
# RADICAL INNOVATION OF CERAMIC TILE INDUSTRY.THE INKJET CASE.

**AUTHOR: Alba Jódar Millán**

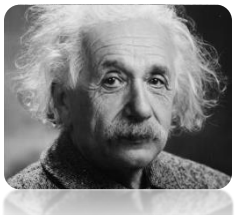
**TUTOR: Francesc Xavier Molina**

**DEGREE IN BUSINESS ADMINISTRATION**

**AE 1049- PROYECT FINAL WORK**

**ACADEMIC YEAR: 2017-2018**

**"Let's not pretend that things will change if we keep doing the same things. The crisis is the best blessing that can happen to people and countries because crisis brings progress. "**



**Albert Einstein**
**(1879-1955)**

## INDEX

# INDEX OF FIGURES AND TABLES

## TABLES



## FIGURES

## 1. INTRODUCTION

We live in a dynamic world of constant change, where society, economy and technology are increasingly sensitive to that transformation due to the rapid pace of life. This change factor leads us to ask how we should act either to maximize performance or to achieve a competitive advantage that can differentiate us from others. If we extrapolate this situation to the world of tiles manufacturers, we find a higher degree of complexity. Today the world knows no boundaries when it comes to exchanging goods and services, arising the problem of the high level of competitiveness that exists between companies in the sector. For this reason, ceramic entrepreneurs need to change tools in order to stand out from competitors.

When we apply these concepts in practice it is when factors or distinctive features make a company, product or service more attractive to consumers. These concepts have as a main function to find customers´ needs and strengthen this approach by offering a product that is superior to competitive features and highly relevant to the consumer. It is for this reason that, by concentrating the Spanish ceramics industry in the form of industrial district, makes competitiveness in the province of Castellón high, forcing ceramic entrepreneurs to introduce technological innovations in their companies.

Ceramic industry has been associated in literature with incremental improvements.
In this particular study we will focus in incremental improvements that have come along in time in ceramic tile industry, such as the Rotocolor technology.
Thanks to the development of the inkjet technology a radical innovation which stands out from existing technology has been reached. Digital decoration of ceramics has been able of creating a new concept in the field of ceramic.

Many local industries have been able to make profit through the use of this new technology.
Firstly, new business opportunities have been generated for cluster businesses.
Secondly, ceramic tile producer companies have developed new types of products with decorations never seen in the market.

This essay is based on key concepts that help understand the importance of innovation in this sector companies.

To reach these conclusions we will guide the essay to understand the concepts of innovation and technological innovation in the first place and then we will make a brief analysis of the ceramic sector and how the introduction of technological innovations has influenced this sector.

Lastly we will talk about how the appearance of the inkjet technology caused a positive impact in the companies.

Finish, there have been many improvements in the sector, making it one of the most stable and dynamic industries, but we must highlight a before and after in the sector was the introduction of inkjet printing in the ceramics field. The inkjet printing has turned out to be, without the shadow of a doubt, a milestone in the development and improvement of production for manufacturers that incorporated this technology. From that moment, several modifications and improvements have made the sector constantly change and grow, innovating and adopting a privileged position worldwide.

# 2. SUMMARY

## 2.1 Goals

With this study we would like to achieve the following objectives:

1. Understand and develop the concepts of innovation and technological innovation, citing some authors and their way of defining these terms, as well as the different types and categories within each concept.
2. Knowing the different factors that favour innovation in a company, especially in the ceramics industry, as they must be prepared for possible changes presented environment.
3. The evolution of technological innovations in the ceramic sector and the impact they have had on the field.
4. We want to get this work a broad perception of kind of technological innovations that make the sector one of the most dynamic and stable. In particular, the inkjet case, since it represents a revolutionary change for companies in the sector.
5. Draw conclusions on inkjet technology and its future applications in the sector.

## 2.2 Structure

The assigned topic is the study of technological innovations in the ceramic sector. To reach a thorough analysis of how it affects innovation in the ceramic tile industry, we will address through a theoretical approach, the concept of innovation and how the ceramic sector responds to this.

To begin with, once established the objectives of the study and a brief introduction to the work, I will focus on the first key concept innovation.

We will analyse the different definitions as well as the most relevant factors and different types and categories. Later, the Spanish ceramic sector will be analysed, studying its general characteristics, its evolution after the crisis and how companies were forced to take innovative measures.

To conclude the theoretical section, the technological innovations that have made the Spanish ceramic sector reach the top globally, implementing multiple and innovative technologies in design and quality, will be analysed.

After analysing the theoretical part, we will focus on those innovations which have been most relevant in the ceramic sector, called radicals, and in particular we will focus on the major impact has been the inkjet printing has had on the ceramic sector. Firstly, the origins of inkjet printing, the introduction and evolution of the ceramic industry, the impact on the industry and, finally, future applications and upgrades.

To conclude this study, we will look at the future, where the Spanish ceramic sector will be located thanks to technological innovation in enterprises.

# 3. THEORICAL FRAMEWORK

## 3.1 Innovation

During the history of our society, innovation has always been involved in a context of industrial and technological development, seen as a crucial element of survival for most businesses. The introduction of new products can be vital to many organizations. However, we can also link this concept with the development of new processes and provide a competitive advantage. This advantage may be a new investment or a small change in the process or product design, or even in the manufacturing process.

Innovation can affect any functional area of the company. For this type of argument it is necessary for any organization to create a strong culture focused on innovation, in which the strategic objectives of the company are reflected. It can be a key to increasing the competitiveness of the company, especially in sectors such as Spanish ceramic, where a large number of companies concentrated in one place exists factor, and require innovative measures to differentiate themselves from their competition.

### 3.1.1 Concept of Innovation

The concept comes from the Latin *innovare* and it refers to *the change or alteration of introducing new things*. Recently the term is defined by the dictionary of the Spanish Language (2001) as the creation or modification of a product and its introduction in the market. The only variation in the definition of the term now involves that the product should enter the market.

Throughout history there are several definitions that have been given to this term. According to Joseph Schumpeter, an Austrian economist and one of the main authors of reference in the study of innovation. Schumpeter (1935) defines innovation as the introduction of a new product or service, a new production method, opening a new market, access to sources of supply of raw materials or the creation of a new structure in a market.

Drucker (1986) defined it as the specific tool of the enterprise. It is the means by which the entrepreneur creates new wealth-producing resources or endows existing resources with the greatest potential to create wealth. While Freeman (1984), is defined as the integration of existing technology and invention to improve or create a product, process or system.

Currently Formichella (2005) believes that innovation is a way by which knowledge is transferred and becomes a process, a product or a service that incorporates new advantages for the market.

Moreover, the Organization for Economic Co-operation and Development (OECD) defines innovation in the Oslo Manual. In its latest version, it refers to the term as the introduction of a new or significantly improved product (good or service), a process, a new marketing method or a new organizational method in internal practices business, workplace organization or external relations.

However, the needs are changing, both for citizens and industry itself, and that is why companies must be updated periodically. In this context is where the term technological innovation appears after leaving commercial innovation, which refers to new forms of communication, distribution, etc. Technological innovation is often directed not only towards marketing the product or service, but it may also be related to production processes within the company. That is, it has to do with the change in the industry in response to changes in technology.

### 3.1.2 Influencing Factors

The reasons that influence innovative activities are numerous. Companies may want to improve their products, processes, open new markets, etc. According to the Oslo Manual (2005), it is important to evaluate because they can explain the behaviour of companies, for example towards its competitors. The chart below shows an adaptation of the Manual on any of these causes:

**Table 1.Innovative causes**

| Competition, Demand and Markets | Production and Distribution |
|---|---|
| Increase market share | Raise quality |
| Improve range products | Decrease costs |
| Meet the customers requirements | Improve capacity |
| New markets | Increase efficiency |
| **Work organization** | **Others** |
| Develop comunication | Decrease environment impact |
| Improve job conditions | Respect policies |
| Build customer relationships | Respect health and safety |

*Source: Own elaboration*

Companies choose to innovate when the reasons for conducting such innovation and benefits to be gained outweigh the difficulties encountered.

