TECHNOLOGICAL ADAPTATION OF THE CERAMIC INDUSTRY TO THE 2050 LOW-CARBON HORIZON

S. Ferrer(1), A. Mezquita(1), E. Monfort(1), E H. Jouhara (2)

(1) Instituto de Tecnología Cerámica (ITC). Asociación de Investigación de las Industrias Cerámicas (AICE). Universitat Jaume I. Castellón. España.

(2) Econotherm UK Ltd, Bridgend, U.K.

1. ABSTRACT

The reduction in industrial greenhouse gas emissions is a high-priority area targeted by emissions abatement policies and strategies owing to their extensive contribution to global warming, by both direct and indirect emissions. In the ceramic sector, achieving the almost 90% emissions reduction target in 2050 will require combining endogenous and exogenous technologies, which will demand radical changes in product design, modifications of processes and technologies, and changes in available energy sources.

This presentation sets out the results obtained during the performance of several projects aimed at increasing energy efficiency in the ceramic tile production process and in the study of the new technological horizon facing the ceramic sector.

The results of these projects have yielded a baseline that serves as a starting point for prospective analysis, within the ceramic tile manufacturing process, towards an energy transition that will necessarily include the use of new production facilities no longer wholly based on fossil energy sources, as well as the incorporation of renewable energies into the manufacturing process.

2. INTRODUCTION

Greenhouse gas (GHG) emissions, which include carbon dioxide (CO_2), are being monitored and controlled internationally, given their relationship with the planet's global warming and hence with Climate Change[1].

The European Union is currently leading international policy in this field and aims to reduce its CO_2 emissions by 40% in 2030[2], relative to those of 1990, as temporary goal on the way to full decarbonisation of the European economy in 2050[3].

GHG emissions come from all fields of society, because all sectors of activity contribute to global emissions. Industrial sectors account for 8.8% of emissions in Europe[4], given the widespread use of fossil fuels in their production processes, and they are being urged to reduce their emissions very significantly by 2050. The emissions reduction target for the industrial sector to which the ceramic sector belongs lies at 34–40% by 2030, and 83–87% by 2050[5].

On the way towards a global low-carbon economy, the European Commission is urging each industrial sector to draw up its own roadmap that takes into account the singularities of each industrial activity.

The European Ceramic Industry Association (Cerame-Unie), which jointly represents the nine ceramic subsectors, published its document in 2012[6]. The emissions of the ceramic sector mainly come from natural gas combustion. The ceramic sector roadmap sets out the most mature technologies with emissions reduction potential, as well as those that have not yet been sufficiently developed for widespread implementation in the industry, despite their potential CO_2 emissions reducing ability.

This study describes some of the efforts made by the ceramic tile industry, through various research projects, to increase its energy efficiency, as well as the technological horizon the tile industry faces on its way towards a drastic reduction of its direct CO_2 emissions.

[1] Paris Agreement. UN Framework Convention on Climate Change. December 2015.

[2] COM/2014/015 final. A policy framework for climate and energy in the period from 2020 to 2030

[3] COM(2018) 773 final. A Clean Planet for all. A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy.

[4] Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019. European Environment Agency (May 2019).

[5] COM(2011) 112 final. A Roadmap for moving to a competitive low carbon economy in 2050.

[6] Paving the way to 2050. The ceramic industry roadmap. Cerame-Unie, 2012.

3. CURRENT SCENARIO 2015–2020

The most mature and most widely implemented technologies are those aimed at recovering waste heat. Firing processes for ceramics require high temperatures, and the kilns in which high-temperature thermal treatments are carried out have a waste heat output in the form of hot gases that can be reused in the manufacturing process, thus reducing total fossil fuel consumption.

Traditionally, waste heat recovery technologies have been based on heat exchangers, using air or thermal oil as heat-transfer fluid. However, a new heat exchange technology based on phase changes in a thermal fluid (Heat Pipe Heat Exchanger, HPHE) is being developed, with applications in various industrial sectors, including the ceramic sector. Several European projects include demonstrators of this technology applied to the ceramic sector, such as the SMARTREC[7] and DREAM[8] projects. Both are funded by the European Commission under the Horizon 2020 programme.

The SMARTREC project (Developing a standard modularised solution for flexible and adaptative integration of heat recovery and thermal storage capable of recovery and management of waste heat), includes installation of a heat recovery system based on phase change in a thermal fluid (HPHE), implemented in the gas exhaust stack of a ceramic tile firing pilot kiln. The installed heat recuperator has a maximum heat recovery power of 65 kW and, in the analysed pilot case, heat is recovered in a hot water stream.

The system was tested under different operating conditions, varying the input hot gas temperature and flow rate, as well as the heated fluid output flow rate. The resulting efficiencies, calculated as recovered heat relative to input total heat, lay between 45 and 65%, depending on operating conditions.

To be noted was the rapid response of the facility in the face of changes in any work variable, as well as the system's ease of operation. It may further be noted that in the tested facility, under the analysed operating conditions, kiln operation was unaffected by the start-up or stoppage of the heat recovery system.

