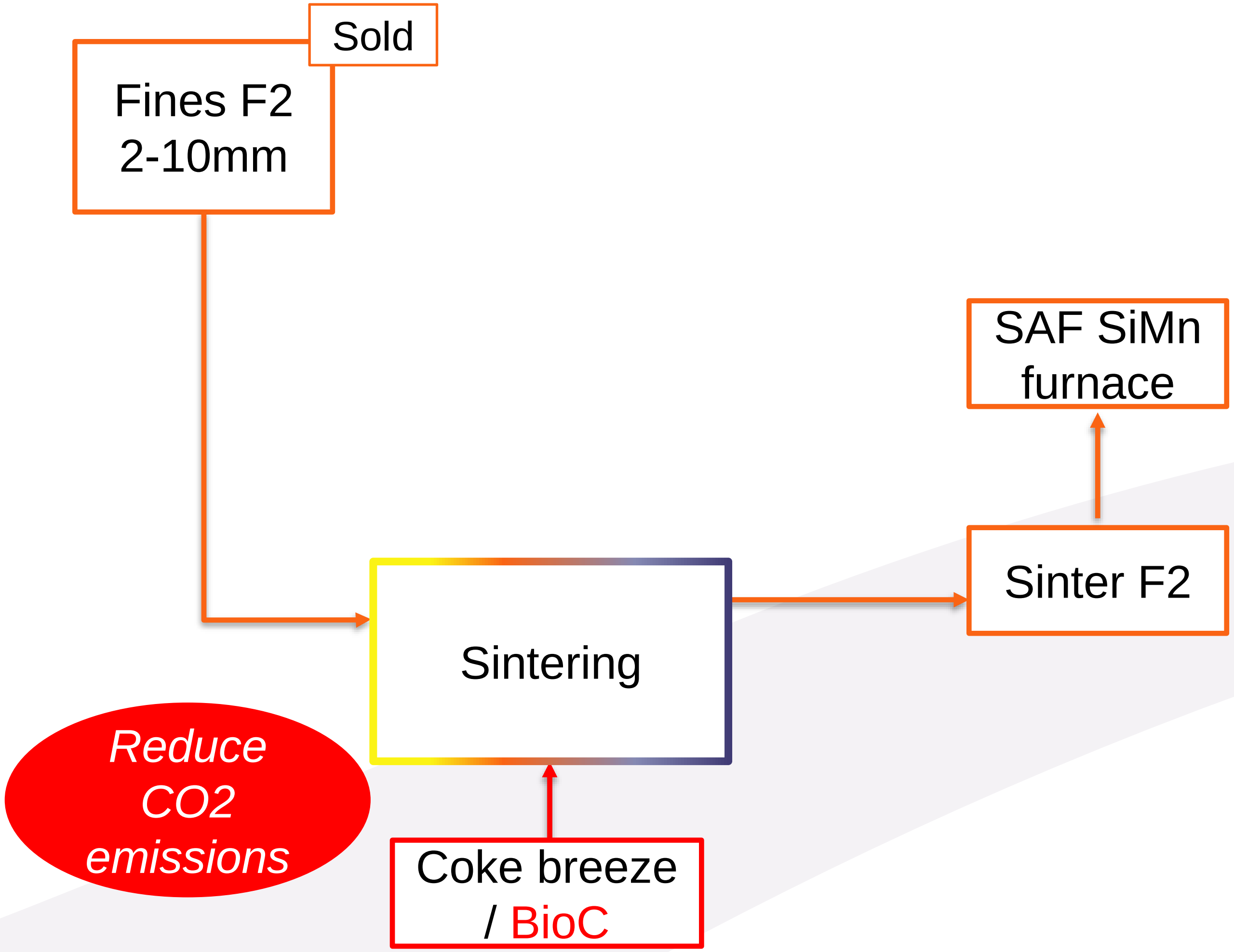
Tumbling & screening



Sintered products

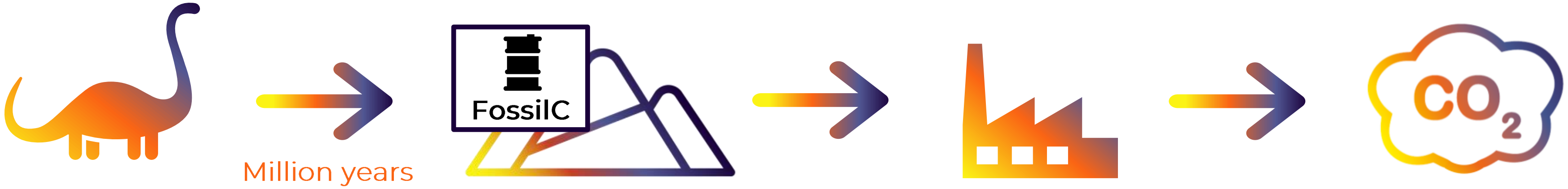
Biocarbon substitution

Context


Sold
Fines F2
2-10mm
SAF SiMn
furnace
Sinter F2
Sintering
Reduce
CO2
emissions
Coke breeze
/ BioC

