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WITH THE CONTRIBUTION OF THE LIFE PROGRAMME OF THE EUROPEAN UNION LIFE19 CCM/IT/001243

Rapid Dry – Improving the ceramic production process step by step

The Rapid Dry project aims at reducing the environmental impacts and increasing the competitiveness of the European ceramic industry and its market share in the high-end segment, through the development of an innovative chamber dryer and new ceramic bodies, able to reduce costs, energy and raw materials consumption while preserving the final product quality.

1. The ceramic sector in Europe and the life Rapid Dry project

The ceramic sector includes products such as tiles, bricks, sanitaryware, tableware, technical ceramics, or vitreous clay pipes. The ceramic non-tiles production accounts for the **60-70%** of the entire ceramic manufacturing.

The **EU ceramics industry** is a world leader in the high-quality production of such ceramic products. EU ceramic manufacturers are mainly highly innovative small and medium-sized enterprises (SMEs), able to quickly react to new opportunities and to the market's demand. In the European Union, the ceramic sector provides **more than 300 thousand jobs** and accounts for about **EUR 27 billion** in production value.

The ceramic industry is part of the so-called **Energy-Intensive Industries** (EIIs), being characterized by high levels of electric and thermal energy consumption throughout its production line. The drying process is the ceramic manufacturing stage with the highest impact, accounting alone for more than 20% of the total thermal energy consumed. As a consequence, it is responsible for a significant amount of fossil fuels burnt, resulting in **CO2 and other greenhouse gases emissions** into air, water waste and land.

These impacts are mainly due to the long drying cycles, which require gradual rising temperatures up to 90°C in a range of time of 16-18 hours.

Considering these aspects, the ceramic manufacturing sector needs to develop new technologies to be able to achieve higher sustainability levels of ceramic production by 2030, and to further improve its performances by 2050.

This interests mainly the ceramic non-tiles production, such as pipes, sanitaryware and tableware, which accounts for 25-30% of CO2 emissions.

The Rapid Dry project aims to answer to the present situation, proposing a technology with a transformative effect on the sustainability of the European ceramic sector.

The project, whose complete name is "Rapid drying of ceramics reducing energy consumption and CO2 emissions while preserving product quality", is co-financed by the European Commission and has started in 2020.
The **objectives** it aims to achieve are:

- Building a prototype **chamber dryer** permitting the **reduction of** both **energy consumption** and **CO2 emissions**; in particular, the project expects to achieve a

reduction of thermal energy consumption by **34%** per kg of fired piece, a reduction of electric energy consumption by **21%** per kg of fired piece, and a total reduction of CO2 emissions by **39%** per kg of fired piece;

- Setting up rigorously **modified ceramic bodies** to optimise the drying curve though preserving excellent performances in quality and resistance; such new formulations are expected to reduce the drying cycle to **8-10 hours**;
- **Reducing** the consumption of **virgin raw materials** coming from national and foreign mines and quarries, by modifying ceramic bodies and introducing the use of recycled raw materials, among which the use of ceramic waste materials is included; the reduction is expected to be between 5 and 15%;
- **Increasing** the quantity of **ceramic waste materials recycled,** thanks to the use of the new bodies.

In addition, these features are expected to **reduce ceramic production costs**, therefore the accessibility of the technology for small and bigger producers and its high cost-efficiency (payback time 4-5 years in EU) will enable the entire sector to shift towards a **low-carbon and resource efficient economy**.

Sources:

- *European Commission: https://ec.europa.eu/growth/sectors/raw-materials/industries/non-metals/ceramics_en*
- *Life Rapid Dry Grant Agreement*

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2. Selection of materials and components for the construction of the dryer and selection of raw materials for the definition of slip formulations

The development of dryers for ceramic manufacturing requires that all plant units foreseen in the global design are subjected to thorough examinations. The selection of materials and components to be used for the dryer construction therefore has been the first objective to achieve, with relevant consequences on the success of the following phases.

The selection has been carried out by SETEC following some pre-identified criteria, like life-time, quality and functional parameters, price, energy saving potential and the associated reduction of CO2 emissions. Among the criteria used, also environmental ones have been included, in order to select materials and components allowing to ensure the desired

reduction of environmental impacts during the drying process.

Starting from an analysis of the materials and components existing in the market and of the best available techniques applied to dryers, SETEC has thus identified the best candidates to respond to the constructive requirements of the pilot dryer.

This assessment has been carried out for the following items:

- Insulating panels
- Burnes
- Fans
- Cones for air movement

Definition of new sanitaryware slips formulations

The second step ahead has been the selection of raw materials and the definition of the new optimal slip formulations.

Several raw materials available in the market have been analysed and subjected to extensive tests to assess their chemical and physical characteristics, in order to select the best candidates to meet the needs of the new formulations. Criteria used in the assessment have been the rupture modulus, dilatometric coefficients, crazing resistance and water absorption. The final choice has been based on quality/price criteria.

Moreover, lab trials have been carried out on a variety of formulations to select the ones with the best performances, since a compromise had to be found between the grain size distribution and the plasticity. Indeed, while the larger grains would make the final piece more fragile, the major plasticity should compensate this as to bring the slips back to the right characteristics to make the final piece justly resistant.

Some raw materials are commonly used in the ceramic district of Civita Castellana and therefore they have been used as the reference standard for their characteristics.

