WHAT WILL THE NEXT DISRUPTIVE INNOVATION IN THE CERAMIC CLUSTER BE?

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ABTRACT

Let's begin with the definition of Disruptive Innovation: a disruptive innovation is the type of innovation that is produced when an innovator launches an innovation onto the market that is simple, convenient, accessible and cost-effective, which completely transforms an industry and generates a new one through a distinctive alternate value proposition.

Disruptive innovations are a type of innovation that affect a certain industry in such a way that they make it change drastically. They can even make the market for its products and services disappear with the emergence of this innovation.

It is important to bear in mind that a disruptive innovation does not have to necessarily be technological, although this is the most common type. It can also be a change in a product or business model.

The clearest example of a disruptive innovation in the last few decades has been the development of the Internet, which we are still experiencing today and which has revolutionised most aspects of our lives.

History is full of examples of disruptive innovations in business such as the railway, computers, the sewing machine, the washing machine and in the ceramic sector, frit compositions, the roller kiln and porous single firing.

Disruptive technological innovations are, at the beginning, low performance and aimed at the least demanding consumers. These users are less profitable for companies that are already established in a specific market. This is because established companies need growth and increased profits based on their products, which creates internal trends towards the development of products with greater performance, aimed at the most demanding consumers that, in addition, provide greater profit margins.

Disruptive technology is progressively improved and gradually occupies the niches rejected by established technology. On occasions it manages to capture the greatest market share, displacing the established technology. An example would be the beginnings of digital photography, which had a much lower resolution, but provided huge reductions in the development costs associated with traditional photography. This same phenomenon was produced in the disruptive innovations in the ceramic industry.

This study aims to analyse the common features of the Disruptive Innovations that have taken place to date, identify their triggers and thus discern the logical path that they have followed, and as a result predict the next breakthroughs. In short, a contribution is involved on the way to the new disruptive innovation that is emerging in our industry.

1. INTRODUCTION

The ceramic cluster has all the typical characteristics of this type of business concentration. It is a network located in a specific area, grounded in a very specific field of activity. It is this network that determines the relations between all the actors, including those of knowledge transfer.

Our industry has traditionally been an open network with a constant flow of information and knowledge. Industry professionals have contributed to this, as well as the transverse organisations present in it and the client-supplier relationships based on proximity.

This flow of knowledge and information makes it relatively easy to identify technical-technological advances in the different ceramic sub-sectors, to study their creation, development, expansion, maturity and, in some cases, decline.

As it also generates and disseminates information, articles, studies, etc. on the history of ceramics, it becomes feasible to analyse the trajectory of such advances.

We find ourselves (2012-2017) in a period of huge advances (changes), not necessarily related to the Great Recession but without doubt somewhat affected by it, which have begun to create a new scenario in the Castellón ceramic cluster from the point of view of the introduction of new technological innovations as well as others that are in the making (in terms of both products and processes), innovations in marketing and even in something as static as the business model.

All of this is no stranger to the generalised trend towards globalisation, the pursuit of lower costs, greater ease of movement of products and services, making them cheaper to buy, the ceaseless quest for personalisation or the individual focus on new advances.

It is appropriate to focus on this point. That is, on what is a generalised (incremental) trend that was already anticipated at the beginning of the 21st century and that can produce sudden breakthroughs (disruptions) that significantly change the way of understanding a sector, in this case that of ceramic tiles.

The years 2000-2008 witnessed apparent constant growth in both demand and supply, but this growth, in accordance with the generalised trend, led to the appearance of other factors over time:

- Greater logistics costs.
- Greater marketing costs.
- Greater R&D&I costs.
- Greater costs in new product development.
- Greater costs in reception control of raw or semi-processed materials.
- The need to systematically increase value in each new stage of the product/process.
- In short, greater costs throughout the chain.

In order to deal with these changes, various strategies were adopted that produced results (for some companies) from 2012-2014 and that meant an important change during the crisis years in market demand with the Great Recession.

Behind all the technical-technological movements throughout history, a series of steps have been maintained in most industrial products and consequently in those of the ceramic tile industry. Crises speed up the transitions between these steps.

It is important to identify these steps for two reasons:

- To better understand the incremental or natural drift and to be able to adapt to it early.
- To identify possible disruptive breakthroughs that allow for the adoption of strategies to deal with them.

