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Recycling physically sorted steelworks slag for the metallurgical and cement industries: conclusions of the ORLA research project

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The "ORLA" research project is attempting to evaluate the pathways and limitations of recycling steelworks slag through sequential physical sorting. The objective was to concentrate two distinct fractions; one comprising the iron-bearing slag for intra-steelworks recycling, and the other the calcium- and calc-silicate-bearing slag for cement-plant recycling. The main minerals associated with the slag —Fe, substituted wustite and calcium ferrite, free lime and magnesia, calcium silicates— were studied in particular with respect to:

- crystallite size in terms of the liberation mesh for sorting and the possibility of a size increase through cooling;
- the presence of free lime (even MgO) associated with the carbonation and hydration phenomena, as this penalises the tests themselves and potentially generates swelling in the relatively long term where the cement industry is concerned;
- evaluating the phosphorus content and speciation, mainly in calcium silicates, which primarily penalises the cement industry.

Batches of slag were prepared that were representative of a steelworks' annual production. The applied techniques showed the scrap to have a good grindability but a limited magnetic separation – the most effective method – due to the highly interlinked mineral phases and a ferric carrier liberation mesh often well below 100 µm. The dry and wet processes were assessed for their advantages and drawbacks in terms of recycling paths. Thermodynamic calculations and both laboratory and full-scale cooling tests have made it possible to determine the crystallisation sequences and the size limitations available for cooling. Cementitious formulas were developed for evaluating the cement-slag substitution capacities associated with current regulatory tests; the tests are encouraging. Ion incorporation [PO_4^{3-}] in the C3S- then C2S-type calcium silicate networks, which is dependent on the slag temperature, in fact pertains to distinct concentrations (application of standard tools – XRD, SEM-EDS, EMP: element mapping and WDS). More detailed studies, using XR µ-Fluorescence and P µ-Xanes on the slag and NMR of P and Si on synthetic samples, have indicated the presence of calcium phosphate microdomains. All the results have made it possible to validate realistic assumptions for recommending a life-cycle analysis of the two channels, thus confirming the interest of the approach in a scheme of CO_2-emission reduction and the use of secondary raw materials.