ESTEP SPRING DISSEMINATION EVENT

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Crosscut project - Carbon Reduction in production routes Operations based on Smart Carbon Usage and digitalisation Techniques – project approach and first results

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PROJECT SCOPE

To demonstrate the flexible utilization of several **alternative SCCs** (secondary carbon carriers) in ironmaking, steelmaking and iron alloys production routes.

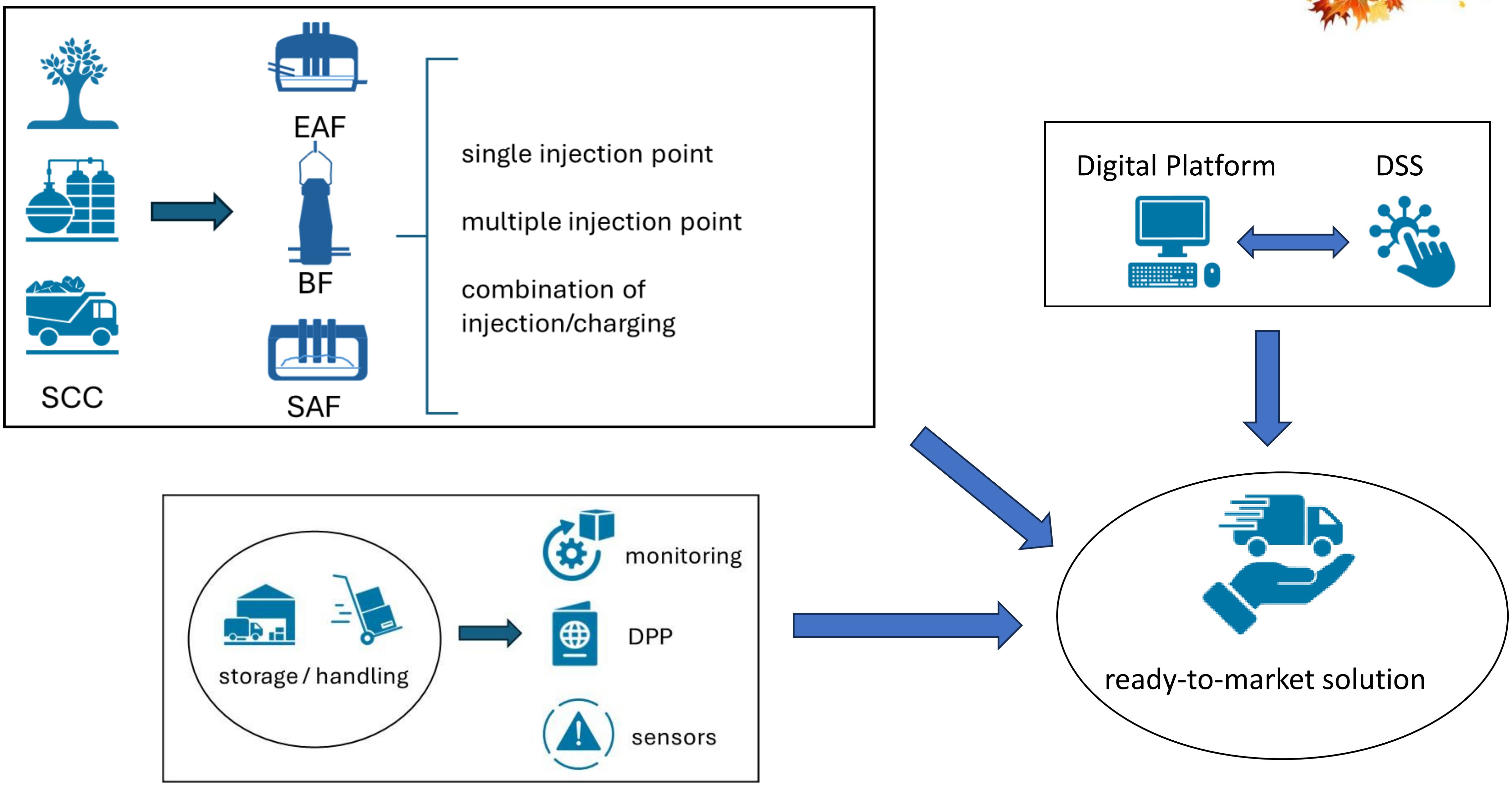
EAF steel production: single, multiple and charging tested at industrial level