**Factors that negatively affect innovation**

There are many reasons why innovative activities may be hampered. They can even find reasons in order not to innovate that lead to negative results. The most important negative factors described in the Oslo Manual (2005), are classified into five areas:

- Factors related to knowledge:
    - Lack of knowledge.
    - Lack of qualified personnel.
    - Difficulty finding suitable partners for joint projects.
    - Lack of information on technology and markets.

  Economic factors:
    - High cost of innovation.
    - Risks and uncertainties.
    - Lack of external funding and / or internal.
    - unfavorable economic situation in the country.

  Factors pertaining to markets:
    - The potential market is dominated by other established companies.
    - Uncertainty.

  Institutional factors:
    - Poor infrastructure and technologies needed.
    - Weak property rights.
    - Existence of legislation, regulations, legality etc. which do not favor innovation.
- Others:
    - Companies think they do not need to innovate due to lack of demand or earlier innovations.

### 3.1.3 Typology of Innovation

Next, we are going to classify innovations in different categories, depending on the type of innovation made by companies. Throughout history the classification of innovations have been modified due to new developments and the implementation of new technologies.

So we can refer to four types of innovations: those relating to products or services, processes, innovations and market organization. The first (product and process) are two more related this to technological innovation.

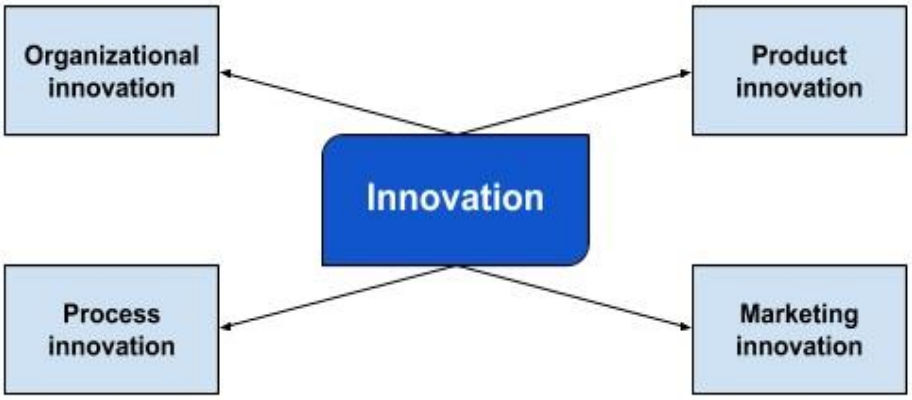
- The product or service innovation is the introduction of a new or improved product or service in a market, including improvements in the modification of their technical characteristics, components, new materials or granting a different use. This kind of innovation allows the company to be placed in a more favorable position in the market and can become leaders of this.

- Process innovation is the introduction of a new or improved production or distribution process. Including changes in techniques, materials or systems used. This kind of innovation is basically used to reduce unit manufacturing costs or marketing - being able to generate a significant cost advantage compared to competition, to increase productivity and to improve the quality of processes.

- Marketing innovation is the implementation of a new marketing technique to modify the design, packaging, market positioning, advertising or price of goods on the market. Such innovation is primarily used to improve business competitiveness and increase sales by improving customer satisfaction, opening the company to new markets or market positioning otherwise.

- Organizational innovation is the implementation of a new organizational system in the company, a radical change in the organization of the workplace or the internationalization of the company.

**Figure 1.Types of innovation**




*Source: Own elaboration*

### 3.1.3.1 Radical and Incremental Innovation

Innovations can also be measured depending on the degree of novelty involving market. Authors like Christopher Freeman began to differentiate more between incremental innovations and radical innovations.

- **Incremental innovation**

It is considered that there is an incremental innovation when a value on an existing product is added through further improvements. Such innovation comes from an existing conceptual basis, and introduces certain changes, small ones in general, which improve the product in some way. It may be an improvement in their image, increase its functionalities or benefits offered, or modification of any aspect in order to improve efficiency. These changes are designed to satisfy consumers and exceed their expectations by increasing duties or improve some aspect of the product or service offered.

From here, a number of creative processes focused on achieving specific purposes are made. The product begins to change thanks to a series of process and a wide range of creative techniques (brainstorming, random words, Synectics, etc.) that enable to find new innovative possibilities.

However, we must keep in mind that this type of innovation is not permanent, but it is given by time and space. This means that companies must be continually researching and innovating to bring new products to market.
There are many examples of incremental product innovation, such as the incorporation of cameras and videos to mobile phones or continuous improvements that provide computers with a much more advanced technology.

Incremental innovation can therefore produce better results and big profits for companies, while progress is generated. Furthermore, this type of improvements affects production processes, causing an increase in the efficiency of these processes.
On the downside, it should be noted that companies that only focus on this type of innovation are at risk of becoming outdated if they are not able to adapt to changes that new markets create.

- **Radical innovation**

Radical innovation occurs when a product or service that is incorporated to market is capable of generating a category that was not known before, causing revolutionary changes in technology. It represents a turning point for existing practices because it is based on a completely new concept. They create a high degree of uncertainty, severely modify the structure of the sectors in which they arise, alter the competitive positions of the established companies and, sometimes, the emergence of new industries.

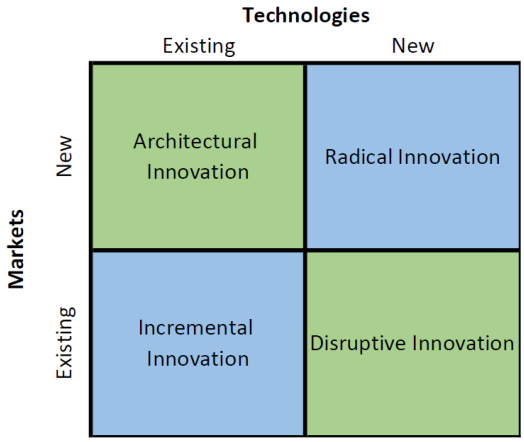
Such innovation comes from processes in which opportunities become visible in an instant, perhaps as an accumulation of experiences, desires and chance. Creativity flies untethered to time or space.
Representative examples include Amazon, which foresaw virtual business selling books, or Apple, who was ahead of Sony in positioning MP3 players. The appearance of the mobile phone also can be considered a radical innovation.

Companies already established are often more careful with this kind of innovation and are often entrepreneurs who plunge in this kind of innovation.

The main advantages include that they generate progress, transforming markets and our way of life. They also facilitate the evolution and possible opening of new markets, thus new work niches. Companies that launch a transforming product do not have competition, but if successful, will soon appear competitors.

The problem when opting for this type of innovation is that it is often more difficult to find financial backing to undertake the project and may take longer to find their place in the market, especially if the strategies put in place to make themselves known and attract customers are not very effective.

**Figure 2.Radical and Incremental Innovation**




*Source: [www.wikicase.wikia.com](http://www.wikicase.wikia.com) (2018)*

Both types of innovations are essential. One pushes forward and transforms society, while the other improve products and services progressively.

# 4. CERAMIC TILE INDUSTRY

According to ASCER, the Spanish ceramics industry is a leader in the domestic market. At present, it is mainly centred in the province of Castellon, and it is an example of the production model to consider: the quality of materials and design and innovation as one of the most important internationally and competes with Italy, one of the leaders in the sector.

