Reuse and recyclability of refractories from steel industry

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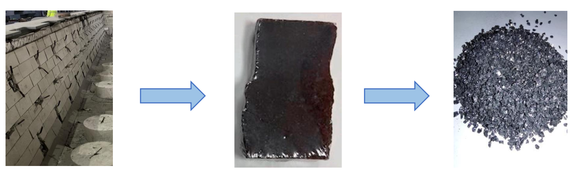
Context:

Part of the CESAREF consortium, the study presented here is dedicated to the characterization of refractory material properties after usage for potential reuse and recyclability determination. The aim of this doctoral study is to provide an insight on the variation of specific materials' key properties (such as thermal conductivity, thermal expansion, Young's module, modulus of rupture) after operations. Mesoscale aging studies may allow to define appropriate Finite Element Models (FEM) to foreseen operative conditions of the refractory.[1] Furthermore, application of an adapted FMECA (Failure Modes, Effects, and Criticality Analysis) fatigue integrated approach can be a further reliable tool to better predict refractories' lifetime.[2] Also, MCDA (Multi Criteria Decision Approach) implementation could help in detecting the necessary strategies to define the most convenient recycling routes.

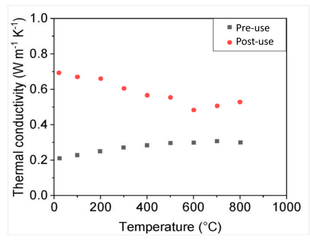
Materials & Methods:

Experimental and numerical characterization of refractory products from the continuous casting tundish to evaluate **key thermomechanical properties and composition evolution:**



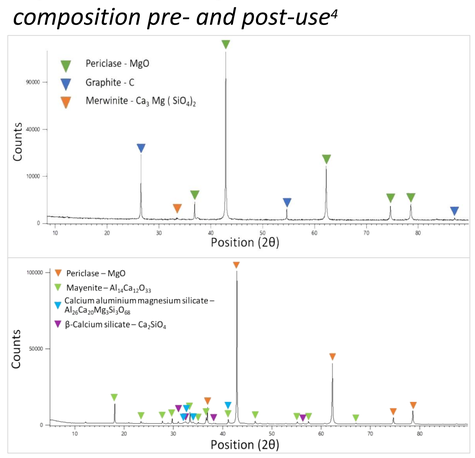
Pre-usage **Post-usage** **After treatment**

LINING	AVERAGE LIFETIME	TYPICAL COMPOSITION	FAILURE	RECYCLABILITY
Working	5 - 15 heats	High purity Al_2O_3-C High purity MgO-C Alumina spinel	Wear Corrosion Spalling	Road-beds, lower purity refractories, slag conditioners
Safety	20 heats - 1 sequence	Bauxite Chamotte High Al_2O_3-SiO_2	Spalling Cracks propagation Shear	Repair material, cement, lime
Insulating	20 heats - 1 sequence	Vermiculite Silica fibers	Secondary phases Densification Carbon-pickup	Insulating systems, soil fertilizers

