Mechanochemical activation of stainless steel slags

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Motivation

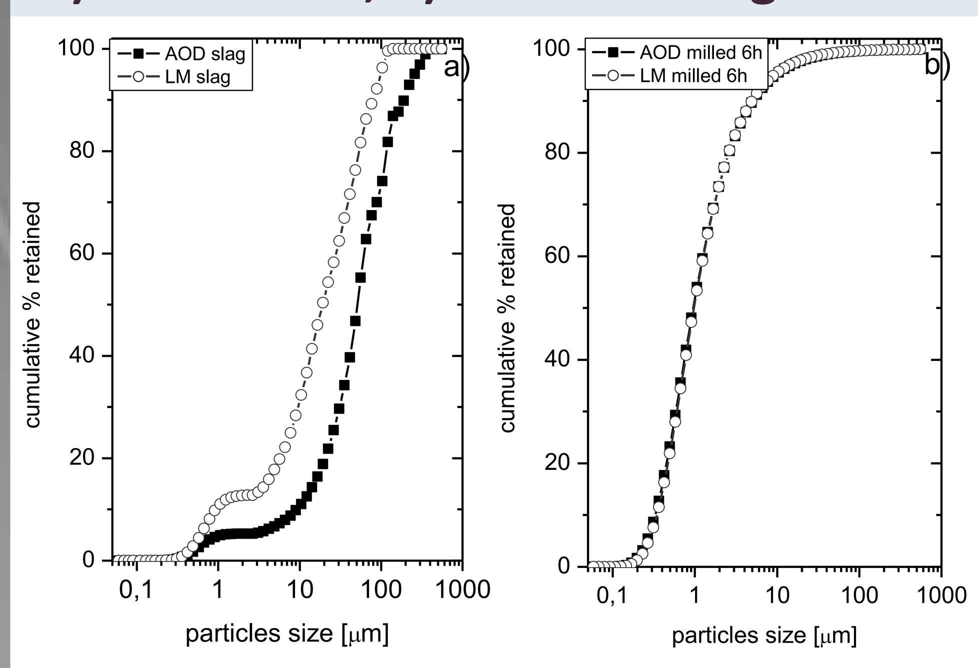
Both, ladle metallurgy (LM) and argon oxygen decarburization (AOD) stainless steel slags can self-pulverize during cooling. These slags consist of substantial amounts of γ-dicalcium silicate and merwinite and exhibit negligible hydraulic reactivity. As stainless steel slags contain around 50 wt% of CaO, a higher value application could be found rather than continue land filling these potential resources.
Mechanochemical activation has been a research topic on a variety of other materials such as granulated blast furnace slag, fly ash, quartz, periclase, etc. as a way to improve their reactivity. The aim of this work is to reveal if prolonged milling could also improve the hydraulic activity of stainless steel slags with high basicity (CaO/SiO_2).

