Use of Metallurgical Residues as potential Raw materials for High Performance Refractory Castables

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Context:

The steelmaking industry generates several by-products during the different stages of steel production. As a by-product, vanadium slag account for more than 60% of the world's overall production. However, it is tough to find vanadium in its pure state as it occurs in combination with various minerals. Using secondary resources for refractory castables solves the issue of natural raw materials, reduces costs related to their extraction and processing, and is friendly to the environment.

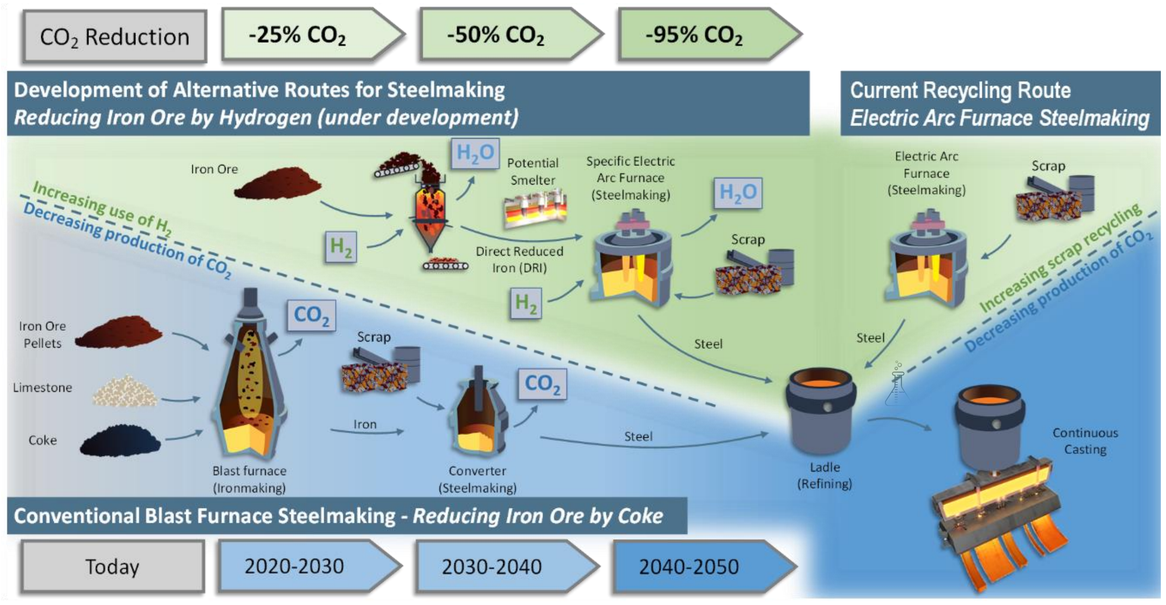
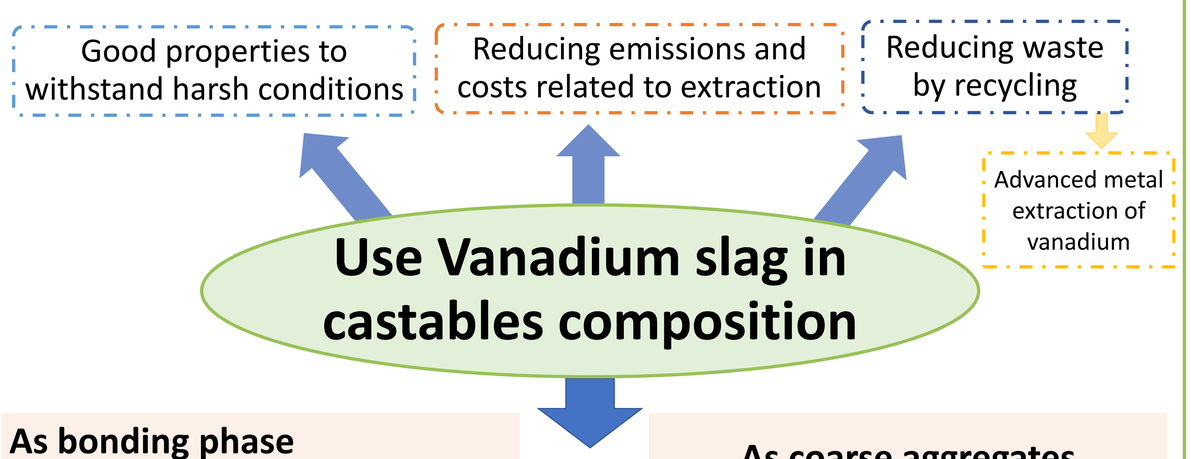


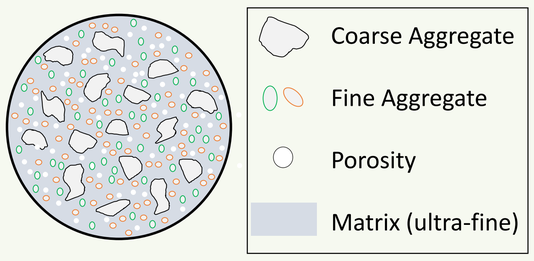
Figure 1. Towards a new steel production route.