In this study, the technical-technological changes that have occurred in the ceramic tile industry throughout its history will be analysed (in a qualitative manner), with a closer analysis of the last 50 years, in order to try to discern the logical incremental drift and a possible disruption that could take place in the next few years.

Bearing in mind that the changes can be profound, it is important to verify whether we are dealing with genuine disruptions or an incremental drift. A disruptive innovation is characterised by creating a new market on providing a set of values that ultimately, and in a more or less unexpected way, end up surpassing an existing market.

2. EXPERIMENTAL

2.1. LITERATURE SURVEY:

The literature survey followed the following script:

- Identifying ceramic products throughout history.
- Identifying technologies associated with these products.
- Verifying elements of supply and demand associated with these.
- Identifying great breakthroughs in products and technologies, their relation to supply and demand and possible causes or triggers in the different periods.

2.2. FIELD SURVEY. QUESTIONNAIRE-SCRIPT:

The study was performed using a qualitative research methodology (**RODRÍGUEZ GÓMEZ G., GIL FLORES J. Y GARCÍA JIMÉNEZ E. (1996)** *Metodología de la Investigación Cualitativa. Spain.* Aljibe. Pp. 39-41).

A questionnaire was written, split into blocks:

- Block 1: Identification. This was used to break down by:
  - sector
  - size
  - turnover
  - location
  - age
  - relation to R&D&I
- Block 2: Questions related to:
  - Innovations introduced by the company to the respondent's knowledge.
  - Sorted by: product, process, organisation, marketing, business model.
  - Those the respondent is aware of in other companies and that stand out.
  - Those that the respondent considers disruptive.
- Block 3:
  - Reasons why the respondent believes these innovations were produced. Objective pursued.
  - Strategy behind this objective.

2.3. POPULATION:

It was sent to 40 people within the sector (different sub-sectors). People with years of experience in the sector.All people are characterised by knowing this development.

During the months of May, June and July 2017. Queries raised in the response were resolved personally.

2.4. SAMPLE:

25 people responded.

The responses were pooled and sent back to the 25 respondents for their verification or change of opinion.

The 25 responses were received again and the final summary was carried out.

2.5. NOTE:

Bearing in mind the aims of this (eminently qualitative) study, the representativity of the sample was not analysed.

It related more to a current perception and foreseeable development.

This study forms part of a wider project in which the phenomena associated with the emergence of innovations in the sector are studied.

3. RESULTS

3.1. FROM THE LITERATURE SURVEY:

This section contains a very brief review of the history of ceramics (ceramic tiles) to identify key moments in its development and in that of the technologies used. For this study, the literature and in particular the bibliographic resources of the Instituto de Promoción Cerámica (IPC), Castellón County Council, were used.

- Antiquity:
  - There is evidence of the use of ceramic tiles in murals that can still be seen today.
  - Associated with buildings representing political or religious power.
  - The shaping technology was manual and firing went from burying with fire to the hearth where flame and product coexisted to later reach separate chambers.
  - Production, beyond pottery, was aimed at production based on specific orders made to the hired artist.
- 15th Century:
  - Glazed ceramic tiles may be found, especially on walls, in architecture.
  - Especially significant in buildings associated with political and/or religious power.
  - These are always single pieces made individually and by hand.
  - Production continued to be manual and was expanded to firing in kilns with separate chambers.
  - Polychrome glazes appeared (based on natural compositions) and geometry was used as a basis for manual decoration.

  - Repetitive (manual) productions were made with a single motif to achieve architectural combinations.
- 16th-18th Centuries:
  - A progression of the above.
  - It continued to be manual.
  - It was extended to use in civil buildings of lower rank than royal palaces.
  - Motifs continued to be those desired by the artist (upon request) for the singularity of the building.
- 18th Century-beginning of 19th Century:
  - Appearance of the steam engine.
  - Gradual introduction into the ceramic industry and mechanisation of milling operations.
  - Appearance of screw presses to manufacture small pieces (buttons and mosaics) in a repetitive and uniform manner.
  - Appearance of decorative stamping.
  - All of the above was developed in England and France.
  - In Spain, pottery continued and series were produced, on demand, in small quantities, focusing on few formal and non-technological variations (Alcora, El Retiro, Granja de San Ildefonso).
  - They began to be used in civil buildings.
  - The necessity of organising in-house production appeared at the start of the industrial era: Sargadelos.
  - Both claddings and floorings continued to be manufactured to order and for luxury architecture.
  - The first serial productions appeared of a more popular character.
- 19th Century:
  - The industrial revolution spread in Spain, appearing later than in Europe.
  - Protectionist measures aimed establishing ceramic industries.
  - Appearance of industrial centres around the big cities and the beginning of the expansion of urban areas and resulting demand for all building-related products.
  - Boom of ceramics as housing-related element.
  - High manual component and appearance, in the second half of the century, of mechanisation elements. Pickman:

- First clearly industrial exponent of ceramic tile manufacture.
- Slip casting and pressing.
- Decoration by stamping various inks.
- Appearance of the ceramicist as process specialist.
- Creation of in-house schooling at the factory.
- Graphic evidence remains of bottle kilns.
- Geographic spread.

  - 30 factories and 34 kilns in the Valencia Region in 1857, of which 14 were specifically for tiles (2 in Castellón: Elías Peris y Cia -1827- and la Valenciana).
  - Spectacular growth until the end of the century with the growing demand for buildings:
    - Hydraulic equipment increasingly used to mechanise operations.
    - Use of steam power.
    - Advances in clay milling and in semi-dry tile forming.
    - Use of stencils for decoration.
    - Not all companies introduced such advances and this was the differentiating key to survival in periods of falling demand.

- 20th Century:
  - The incorporation of the modernist style into the field of architecture revalued the use of ceramics.
  - Two avenues appeared: architectural use of ceramics at the request of the modernist artist and use in popular building.
  - Valencian focus on tile production.
  - Appearance of electrical energy.
  - Technological advances in all manufacturing processes. Continuous kilns, friction presses, milling drums.
  - Huge boom in the first quarter of the century to satisfy demand.
  - Major global crisis and period of drop in demand that made the number of tile manufacturing companies fall sharply.
  - From 43 factories in Castellón in 1930, 26 remained in 1935.
  - The civil war imposed a lengthy stop on technological development.
  - In 1946 there were 65 Arab kilns and 45 continuous kilns (glazed tiles), 64 mechanical presses and 60 manual presses, 31 mechanical clay crushing machines, 3 kilns for calcining colours and 19 for frit fusion, Alsing mills and 5,192 square metres were produced daily at the 38 companies in Castellón, which already accounted for 66% of Spanish production.
  - The Spanish National Housing Plans I and II (1955-1965) led to a huge increase in production.

- At the same time there was a decline in quality and drastic reduction in the range of complementary pieces, which had contributed so much to the previous boom with modernist architecture.
- The increase in production to satisfy demand was at the detriment of decoration and polychromy.
- From 1970 and especially 1980 onwards (gas) we already had what many of us are familiar with.

This very brief review allows us to discern some determining milestones for the issue that concerns us in this study:

- A very long period (centuries) of minimal craft production, upon personal request, for luxury building, associated with the tastes of the artist and those commissioning the work. Commission. Limited spread of technology.
- Recent but accelerated period of increase in production to satisfy growing building demand, in parallel with the appearance of steam, electric and gas energy allowing mechanisation and actual industrial mass production.
- Both periods entailed a different type of product-decoration: exclusively personal in one period and mass production (impersonal) in the other.
- In addition, to achieve this breakthrough it was necessary to focus technological advances on making the product cheaper for mass use.
- Innovations were aimed at:
  - Mechanising.
  - Increasing production (same or new markets).
  - Reducing costs (growing demand).

But this history provides episodes that have been repeated such as the various crises, some of which were dramatic and led to similar results: company shutdowns and development of innovations for survival and/or advancement when demand later returned.

3.2. FROM THE FIELD SURVEY. QUESTIONNAIRE-SCRIPT:

For the purposes of this study, only the following results were considered:

Identified innovation	Sector	Product	Process	Marketing	Organisation	Business model
Tunnel kiln	Machinery		x			
Friction presses	Machinery		x			
Glazing line	Machinery		x			
Fritted glazes	Glazes	x				
Gas	Machinery		x		x	
Hydraulic presses	Machinery	x	x		x	
Roller kiln	Machinery	x	x		x	
Spray dryer	Machinery	x	x		x	
Single-fired stoneware tile	TilesM	x	x	x	x	x
Monoporosa	TilesM	x	x	x	x	x
Automatic sorting machine	Machinery	x	x		x	
Sales with own network	Tiles			x	x	x
Designs incorporated into the glazes	Glazes			x	x	x
Grits	Glazes	x	x	x		x
Automated guided vehicles	Machinery	x	x		x	
Technical porcelain tile	TilesM	x	x	x	x	x
Cogeneration	Machinery		x			
Preparation of picking loads	Tiles			x	x	x
Roller decoration (Rotocolor)	Machinery	x	x	x		
Glazes with various properties	TilesE	x		x		
Glazed porcelain tile						
Inkjet	Machinery	x	x	x	x	x
Artificial vision	Machinery	x	x		x	

Identified innovations and their classification by type

Identified innovation	Incremental	Disruptive	Final objective*
Tunnel kiln		x	1,2,A**
Friction presses		x	1,2,3A
Glazing line	x		1,2,3,A
Fritted glazes		x	1,2,3,A,B**
Gas		x	1,2,3,
Hydraulic presses	x		1,2,3,A
Roller kiln		x	1,2,3,A
Spray dryer		x	3
Single-fired stoneware tile		x	1,2,3,A,B
Monoporosa		x	1,2,3,A,B
Automatic sorting machine		x	1,2,3,
Sales with own network	x		A,B
Designs incorporated into the glazes	x		1,A,B
Grits		x	1,A,B
Automated guided vehicles	x		2
Technical porcelain tile		x	A,B
Cogeneration	x		2
Preparation of picking loads	x		A,B
Roller decoration (Rotocolor)		x	1,2,3,A
Glazes with various properties	x		A,B
Glazed porcelain tile			1,2,3,A,B
Inkjet		x	1,2,3,A,B
Artificial vision		x	1,2,3,

Identified innovations and separation. Objective pursued.
**** 1: increasing production; 2: reducing costs, 3: improving quality (homogenise);***
***** A: increasing sales in the same markets; B: new markets.***

Identified innovation	**Period***	**Market situation**
Tunnel kiln	1960	Strong building boom 1960-1973
Friction presses	1960	"
Glazing line	1960	"
Fritted glazes	1960	"
Hydraulic press	1970	"
Gas	1980	"
Roller kiln	1980	Building depression
Spray dryer	1980	"
Single-fired stoneware tile	1980	"
Monoporosa	1985	"
Automatic sorting machine	1980	"
Sales with own network	1985	"
Designs incorporated into the glazes	1985	"
Grits	1985	"
Automated guided vehicles	1990	New boom
Technical porcelain tile	1990	"
Cogeneration	1990	"
Preparation of picking loads	1990	" until the Gulf War
Roller decoration (Rotocolor)	1995	Increase in building in Spain
Glazes with various properties	2000	"
Glazed porcelain tile	2000	"
Inkjet	2005	"
Artificial vision	2010	Great recession

**Approximate time periods were taken and rounded to the nearest 5 years*
Identified innovations, their position in time and market situation

From these data, it may be observed that:

- Most innovations were centred in the machinery sector followed by the glaze sector.
- Those centred in the tile sector were usually associated with one of the above two sectors except in the case of "sales with own network" and "preparation of picking load".
- They fundamentally affected the product, within each sector, and the process.
- Those that affected the organisation and marketing had their origins in product/process innovation and in the machinery and glaze sectors.
- Innovations in the business model were associated with product innovation, either in glaze or machinery.
- The only business model innovation in the tile sector was that of marketing with an own channel.
- These data are consistent with the Spanish National Statistics Institute results on identifying innovations introduced by companies:

Technological innovation	CNAE 2630	CNAE 26
EIN (innovating companies or companies with ongoing innovations or unsuccessful innovations) out of the total companies	33.8	27.7
Companies that carry out product innovation	76.9	56
Companies that carry out process innovation	75.9	80.3
Companies that carry out both	52.8	36.2
Innovation in the company itself	25.7	19.7
Companies that have cooperated in innovation	9.6	4.4
Companies that have received public funding	27.2	30.2

Technological innovation of ceramic companies in general (CNAE 26 (National classification of Economic Activities)) and those of the cluster in particular (CNAE 2630).