In an industrial facility, the heat-recovering fluid may be water, air, or thermal oil. If water is heated, its main use will be as sanitary hot water, because hot water is not needed in the industrial process. However, the ceramic sector does not usually recover heat in hot water, since company demand is very small compared to the amount of water that would be generated.

If the heated fluid is ambient air or thermal oil, the heat can be recovered in the drying facilities, thus reducing natural gas consumption in the dryers, and hence avoiding the CO_2 emissions relating to natural gas combustion.

The DREAM project (Design for resource and energy efficiency in ceramic kilns) has implemented several technological solutions to improve energy efficiency in ceramic tile firing kilns. One such solution consists of heat recovery from the kiln cooling zone, based on using HPHE. In this case, a heat recuperator has been installed in an industrial kiln and it uses the heat of the gases exiting the kiln cooling stack to heat the ambient air used as preheated combustion air at the kiln burners. The heat recuperator, based on phase change in a thermal fluid (HPHE), recovers up to 100 kW heat, yielding natural

[7] http://smartrec.eu/

[8] https://www.spire2030.eu/dream

gas savings and related decrease in CO_2 emissions. The facility's payback time was estimated at about 15 months.

4. 2020–2050 VISION

The ceramic tile manufacturing sector is part of the industrial sector, one of sectors with the highest energy consumption in the Valencia Region, only surpassed by the transportation sector.[9]

In 2018, ceramic tile production[10] was 530 million m^2. Energy consumption in this industrial sector rose to 14767 GWh in 2018, electricity consumption accounting for 8.4% and natural gas consumption accounting for the remaining 91.6% hereof in the manufacturing process. Total carbon dioxide emissions in that year were 2.7 million tonnes of CO_2, of which 10% were process emissions and 90% emissions from natural gas combustion.

Analysing the sectoral evolution of energy consumptions and CO_2 emissions in the decade 2008–2018, the specific consumption of electric power (kWh/m^2) decreased slightly by 2.5%, specific natural gas consumption (kWh/m^2) fell by 11.2%, and specific emissions of CO_2 (kg CO_2/m^2) diminished by 11.3%.

The results reflect the adaptation of the industrial ceramic sector to an increasingly competitive and restrictive setting in regard to CO_2 emissions. Thus, the gradual adaptation to the industry 4.0 environment and increased process automation and control, both being processes that require greater electricity consumption, have led the sector's electricity consumption to decrease very little, despite growing efforts to raise energy efficiency in the highest energy-consuming equipment and facilities.

As regards natural gas consumption and the resulting CO_2 emissions, in the last decade, both factors decreased by over 11%, which reflects the great effort made by the sector to reduce its natural gas consumption and increase the efficiency of its facilities. Among the energy saving actions carried out in production plants, to be noted has been the implementation of heat recovery facilities and the installation of more efficient burners, as well as greater control and monitoring of the process variables that most affect natural gas consumption, in both dryers and kilns.

However, given the maturity of the technology used, great reductions in gas consumption and, hence, in CO_2 emissions are not to be expected in the next few years, unless important technological changes emerge. It should be borne in mind that, in spite of all the efforts made, the sector as a whole has a CO_2 emissions deficit and therefore bears additional costs on emissions exceeding the allocated quotas.

In view of the low-carbon horizon set by the European Union, the industrial sectors need to begin to seek alternatives to the current process that will, as principal impact, drastically reduce CO_2 emissions. However, this needs to be done without jeopardising the volume or quality of the ceramic products made. Such alternatives include the implementation of CO_2-capturing technologies and electrification of dryers and kilns accompanied by implementation of own power generation systems, among others.

[9] Energy data of the Valencia Region 2015. Generalitat Valenciana. Ivace Energía.

[10] ASCER, 2019. www.ascer.es

Some of the technologies mentioned are mature enough to warrant thinking about the possibility of implementing some demonstrator pilot facility, which will facilitate its general implementation in the sector in the middle term. However, this will only be possible with the necessary institutional and financial support for effective execution of the necessary investments in this technological transition that lies just around the corner.

5. CONCLUSIONS

The ceramic tile manufacturing sector has made and continues to make efforts aimed at reducing natural gas consumption in order to cut costs associated with fuel consumption as well as to decrease CO_2 emissions, which also already represent an extra cost that companies must bear.

The technology used at present is a mature technology, which is highly optimised from an energy efficiency viewpoint. There is still a certain margin for improvement in efficiency, though it will not suffice to meet EU emissions reduction targets.

We therefore find ourselves, inevitably, at the gates of a technological transition that needs to be made to minimise CO_2 emissions without losing sight of business competitiveness or the quality and diversification of the end product.

6. ACKNOWLEDGEMENTS

The SMARTREC project has received funding from the European Union Horizon 2020 Programme for Research and Innovation, under Funding Agreement Number 723838.

The DREAM project has received funding from the European Union Horizon 2020 Programme for Research and Innovation, under Funding Agreement Number 723641.

This study also sets out some of the results obtained in the project "Circular economy strategies for a low-carbon ceramic industry (*CerOh! Strategies*)", co-funded by the Valencian Institute for Business Competitiveness (IVACE) and the European Union through the 2014–2020 ERDF Operational programme of the Valencia Region (IMDEEA/2019/5). The lines of study described in this work are in the execution stage as the project will end in December 2020.