Integrated production route: pilot tests coupled with analysis and feasibility study considering utilization in coke making, sintering and injection in BF.

Iron alloys plant (SAF), SCCs will be used for FeCr production.

Activities are integrated with the **development of digital platform for materials management** inside the factory and the integration of a Decision Support System (DSS).
The requirements for steel digital product passport **(DPP)** are analysed too.

PROJECT SCHEME



WHY MULTIMATERIAL APPROACH

- The demand of SCC for ironmaking and steelmaking is huge (to achieve a significant CO_2 reduction). On a conservative basis SCC demand maybe 8,5Mt per year (130Mt annual production, 55%BF and 45%EAF, 2024 data from Eurofer) with CO_2 savings of 22Mt

- The availability of a single material may differ during the year

- The characteristics of the materials are different and blending may be necessary: volatile matter, fixed carbon and presence of contaminants (e.g S, P) are strongly variable from polymers to pyrolyzed biomass

- Depending on specific application one material fits better respect another one: for example, polymer grains are suitable for EAF (or BF) injection, while pyrolyzed biomasses are suitable for basket charging in EAF

PROJECT CONSORTIUM

Crosscut

1	RINA CONSULTING - CENTRO SVILUPPO MATERIALI SPA	IT	Coordinator
2	Laminés Marchands Européens	FR	Partner
3	SIDENOR ACEROS ESPECIALES SL	ES	Partner
4	SIDENOR INVESTIGACION Y DESARROLLOSA	ES	Affiliated
5	FERRIERE NORD SPA	IT	Partner
6	COMPAGNIA SIDERURGICA ITALIANA S.P.A.	IT	Affiliated
7	SIEC BADAWCZA LUKASIEWICZ - GORNOSLASKI INSTYTUT	PL	Partner
8	SWERIM AB	SE	Partner
9	ACCIAIERIE D ITALIA SPA	IT	Partner
10	Vargön Alloys AB	SE	Partner

Project first results

1. Materials inventory

2. EAF utilization: preparatory activities for EAF injection tests in Feno and LME

3. SCC utilization for FeCr production

4. First analysis of steel digital product passport requirements

5. Utilization of SCC in sintering

Project first results

1. Materials inventory

Materials inventory based on both data from other projects and newly collected samples

New samples of EoL tires collected and delivered to ADI and GIT for analysis and utilization in sintering pilot plant

New samples of car fluff collected (analysis ongoing)

Feno installed a C14 analyser for the determination of biogenic material and perform precise evaluation of CO_2 savings

Materials inventory

Secondary Carbon Carriers

Hycrochar data from Bioresteel project (Ingelia producer)

	Antracite	Wood residues	biochar	biochar	biochar	hydrochar	hydrochar	hydrochar	hydrochar
			commercial	commercial	commercial	Pristine green waste	Pyrolyzed green waste	FORSU	HTC-alperujo
Ultimate analysis									
HHV* (MJ/kg)	29,66	24,7		19,43	13,39	21,79	19,73	20,32	26,38
LHV* (MJ/kg)	29,55	23,8		18,28	12,23	20,65	19,51	20,02	24,97
Cl (%)		0,012		0,017	0,02	0,38	0,1	0,37	0,07
S (%)	0,5-1,5	0,03	0,1-0,4	0,133	0,056	16,74	0,44	0,53	0,2
H (%)	0,5-1,5	5,8-6,4		1,41	0,79	5,1	1,02	1,45	6,38
N (%)				0,32	0,36	1,91	1,52	1,31	1,65
C (%)	80-85	48-52		52,98	45,52	50,97	74,6	51,86	54,3
O (%)				10,1	<5	20,44	<5	11,49	24,02
Proximate analysis									
Volatile matter (%)	5,0-15,0		3-20	61,5	56,1	61,7	14,4	34,7	71
Ash(%)	7,0-10,0	1,7	1,4-25	3,34	13,66	15,6	38,1	32,46	8,98
Density (g/cm3)				0,51	0,58				
Fixed carbon (%)	75-88		55-90	33,33	20,86	22,7	47,5	32,84	20,02

