Layman’s report
Project information

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WITH THE COLLABORATION OF GENERALITAT VALENCIANA THROUGH IVACE

Project coordinator

Project partners
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ENIRONMENTAL ISSUES

The environmental problem addressed in this project is the management of sands and dusts discarded in the iron foundry industry, coming from both green molding and chemical molding foundry processes, which currently represent around 300,000 tons per year in Spain.

Although there are several valorization alternatives, which have been demonstrated and can be applied to different foundry by-products fractions as well as the efforts of the foundry industry to maximize the valorization of these by-products, the real situation is that more than 50% of these by-products are currently deposited in landfills.

On the other hand, the sector of ceramic tile production consumes large quantities of raw materials, especially sands and clays, which could be partially replaced by these by-products.
The LIFE+ FOUNDRYTILE project has a double effect. On the one hand, the management of the foundry by-products is improved and, on the other hand, the environmental impact caused by extractive activities in quarries (Directive 2006/21/EC and related) as well as the preparation of sands is reduced. Consequently, the solution proposed in this project, clearly promotes the concept of circular economy, key to sustainable development, since it reinforces the industrial symbiosis between companies from the foundry and the ceramic sector, as it is shown on the flow chart of Figure 1.

The opportunity of the application is based on the mineralogical composition and the quantities generated of these by-products since they can partially replace clays and sands used in the ceramic tiles production. According to the economic activity of both sectors, in the case of Spain, with a substitution degree of 5%, the production of tiles could absorb all by-products, both sands and dusts, reaching a 75% recovery at European level.

Figure 1.
Flow chart for the approach of Industrial Symbiosis strategies
The FOUNDRYTILE project has demonstrated the technical, economic and environmental feasibility of the valorization of iron foundry sands and dusts in the ceramic tile production process. The innovative character is provided by the utilization of green and chemically bonded foundry sands and dusts in the production of ceramic tiles replacing natural raw materials, red clay (for red-firing ceramic products) and white clays (for ceramic white cooking products). Consequently, the project contributes to the implementation of the European Waste Directive (Directive 2008/98/EC) and the objectives and goals of the Roadmap towards an efficient use of resources in Europe.
THE NEW APPLICATIONS WILL HAVE THE FOLLOWING MAIN BENEFITS:

1. Preservation of natural resources.
2. Increase of foundry waste valorization.
3. Environmental footprint reduction.
4. Increase in the competitiveness of companies from the foundry and ceramic sectors.
In the project, 23 samples of sands and dusts have been characterized to obtain a representative sample at national level. The results obtained in the characterization show that the carbon and the organic compounds present in the by-products are the most critical aspects for their valorization as raw materials for the production of ceramic tiles since they generate the defect called "black heart" in the ceramic pieces. For this reason, different pre-treatments have been tested for the conditioning of foundry by-products in order to increase their percentage of substitution. As shown in the following figure, the thermal treatments are valid for the elimination of coal and organic compounds, thus allowing to increase the percentage of valorization.

Figure 2.
"Black heart" formation of a ceramic composition (STD) and samples obtained by adding 5% of treated (S-T) and untreated (S) by-products.

Representative compositions of different types of ceramic tiles have been prepared and characterized. In the case of unprocessed foundry by-products it has been possible to introduce up to 2,2% of by-products in ceramic tiles composition.

For foundry by-products which have been thermally pre-treated, the percentages of substitution can be increased up to 5%. These compositions have been prepared and initially characterized on a laboratory scale and subsequently on a pilot scale.
Before the industrial tests, prototypes of the different types of ceramic tiles have been obtained. These prototypes have been prepared by reproducing the manufacturing process of ceramic tiles at a pilot scale.

These tests have allowed obtaining prototypes of the different types of ceramic tiles with 2.2% of a mixture of by-products (except in porcelain stoneware tiles in which this percentage has been 1% to avoid an excessive tendency to the formation of black core).

