TOWARDS A LOW-CARBON ECONOMY: DEVELOPMENT OF NON-FIRED CERAMIC MATERIALS

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ABSTRACT

The European Commission is calling for a climate-neutral Europe by 2050. In fact, when the agreed legislation has been fully applied, it is estimated that the total reduction in greenhouse gas emissions will be about 45% in 2030 and 60% in 2050 (relative to 1990 values).

The project's main aim is to demonstrate the technical, economic, and environmental feasibility of manufacturing ceramics using a process that involves a considerable decrease in CO2 emissions in order to meet EU climate and environmental directives.

The process involved in obtaining these materials is conducted at ambient or relatively low temperatures (T<150 ºC). As starting materials, aluminosilicate waste and an alkali activator are used which, after mixing and undergoing a curing stage, give rise to a compact product with high mechanical strength.

The project focuses on the manufacture of these new products in countries from the south and north of Europe (specifically in Spain and Germany), in which the available wastes and construction requirements are quite different.

1. INTRODUCTION

On 28 November 2018, the European Commission presented its long-term strategic vision for a prosperous, modern, competitive, and climate-neutral economy up to 2050. The strategy sets out how Europe can lead the way to climatic neutrality by investing in realistic technological solutions, educating citizens, and harmonising actions in key fields such as industrial policy, financing, and research, concurrently assuring a social fair transition. As a result of the invitations formulated by the European Parliament and European Council, the European Commission's vision for a climate-neutral future encompasses practically all the European Union (EU) policies and is consistent with the Paris Agreement's aim of keeping global temperature warming below 2 °C and pursuing efforts to keep it at 1.5 °C [1],[2].

The EU is well on the way to meeting its targeted 20% emissions reduction by 2020 and is adopting legislation for its 2030 target. The most recent figures are as follows [1]:

- The EU reduced its emissions by 23% between 1990 and 2016, while the EU economy grew by 53% during the same period.
- EU emissions decreased by 0.7% in 2016, while Gross Domestic Product (GDP) increased by 1.9%.

The EU continues to participate actively in international climate policy and is adopting legislation to achieve an emissions reduction of at least 40–45% by 2030 (within its Framework on climate and energy for 2030 and in contribution to the Paris Agreement), and of 60% by 2050 (relative to 1990 values) [1],[2]. In view of the United States withdrawal from the Paris Agreement and with the responsibility entailed in being responsible for about 10% of global emissions, the EU has even become the leader in the fight against climate change and is considering modifying its objectives and ending all greenhouse gases emissions, in order to thus achieve climate neutrality in Europe by 2050; i.e. to attain 100% reduction in CO_2 emissions [3].

To do so, the European Commission is launching a series of calls and is funding proposals that contribute to achieving the targeted reduction in greenhouse gas emissions.

2. TOWARDS A LOW-CARBON ECONOMY. DEVELOPMENT OF WASTE-BASED NON-FIRED CONSTRUCTION MATERIALS (LIFE HYPOBRICK PROJECT)

The project's main aim is to demonstrate the feasibility of manufacturing ceramics based on the use of a new process called alkali activation. This process considerably reduces CO_2 emissions and seeks to meet EU climate and environmental directives, which include reducing the intensity of industrial greenhouse gases emissions.

Alkali activation is a process in which an aluminosilicate material is mixed with an alkali activator to yield a plastic mass that can set and harden in a short period of time. The resulting reaction product is a compact material with cementing properties and high mechanical strength. The alkali-activated materials develop as a result of the polymerisation of single tetrahedral units of silicon and aluminium. The chemical process entailed in forming these materials consists of a first step in which the raw materials are dissolved in the alkali solution to form inorganic monomers, and a second step involving monomer polycondensation to form oxide–polymer structures in three-dimensional lattices. Both steps occur at ambient or very low temperatures, so that an eco-efficient process is involved [4],[5].

Ceramic materials production processes vary as a function of the type of product, shaping method, and physical characteristics of the raw materials used.

Rustic tiles are usually manufactured by dry milling. The milled raw materials are then mixed with water and some additives, yielding a cohesive mass that can be readily moulded. The unglazed tiles are usually formed by extrusion and they represent a field of tiles characterised by a rustic decorative effect. Although extrusion is used for this type of ceramic product, the tiles can also be glazed, and both glazed and unglazed tiles are fabricated by single firing at temperatures above 1000 °C (Figure 1).

The main differences in the alkali-activation process (Figure 2), with respect to the traditional ceramic process (Figure 1), are the replacement of the firing stage with a low-temperature curing stage and the possibility of recycling a wide variety of industrial wastes instead of using raw materials.