Materials inventory

Secondary Carbon Carriers

	Plastic residue	Plastic residue	SRA		EOL tires (1)	EOL tires (2)
	3-20 mm	3-10 mm	polymers from plastic residue			1-4 mm
Ultimate analysis						
HHV* (MJ/kg)	32,37	32,5	39,87			35
LHV* (MJ/kg)			36,71			34
Cl (%)	0.38	0.37	0,93			
S (%)	0,03	0,03			1,8	1,5-2,0
H (%)	10	10	12,17			8,2
N (%)	1,1	1,2				1,3-2,0
C (%)	64	65	75,5			78-80
O (%)	14.8	15.1	8			<1
Proximate analysis						
Volatile matter (%)	88,89	87,52	90		64	63-35
Ash(%)	9,6	9,5			7,29	8,0-10,0
Density (g/cm3)			0,3686			1
Fixed carbon (%)	1,5	1,5	2		28,7	25-27

SRA/plastic grains data from Polynspire and Onlyplastic projects Material provided by I BLU

EOL tires data from Rina internal analysis and from Sidenor

New EOL samples collected by ADI and analysis ongoing

Project first results

1. Materials inventory

- Polymers grains have a quite constant reproducibility of composition (and a well assesed value chain). High carbon content makes this material suitable for BF and EAF inection. High volatile content prevent utilization in EAF basket

- EoT different samples showed similar properties. C∼ 30% due to carbon black in the blend of tires

- Biochar properties are strongly variable depending on input biomass and conversion technology (torrefaction, pyrolysis, hydrothermal carbonization)

Project first results

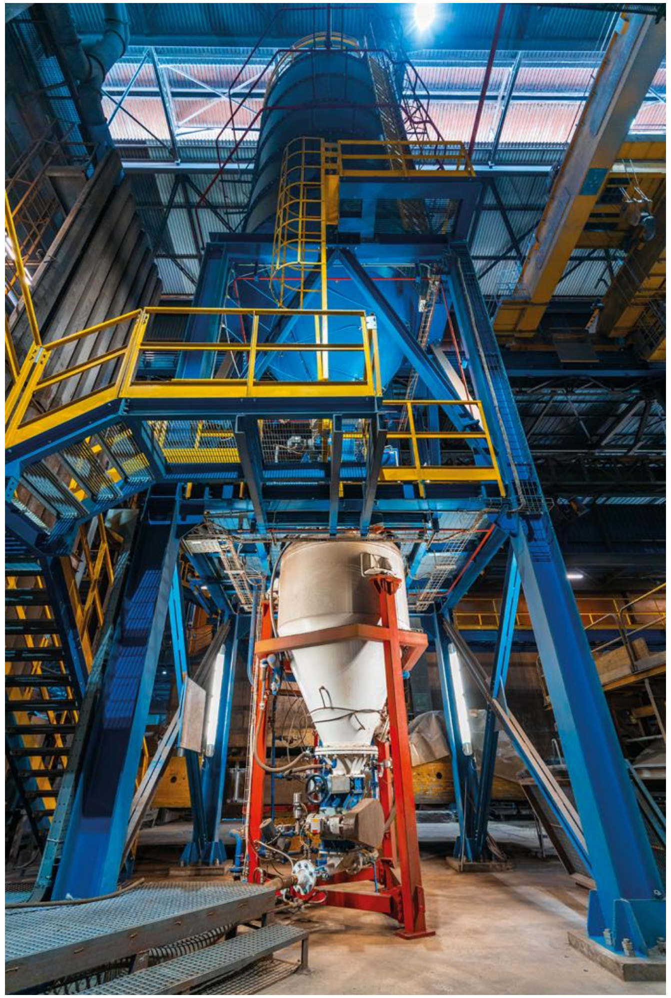
2 Preparatory activities for EAF injection tests in Feno and LME

