

Possible effects of aluminium rich particles on the microstructure of Portland cement clinker

Matthias Böhm, VDZ gGmbH, Tannenstraße 2, 40476 Duesseldorf, Germany, matthias.boehm@vdz-online.de

Roland Pierkes, VDZ gGmbH, Tannenstraße 2, 40476 Duesseldorf, Germany, roland.pierkes@vdz-online.de

Aneta Knöpfelmacher, VDZ gGmbH, Tannenstraße 2, 40476 Duesseldorf, Germany, aneta.knoepfelmacher@vdz-online.de

Klaus Lipus, VDZ gGmbH, Tannenstraße 2, 40476 Duesseldorf, Germany, klaus.lipus@vdz-online.de

INTRODUCTION

The increasing use of alternative raw materials and fuels in the production process of Portland cement clinker allows a reduction in the consumption of natural raw materials and fossil fuels, thereby decreasing the exploitation of natural resources as well as the specific CO₂ emissions of cement. However, some alternative materials might have an impact on the clinkering reactions and thereby on the mineralogy and microstructure of Portland cement clinker. In this contribution a microstructural phenomenon is described that was observed in clinker samples from different rotary kilns in which refuse derived fuels (RDF) that contained coarse particles rich in aluminium were used at the main burner.

MICROSTRUCTURAL FEATURES

The clinker samples often contained pores that were surrounded concentrically by a thin layer of free lime, a thin layer of alite and finally a thicker layer of belite. Beyond this lay a regular, alite-rich clinker microstructure (Figure 1). In some cases, the structures were lacking individual rings or ring segments (free lime or free lime together with alite), but contact between belite and free lime was never observed (Figure 2). This shows that the structures cannot be attributed to the decomposition of alite during the cooling process.

INDICATIONS FOR REACTIONS DURING THE CLINKER BURNING PROCESS

The observations indicate that the underlying mechanism initially created a concentration of CaO towards the centre of the structure accompanied by depletion of CaO towards the outside. The accumulation of CaO in the centre led to the formation of free lime, while at the same time the CaO depletion on the outside led to the formation of belite. Only then did the belite-rich ring react with the inner CaO-rich

ring to form a ring of alite. The underlying mechanism also caused the formation of the pores.

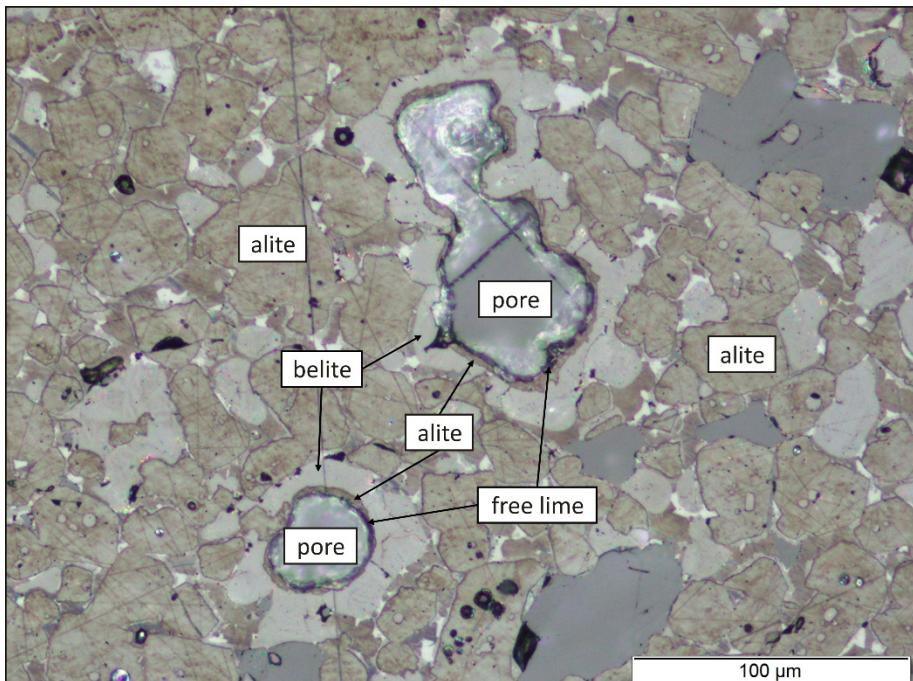


Figure 1: Two concentric structures of (from the inside out) pore, free lime, alite and belite, surrounded by a normal, alite-rich, microstructure.