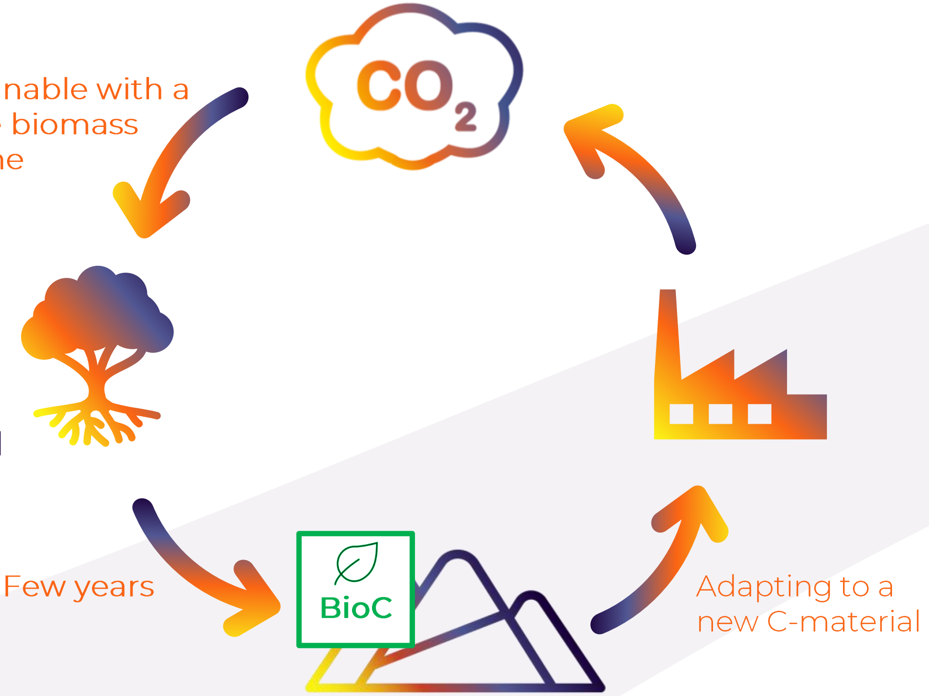
What is Biocarbon ?

Current situation: fossil carbon from the geosphere is continuously added to the atmosphere



Biocarbon situation: atmospheric carbon is looped in few years through the biosphere

Biomass resources: wood (timber & residues), agriculture residues, food processing waste (and many more)



Charcoal/biochar: Carbonized biomass with high fixed C (>75%), medium volatiles (20%), low ash (<5%). Low density & fragile

Stakes

Technical motivations for charcoal substitution in sintering:

- **Coke mostly act as a fuel (energy source)**
- **The mechanical properties of coke are not critical in sintering**
- **Charcoal is more reactive than coke (kinetics)**

Economical & sustainability motivations:

- **In 2021, the CO_2 emissions related to the use of coke breeze at the CIM accounted for 9% of the total group emissions linked to solid fuel & reductant**
- **Sinter is primarily used inside the group and is a critical component of Mn furnaces burden**

Sinter-making with certified biocarbons* can help to tackle an important source of the group CO_2 emissions; but also reduce the CO_2 footprint of all Mn-alloys products (scope 3).

**FSC and/or PAFC certifications*

Pilot objectives

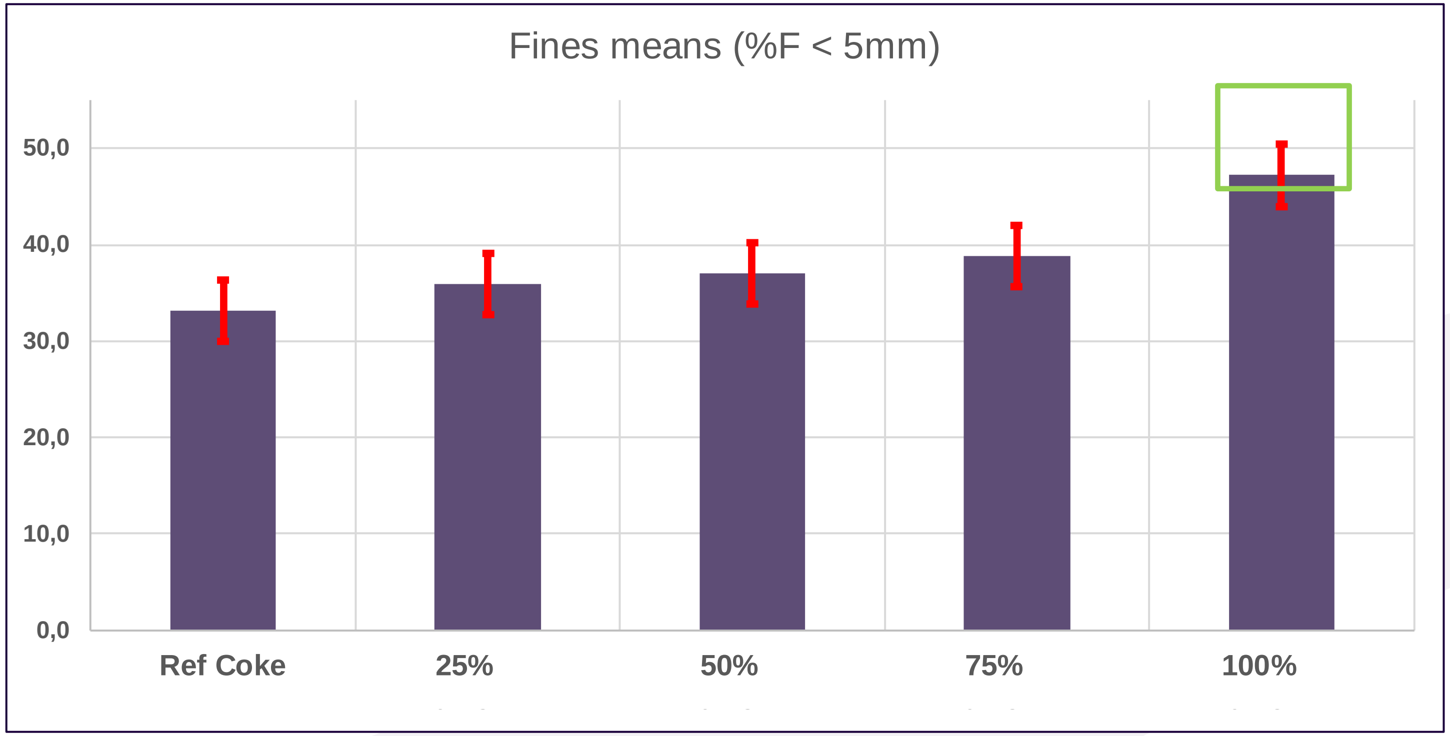
- Substitute coke by BioC (25% / 50% / 75% / 100%)

