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SYNTHESIS OF A HYDRAULIC BINDER FROM A Ca-Si BASED METALLURGICAL RESIDUE THROUGH HIGH TEMPERATURE POST-TREATMENT

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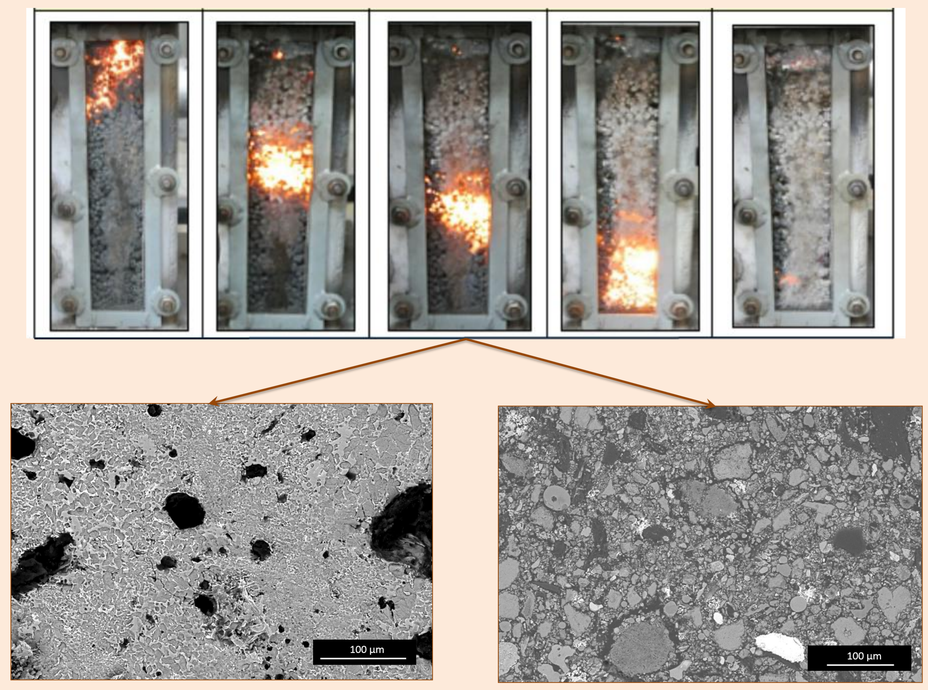
Abstract

This paper explores the possibility to convert a Ca-Si-rich metallurgical residue with approximately 20 wt.% amorphous carbon into a hydraulic binder. The challenge lies in developing an industrially-realistic process that exploits the potential of the residue. Two are the key elements in the strategy followed: adapt the Ca-Si-rich initial chemistry towards a “classical” ordinary Portland cement (OPC) clinker composition, while using the carbon of the mixture as a fuel to reach the desired temperature. In the first approach, the metallurgical residue (MR) was heated to 1350 ˚C without any additions and was subsequently air quenched. In the second approach, 37 wt.% of $CaCO_3$ was added, to resemble the chemistry of CEM I OPC. The modified MR was heated to 1450 ˚C and was air quenched. The resulting materials were characterized with respect to their chemical and mineralogical compositions. XRD analyses demonstrated that by only reheating the MR to 1350 ˚C, an increased formation of β-C_2S (belite) and C_2AS (gehlenite) was achieved. In the sample adapted with $CaCO_3$, additionally to the β-C_2S, the formation of the C_3S phase (hatrurite) was observed. These results demonstrated that MR could be transformed into a cementitious binder, while its reactivity can be improved by $CaCO_3$ addition. Upscaling experiment in a sinter pot showed that this process is a promising and realistic path for valorizing investigated MR.

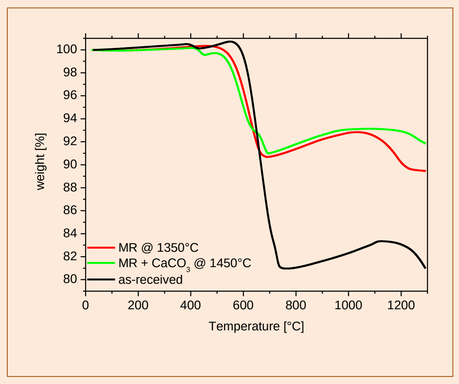
Results

Phase name	Formula	As-received	MR @ 1350 °C	MR + $CaCO_3$ @ 1450 °C	Sinter pot
Gehlenite	Ca_2AlSiO_7	11	36	4	-
Quartz	SiO_2	11	9	4	< 1
Portlandite	$Ca(OH)_2$	13	-	-	2
Belite	β- Ca_2SiO_4	12	35	20	25
C_2S – gamma	γ- Ca_2SiO_4	-	6	1	6
Lime	CaO	5	-	< 1	-
Hatrurite	Ca_3SiO_5	-	-	27	9
C_3A	Ca_3Al2O_6	-	2	8	3
C_4AF	$Ca_4Al_2Fe_2O_{10}$	-	< 1	5	12
Jasmundite	$Ca_{22}Si_8O_{36}S_2$	-	-	15	4
Calcite	CaCO3	< 1	3	6	25
Bredigite	$Ca_7MgSi_4O_{16}$	-	4	4	-
Phases < 2 wt%		TiO_2, Fe_3O_4, CA_2, $C_{12}A_{14}$, Fe	Fe_3O_4, CA, Fe	$C_{12}A_{14}$, Fe	-
Amorphous / undetected		40	< 1	3	13

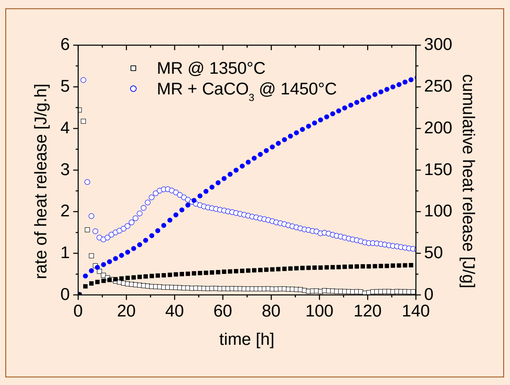
Upscaling experiment in a sinter pot



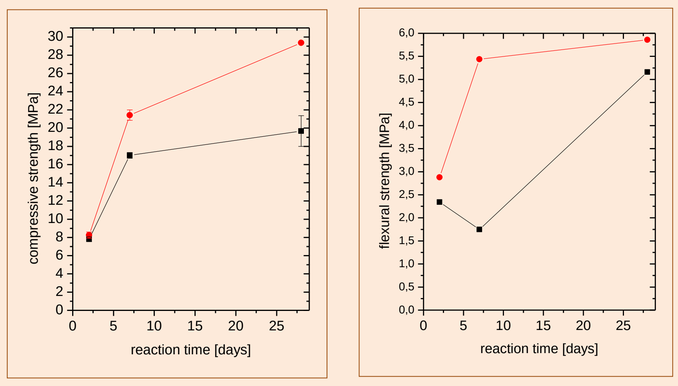
Thermogravimetric analysis



Isothermal calorimetry



Mechanical strength



Conclusions

It has been shown that MR can be converted into a hydraulic binder and its reactivity can be improved by doping with $CaCO_3$. A sinter pot experiment proved that the process can be upscaled, although some optimisation is needed. Still, the reactivity of this material is promising and the produced material can be used, already in its current stage, for certain applications, e.g. the production of paving tiles.

Acknowledgement

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