Results

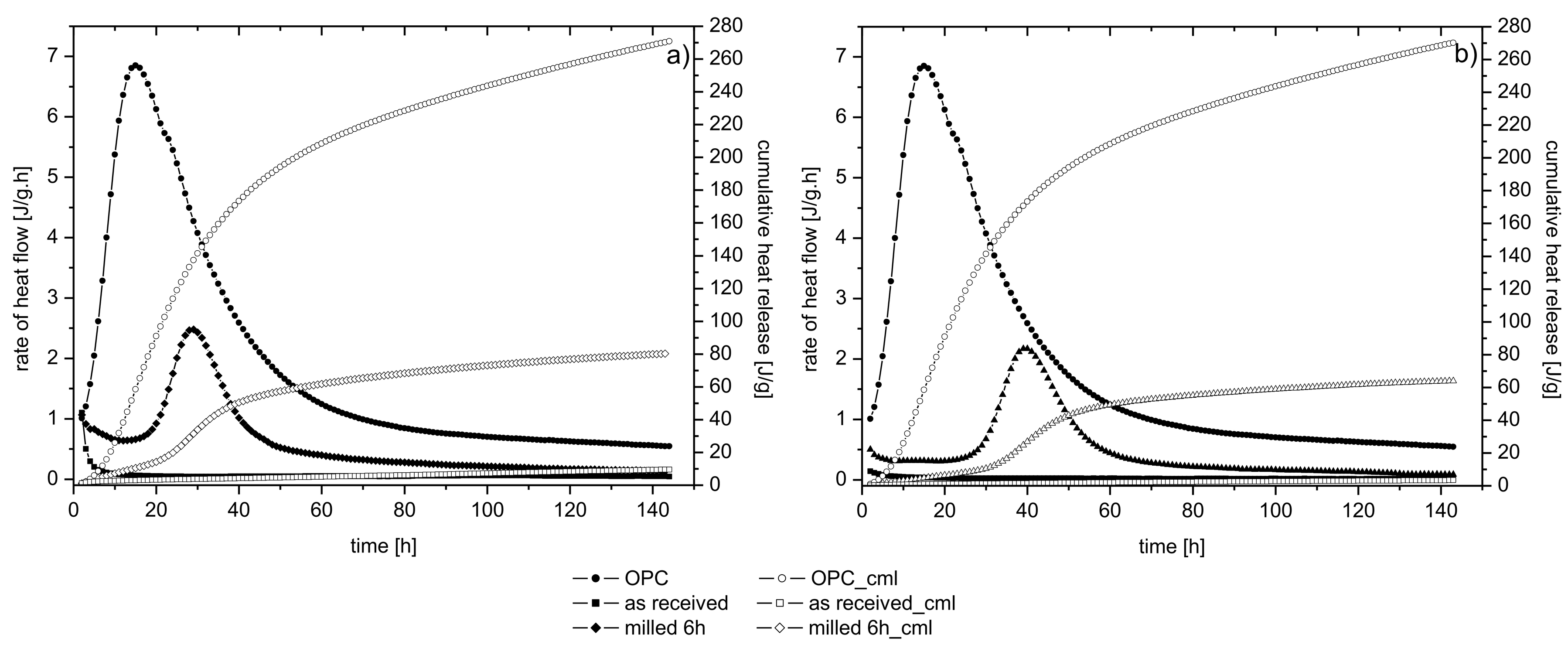
Component	AOD slag	LM slag
CaO	55.6	51.5
SiO_2	31.7	28.3
MgO	9.8	11.3
Al_2O_3	1.2	1.2
Cr_2O_3	0.3	3.9
others	1.4	3.8

Phase	Chemical formula	AOD wt.%	LM wt.%
γ – dicalcium silicate	γ – $(CaO)_2.SiO_2$	14.8±0.4	35.8±2.6
β – dicalcium silicate	β – $(CaO)_2.SiO_2$	b.d.l.	0.2±0.2
Merwinite	$Ca_3Mg(SiO_4)_2$	35.1±7.5	6.6±0.6
Bredigite	$Ca_{1.7}Mg_{0.3}SiO_4$	14.9±1.6	7.0±0.5
Wollastonite	$CaSiO_3$	3.7±0.4	2.0±0.1
Periclase	MgO	6.6±0.4	15.9±1.4
Cuspidine	$Ca_4Si_2F_2O_7$	0.81±0.5	10.2±1.0
Fluorite	CaF_2	3.5±0.4	1.6±0.1
Magnesiochromite	$MgCr_2O_4$	b.d.l.	3.2±0.3
Others/Amorphous		21.0±8.8	16.7±4.0