Fines generation

Constant Fix C

% of fines generated without aging (%F < 5 mm)

- Similar magnitude than reference coke until 75% substitution
- Tendency : Increase when BioC % increases



Least significant difference test: 4.5

Confidence interval of 95% with common std deviation: 3.2

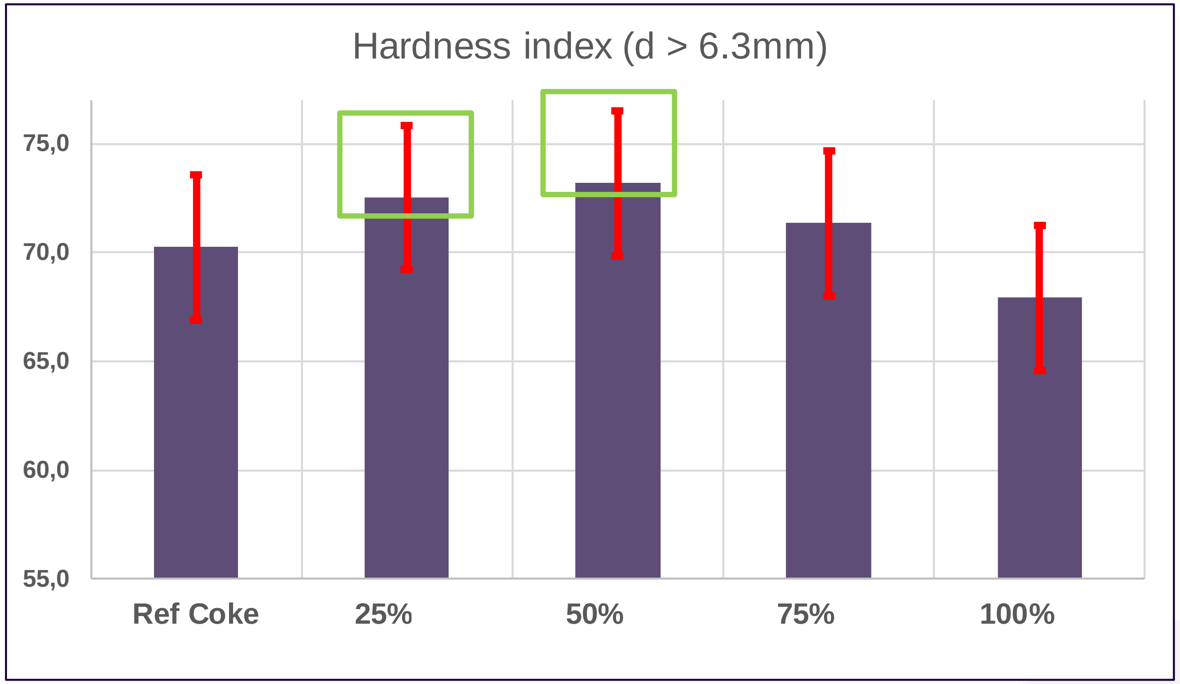
If %BioC ↗
Then %F ↗

Characterization after ageing

Constant Fix C

Hardness index after aging (d > 6.3 mm)