Goals:



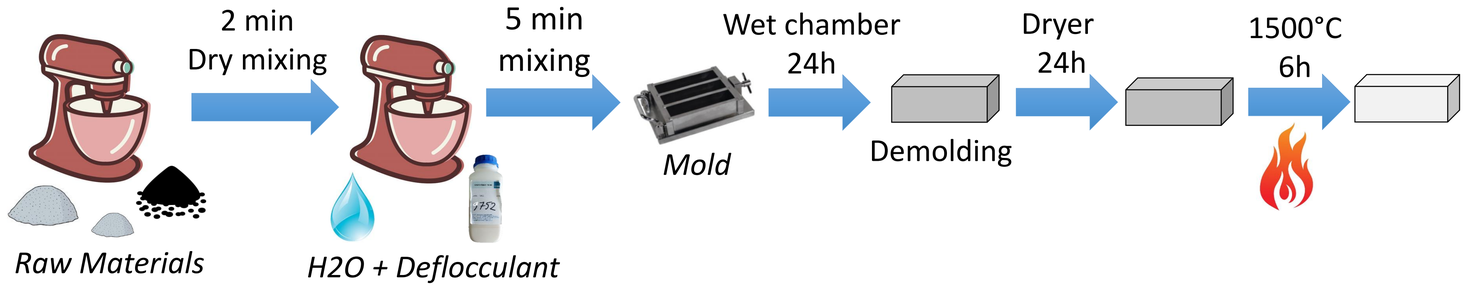
	Reference with Secar 71 (%)	Samples with Slag (%)
Tabular Alumina		
1-3mm	35	35
0.5-1mm	10	10
0.2-0.6mm	10	10
0-0.3mm	17.5	17.5
0-0.045mm	10	10
Reactive Alumina		
<0.001mm	12.5	12.5
Bonding Phase		
Secar 71	5	A-5
Vanadium slag	-	0<A≤5
Water	5	5
Deflocculant	0.1	0.1

Castable Microstructure

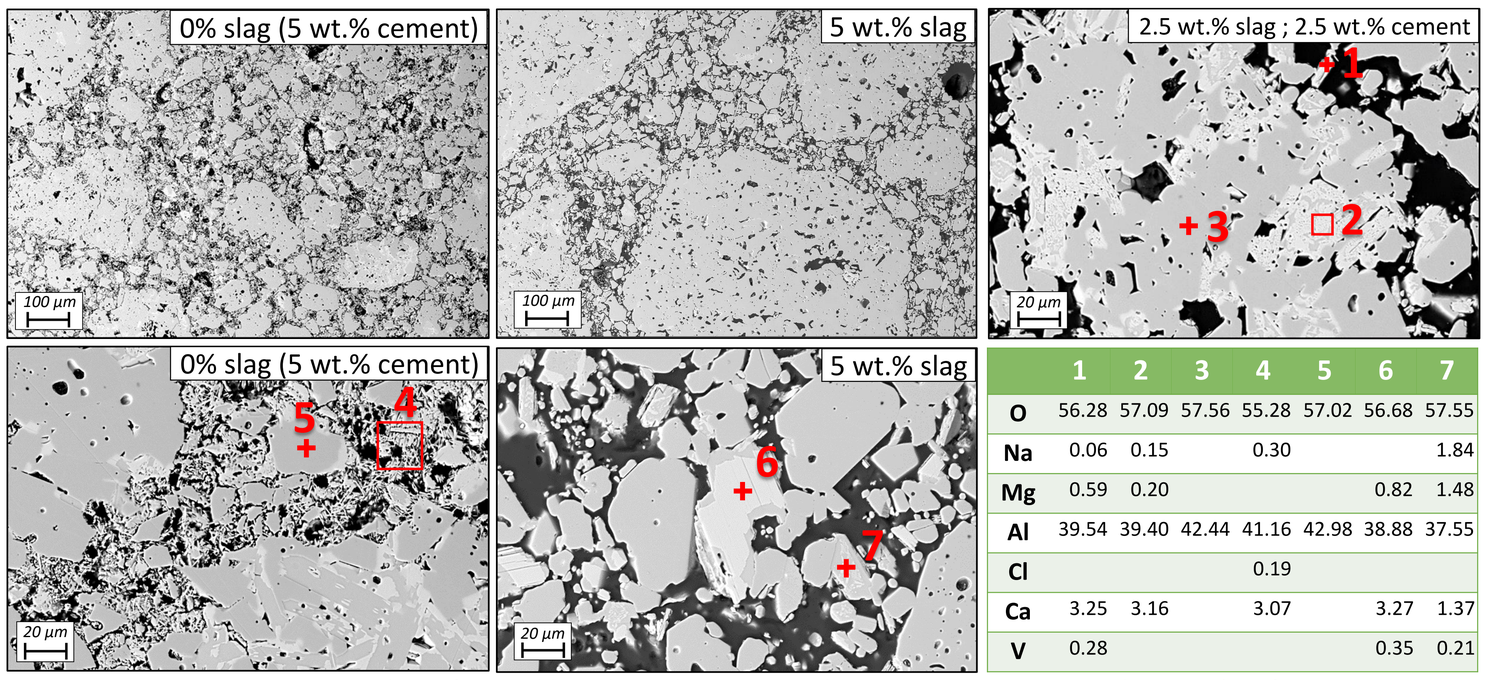


Results and Discussion:

❑ Process



❑ Microstructural analysis after sintering at 1500°C

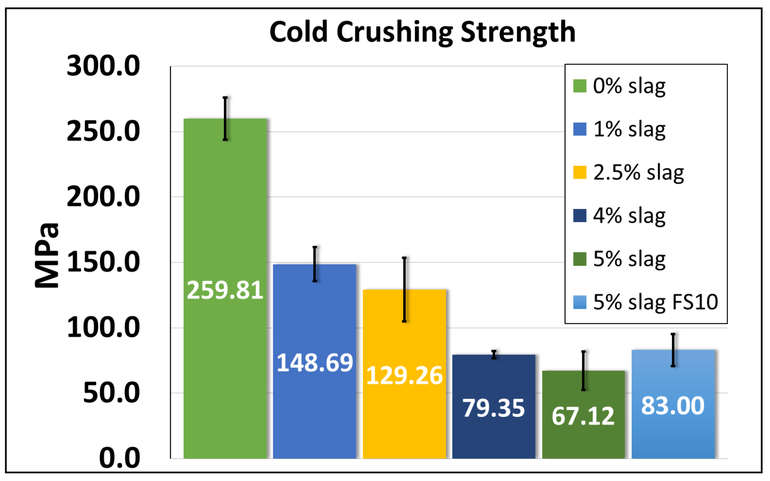


	1	2	3	4	5	6	7
O	56.28	57.09	57.56	55.28	57.02	56.68	57.55
Na	0.06	0.15		0.30			1.84
Mg	0.59	0.20				0.82	1.48
Al	39.54	39.40	42.44	41.16	42.98	38.88	37.55
Cl				0.19			
Ca	3.25	3.16		3.07		3.27	1.37
V	0.28					0.35	0.21

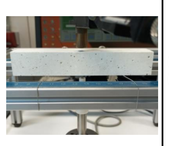
Figure 2. Microstructure analysis of a castable with 0% slag; 2.5 wt.% slag and 2.5 wt.% cement and 5 wt.% slag after sintering at 1500°C for 6h and corresponding EDS scans of the different points on the graph.

❑ Mechanical properties

- Cold Crushing Strength determination (CCS):



- Resonant Frequency Damping Analysis (RFDA):



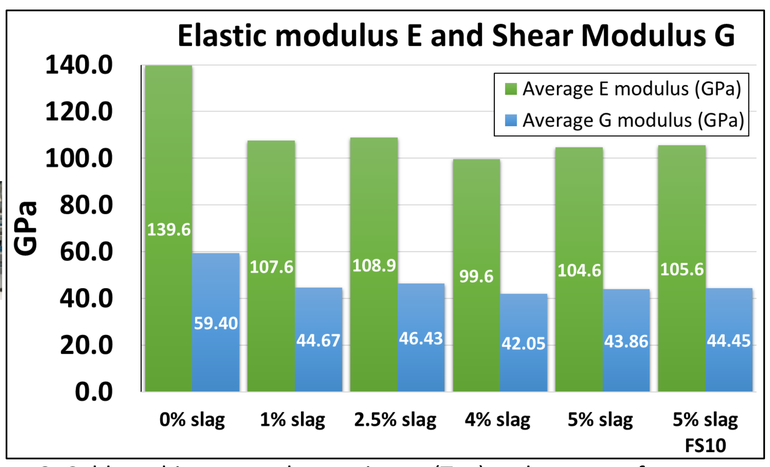


Figure 3. Cold crushing strength experiment (Top) and resonant frequency damping analysis (Bottom) on castables after sintering at 1500°C/6h.

Conclusion:

- Strength decreases significantly when adding slag to the formulation but the reference is based on high alumina castables, rarely employed in industries
- E and G modulus data do not display considerable deviation with the different amounts of slag
- Vanadium reacts preferably with Mg, Al and Ca towards a stable phase after sintering and does not attack the alumina grains.

Ongoing work:

- ✓ Development of mineral processing route of aggregates and study of the behavior in refractory castables.
- ✓ Further thermo-mechanical tests with castables containing vanadium slag as the bonding phase.
- ✓ Different trials to extract the vanadium in a sustainable way
- ✓ Contact different slag suppliers for further comparison with current slag composition

CESAREF PhD 04 :

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Beneficiaries