The formation of layers of belite around pores was described earlier and could be attributed to local enrichments of an Al_2O_3 source [1]. Correspondingly all of the observations described above can be explained by the reaction of coarse aluminium-rich particles in the kiln charge. The locally enriched Al_2O_3 initially reacted, before reaching the sintering zone of the kiln, with the CaO from the surrounding kiln charge, which was thus depleted in CaO . Eventually Al_2O_3 and CaO formed calcium rich aluminates. The ring depleted in CaO remained as a belite ring in the clinker. In the sintering zone, the calcium aluminates contributed to the formation of clinker melt. Calcium rich aluminates involved in the formation of the melting phase melt incongruously, resulting in free lime remaining as a solid phase [2]. In the analysed clinkers, the incongruous melting caused the formation of free lime in the vicinity of the (former) aluminium-rich particle. This is how the ring of free lime was formed. The C_3A -rich melt moved into the surroundings, leaving behind the pore in the core of the observed structure. Finally the free lime ring partially reacted in the sintering zone with the belite ring, causing the alite ring to form between them. Complete

reaction between belite and free lime to form alite did not occur in the structures for kinetic reasons.

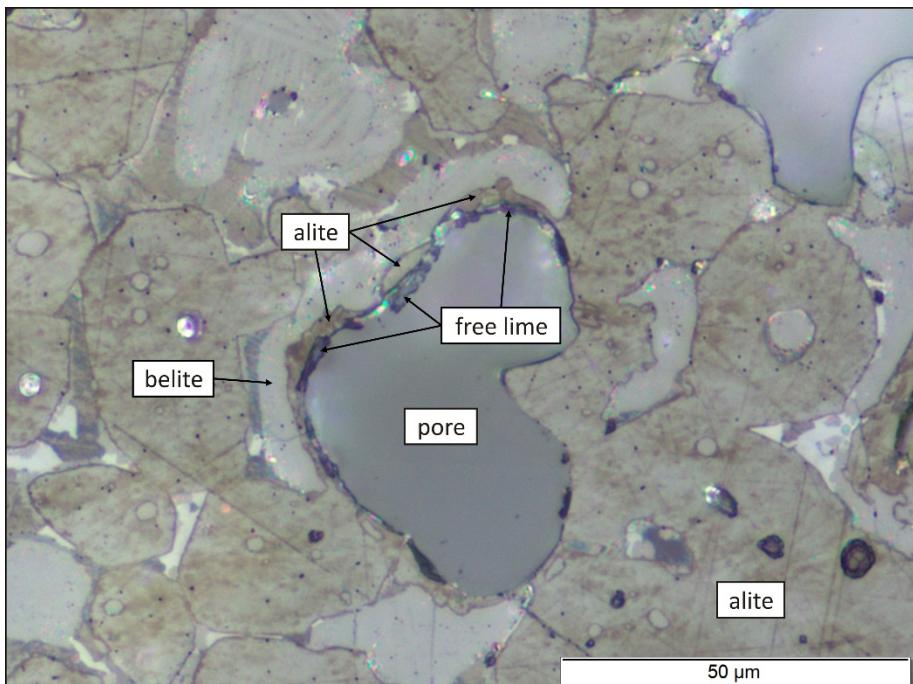


Figure 2: Concentric structure of (from the inside out) pore, free lime, alite and belite, surrounded by a normal, alite-rich, microstructure.

In all cases in which the described features were observed, the cement plants had used refuse derived fuels (RDF) that contained coarse particles rich in aluminium at the main burner. After burnout the corresponding ash particles left the flame towards the kiln inlet, fell onto the kiln charge, were embedded into the kiln charge and probably reacted with it in the way described above.

CONCLUSIONS

The observations show that the effects of certain fuels on the clinker properties can be investigated effectively with an optical microscope. It could be shown how coarse Al₂O₃-rich particles can lead to a minor increase in the contents of free lime and belite and correspondingly to a minor reduction in the alite content.

Such knowledge can essentially help cement producers to further increase the use of alternative materials in the clinker production process while at the same time keeping the quality level unchanged.

REFERENCES

- [1] Böhm, M. (2011). Evaluation of Portland cement clinker with optical microscopy – case studies II. Proceedings of the 13th Euroseminar on Microscopy Applied to Building Materials, Ljubljana, 14-18 June 2011
- [2] Taylor, H. F. W. (1997). Cement chemistry. 2nd edition, London, United Kingdom: Thomas Telford
- [3] Böhm, M., Knöpfelmacher, A., Pierkes, R. (2017). Alite decomposition vs. alite corrosion. Proceedings of the 16th Euroseminar on Microscopy Applied to Building Materials, Les Diablerets, 14-17 May 2017