- Optimum of BioC substitution



Least significant difference test: 4.7

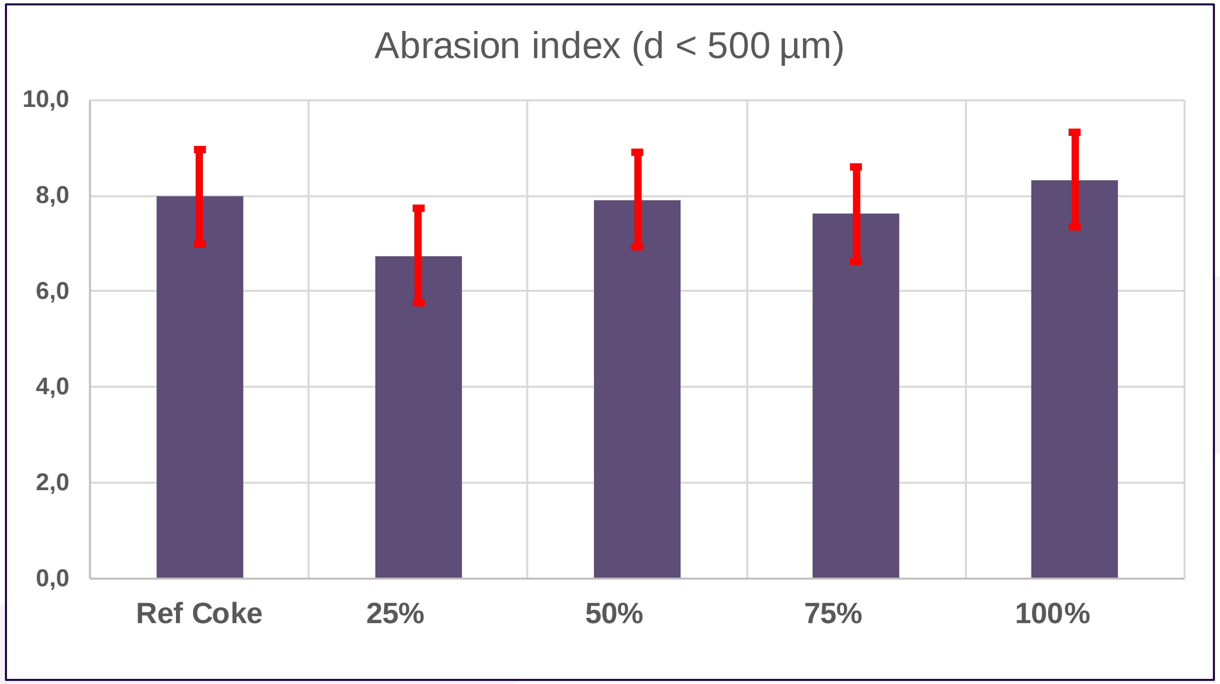
Confidence interval of 95% with common std deviation: 3.3

Hardness eq or better than the reference

If %BioC ↗ then hardness↘

Abrasion index after aging (d < 500 µm)

- Equivalent to the reference except 100% substitution



Least significant difference test: 1.4

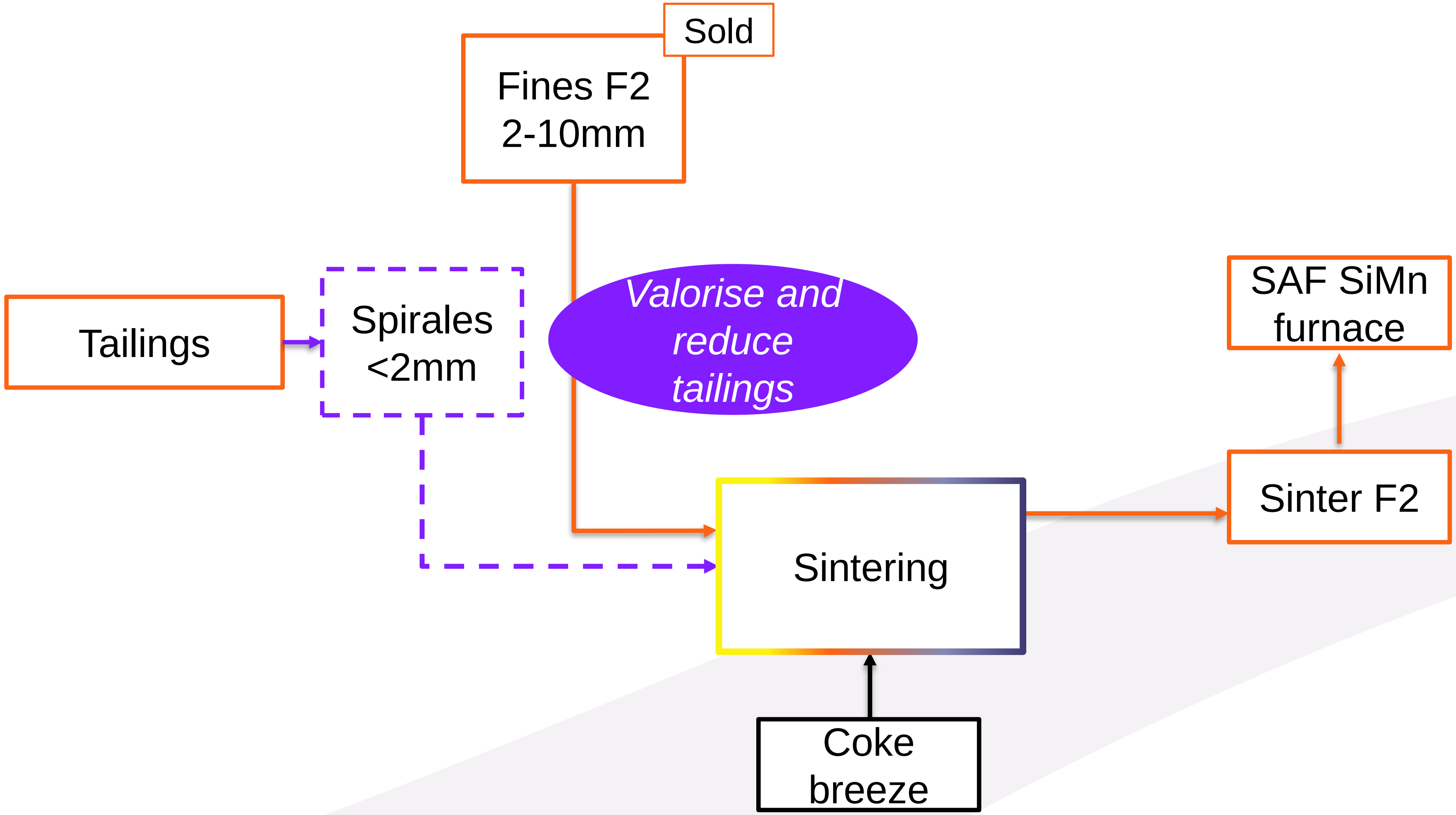
Confidence interval of 95% with common std deviation: 1.0