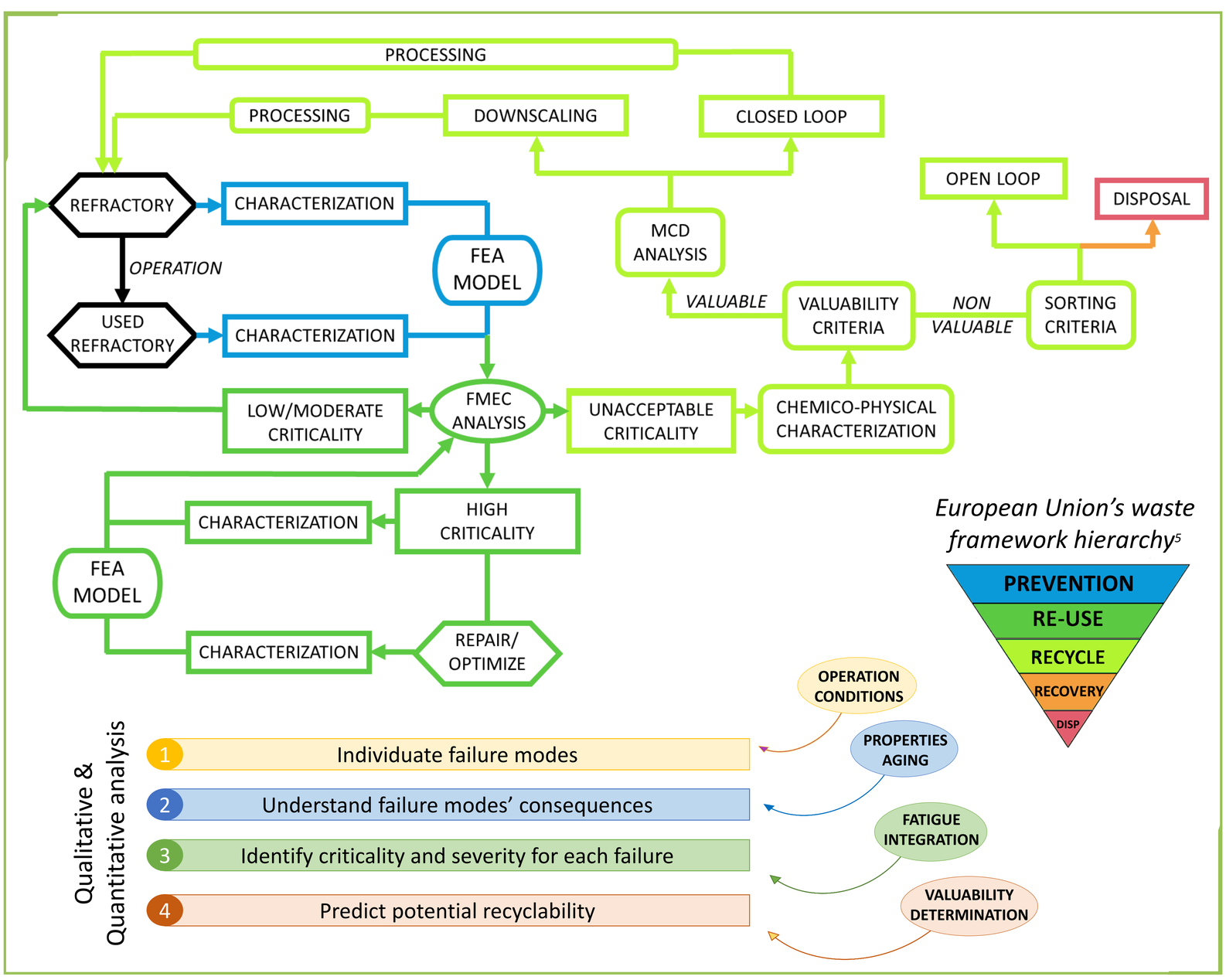


Vermiculite insulating boards thermal conductivity pre- and post-use[3]

MgO-based working line brick composition pre- and post-use[4]



Objectives:



European Union's waste framework hierarchy[5]

Perspectives:

This research considers the hierarchy:

- Prevention;
- Reuse;
- Recycling;

pivotal to achieve the sustainability and circularity targets requested from European Union, in particular in the steel production field.

The project will adapt the strategy here proposed to achieve the necessary goals. The research path can be divided in three key steps:

1. Post-mortem thermomechanical characterization associated to numerical simulations for failure prevention;
2. Adapted failure modes, effects, and criticality analysis with integrated aging of materials to enhance reuse;
3. Finally, multi criteria decision analysis to identify potential recyclability.

References:

[1]Kakroudi G., Huger M., Gault C., & Chotard, T., J Eur Ceram Soc 29, (2009)
[2]Robert Borgovini, Stephen Pemberton & Michael Rossi. Failure Mode, Effects and Criticality Analysis (FMECA). (1993)
[3]D. Vitiello et al., Open Ceramics 11 (2022) 100294
[4]C. Reynaert, PhD Thesis, AGH University
[5]European Parliament, C. of the E. U. Directive 2008/98/EC

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Beneficiaries