FENO

- Engineering phase with supplier for the new Injection system
- Analysis of availability and new suppliers for SCC
- Start to analyse SCC with the new C14 laboratory instrument

LME

- Analysis of providers to rent the injection system for single point injection



Based on the results and materials characteristics Sidenor will perfom a replicability analysis

Project first results

2. First analysis of steel **D**igital **P**roduct **P**assport requirements

The Digital Product Passport (DPP) is part of the EU's Ecodesign for Sustainable Products Regulation (ESPR - 2024).

Delegates Acts with specific regulations for iron and steel scheduled to be finalized in 2026. The obligation of implementation expected in 2027-2028.

The DPP for steel will require detailed and standardized information of a large set of technical, data-driven requirements. Data should be accessible via a QR code or RFID (Radio Frequency Identification) tag.

Data to be collected for DPP:
Material Composition & Origin, Environmental Impact Data (e.g. carbon footprint, energy consumption..), Recycled Content (amount of recycled, secondary, or sustainable materials incorporated into the steel), Certifications & Compliance, Circular Economy Data (info about repair, reuse, disassembly, and recycling at the end-of-life stage) and Unique Identifier (ISO/IEC 15459 to ensure traceability throughout the supply chain)

Project first results

2. First analysis of steel **D**igital **P**roduct **P**assport requirements

Analysis of the different value chains ongoing

- More accessible data for polymers grains (commercial product already exist and manufactured according to an Italian technical regulation) and for EoT grains

- Biochar market already exists but not tailored for steelmaking:
  - torrefied pellets for energy purposes
  - hydrochar for power/heating, (on going project, BioReSteel)
  - pyrolyzed material for domestic use, for human and pet food and nutraceuticals, plant cultivation (soil conditioner).

- Car fluff has currently very limited utilization. Material can be upgraded by improved sorting, but the value chain is to be created