Abrasion equivalent to the reference

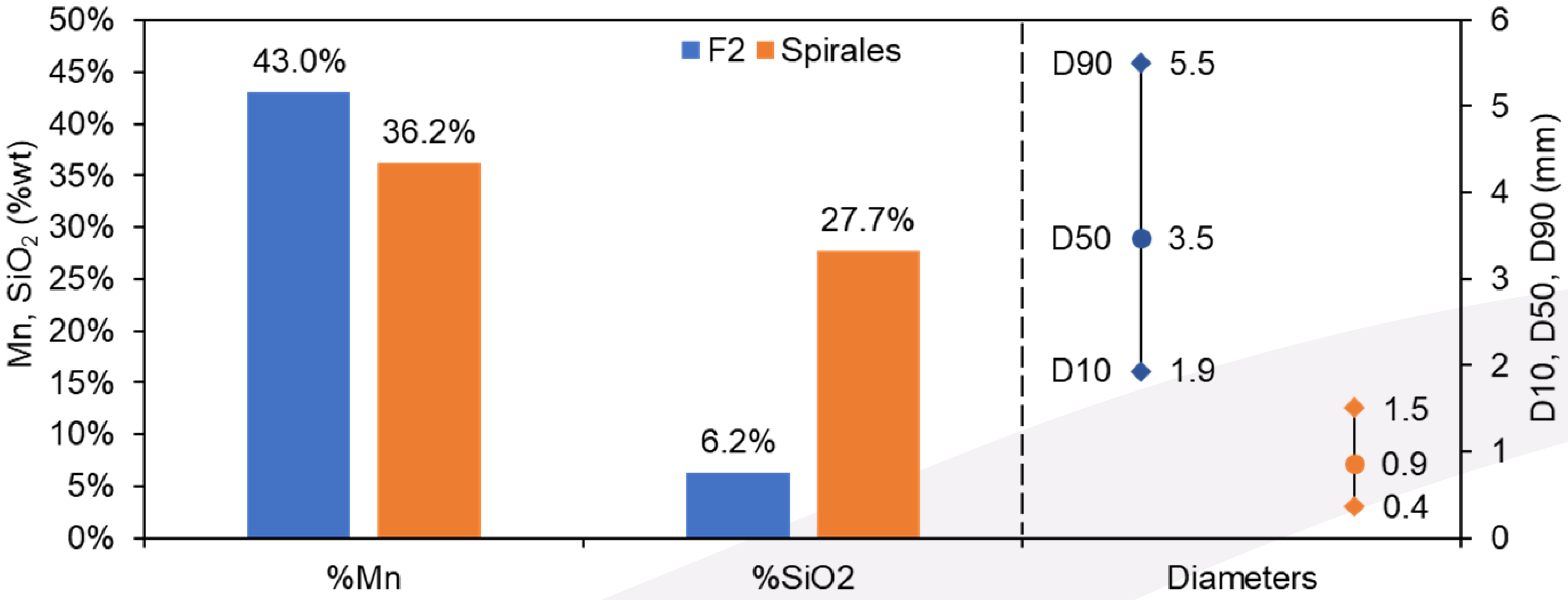
If %BioC ↗ then abrasion ↗

Valorization of tailings

Context and stakes



Spirals fines: high SiO2, small size



↗ SiO_2: can increase the %binding phase

< 2 mm fines : can degrade permeability

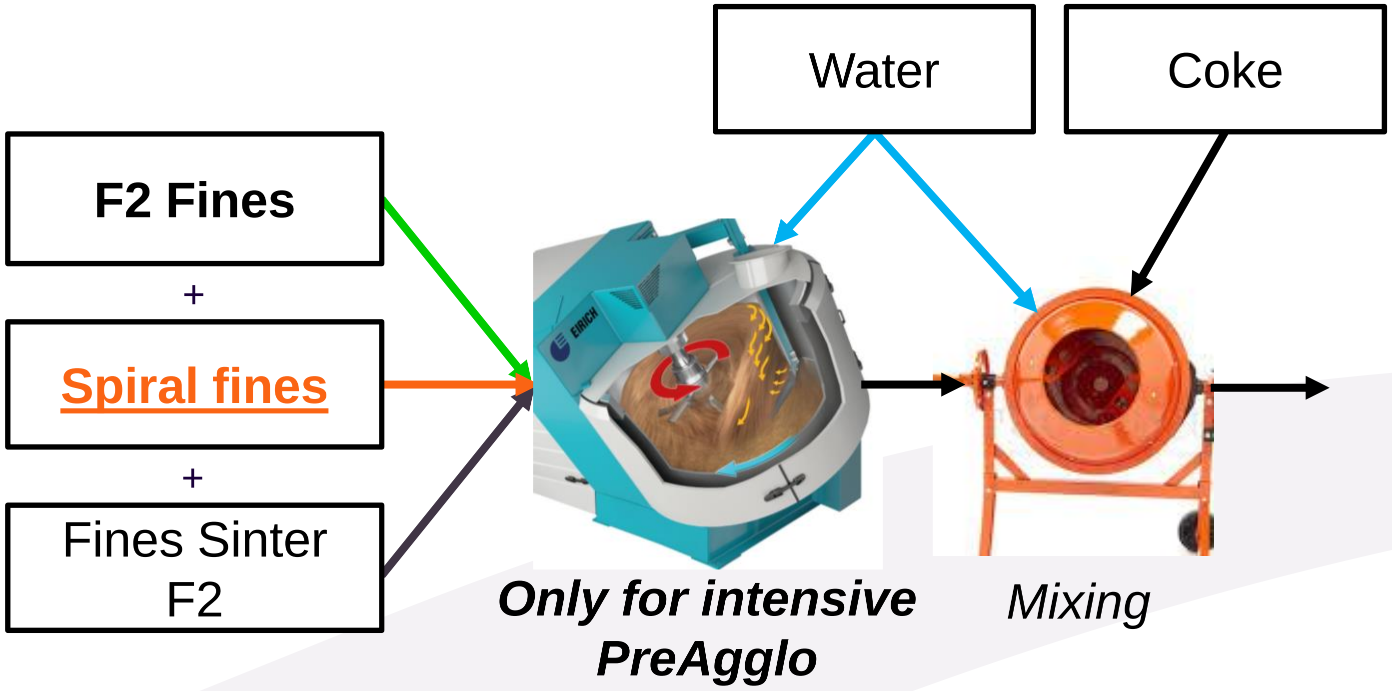
How to keep enough productivity with spirales ?