Figure 3.
Manufacturing process of ceramic tiles.
Finally, industrial tests have been carried out with the two types of ceramic supports (white wall tile and porcelain tile) manufactured by EUROATOMIZADO, the partner in charge of industrial testing. 20 tons of each of the two types of product have been produced, adding the by-products and without them. As in the pilot tests, 2,2% of foundry by-products have been added to the wall tile composition and 1% to the porcelain tile composition. The compositions have been prepared in EUROATOMIZADO and 800 m2 of each product have been obtained in a ceramic tile manufacturing company located in the province of Castellón, the core of the Spanish ceramic cluster. To obtain flawless pieces (especially the one already mentioned, black core), it has been necessary to increase the duration of the firing cycle by approximately 15% in wall tiles and porcelain tiles compared to tiles without by-products.
On the industrial tests, the emissions produced during firing processes have been analyzed, and it has been proven that the introduction of foundry by-products does not produce significant changes on the emissions of particles or gases with respect to tiles without by-products.

On the other hand, the tiles produced exceed the technical requirements set by the European ceramic tile regulations.
Database with the characteristics of foundry by-products and acceptability criteria for ceramic products.

Characterization of 23 representative samples of 20 types of foundry sands and dusts from 10 foundries.

Evaluation of different technologies to adequate by-products by reducing their iron and organic carbon content. It is demonstrated that the magnetic separation and the thermal treatment allow increasing the substitution ratio of by-products from 2.2 to 5%.

Formulation and characterization of ceramic tile compositions of different types with percentages of by-products comprised between 1 and 5%.

Validation on a pilot scale of the 4 main types of ceramic compositions with percentages of by-products of 2.2% (for three of the types) and 1% (for the type of tile with the highest purity requirements in raw materials).

Production of 20 tons of atomized powder for both red tiles and porcelain tiles with by-products and manufacture of approximately 800 m² of tiles for each product in a ceramic tile manufacturing company located in the province of Castellón, the core of the Spanish ceramic cluster.

Verification of the absence of impact on gaseous emissions associated with the firing of ceramic tiles due to the introduction of by-products.
Through the Life Cycle Analysis (LCA) methodology, it has been demonstrated that the proposed by-product valorization involves environmental benefits for all the evaluated products, confirming its viability as a circular economy strategy.

In the Cost Cycle Analysis (LCC), it has been validated that the valorization of foundry by-products allows a cost reduction in both sectors involved, mainly due to the reduction of raw materials consumption in the ceramic sector and to the reduction of waste management costs in foundry industry.

The Chemical Risk Analysis for human health has shown that the use and manufacture of tiles incorporating foundry by-products does not result in an unacceptable additional risk to human health.

Participation of more than 300 agents of the ceramic sector and foundry companies in the project.

Dissemination of the importance of the use of by-products and promotion of their acceptance by society.

Dissemination of project experiences to companies and / or entities at European level.
IMPACT OF THE PROJECT FOR SOCIETY LONG-TERM

- Contribution to the establishment of industrial symbiosis strategies focused on promoting the circular economy, transforming a waste (sand and fine fraction of foundry sands) into a resource for another sector.
- Valorization of about 260,000 tons per year of foundry by-products in the ceramic sector at national level with the consequent decrease of by-products deposited in landfills.
- Reduction of the environmental impact in the production process of ceramic tiles. FOUNDRYTILE provides environmental advantages over conventional production for a maximum transport distance of by-products between 875 and 1,025 km (depending on the type of evaluated products), taking into account CO₂ emissions. This fact guarantees the environmental viability of the FOUNDRYTILE solution at a European level.
- Reduction of the carbon footprint throughout the life cycle of ceramic tiles, saving up to 8,500 tons of CO₂ per year at national sectorial level.
- Reduction of the extraction of natural raw materials from quarries with the consequent preservation of natural resources.
- Reduction of the cost derived from the management of foundry by-products.
- Reduction of the manufacturing costs of ceramic tiles by replacing conventional raw materials by foundry by-products.
- Improvement of the competitiveness of ceramic companies by reducing the costs associated with raw materials.
- Increase the knowledge and training of workers in the ceramic and foundry sector in the field of circular economy.
- The results of the FOUNDRYTILE will be a reference at European level through the documents of best available techniques (BREF documents), both from the ceramic sector and from the foundry sector.

SOME NUMBERS

Saving up to 8,500 tons of CO₂ per year

Substitution of 2% of raw material by by-products foundry
The FOUNDRYTILE project has carried out a large number of varied dissemination activities, with the aim of disseminating the results of the project to interest groups: foundry companies, companies from the ceramic sector, experts, scientists, technology developers and environmental authorities, among others.