Project first results

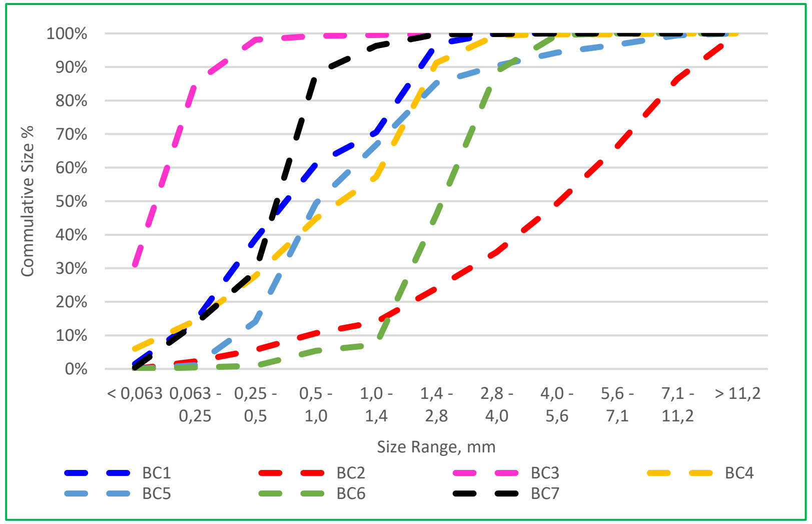
3. SCC for FeCr production

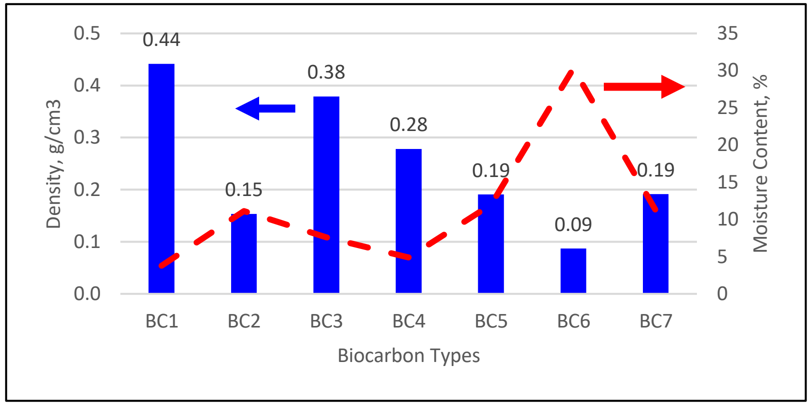
Swerim, in collaboration with **Vargön Alloys**, has worked on WP7, which focuses on developing SCC-chromite ore briquettes for use in submerged arc furnace (SAF).

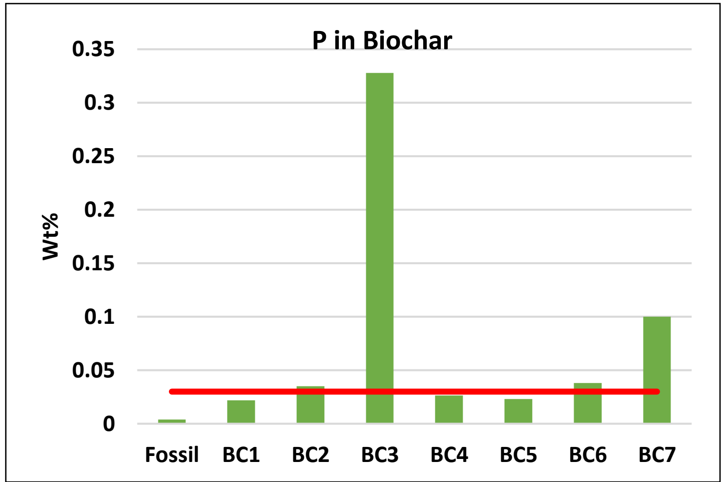
A) Material Inventory

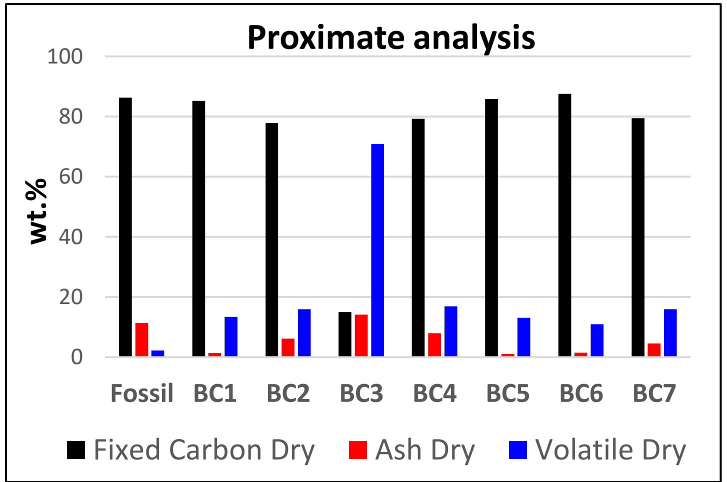
- Different types of secondary carbon carriers (SCC) derived from bio-feedstock supplied by various vendors have undergone physical and chemical characterization. Controlling particle size distribution (PSD) is crucial for developing briquettes with adequate mechanical strength.