Tests on plastic raw materials include the following:

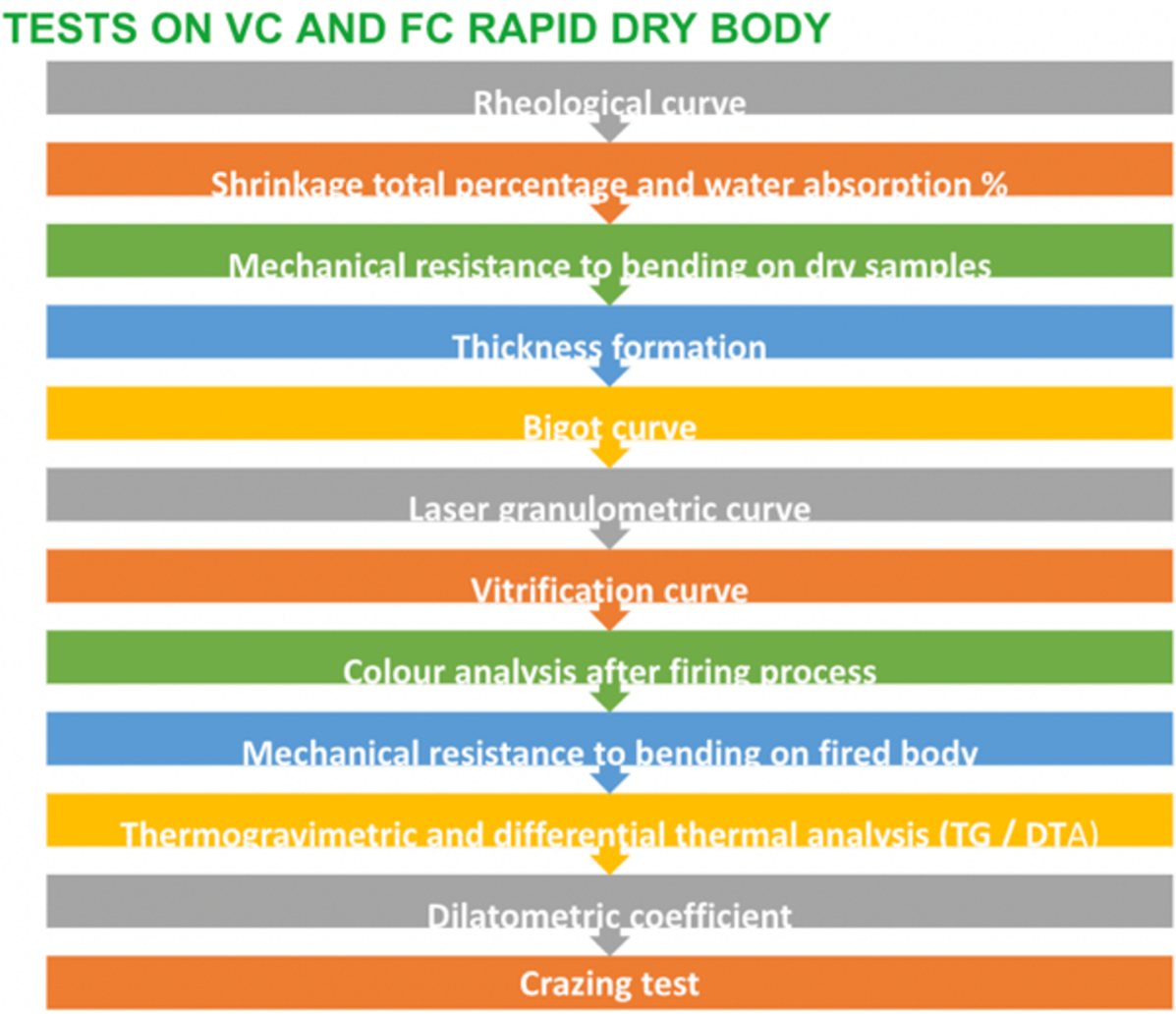
- Rheological curve
- Residue percentage on sieve
- Mechanical resistance to bending on dry body
- Thickness formation
- Bigot curve
- Laser granulometric curve
- Vitrification curve
- Colour analysis after firing process
- Mechanical resistance to bending on fired body
- Thermogravimetric and differential thermal analysis (TG / DTA):
- Shrinkage total percentage

Tests on "hard" raw materials include the following:

- Laser granulometric curve
- Dilatometric curve
- Chemical analysis
- Colour after firing

The test results obtained have been compared and evaluated. The best mixture that meets the desired characteristics for the final ceramic body has been further tested and its final chemical-physical characteristics have been evaluated.

This kind of assessments will be carried out also later in the project, analysing the ceramic bodies produced to make sure their characteristics meet the desired quality standard, and modifying formulations if they don't.



3. Dryer design phase - completed

SETEC has completed the design phase of a new ceramic dryer prototype, ensuring a result able to minimize energy consumption, optimize performance and guarantee the safety of the system.

Among the most innovative aspects of the dryer there are two softwares, one employed during the design phase, the other actively involved in the dryer functioning:

- In the design phase, an advanced calculation software programme has allowed to model the prototype through a series of 3D simulations. This modelling approach enabled SETEC to get the optimal design and assembly, within the functioning of the selected materials and prototype cost boundaries;
- In the dryer prototype, the PLC software (Programmable Logic Controller) allows control of all the major functions of the dryer, including air movement through cones and air recirculation.

Automation has been designed specifically and works through a switchboard that provides and guarantees the correct behaviour of the operative parameters. Parameters are pre-

entered for the automatic adjustment of temperature in the various zones of the dryer.

Ultimately, the estimation of the air movement and air recirculation and the possibility to regulate them allows the extreme flexibility and elasticity in dealing with the heat cycle, which can be adapted to the products characteristics.
Following the completion of the design, the technical staff will be in charge of purchasing the materials and components necessary to start the construction phase.

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