Valencia and Castellon businessman is innovative in design and production and has introduced new technologies, has improved the quality of ceramic products and production processes, looking for the high-end market. Furthermore, ceramics producers are positioned on every high-quality list. It is undoubtedly a model of success to consider with respect to other sectors thanks to its professionalism, innovation, modernization and outsourcing.

## 4.1 General Characteristics of Ceramic Tile Industry

The Spanish tile industry is considered as an industry concentrated mainly in the province of Castellón with a powerful cluster of companies. After the severe crisis suffered after the bursting of the housing bubble, it seems to have recovered permanently. With a sales structure focused on the foreign market, the sector had a turnover of more than 4,500 million euros in 2016 and accumulated several years of growth in sales and employment with several companies at the head, such as Esmalglass, with more than 400 million in sales, Pamesa or Porcelanosa.

This industry segment employs almost 3,700 people and had a turnover of more than 1,200 million euros in 2016, of which 70% were exports.

Foreign sales suffered a slight decline of 1.26%, which was offset by the improved performance of the domestic market, where turnover rose above 5%, but also improved the recovery of the construction sector in Spain.

The pure ceramic segment has more international competition, but it is still the leading European producer and the second largest exporter by volume.

The ceramic tile industry is considered one of the most dynamic, with Italy, the world leader in quality, technology, prestige and design. Currently there are no ceramics industries worldwide as thrown into R & D, sector promotion in international markets and the appreciation of the product as the Spanish ceramic industry

Analysing the turnover of the industry as a whole, approximately 80% are exports, while the rest are to meet domestic demand. The great ability to export products make it to position itself in major export sectors of Spain, and also make it the second largest surplus industry that contributes to the trade balance of Spain. The trade surplus amounted to 2,493 million euros.

This association represents more than 150 manufacturers in 2016, with total sales of 3,316 million euros, of which 2,570 were exports to over 170 countries.
Pamesa and Porcelanosa are two of the most recognized brands, also internationally. Their property is still in Spanish hands. The first had a turnover of 845 million euros in 2016, 7% and the second had a turnover of 475 million euros in 2017, 15% more than in 2015.

The sector is concentrated mostly in the province of Castellón, with a large growth, increasing the number of companies, thanks to their success in design and quality.

It is considered that a cluster has been consolidated in the Valencia region, and especially in the province of Castellon, marked out to the north by Alcora and Borriol, west of Onda, south of Nules area and east in Castellon de la Plana.

The sector is formed as an industrial district or cluster, where there are all features within a certain geographic area, with the support of a large number of ancillary businesses. This gives it a unique character and is one of the keys to its global competitiveness.

### 4.1.1 Cluster or Industrial District

According to the book Guerras Navas (2007) Strategic Business Management, "an industrial district also called cluster or cluster of companies is a group of many companies and related institutions related to the same economic activity, located in an environment specific geographical. The district includes companies belonging to the main industrial sector that identifies institutions that support the activities undertaken by these companies and others belonging to other sectors, but they have some relationship with companies in the industry".

The types of agents found in an industrial district are:

1. Companies with the same activity, which offer the same type of end product or service.
2. Public and private organizations, to facilitate and provide technical and expert support.
3. Companies that are both in the later stage and before the full cycle operation of main product of the company.

Therefore, all companies that are within the industrial district are greatly favored by the advantages of the concentration of companies, which favors access to resources and capabilities needed to compete effectively in the sector. Some of the advantages that this entails are:

- Ease of access to commercial networks and industrial materials.
- Increased productivity.
- Proximity to suppliers.
- Decrease supply costs and transportation.
- Reducing waiting time.
- Skilled labour.
- Increased lasting business relationships.

Another important advantage is the support received by public bodies, by providing general or specialized infrastructure companies, as might be the Ceramic Technology Institute of Castellón which is discussed in the following section.

We also noticed the stimulus to innovation that happens within the district, since there is usually proximity to research centres, and to new customer needs or new technological trends. This is also due to the high competitiveness in the sector, which forces the necessity of being distinguished more creatively, stimulating pressure to innovate. This creates a more dynamic industry, constantly seeking improvements in the production process.

According to Budí (2008), in a study of the District of Ceramics in Castellon, "the cluster covers the space within the environment Castellón de la Plana, within a radius of about 30 kilometres, located on the Mediterranean side and integrated 25 municipalities that make up an urban area of about 250,000 inhabitants, where is concentrated almost all the production of tiles in Spain ".

**Figure 3.Location of the Cluster in Castellón**


*Source: Budí (2008)*

The sector became concentrated mainly in the province of Castellón. Given its tremendous growth, many studies conclude that the success of this industry is due to its geographic concentration, leading to the cluster.

## 4.2 Related and Supporting Organizations

The Spanish ceramics sector receives support from organizations aimed at improving the visibility, positioning and performance of the components of these organizations through an innovative offer. His vision is to turn the ceramic industry cluster international leader. It is therefore ensuring that its members are part of the cluster and that one of their main concerns is innovation.

### 4.2.1 Institute of Ceramic Technology

According to information provided by the Institute of Ceramic Technology (ITC) (2015), it is due to the fact that the province of Castellon is the epicentre of ceramic production that we find this institute, which is a research centre established by the agreement between the Association of Research Ceramic Industry (AICE) and Jaume I University of Castellón (UJI). Born in 1969 in response to the needs and requirements of industries in the Spanish ceramic cluster, fostering over the years a system of university-industry cooperation has been successful in finding the high development of Spanish industry ceramic tile manufacturing.

Ceramic Technology Institute (ITC) has over 40 years of history. It plays a key role in developing and seeking competitive advantages in this sector.

ITC intends to lead the processes of technological innovation and design of Spanish ceramics sector anticipating market needs and consumers about the uses and applications of ceramic materials, through professionalised management of a qualified and committed team with excellence in the sector.
Throughout its history, it has been driven by a fundamental objective:
"Provide solid support to the Spanish ceramics industry consists mostly of small and medium enterprises in order to promote and increase their competitiveness in international markets."

This support has resulted in the design and development activities and technological services designed to meet the needs of SMEs which do not have technology, scientific equipment or human resources to carry out the actions R&D or technology transfer leading to innovation. That is why ITC is established as the technology partner of companies in the ceramic sector. In a global environment with many complications, ITC, such as knowledge-based society offers ceramics companies services, equipment and infrastructure so that businesses can rely on them, having access to strategic information needed in key market, environment, technology, design, technology trends, etc., to continue to decide their future with the maximum possible guarantees.

The Institute of Ceramic Technology emerged thanks to an agreement between the Association of Ceramic Industry Research (AICE) and Universitat Jaume I of Castellón. It has the support of the Institute for Small and Medium Industry of the Generalitat Valenciana (IVACE) Ministry of Economy, Industry, Tourism, and Employment of the Generalitat Valenciana. It is integrated into the networks REDIT Technological Institutes of the Valencian Community, in the Network of Valencian Universities for the promotion of Research, Development and Innovation (RUVID) and the National Federation of Technology Centers (FEDIT).

This institute has a number of associated companies. As of December 31, 2014, the ITC had 194 member companies.

The challenges that the ceramic industry is facing today, have produced awareness and opening lines emerging research aimed at obtaining new ceramic materials with improved performance, greater strength, new uses and functions, you achieved for research in R & D or technology transfer shares from other sectors.

It highlights the public recognition that the ITC has been through the award of a number of awards. In addition, there are many authors who cite the ITC as a model of good practice in relations University- Company and as a support and solutions generating agent, a catalyst and promoter of the competitiveness of the Spanish ceramics industry.

### 4.2.2 Spanish Association of Manufacturers of Ceramic Tile

The Spanish Association of Manufacturers of Ceramic Tiles (ASCER) was created in 1977. The Association represents approximately 95% of the production sector, the greatest representation in Spain. The headquarters is located in Castellon de la Plana due to the concentration of industries, as industrial district.