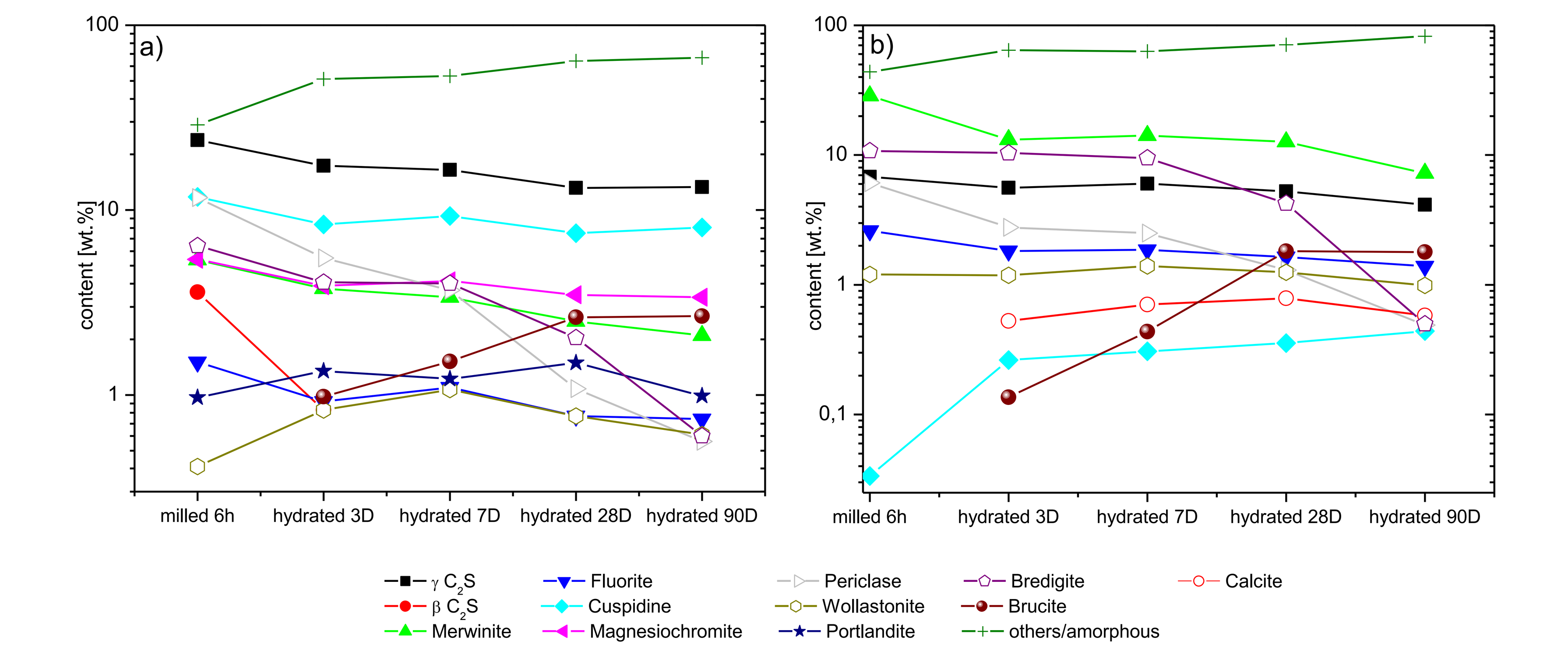
Particle size distribution a) as received, b) 6h milled slags



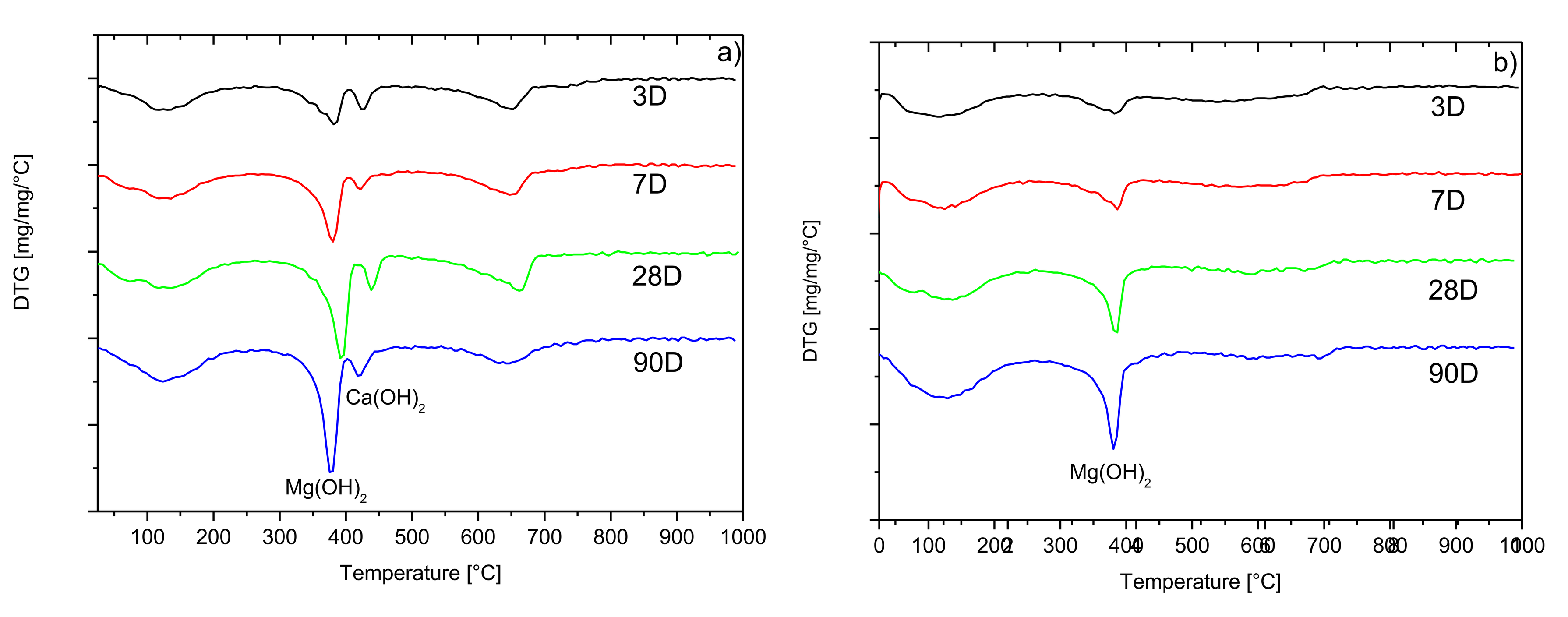
Calorimetry measurements a) LM slag, b) AOD slag



