Recycling index determination for SRF co-processed in the cement industry

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The gradual replacement of fossil fuels with alternatives is ongoing in the cement industry. This is in pursuit of decarbonization objectives of the sector and in alignment with the respective roadmaps and EU circular economy principles. Solid recovered fuels (SRF) are already a large part of this transition and are expected to dominate the supply chain in the next years. Besides saving natural resources and costs, there are additional benefits in re-using secondary materials that would otherwise have to be landfilled, with the condition that they do not contain any hazardous components that would impair the emissions of the cement plant or the composition of the clinker (Schneider et al., 2011).

SRF is a quality-assured subgroup of refuse-derived fuel (RDF) exclusively produced from non-hazardous solid waste. During co-processing, SRF is used not only as a source of energy (energy recovery), but also to – simultaneously - replace natural mineral resources (material recycling) that comprise the cement clinker raw meal. This is technically feasible and sound, since the mineral part of SRF (i.e. its ash content) consists of oxides that are the same with the ones found in the raw materials used during clinker manufacturing (Aldrian et al. 2020). Therefore, the use of SRF plays a very important part in circular economy. Under this frame, the ISO/TC 300/Working Group 5, has undertaken the task of developing a standardized method for the determination of the recycled part of SRF, which would be relevant for the calculation of different recycling rates. It is expressed as the "Recycling index" of SRF.

The endeavor above is ongoing, and full ISO standard that will point out to a consistent calculation of the R-index, is expected to be published soon. In the work described herein, 65 SRF samples co-processed in Titan Kamari plant were investigated in terms of ash content, chemistry and ultimately their R-indices. Methodologies like ICP-MS and XRF both on the raw and ignited SRF sample were used and several expressions of the R-index were calculated, taking into account different contributing oxides found in the ash of SRF either by considering the four main chemical compounds, or additional oxides that are part of clinker phases and are introduced by raw materials.

The three formulas used are:

1st model: R-index 4=AC/100 $(W_{SiO2}+W_{CaO}+W_{Al2O3}+W_{Fe2O3})$

2nd model: R-index 9=AC/100 $(W_{SiO2}+W_{CaO}+W_{Al2O3}+W_{Fe2O3}+W_{MgO}+W_{TiO2}+W_{SO3}+W_{K2O}+W_{Na2O})$

3rd model: R-index =AC

where

AC is the ash content (wt % dry mass)

W oxide is the mass share of selected element oxides in the ash (wt % dry mass).

Figure 1 below summarizes the average SRF ash elemental composition. It may be seen that the main constituents of all analyzed SRF ashes are CaO, SiO_2, Al_2O_3, and Fe_2O_3, i.e. identical to the main 4 components required for conventional clinker phases, namely C3S, C2S, C3A and C4AF.

Analysis also revealed that SRF ashes on average, consist of 58.8 % of SiO_2, CaO, Al_2O_3, and Fe_2O_3 the four main chemical components that are considered as primary raw materials for the production of cement clinker.

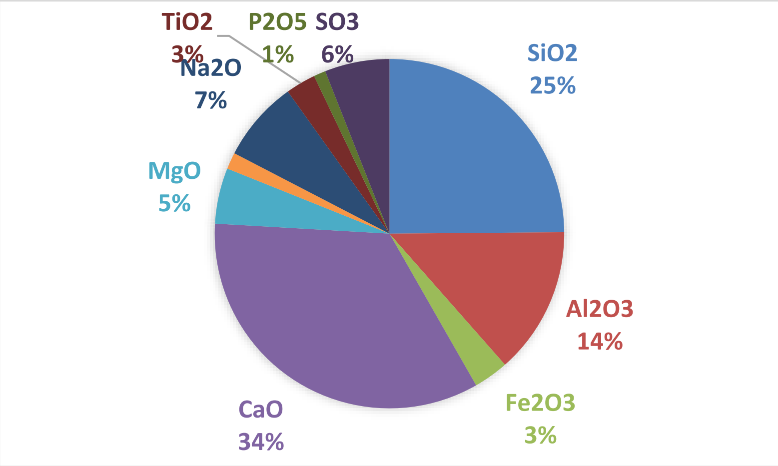

Figure 1 Average ash composition of SRF (65 samples analyzed)

Recycling index calculations

Table 1 summarizes the R-index calculated per SRF and formula used. Average values are presented herein per supplier for all 65 SRF analyzed.

Table 1 R-indices calculated per formula used in the case of different SRF suppliers.

Parameter/supplier	1	2	3	4	5	AVG
%R-index 4	7.91	12.08	11.04	11.01	13.96	11,20
%R-index 9	11.41	15.61	13.46	14.10	17.83	14,48
%AC	13.79	21.08	17.68	17.56	25.53	19,13
Average						14.94

It is evident that as the calculating formula includes more participating element oxides, Ri values increase for all SRF qualities. In particular, the R-indices calculated for the 65 SRF samples ranged from 7.9% to 14.0% when the four basic oxides were used (formula R4). The respective range using additional oxides like MgO and SO3 (formula R9) was found to be between 11.4% and 17.8%. Finally, considering the R-index equal to SRF ash content logically provides the greatest R-indices for all SRFs examined, with a range of 13.8% to 25.5%.

Conclusions

A combination of igniting SRF at 550ºC and then performing an XRF analysis on the collected ash, could provide a quick and credible chemistry profile for the majority of SRF available.

Recycling indices ranged significantly depending on the SRF characteristics (ash content and chemistry) and model applied, providing an average R-index of approx. 14.5%.

SRF inorganic part can credibly contribute not only towards reducing the cement industry dependency on extracted raw materials, but also in favour of its higher recycling footprint.

With ISO standard on R-index issuance, it is expected that producers, suppliers, end-users and competent authorities will have a reliable and consistent method for the determination of the recycled part of SRF.

References

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