- In addition to the essential biocarbon parameter, C-fix, the key factor for biochar used in FeCr production is phosphorus (P) content. This has been analyzed and compared against acceptable limits. Selection of biocarbon has been made during agglomeration, (**P content below 0.03%**).









Project first results

3. SCC for FeCr production

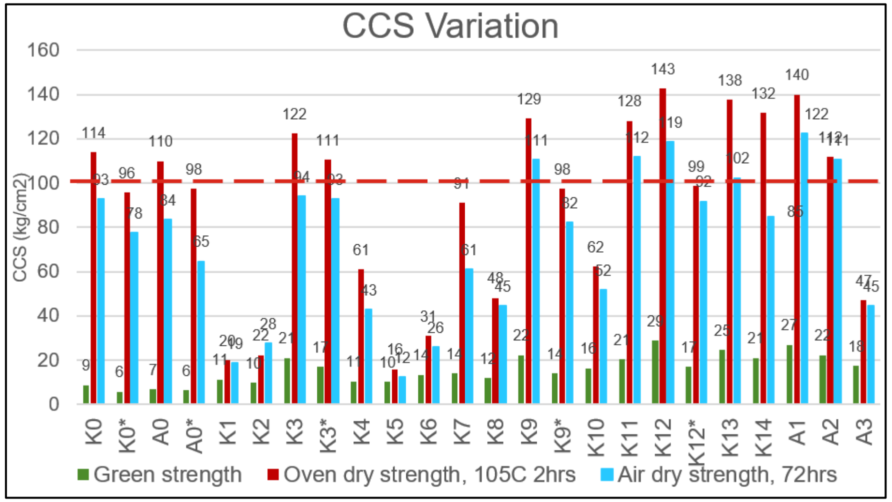
B) Laboratory scale briquetting

- Several recipes have been developed using different sources of SCC in combination with chromite ores. A semi-automatic piston press has been utilized for the briquetting process. Various parameters have been tested and optimized, including chromite ore types, biocarbon types, biocarbon ratios, binder types, binder dosage, and moisture content.

- The mechanical strength was evaluated based on cross-compression strength (CCS), splitting tensile strength (STS), and the drop test.

- The results indicated that the fast drying strength was dominant than the slow air dry strength. Decrease of compaction pressure from 300kN to 150kN have reduced the strength. The best binder combinations to work with, have been determined with a minimal strength acceptance level of 100kg/cm^2

Recipe	Ore 1	Ore 2	Binder	BC1	BC2	BC5	BC3	BC7	BC6
K0		95	5						
K0*		95	5						
A0	95		5						
A0*	95		5						
K1		75	5	20					
K2		75	5	20					
K3		75	5	20					
K3*		75	5	20					
K4		75	5	20					
K5		75	5	20					
K6		75	5	19			1		
K7		75	5		20				
K8		75	5		20				
K9		75	5			20			
K9*		75	5			20			
K10		75	5			20			
K11		75	5	19			1		
K12		75	5			19	1		
K12*		75	5			19	1		
K13		75	5			19		1	
K14		75	5			19			1
A1	75		5			19	1		
A2	75		5	20					
A3	75		5	20					



Notes: Several binders have been tested at variant compositions; Recipes with * meant that the compaction pressure was 150kN instead of 300kN

