Sustainable materialization of residues from thermal process into construction materials

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SMART-PRO²
Sustainable Materialization of Residues from Thermal Processes into Products

Objective

With the objective of developing novel construction materials through waste valorization, high temperature waste residues form industries mostly, steel making industries, are targeted. The aim is to improve the valorization of these residues into binders, building blocks or aggregates, identify the product requirements and process improvements to increase the application yield and quality and the reduction of energy requirements and carbon dioxide emissions in the production of construction materials. Possible non-structural materials which can act as carbon sinks shall also be explored.

Introduction

Solid residues (slag) and carbon dioxide are the two most important wastes generated from high temperature processes. On the other hand production of construction materials also release large amount of carbon dioxide into the atmosphere. Besides the slags for the steel production, especially stainless steel production, are either valorized in to low edit value materials like aggregates or not valorized at all. The steel slag can have binding potential due to the presence of high amount of calcium oxide. But mostly the minerals present in steel slag are non hydraulic. A three way approach is therefore applied, first attempts are made to activate the slags using alkalis and curing them at elevated temperatures, second carbonating the slags to develop suitable and required strength and third, processing the materials at hot stage to improve the properties of the resulting material.

Materials and Methods

Several types of residues are planned to be studied. It includes continuous casting slag, argon oxygen decarburizer slag (AOD), electric arc furnace slag (EAF), coming from the stainless steel production plant, basic oxygen furnace (BOF) slag coming from steel production, fayalite slags from copper production, fly ash from coal fired thermal power plants, bottom ash from incinerators, etc.

Various analytical techniques are used in order to understand the nature of the material and the end product. Quantitative phase analysis by X-ray diffraction (XRD) helps to understand the type and quantity of the minerals, X-ray fluorescence helps to know the type of elements in the material. Subsequently, isothermal induction calorimetry helps to investigate any possible binding reactions in the system. Actual strength analysis of the material is done by performing compression tests on the mortars prepared with the materials. Further, the hydrated phases are analyzed by thermogravimetric analysis and XRD.

Outcomes and intended applications

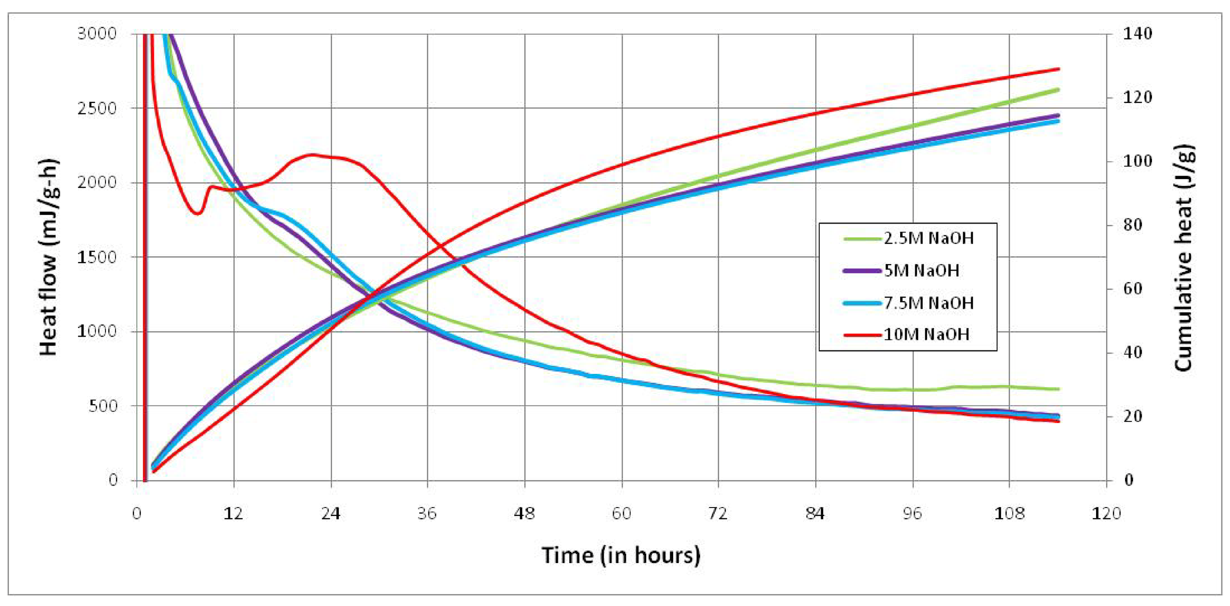

Fig 1 Calorimetry of CtCS_45* with NaOH at 80°C

Various applications intended form these high temperature residues are:

Building Blocks
Supplementary cementitious materials in blended cements
Raw materials for binder production
Non structural elements, such as thermal encapsulated CO_2
Carbon sinks

Current work with Continuous casting stainless steel slags (CtCS) shows that the material shows improved binding properties in the presence of alkalis and calorimetry results at 80°C show that 10M NaOH is most effective in terms of heat flow peaks and cumulative heat generation, although tests on steam cured mortars at 80°C show that best strength at all times is aceived with 7.5M NaOH.

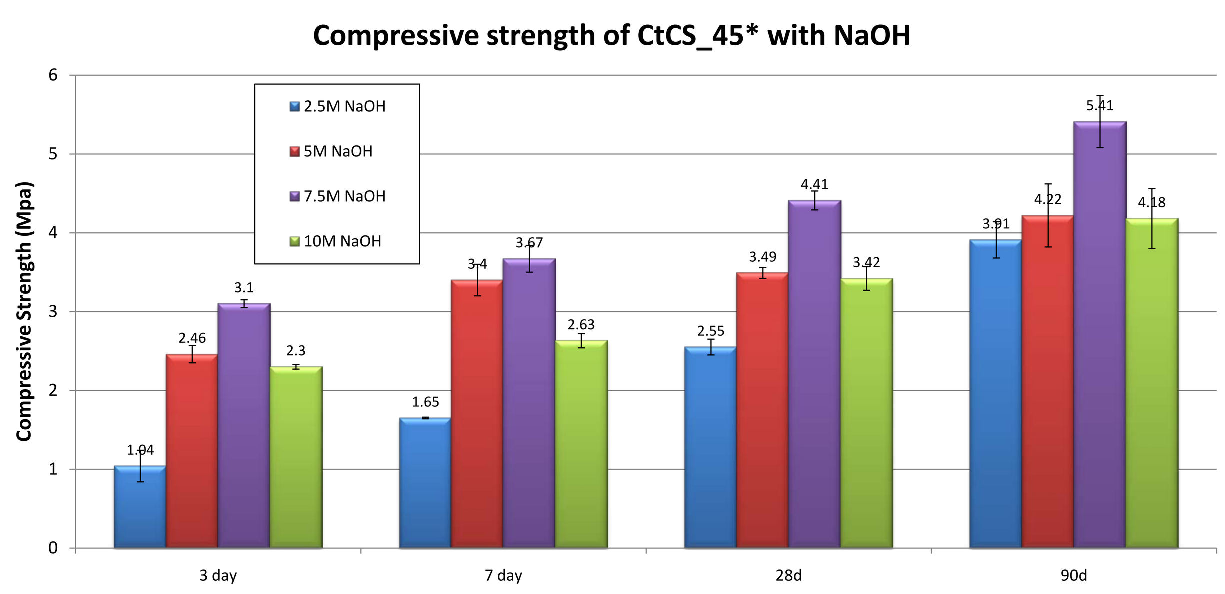

Fig 2 Compressive strength of slag mortars with different NaOH solutions

* CtCS_45 is the fraction of continuous casting slag lower than 45µm.

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