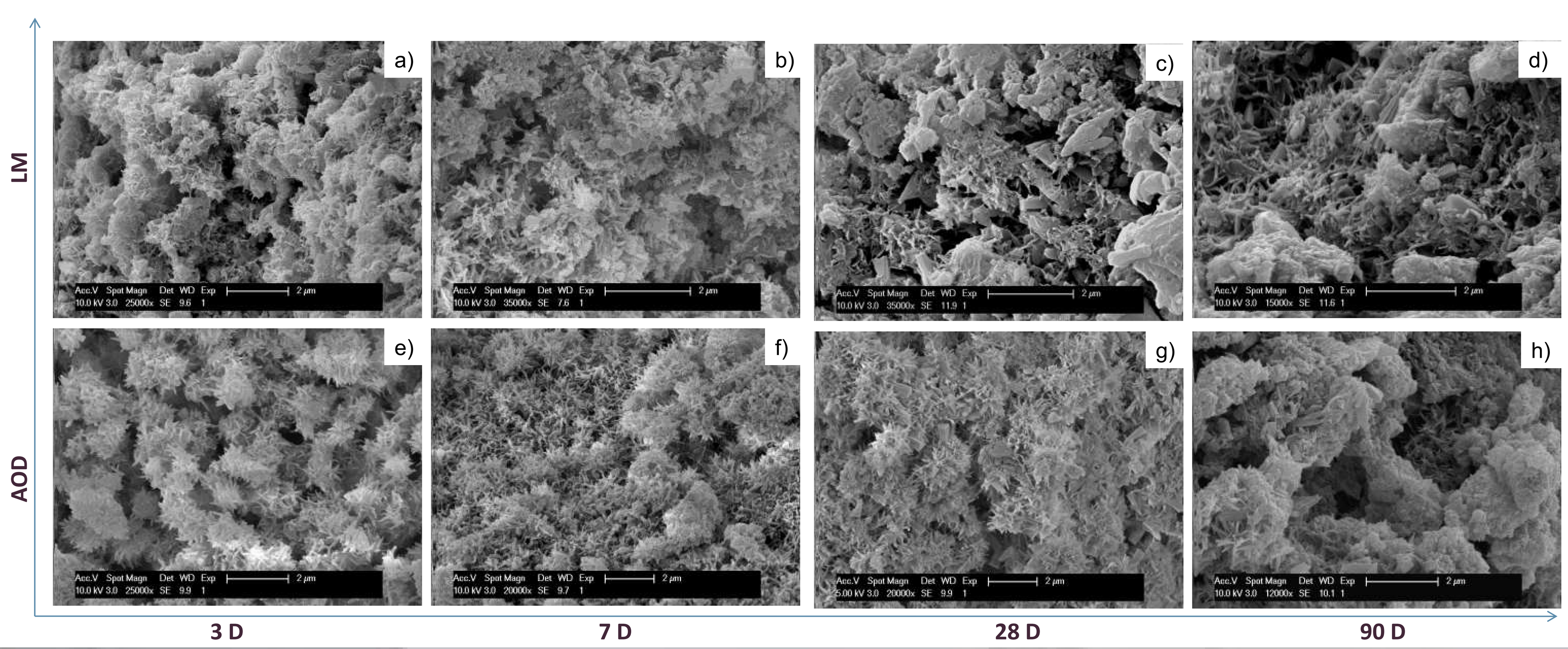
Change of present phase content a) LM slag, b) AOD slag



DTG a) LM slag, b) AOD slag



SE micrographs of LM a)-d) and AOD e)-h) slag



Conclusions

- ✓ The mechanochemical activation resulted in significant increase of surface area and increase of XRD- amorphous phase.
- ✓ Mechanochemically activated slags showed significantly higher reactivity when mixed with water.
- ✓ The amount of all present phases decreased and the amorphous portion increased with the hydration time.
- ✓ The morphology of the hydrated product consisted of fibers (AOD) and flakes (LM) which grew and connected to create more compact features.

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