Impact of F2 fines substitution by spirales ?

- Chemical composition
- Quality / Productivity

Impact of specific cold pre-agglomeration ?

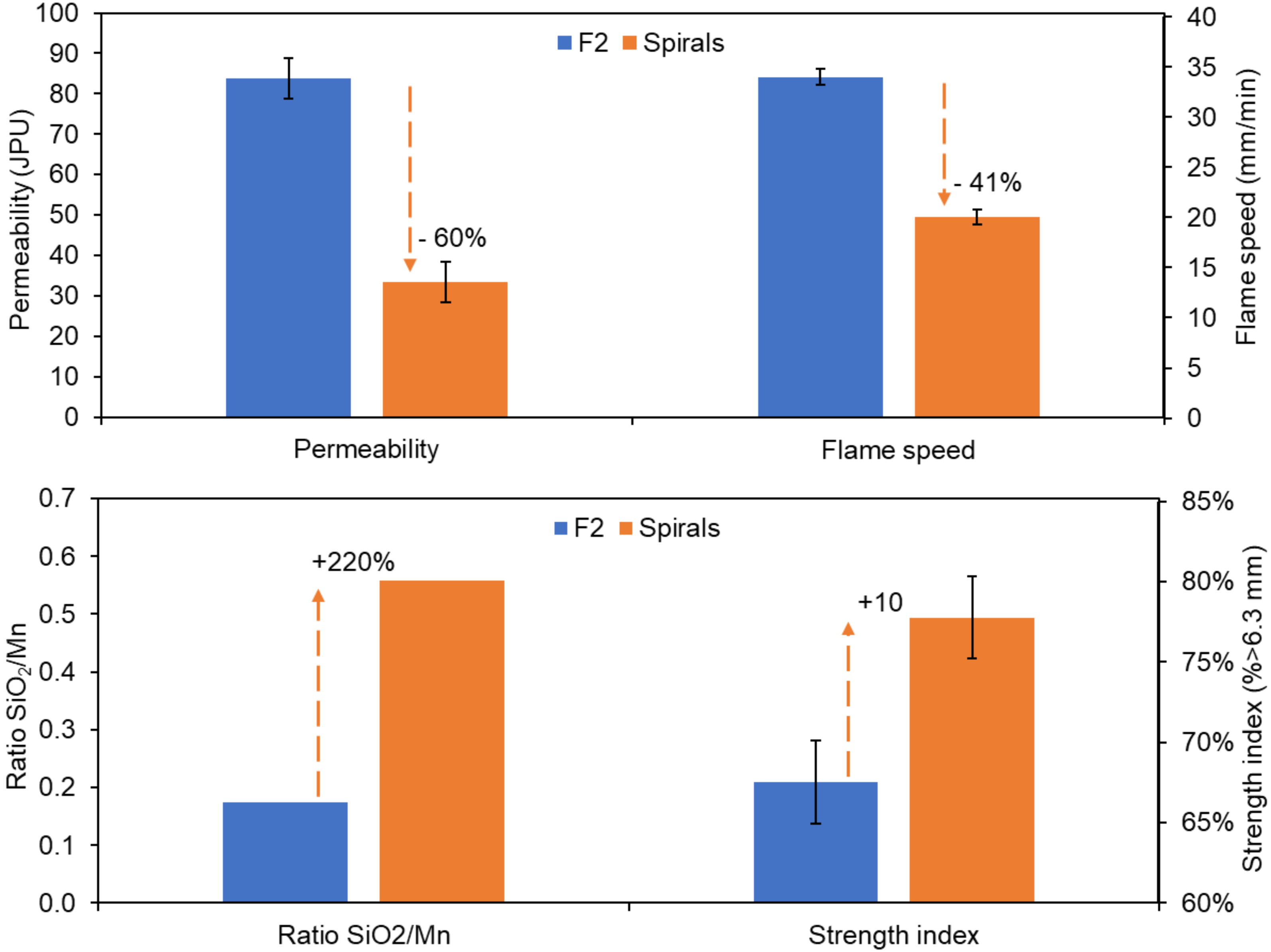
- Impact on permeability → Quality / Productivity
- No impact on chemical composition



Trials :