ASCER is regarded as an organization supporting, defending and promoting the interests of the ceramics industry. Its activities are defined by the need for action together in those areas where businesses, in particular, can not be performed successfully. Collective activities require a high functional flexibility to respond effectively to changes in the environment is. Therefore, functional flexibility is the main denominator of the type of work carried out by the Association.

The services are provided in different areas:

- Innovation Area
- Labour Affairs and Training
- Industrial Affairs
- Statistics
- Legal service
- Database
- institutional relations
- Agreements with suppliers
- Others.

The Spanish tile industry is a world leader in innovation thanks to its business network. ASCER, as support for the sector has since 2007 with an R + D + i, from which have been promoted and carried out several projects of sectoral interest.
Some of the most important projects are:

- Drac project
- Project 4 Senses
- Research on new uses of ceramics

ASCER
Asociación Española
de Fabricantes de Azulejos
y Pavimentos Cerámicos

**Group of innovative companies**

In 2007 the first Strategic Plan for Innovation was designed, in collaboration with ITC, where the ceramic industry was recognized by the Ministry of Industry as an Innovative Business Association (AEI). Part of the AEI are the Spanish Association of Manufacturers of Ceramic Tiles (ASCER), the Institute of Ceramic Technology (ITC) and about 40 more companies.

## 4.3 Evolution of Ceramic Tile Industry

The Spanish ceramics sector has been growing despite the complicated situation suffered by the firms after the Spanish economic crisis, when many companies were forced to close down. Those who followed in the sector were forced to take measures to market changes and to new consumer needs.

Many companies allocated their efforts to finding technological innovations that allow them to stay in the market. Thanks to this, the Spanish ceramics sector has become one of the most dynamic and innovative sectors of the national economy, also occupying leadership positions in the international arena.

Currently, the ceramics sector has become one of the most important in the Valencian Community and the national scene, excelling in the fields of design, quality and economic development.

Closing forecasts 2018 growth are light but gaining in strength and weight in the aggregate growth of the sector.

Nationally, the recovery of domestic consumption is consolidated; and growth is strong. Production and sectoral employment have increased generating approximately 500 direct jobs. Accordingly, as shown below with data submitted by ASCER, sales in the sector have increased, with growing forecasts.

### 4.3.1 Production and Domestic Sales

According to ASCER, in 2017 the Spanish production of tiles and ceramic floor tiles grew by around 7%. Sectoral employment remains fairly stable. In addition production in 2017 it reached 530 million m2 coming to position itself as the first European producer.

**Table 2.Ceramic Tile Industry (sales in millions EUR and production in millions square meter)**

| Ceramic Industry (2017) | |
|---|---|
| **Production** | **Exports** |
| 530 | 2.686 |
| **Employment** | **Total sales** |
| 15.600 | 3.510 |

*Source: Adapted from ASCER (2017)*

**Table 3.National Production and Sales**

| Production and sales of the industry | | | | | |
|---|---|---|---|---|---|
| | **2013** | **2014** | **2015** | **2016** | **2017** |
| **Production** | 420 | 425 | 440 | 492 | 530 |
| **National market sales** | 557 | 574 | 643 | 746 | 824 |
| **Exports** | 2240 | 2328 | 2452 | 2570 | 2686 |
| **Total sales** | 2793 | 2902 | 3095 | 3316 | 3510 |
| Sales in millions of EUR and production in millions of square meters | | | | | |

*Source: Adapted from ASCER (2017)*

The estimated production in 2017 was about 530 million square meters, up 7% over the previous year. Therefore the total domestic sales also increased over the previous year, reaching 3,510 million euros (+ 5.8%).

In the above table, data of interest are shown. They emphasize exports as the Spanish ceramics sector accounts for 80% of all ceramic industry. Increasing exports valued at approximately 116 million euros compared to 2016 is observed.

With respect to the domestic market, it highlights a continued increase in domestic sales. From 2013 to 2017, the figure has increased by 47%.

Most consumers prefer the Spanish industry for its quality and design products. It is for this reason that the sales volume has increased considerably in recent years.

The high figures reaching the sector in recent years due to the presence of innovation in companies, which make the Spanish ceramic sector is one of the most important worldwide.

## 4.4 Innovation in the Ceramic Sector

Traditionally in the world of ceramic industry, technological innovation in machinery came from the Italian ceramic sector. However, innovations in glazes and pigments were made by the Spanish industry. In this field, the Spanish glaze companies occupy the most privileged place.

The process of decorating pieces is gaining more and more importance because it adds value to the final product, achieving competitive differentiation. It was for this reason that in 1994, printing technology innovation emerged as the main technology in the sector of decorated pieces. Decoration of pieces became possible through a series of screens that printed the desired drawing with the desired colour directly on the product. This technology originated many problems, because if you wanted to print multiple drawings, you needed to change screens, among many other problems.

Later a new production system appeared, the Rotocolor system. The new system had positive aspects in relation to the old screens. It was also a rotating system for glazed tile decoration. However, it was also necessary to change cylinders for the production of different designs. There were problems with the colours needed for the production of drawing and required continuous revisions in the final product.

It is for this reason that the sector companies spent their efforts in search of other innovations or improvement of existing ones, with the aim of improving the production process and add value to the final product offered.

Currently, the Spanish ceramics continues to open new horizons in the research sector of materials for architecture and habitat. In recent years many have been implemented and concrete solutions that combine innovative technology and ceramic materials, taking into account the design and improvement of the quality of products for users.

**Figure 4.Rotocolor System**

*Source: www.system-ceramics.com (2018)*

### 4.4.1 Trends in the International Framework

The Spanish ceramics sector owes its privileged position worldwide in the sector to its firm commitment to R&D. Emphasizing its continued investment by both companies individually and all of them as a whole through sectoral projects where institutions such as the Technological Institute of Ceramics (ITC) and ASCER play a key role.

In recent years information on the innovation process in the Spanish ceramic sector regarding the most significant developments in the international framework has been collected, for possible future trends. Here are some of the highlights over recent years advances are included.

**Table 4.Innovations in the Ceramic Tile Industry**

| Field | Type | Concept | Years |
|---|---|---|---|
| **Material** | **Surface** | Self-cleaning enamels | **2004** |
| | **Support** | Ceramics that regulates the humidity | **2004** |
| | | Ceramics reinforced with fibres | **2006** |
| **Process** | **Formed** | Compacts previously (press, plate) | **2004** |
| | | Large format extrusion | **2006** |
| | **Others** | Crude cut | **2002** |
| | | Mixed oven (convection-microwaves) | **2006** |

*Source: Own elaboration*

In this context a major technology-oriented approach is observed, and can be concluded that the Spanish ceramic cluster has great capacity for rapid assimilation of external innovations.

In turn, it is taking a progressive approach to the field of organization and product. Several companies have joined this new approach, as in the case of a company associated with World Wide Fund to Nature (WWF / Adena), giving the user the feeling of working with the reforestation of the planet, since the company produce ceramic inspired by wood, and promises to plant trees in the natural park of Abisko (Sweden).

Another example of a company, redefines the ceramic coating as rigid and flexible coatings proposing soft coating thanks to the use of very small formats fixed on elastic supports which can be used for the furniture sector.

On the other hand, advances in new technologies not related to the ceramic industry, can offer the possibility of providing new functionalities to the ceramic product. In this regard biotechnology and nanotechnology they stand out as the most active fields in the scientific landscape.

### 4.4.2 Innovations related with the Product Customization

The ceramics industry has for many years used a traditional product based on rectangular pieces fixed with bonding material. However, this concept has evolved steadily thanks to the efforts of companies towards innovation and to the institutions and support agencies.