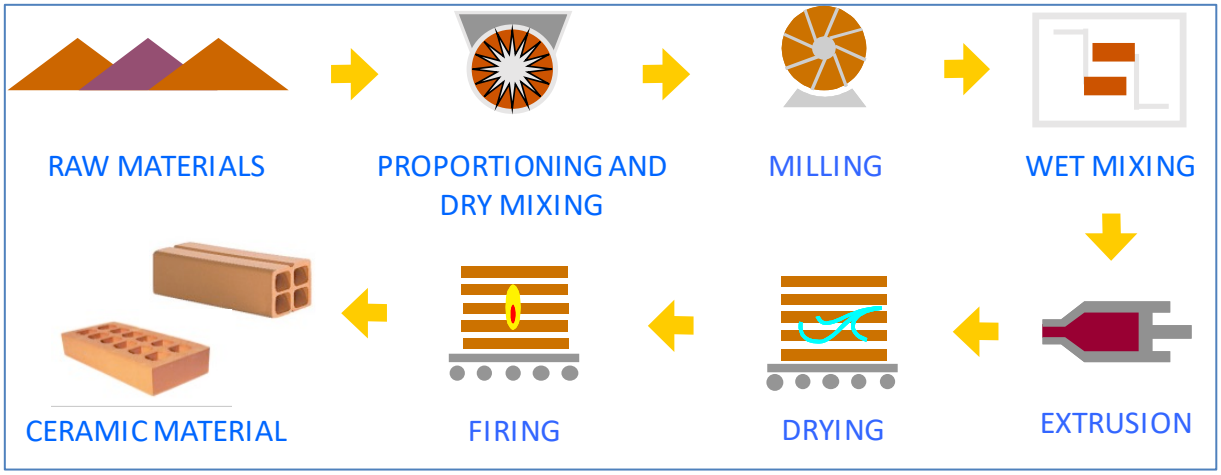

Figure 1. *Process of obtaining ceramic material by extrusion*

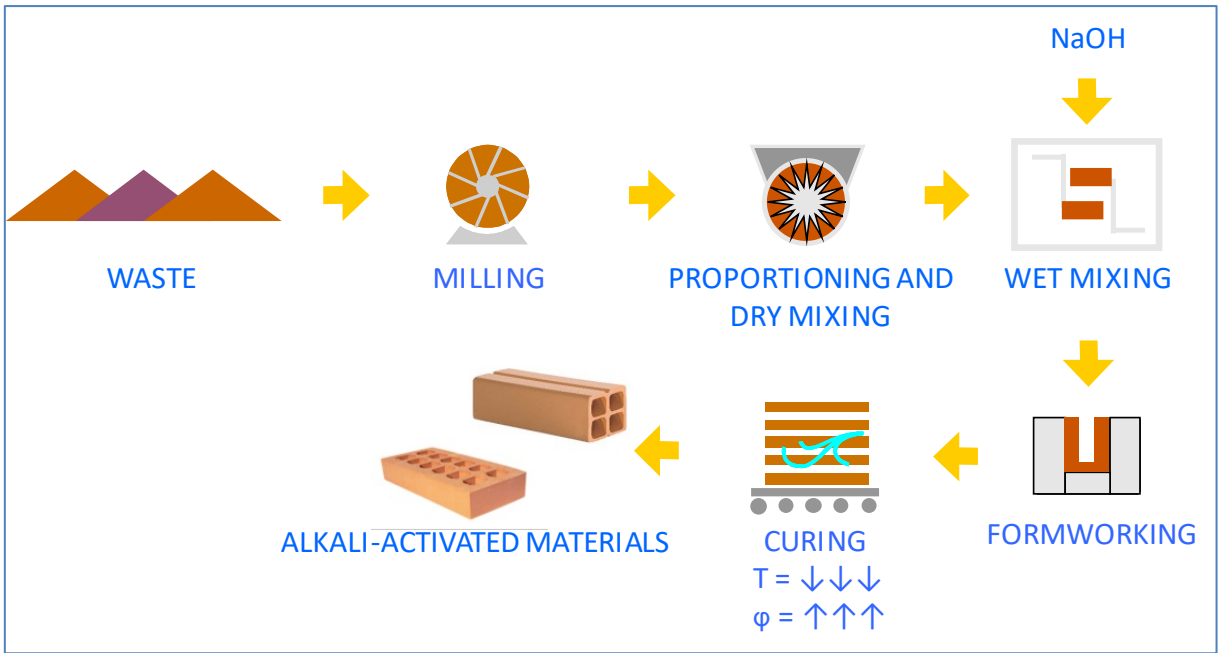

Figure 2. *Process of obtaining alkali-activated material*

In this project, besides lowering process temperature and thus reducing energy consumption and air emissions, alkali-activated materials are prepared using waste (and not primary aluminosilicate raw materials) [6],[7]. The project will therefore contribute to achieving the following EU policy targets [8]:

- Reducing and reusing the waste generated in the ceramic sector as well as in other industrial sectors. It will enable 100% reduction in primary aluminosilicate raw materials consumption.
- Maximising recycling. Recycling will increase of currently landfilled wastes, such as waste from the ceramic tile sector (fired tile scrap), fly ashes from

thermoelectric power stations, glass from cathode ray tubes, plastics from electrical and electronic equipment, and construction and demolition waste.

- Reducing carbon dioxide emissions. Greenhouse gases emissions will be reduced by more than 85%.
- Lowering energy consumption. Thermal energy (which accounts for 90% of all energy consumption in the process) will be decreased by over 85%.
- Reducing volatile compound emissions such as sulphur, fluorine, and chlorine emissions from ceramic raw materials. A 100% reduction will be involved, as the firing stage is fully suppressed.

The different climate conditions in the north (Germany) and south (Spain) of Europe have led to slightly different construction products and construction systems. These construction differences and the fact that the available wastes in these two countries are quite different are the main reasons for the project's good replicability and transnationality. The results will enable the trends in a significant number of European countries to be encompassed.

The implementation of the project in only a small percentage of European ceramics production (3.6 million tons) will contribute to environment protection and sustainable development: it will reduce thermal energy consumption by 7.5 million GJ and lower emissions by over 660,000 tons of CO_2. Further to be noted are the savings in natural raw materials, the recycling of currently landfilled wastes, and the reduction in particle, organic compound, and acid emissions.

3. CONCLUSIONS

The project's main aim is to demonstrate the technical, economic, environmental, and social feasibility of manufacturing waste-based ceramics using a process with low-level CO_2 emissions.

The ceramic sector belongs to the group of energy-intensive industries, an area targeted by the LIFE 2018 programme, which must therefore meet the EU climate and environmental directives to reduce the intensity of greenhouse gases emissions from the industrial sector.

4. REFERENCES

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5. ACKNOWLEDGEMENTS

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