Project first results

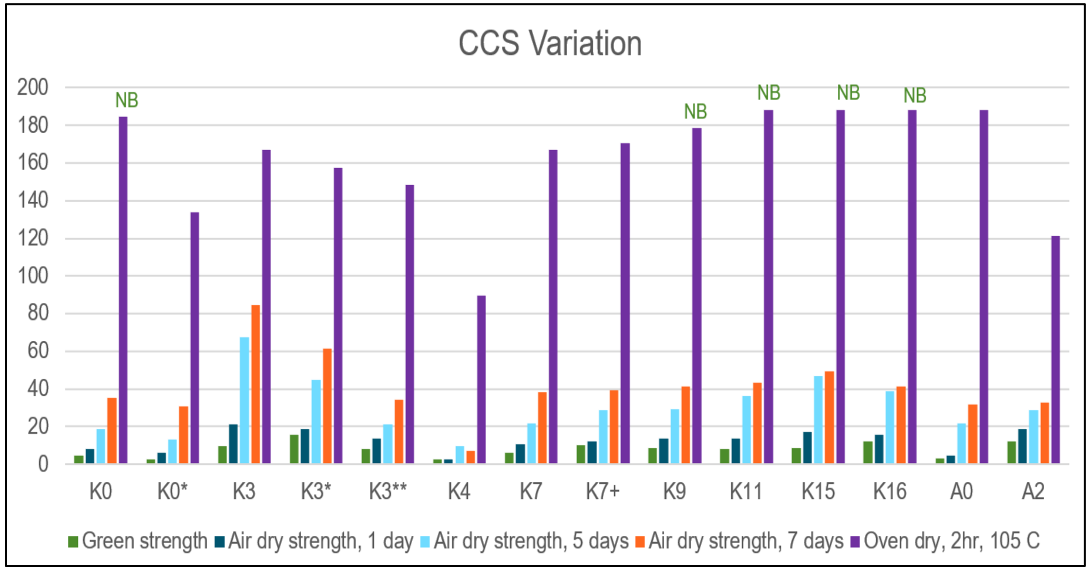
3. SCC for FeCr production

C) Technical scale briquetting

SCC-Chromite Extruded Briquettes

Recipe	Ore 1	Ore 2	Binders	BC1	BC2	BC5	BC3	BC7	BC6
K0		97	3						
A0	95		5						
K3		75	5	20					
K4		75	5	20					
K7		75	5		20				
K7+		75	5		20				
K9		75	5			20			
K11		75	5	19			1		
K15		75	5	19				1	
K16		75	5	19					1
A2	75		5	20					
K17		95	5						

- The best recipes from the laboratory-scale briquetting were selected for upscaling to technical-scale extrusion at Swerim.
- The results indicate that reducing binder has reduced the briquette strength; increasing moisture content reduced strength; strength improved with more time for air dry, with oven dry outperforming every other setups



Notes: Several binders have been tested at variant compositions; Recipes with + meant that the moisture content has been changed. **NB** means briquettes did not broken.

Project first results

3. Utilization for sintering process

Utilization of SCC in sintering process is a valuable solution to reduce coke utilization and consequently to reduce the CO2 emissions from sintering. In Crosscut process, both biogenic (ligneous biomass and biochar) and non biogenic (as rubber grains) are evaluated and tested

Thermogravimetric analysis (TGA) is used to characterise thermal behaviour of SCC. TGA permitted to understand the decomposition behaviour of the materials under sintering conditions. The tests were performed under inert conditions (Ar atmosphere); three different heating rates were used of 5, 10 and 15 K/min

After TGA characterization the material has been used in the pilot sintering plant.

Limestone and dolomite have been added to the mix as fluxes to achieve a target basicity of 1.2.

The reference sinter (with coke breeze) was used to compare substitute fuels, maintaining constant carbon content.

Detailed presentation with achieved results detailed described in next presentation

Next activities

- Preparatory activities in FENO and LME for industrial trials,
- Collection of data for the utilization in integrated route,
- Analysis of value chain of the materials in order to define the necessary data for steel DPP and also definition of optimal tool for data collection and storage,
- Analysis of EAF available models in order to be adapted to utilization of different SCC in melting processes,
- Regarding FeCr production with biochar, further evaluations are ongoing for the extruded briquettes. After completing all assessments, the best recipes will be recommended for the pilot-scale extruder at Vargön Alloys.

Thanks for your attention

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