Currently, the ceramic industry is at a stage where ceramic products retake importance of being able to adapt to the needs presented by the sector. This is due to the incorporation of new technologies to improve the product offering more varieties of the same. Most of these technologies will be applied once the tiles have been cooked but are also applicable to pre-cooking stage or at the time of pressing.

#### 4.4.2.1 Processes During the Manufacture

Some of the technological systems applied during the production of the parts are the ink jet printing or inkjet and customizing reliefs. These systems must be previously defined in the manufacturing process.

- Inkjet

System based on the use of a small number of basic inks with an electronic process that transfers pictures on the surface of the workpiece with the colors and shapes that we desire. The printing system of ceramic pieces allows printing without stopping the workpiece, since the ink is deposited on the workpiece through nozzles. This process allows full customization of the piece, despite reliefs.

Some of the advantages of this system are: faster and controlled non-contact printing and the ability to print large images. It also allows all necessary adjustments at all stages of the process quickly without having to create new screens or inks.

- Reliefs milling machine

Reliefs for the acquisition of the coatings sector employs specific machinery, which normally works with laser scanners. Thanks to this, you can get reliefs and textures of a large number of sources such as organic and non cohesive mineral. We can transfer on the surface a variety of materials by milling, which is controlled by numerical control. Depending on the use of parts are used in the milling process different material. Thus obtaining single pieces adaptable to different reliefs. If a larger number of parts is required, a punch press industrial is placed.

**Figure 5.Reliefs Milling Machine**


*Source: Weiss Machine & Tools (2018)*

#### 4.4.2.2 Processes Back to the Manufacture

Once the pieces have been cooked, unlike in the previous section, personalization systems products after manufacture will be used. Some of these systems are:

- Grinding machine

Machinery that allows modification of the dimensions of the piece, obtaining the necessary steps. Also they alter the finished edges by grinding or by sintered diamond discs. For higher cutting quality without getting lost production, many diamond grains and binder are used differently. The purpose of this machine is to obtain the squaring of the part by removing the edges, obtaining a piece of controlled dimensions.

**Figure 6: Grinding Machine**

*Source: Weiss Machine & Tools (2018)*

- Cutting-disk machines

These machines can obtain a precise division of the workpiece, using as the grinding discs placed in packages sintered diamond disks and several different axes centered on a line feed. This system allows small pieces from a large one, but only being able to make straight cuts, not circular nor interior to the piece.

- Hydraulic cutting machine

The water is subjected to high pressure through a hydraulic circuit and intensifier pressure directed through a small hole diamond to a mixing chamber where the abrasive is added (typically garnet) to enhance cutting. This system has complete freedom and precision cutting since the whole system is controlled by numerical control. It allows recesses few millimetres wide without cutting the workpiece, and which are subsequently filled with grout and this results in coatings whose appearance is of a smaller format installed.

**Figure 7: Hydraulic Cutting Machine**

*Source: Weiss Machine & Tools (2018)*

- Sandblasting process

Process in order to produce an abrasion on the surface of the workpiece by projecting high pressure sand passes decoration or signalling. The areas that are not protected with abrasion are an adhesive film, controlling the machining depth if the application time is varied. Its application is manual.

- Laser marking

This tool is one of the major future trends for the ceramic industry as it is an advanced technology that allows customized intervention on the pieces. The effect of the laser depends on the product and decorative applications thereof. Depending on the type of parts used similar processes to the above. For similar pieces polished abrading process used sandblasting. In the case of enamelled parts enamel characteristics define the effect achieved.

- PVD (Physical Vapour Deposition)

Set of coating techniques that can fit very thin layers of materials on ceramic tiles, as metals and metal compounds that give the piece a metallic appearance. Once the metal surface is polished, it adopts a mirror-like appearance. With this kind of technique pieces of various types can be coated, both flat and embossed or special.

- Folding tile pieces

This system is based on pieces of cooked and placed on a support through a roller oven until the ceramic piece acquire a plastic consistency, due to the high temperature to which it is subjected. This ensures that the piece can be folded and can take the form of support. There are standard formats that provide bent pieces that can be placed as baseboards, steps, corners, etc.

**Figure 8.Folding Tile Pieces**

*Source: www.interempresas.net (2018)*

### 4.4.3 New Products and Innovative Systems

Some of the innovations in the ceramic sector have led in most cases to improve the adequacy of ceramic systems to the particular needs of customers. A good example of innovative systems in the ceramic sector would be films based positioning systems and dry systems.

❏ **System of sheets in pavements**

This type of system emerged in 2002, and was presented to the public the first plant that could produce ceramic porcelain tiles large, with a thickness less than that usually present the tiles. Later the plant was improved, currently producing pieces of 3600 x 1200 mm and a thickness of 3 mm. Currently the supply of this type of thin parts made with standard lines is varied where you can find a wide range of finishes and formats that can reach 1300 x 1000 mm. Some of the advantages of this type of product that make it so attractive are:

- Reduction of energy used in the manufacturing process and transport.
- Lower volume in rehabilitation works.
- Lower anchorage requirements due to its lower weight.
- Possibility of use in furniture, ceiling, etc.

Notably, the application of this product requires careful placement pavements protecting especially the perfect finish of the exterior of the blade.

❏ **Dry laying systems**

This system emerged with the aim of reducing the disadvantages associated with the wet work order to implant alternative positioning systems where the bonding materials are not required. These systems are not replacement to other but complementary, providing new functions to ceramic products and therefore must be used in certain applications.

These systems can be grouped into the following families:

- ❖ Systems with substrates:

A tray of another material which is located under the ceramic tile generating a whole need not be attached to the lower substrate is used. This is one of the most widely used systems on the market.

- ❖ Systems with connectors or locking elements perimeter:

The parts are interconnected by connectors that are assembled by the edges of the tile. This acts like a normal system just in use as a material parietal fixing lower modulus of elasticity which makes the ceramic product reduces stresses compared to other systems.

- ❖ Systems with more anchors or substructure substructures.

The tiles are fixed by anchoring the lower substrate. In the case of flooring, the anchor can be to fix the piece to avoid horizontal movements by blocking the lifting force of gravity plus a small contribution anchor.

Moreover, these systems add new functionality to the coating or insulating obtaining acoustic improvements, since these often require pavements interlayers between the substrate and the coating. Regarding the grouting, they can be used together prefabricated elastic materials.

These systems have variations as in the case of floor heating by incorporating electrical systems for its simplicity and low thickness, makes it a good alternative to floor heating by hot water.

Some of the advantages possessed by these systems are the possibility of treading the pavement immediately when newly installed, ease of assembly and disassembly and installation of intermediate substrates that generate new functionality to the coating.

On the contrary, it is noteworthy that this type of system has a low resistance to bending or impact. It is therefore recommended to follow the manufacturer's instructions.

**Figure 9.Dry Laying Systems**

*Source: Grupo Azulev (2018)*

### 4.4.3.1 Ceramic Systems for special Projects

The most used method in the field of ceramic coatings is dry pressing of ceramic pieces followed by extrusion and pressed in a plastic state. This system generates high productivity. Next, three projects that adapt the ceramic product to alternative systems to dry pressing are shown.

Extrusions

Method used for the manufacture of spare columns Spain Pavilion at Expo Zaragoza. This system is used whenever parts are getting constant section. (Photo)

Extrusions and stampings

This method is to extrude a sheet which will then cut with a die, can generate a variety of forms to be a very flexible production system. An example would be the promenade of Benidorm which was designed by C. Ferrater and X. Martí.

Pressed plastic states

Method using plaster molds formed by two pieces of the same material corresponding to the upper and lower half of the product, where clay is introduced in plastic state will acquire the shape of the molds. This is the case of manufactured parts Spain Pavilion Aichi, created by pressing plastic state and glazed by airbrushing.