- Innovations always contain a factor of cost improvement and increase in production.
- In some cases, they focus on increasing sales in the same markets and in a few others on penetrating new markets.
- When these innovations are set in historical economic contexts, taking into account the interval between the appearance of the innovation and its original idea, the following may be noted (P. Corma Qualicer 2006) for the specific case of ceramic tiles:

- The innovations clearly corresponded to two specific factors:
  - *A defensive factor:*
    - Of external origin: External influences on organisations:
      - Demand: The increase in demand made the sector increase its supply and, in order to do so, innovations were used in processes as was the case of their continuous automation.
      - Factors encouraging demand: This may be the economic situation and, in a clearer sense still, the exchange rate of the dollar to Spanish currency (either the peseta or euro), which enhanced competitiveness in international markets.

    - Of internal origin: The difficulties that arose from factors influencing cost, such as energy prices and their influence on the need to save energy:
      - Exclusively through processes
      - Or by processes that led to new products.

  - A preventive or offensive factor:
    - Against those of external origin:
      - Encouraging demand through a new range in the form of a differentiated product and the associated innovations: Fundamentally product-based innovations.
      - Encouraging demand through competitive pricing (costs) and, in order to do so, developing innovations, fundamentally in processes and their automation.
    - Against those of internal origin:
      - Anticipating foreseeable influences, such as energy costs, transport costs, competition in local/remote markets, etc. For this, companies are turning to differentiating innovations in terms of products (design, characteristics and applications), processes (basically in costs, logistics and marketing) and more generally (brand and distribution channel)

Analysing all innovations reveals that they prove to be:

- Defensive in most cases
- The first companies to introduce them, despite being defensive, make them offensive and, therefore, gain time over the competition
- Fundamentally relating to processes, in quantity as well as in rupturing effect not substantially different from those already existing. This was valid even in the case of new product launches.
- Product-based innovations cannot clearly be considered innovations.
- In practically all innovations, the need occurred first and the innovation was then developed.

In view of these data and using both results (literature and questionnaire), the following may be observed:

- Continuity of the production of individual craftwork for centuries.
- Craftwork was based on orders received by the artist/architect.
- The move to industrialisation transformed the above to batch production.
- The pieces were not produced individually but were produced in batches in any of the processes.
- This was the result of mechanisation and the need to increase productivity and make products affordable in terms of market demand.
- But this resulted in loss of aesthetic quality.
- Modern technologies seek to return to piece-based production while maintaining mechanised, automated and even robotic production.
- This symbiosis of the individual piece with industrial mass production is characterising recent innovations.
- The goal is to recover aesthetic quality and a personalised product but at accessible prices in terms of demand.

Following this common theme, we may ask ourselves where the ceramic tile industry is heading:

- Is it sure to take a dual path imitating the past? One, a mass-market, and the other, a specific, approach?
- Or will it follow a path that learns from the past and makes both options feasible?

One trend will be that of following the incremental path that we have witnessed for the last 3-5 years in terms of technologies, products and use.

The spectacular advance of technologies applicable to the production of ceramics enables one to envisage new alternatives in terms of disruptions:

- Products wholly adapted to a specific demand.
- Without undermining (when not improving) the price.
- Supplying all markets.

Ceramic companies are attempting to achieve these three characteristics with currently available technologies, but they are attaining this based on facilities that perfect earlier ones.

The disruptive breakthrough we are heading towards, but which has not yet materialised, is that of covering any surface with ceramics, it being the individual users who decide how they want this.

This principle implies that the ceramics are not produced and, subsequently, taken to the user. It implies that the user does this in real time. Technologies are available (plasma spraying and 3D printing), but still far from suitable for mass use in this sense.

This trend clashes with a reality that needs to be overcome, namely that 90% of marketing is through B2B intermediaries, but that this will tend disruptively towards B2C.

This paper seeks to shed light on the possible drift in the near future that could occur in the ceramic tile industry, and that suppliers of machinery and glazes (true drivers of innovation) may already be considering.

4. CONCLUSIONS

The study of the history of ceramic products (ceramic tiles) allows us to see the development of shapes and decorations, of supply and demand, of the technology associated with each period and all their interrelations.

It also allows us to analyse the essential reasons that have caused the aesthetics and beauty of tiles to develop, how the product has been popularised and mass produced and how technological innovations have influenced this process.

This analysis and the importance of current trends towards the personalisation of all products may help to discern the path that emerging innovations will follow within the sector, such as greater personalisation and lower costs.

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