- Different substitution rates : 0%, 40%, and 100% Spirales
- Cold pre-agglomeration : without or with High Intensity mix (HI)

Sinter with spirals fines: higher strength but lower speed



Loss of permeability
→ Lower flame speed

Gain of %binding phase
→ Higher sinter strength

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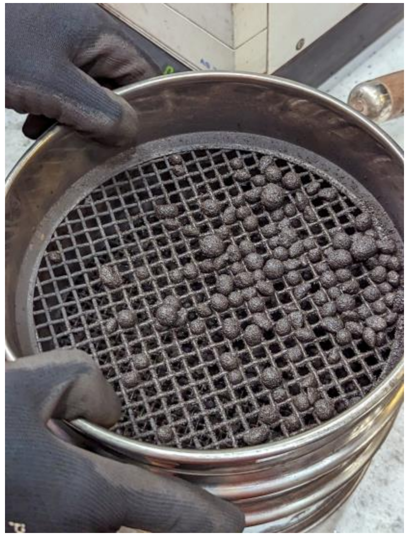
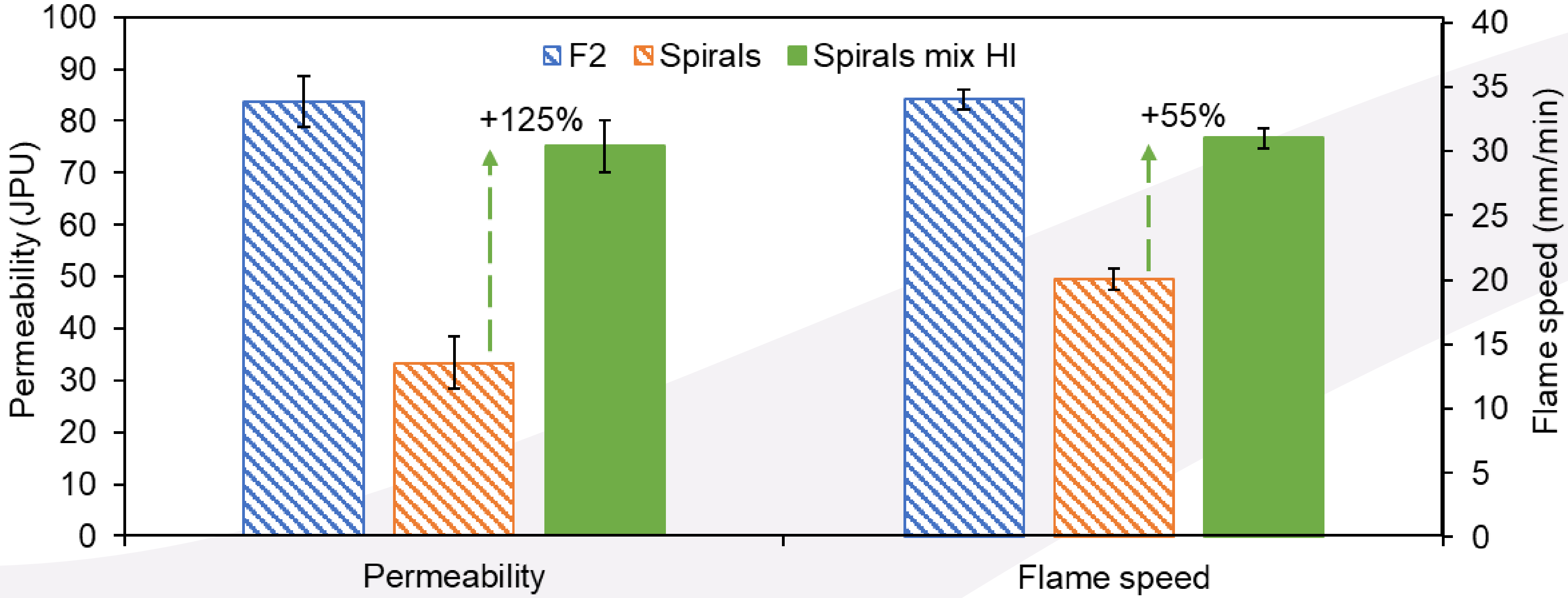
Sinter with spirals fines: benefits of high-intensity mixing