# 5. RADICAL INNOVATION: INKJET TECHNOLOGY

## 5.1 Evolution of Inkjet Technology

Inkjet technology refers to electronic printing systems. Historically, we can place the first printer computer in 1953, but could only print text. Then, 14 years after the copying machine in black and white was developed and in 1973, is incorporated by Canon colour mark.

In 1980, the first laser for print appears and 8 years later, is improved in order to work in colour. In the following years it was used as a common object in any area of work and some companies began to use it.

The implementation of this technology to the industrial sector was complicated because it had many problems and many companies decided to continue the use of traditional technologies. It was then that in 1998, the company Kerajet enter the digital printing inkjet technology in the ceramic sector. He created the first prototype machinery for inkjet digital decoration of ceramic tiles.

The first inkjet machine for parts decoration was presented in 2000 in Cevisama. The first inks for this machine were patented by Ferro that year. The presentation of this machine had a great impact and from that moment, the evolution has been constant, especially because of the high competition in that sector and the need to incorporate improvements in the materials needed for the process inkjet as inks, dyes, electronics, chemicals, etc.

Currently, there are many companies competing in the development of this type of machinery since it was a revolution for the ceramic industry, marking a before and an after. Thanks to this new technology efficiency in the production of decorated tiles is increased.

Over the years, many changes that have taken this technology has undergone many changes to achieve the best results. Fewer and fewer errors arise in use, the staffs are highly qualified and experienced, and the design process is faster, more efficient and has a greater amount of applicable designs.

Inkjet technology occupies a privileged position in the evolution of ceramic technology sector, which marked a radical change in the sector. It has created a technological revolution that has broken with the traditional decoration systems tiles, considered one of the greatest technological innovations of recent years. There are still many improvements and new functionalities that inkjet technology can generate, in the ceramics sector, as in others.

## 5.2 Description of Inkjet technology

The inkjet technology is known as ink printing machines. It is considered the digital decoration technology, based on a transfer system of designs on different surfaces (smooth or structured), which allows printing the ceramic pieces completely. Through this innovation high definition and realistic images / designs are achieved. Imagination is the limit with this method of digital printing.

This digital system is a contactless printing process in which images are formed by droplets fired at high speeds from nozzles printheads. Ink droplets are combined with precision resulting in various colors, which observed at a distance, make up a picture. Among the benefits that this technology offers include:

- The definition of the digital image and process flexibility imply that each tile may be different if so required, enabling a more realistic representation of natural material, such as stone, marble, wood, etc., there also being the possibility Print unique products.
- Variety of new effects that would be unthinkable in any other decoration technique.
- Quality far superior to other printing technologies.
- Decoration to the workpiece edge.
- Easy for short runs and special pieces (murals).
- Customization through small changes in basic design is simple;
- The ecological footprint of the machine are smaller than in conventional processes.

Major advances in technology allow us to reach decorating homes with increasing realism, with different textures and structures of nature.

### 5.2.1 Types of Methods

Inkjet technology is characterized by printing inkjet contactless. Depending on the mechanism used ink supply, various methods are distinguished:

1. Injection or continuous jet continuous ink jet (CIJ). This technology consists of a continuous stream of ink droplets are transported through an electronic field to the surface of the part you want to decorate. It is a very versatile, able to print on almost any system.

2. Thermal inkjet or Thermal Ink Jet (TIJ). In this system an electric current is applied to a series heating elements forming ink droplets. Once the drop is formed is ejected accurately to the printing surface. Then it stops applying the electrical current and the resistive element is refilled ink to start the cycle again. This system provides high print quality.

3. Injection or drop on demand drop on demand (DOD). Ink droplets are ejected from the printhead by a pressure pulse generated by an electric field. They are ejected only when required, so the expression is used on demand.

### 5.2.2 Productive Process

In recent years there has been a continuing trend to simplify printing. From the prints and engraved silicone rollers displays to digital direct printing systems for direct printing on ceramic tiles currently used. However, to obtain the desired print results prior adjustment and control systems used throughout the process is necessary.

To prepare the system, each element must be calibrated such as input devices and output (scanner, monitor) and, above all, to adjust the ink limit and linearization.

Referring to design and development phase, we distinguish the following steps.

The first stage refers to the acquisition of the image. The better, the easier it later works. Currently many companies have introduced digital cameras, as scanners had some problems. Thanks to this, the resolution and depth of appropriate colour can be obtained, and fit models relief.

Subsequently, the image is manipulated to fit the ceramic design. It includes varied operations such as resizing, setting intensity levels, contours, etc. All these operations are performed from the monitor, so it is very important that it is properly calibrated and profiled. Once made all the necessary adjustments, the print image is produced in the ceramic pieces through heads that inject ink following printing orders previously inserted into the monitor.

Then a test print should be done, the corrections that might be necessary and ultimately batch printing.

## 5.3 Impact of Inkjet Technology

In recent years, techniques for decorating ceramic pieces have evolved because of the need to bring to market new products with different aesthetic finishes, which make companies different from others.

Initially, the techniques used were flat and rotary screen printing. simple and cheap but low quality techniques. Then with decoration gravure quality was improved but the price of silicone roller was too high.

In the nineties, flexography appeared, but its implementation was not so successful. From that moment, inkjet printing systems appeared through office applications. This technology still requires considerable research related to inks, printheads and printers. Then the features of this technology were modified, having an impact in the ceramic industry, a revolution.

The development of new heads and pigmented inks can be considered key to the development of these technology elements. There are other elements that make overcome an industrial reality, as the transport system of the workpiece, the ink supply, power data, etc.

Some of the technical and economic advantages of using inkjet technology are:

- Relief decoration
- Decoration to the edge
- Non-contact printing (reduces low raw)
- Image quality
- on-line control and corrections in design,
- Unlimited design variations
- immediate changes
- Simplification inks (reduce inventories)
- Process economics, both small and large batches
- Product customization easily
- Reduced labour
- Shorter product development

Inkjet technology has been a radical change for companies, since it allows commercial strategy based on differentiated products, optimize the manufacturing process and improve relationship marketing.

Since the appearance of the first inkjet machine, other improved machines have appeared, with more than 14 different machines that exist in the market for ceramics printing. Using inkjet technology is increasing, as there were 538 installed worldwide in ceramic sector company's machines in 2010.

Currently, digital printing is used for decoration in 41 countries. Spain began this technology and remains the largest number of machines are installed. Second is Italy. In late 2010 between Spain and Italy had almost 80% of all machines installed worldwide. China, India and Brazil, had a relatively small number but the figure has increased considerably and moved to the third, fourth and fifth in number of installed machines. Also there are joining countries like Turkey, Egypt, Indonesia, Algeria and Saudi Arabia, among others.

## 5.4 Kerajet Case

As stated above, the base of printing technology came from Italian companies. In 1994, an Italian company launched the Rotocolor machine, which was a great innovation in the sector. Although this technique exceeded expectations time, still it had problems in producing designs and this generated the need for skilled technicians in the process. There were more problems that arose and created instability in the process, as well as difficulty in reproducing certain designs.

In 1998, an engineer from Castellon, with extensive experience in the sector, began researching new opportunities in ceramic decoration in order to develop a technology based on digital inkjet printers. This technology was a clear example of radical innovation in the sector and also marked a break with the traditional technology used previously, screen-printing. It was given an entirely digital approach because computers were incorporated into the production line with possibility of Just in time in a sector characterized by long series and a permanent problem stock. This was carried out by the company Kerajet.

A year later, by the CDTI (Center for the Development of Industrial Technology), he developed the first prototype based on inkjet printing.

In March 2000, the company introduced its first prototype Kerajet in CEVISAMA exhibition, which won the "Alfa de Oro" as a reward for innovation.

Another crucial point of its success was the international PCT patent application. The company protects their knowledge through the Industrial Property in various forms. That was how established itself as the first company with this technology. From now other companies are entering the market for ceramic decoration, as manufacturers head for inkjet printers. As a result after the R & D efforts, the main producers of enamel and pigments, special inks developed for decorating parts.

The new technology was recognized as a major competitive tool for Kerajet. The company continued to create new models of machines with numerous attributes and great improvements. Currently, there are more than 500 production lines equipped with ceramic floor Kerajet machines.

The continuous effort in following years presenting new equipment with better features. A differentiator element its innovative strategy was its collaboration with other organizations:

- In 2005, it collaborated with the Universidad Autónoma de Madrid in research related to technology and design of electronic systems.
- In 2007, ROTOJET development kit that fits into the machine Rotocolor of the Italian company System Spa.
- During 2004-2008, with the company Seiko, it developed some heads exceeding the problems of alternative technology Xaar Ltd.

Another important aspect was the development of nano-pigments based on organic solvents ceramic inks and water-based base oil. This will encourage manufacturers to develop their own glazes inks. Mastery of inkjet technology represents an annual market of 60 million euros in Spain.

Finally, the importance of innovation for Kerajet, shown in the most significant throughout its history milestones.

**Table 5.Most important milestones of Kerajet SA**

| | |
|---|---|
| **1999** | Start of R&D activities |
| **2000** | Presentation of the prototype in Cevisama and development of 2 new prototypes. |
| **2001** | Start of commercialization |
| **2002** | Presentation of the Kerajet K560 and "Series 25" inks at Cersaie |
| **2004** | Collaboration agreement with Seiko and Kerajet K700 presentation |
| **2005** | Presentation of the flat plotter. |
| **2006** | Presentation of the plotter for cardboard. |
| **2007** | Development of the Kit Rotojet |
| **2008** | Development of the Kerajet K1000 for special widths up to 1000 mm. |
| **2009** | First industrial tests of cardboard with UV inks. |
| **2010** | Development of the Kerajet K1200 for special widths of up to 1200 mm. |

*Source: Own elaboration*

We can conclude that Kerajet SA is based on offering the most advanced technology for digital printing and decoration of ceramic material, however, is also developing digital printing machinery for other sectors such as cardboard, textiles or glass. Its goal is continuous innovation and the pursuit of technology leadership to deliver the best solutions highest level of performance.

## 5.5 Applications in Different Sectors

In recent years, the inkjet ink technology has demonstrated its ability to provide advantages in manufacturing processes of various industries. In addition, it has become a strong trend in decorating ceramic pieces being its growing implantation. Therefore, the objective of public companies grows considerably the product opening new market capable of absorbing consecutive increases production.

Digital printing can be applied to many different sectors, including their own ceramic sector. Through an adjustable production machinery can be generated to suit the needs of any customer in terms of bandwidth, measurements, image dimensions, etc. Also, printing may be performed on multiple materials such as plastic, glass or metal. This generates competitive advantages over traditional techniques, especially in product customization and implementation of high-speed short series. The high printing speed is due to technological advances in electronics and manufacturing industrial heads. This is to achieve personalized mass production, ie in customizing millions of units.

Currently, inkjet printing is already used in:

- Glass decoration
- dinnerware decoration
- ceramic tile decoration
- Cork decoration
- cardboard decoration
- wood decoration
- PVC flooring decoration
- Labelled
- Signalling
- Industrial textile production
- Manufacturing laminate flooring

The leading sectors in the use of inkjet technology are:

- Ceramic Printing: Digital Printing Systems Single Pass Ceramic high performance. It integrates advanced technology applied to the digital printing of ceramic, salts, enamels, inks pigments, etc.

**Figure 10.Ceramic Printing**

*Source: Kerajet SA (2018)*

- Glass decoration: digital printing systems on glass surfaces. Using inkjet printers with inorganic ink. Its applications are industrial marking glass.

**Figure 11.Glass Decoration**

*Source: Kerajet SA (2018)*

- Textile Printing: inkjet technology aimed to the textile sector, applicable in fashion, home, visual communication, textiles, etc.

**Figure 12.Textile Printing**

*Source: Kerajet SA (2018)*

- Label printing: printers designed for short and medium print runs narrowband. Self-adhesive strips applications (food, cosmetics, industrial, etc.)

**Figure 13.Print Labels**

*Source: Durst Ibérica (2018)*

- Dinnerware decoration: decoration plates, bowls, cups, etc.

**Figure 14.Dinnerware Decoration**

*Source: Kerajet SA (2018)*

Industrial applications using inkjet technology can be divided into two groups. First, high-volume industrial applications. These are applied in large and complex industrial processes where digital decoration is integrated into the production line. It is used for large volumes with low margins. For this equipment Inkjet high speed (Single-pass) with specific inks is used for each application. Such applications are usually found in textile production, ceramics, labelling, etc.

On the contrary we find semi-industrial for decoration in small batches customizable durable goods applications. These processes require less investment because they are not integrated processes. Multi-Pass Inkjet equipment Standard, which do not always require the use of special inks are used. Such applications are usually given in interior decoration glass, ceramic piece simulation, customized doors and furniture, etc.
The semi-industrial applications are increasing as customizing durable elements is sought. Increasingly larger companies aimed at providing support custom digital decoration projects for industrial manufacturers. Thus, the inkjet technology market is growing, and increasingly, are manufacturers who need a "digital" partner.

It is for this reason that the higher the technological mastery and greater the skills to find new applications, the greater the chances of survival. Therefore, it is considered to continuous innovation is considered as a key survival factor, promoting technological advances (in products and processes).

To identify future business opportunities seeking new ways of working is needed. This requires increasing R & D activities within the company, increase quality and product durability through pre- and post-printing applications such as: testing, analysis, etc. It is important to be familiar with:

- New media (wood, glass, acrylic high strength ...)
- New accessories (lacquers, primers)
- New tools (sanders, washing equipment, etc.)

Thanks to this, companies will be able to detect new business opportunities to diversify to meet demand in each market. More and more business opportunities presented in the market but require greater specialization. Therefore, companies in the sector should explore well the markets, changing its approach and working methods to meet the demand for each. As companies choose to investigate, they will be able to offer a differentiated and better product, competing with those who do not make an effort in the search for new sectors.

Finally, note that digital printing technology is relatively new, and therefore is applicable and extensible aforementioned sectors (wood, glass, etc.). Moreover, analysing the sectors with the most potential we focus on textiles and packaging together with the labelling. The textile sector has evolved, so you could get to make clothing of all kinds in large volumes at low cost. Likewise, it could happen with other sectors, since one of the goals of digital printing is the production of large amounts arising from different models. That is why the scope of inkjet technology has no limits, being able to produce any type of object. Glass machinery can paint glasses for the home, even the windows of a vehicle. Therefore, it could produce any type of product including a car door, so you could also diversify into the automotive sector. The limit would be the type of ink, and the ink used in the textile sector is not the same as the glass and the material to be perform printing.

In conclusion, one could say that the inkjet technology is applicable to any sector since the construction of machinery for the printing of any product would not be a problem if a large viewing radar is available. The problem lies in the ink used and the material that you want to print, because the ink used for printing on glass is not the same as the textile, but it depends on the paint process and development conducted in inks to increase their future applications.

## CONCLUSIONS

Today's society is facing continuous changes, being an increasingly dynamic society in which there are no borders. Therefore, more and more companies take on these changes, being the ceramic industry one of the most competitive. For this reason, ceramic entrepreneurs need differentiating tools to stand out from the others, with technological innovation as a challenge of paramount importance.