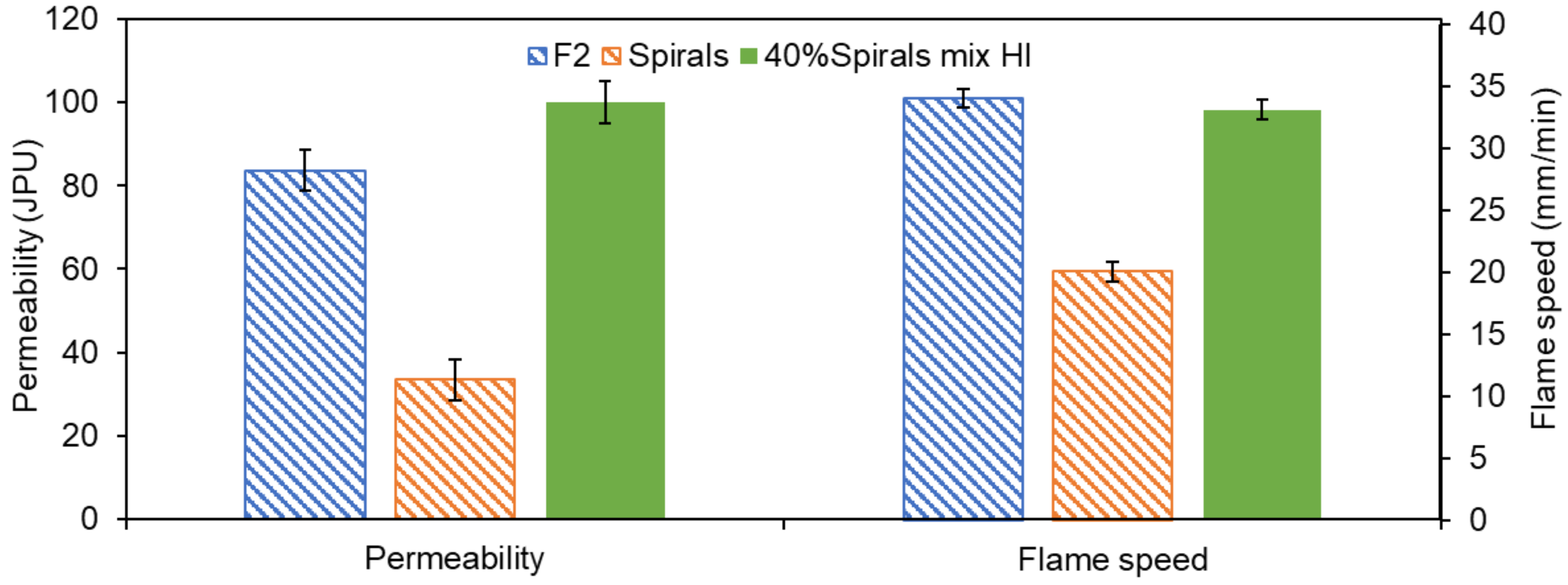
Mix HI (High Intensity)
5 min **1500 + 300** RPM

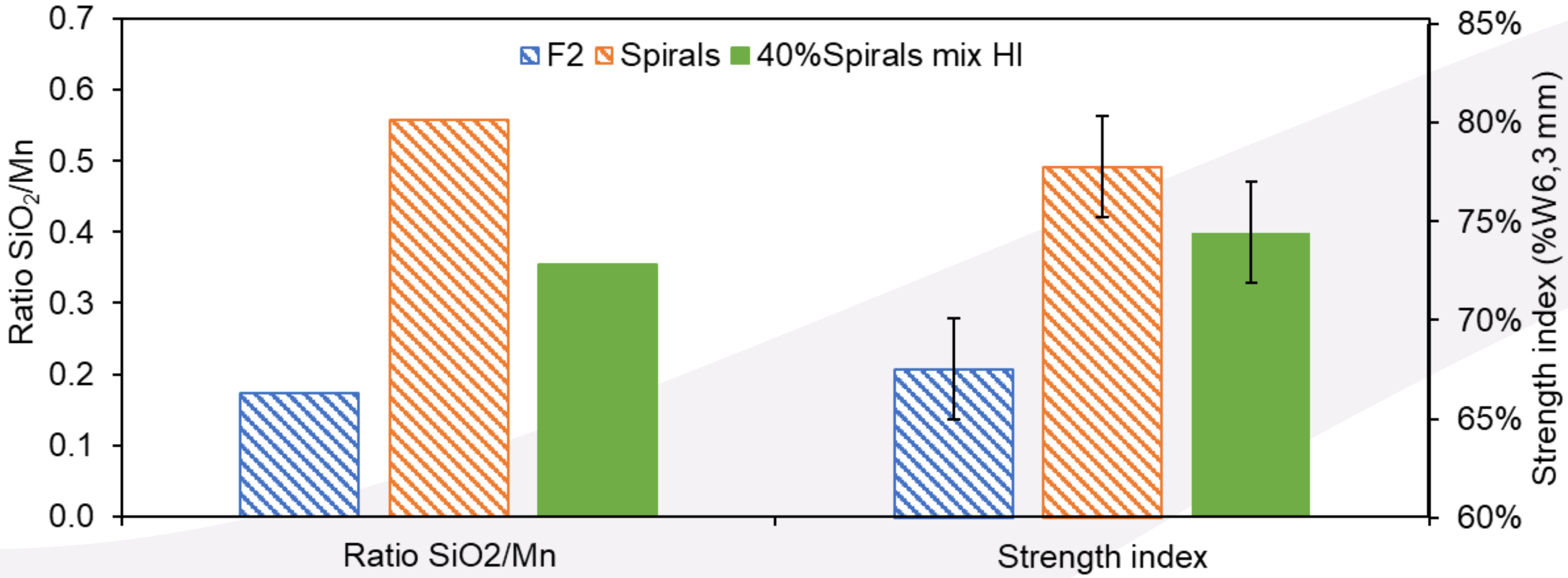




Recovery of permeability, higher flame speed (with consistently high strength)

Sinter with spirals fines: blend of 40% Spirals + high-intensity mixing





40% Spirals + mix HI
→ Proper speed, high strength

Conclusions

An agile tool which has proved its representativity …

- **Static** configuration to simulate a **dynamic** process
- **Batch** operation to simulate a **continuous** industrial process

… but still looking at optimization depending on current stakes

- Batch minimum size / critical materials avalaibility
- Gas analysis / environnement stakes
- Sensitivity and variability optimization on going

Which brings needed data before industrial trials and let us innovate!

- Key information before commitment in investments decisions
  - → Process modifications (impact of pre-agglomeration, strategy of feed loading)
  - → Impacts on product and environment (gas)
  - → New products potentiality (quality, productivity)

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