The grouping of ceramics companies in industrial districts can generate improvements since its territorial proximity attract different suppliers and are supported by organizations to improve the position of these companies, through an innovative offer. There are numerous incremental innovations that have appeared in the Spanish ceramic sector, but if something caused the Spanish companies position themselves on the front lines worldwide was the appearance of inkjet technology.

Inkjet technology changed the way to decorate the parts to a fully mechanized process capable of printing complete ceramic pieces of different designs and different surfaces, becoming a clear example of radical innovation. Although there are already other manufacturers of machinery for tile manufacturing inkjet, Kerajet was the first and has been rewarded for its innovation worldwide in digital printing technology. It is currently opening a huge market and business field for the entire sector.

Beyond a shadow of a doubt, digital printing technology has made great progress since its beginning, allowing having a massive industrial implementation in the field of ceramic tiles. However, this technology is not limited to the decoration of tiles, but it also allows multiple effects, reliefs and even glazes. Also thanks to the efforts for R & D, applications targeting sectors unrelated to ceramics have been found. More and more companies implement diversification strategies to generate high-value products that are impossible to produce by companies that do not have this technology. This has been a great benefit to those companies for the development of this technology, introduced in sectors such as glass, wood and textile.

Using inkjet technology will continue to grow and spread to all sectors as they can be used to produce almost anything. The limit depends on the inks that are developed. If there is a type of ink for each material, anything could be produced. This would have a great impact for business inkjet machines, since many could not cover the market demand.

Finally, it is important to analyse the great impact the appearance of inkjet technology has had in the ceramic sector companies in order to assess the scope thereof, and how this technology and its future applications could affect the global market.

## REFERENCES

ACIMAC (2017). *Digital Decoration of Ceramic Tiles*. [Pdf] ACIMAC Available at: http://www.ceramicworldweb.it/filealbum/Home/cww/pdf/quaderni-acimac/2016/ACIMAC%20Decorazione%20Digitale%202017%20ENG.pdf [Accessed at: 20 April 2018]

Albors-Garrigos, J. (2002). *Networking and technology transfer in the Spanish ceramic tiles cluster*: *Its role in the sector competitiveness*. The Journal of Technology Transfer, 27 (3), 263-273.

Albors-Garrigos, J., & Hervás-Oliver, J. L. (2012). *Radical Innovation and Technology Diffusion in Traditional Clusters: How High-Tech Industries Reinvented a Traditional Cluster*, in: Bas, T. G., & Zhao, J. (2012). Comparing High Technology Firms in Developed and Developing Countries. Cluster Growth Initiatives, 99-109

K. P. M. G. (2016). *El sector del azulejo en España a través de 21 grandes empresas*. [Pdf] Available at: https://assets.kpmg.com/content/dam/kpmg/pdf/2016/05/Informe-sector-azulejero-mayo-2016.pdf [Accessed at: 25 March 2018]

ASCER (2015). Asociación Española de Fabricantes de Azulejos y Pavimentos Cerámicos https://www.ascer.es/ [Accessed at 25 March 2018]

ASCER (Asociación Española de Fabricantes de Azulejos y Pavimentos Cerámicos) 2014: *ASCER presenta el balance económico del sector cerámico español en 2014* [Online] Available at: https://www.ascer.es/prensaNoticias.aspx?id=9879 [Accessed at: 8 April 2018]

ASEBEC (2018) Asociación Española de Maquinaria y Bienes de Equipo para la Industria Cerámica http://www.asebec.org/ [Accessed at 10 April 2018]

ATC (2018) Asociación Española de Técnicos Cerámicos http://www.atece.org [Accessed at 20 April 2018]

Budí, V. (2008). *"El distrito de la cerámica en Castellón"*. [Pdf] Available at: http://www.publicacionescajamar.es/pdf/publicaciones-periodicas/mediterraneo-economico/13/13-227.pdf [Accessed at 20 March 2018]

Clúster Competitividad. (1999). *El Clúster cerámico en Castellón. Iniciativa de refuerzo de la competitividad*. Valencia: Bancaja

Corma-Canós, F. (2007). *Modelo de innovación en el clúster cerámico*. Castellón: Asociación Española de Técnicos Cerámicos

Drucker, P. (1986). "La innovación y el Emprendimiento". Apóstrofe. Barcelona.

Echevarría, J. (2008). El manual de Oslo y la innovación social. *Arbor, 184(732*), 609-618.

CEVISAMA (2015): *El sector cerámico español consolida su crecimiento*. [Online] Available at: https://cevisama.feriavalencia.com/el-sector-ceramico-espanol-consolida-su-crecimiento/ [Accessed at 27 April 2018]

Formichella, M. (2005): *"La evolución del concepto de innovación y su relación con el desarrollo*". [Pdf] Available at: https://www.researchgate.net/publication/237121706_LA_EVOLUCION_DEL_CONCEPTO_DE_INNOVACION_Y_SU_RELACION_CON_EL_DESARROLLO [Accessed at 14 May 2018]

Freeman, C. (1984): *"The role of Technical Change in National Economic Development".* Science Policy Research Unit. University of Sussex.

Guerras y Navas. (2007). *La Dirección Estrátegica de la Empresa.* Navarra: Civitas

ITC (2018) Instituto de Tecnología Cerámica http://www.itc.uji.es [Accessed at 8 May 2018]

Kerajet (2018) www.kerajet.com [Accessed at 10 May 2018]

Kodama F. (1992) Technology Fusion and the new R&D, *Harvard business review* 70, 70-8.

Molina-Morales, F. X. (2002). Industrial districts and innovation: the case of the Spanish ceramic tiles industry. *Entrepreneurship & Regional Development*, vol.14 (4), 317-335.

Molina-Morales, F. X., & Vázquez, Á. (2007). Factores inhibidores de la relocalización de actividades en los distritos industriales. *El caso de la cerámica de Castellón*. Cuadernos de Estudios Empresariales, 17, 9-30.

OCDE (2005) Oslo Manual: *"Guidelines for Collecting and Interpreting Innovation Data. Organisation for Economic Co-operation and Development"*. Statistical Office of European Communities, Paris.

OCDE y EUROSTAT (2005). Manual de Oslo: "*Guía para la realización de mediciones y estudios de actividades científicas y tecnológicas*", Tercera Edición, París: OECD. [Online] Available at: http://browse.oecdbookshop.org/oecd/pdfs/free/9205114e.pdf [Accessed at 2 May 2018]

Porter, M. E. (1998). Clusters and the new economics of competition. Boston*: Harvard Business Review*, 76 (6), 77-90.

Porter, M. E., & Stern, S. (2001). *Innovation: location matters*. Sloan management revie, 42 (4), 28-43.

Revista cerámica (2015) http://revistaceramica.com/ [Accessed at 7 May 2018]

Schumpeter, J: (1935). *Análisis del cambio económico. Ensayos sobre el ciclo económico*. Ed. Fondo de cultura económica, México. [Pdf] Available at: http://eumed.net/cursecon/textos/schump-cambio.pdf [Accessed at 10 March 2018]

Stiglitz, J. E., & Weiss, A. (1981). *Credit rationing in markets with imperfect information*. The American economic review, 71 (3), 393-410.

## ANNEX 1

**Picture 1: First printed tile with Inkjet technology (12/1998)**


*Source: Own elaboration*

**Picture 2.First Inkjet Prototype**


*Source: Own elaboration*

**Picture 3.First Commercial Inkjet Prototype**


*Source: Own elaboration*

**Picture 4.Inkjet Prototype presented at Cevisama 2008**


*Source: Own elaboration*

**Picture 5.Printing Ceramic Tile with Inkjet Technology**


*Source: Own elaboration*

**Picture 6.Dinnerware Decorated with Inkjet Technology**

*Source: Own elaboration*