STUDY OF THE MANUFACTURING AND INVESTMENT COSTS OF DIFFERENT CERAMIC TILE PRODUCTION METHODS

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1. ABSTRACT

The present paper compares the manufacturing costs and investments required to produce large-size ceramic tiles (> 60 cm x 60 cm), using two different forming technologies: pressing in hydraulic presses and forming using technologies that yield large slabs (> 120 cm x 240 cm)

The composition used in all cases was a porcelain stoneware composition. The study addressed the manufacture of floor tiles (12-mm thick) and wall tiles (6-mm thick) using this composition, with a 50% production of each product. Most of the facilities (drying, glaze, decoration, etc.) were common, only pressing being fundamentally different. Four different processes were analysed, using 2 conventional pressing facilities and 2 other facilities that formed large-size slabs. In all cases, plants were designed for an annual production of about 1,800,000 m^2. All the material produced was assumed to undergo dry rectification.

The results obtained allow identification of the most significant costs in each of the processes analysed, as well as quantification of the required investments. The paper provides information that facilitates the economic estimation of other possible processing options for this type of product, not analysed in this study.

2. INTRODUCTION

In the last 40 years, the ceramic tile manufacturing process and the type of products manufactured have undergone a true revolution. From dry double-firing processes, used mainly to manufacture earthenware wall tiles, to the current wet single-firing processes, used to manufacture stoneware, porcelain stoneware and wall tiles. Publications were found in the literature surveyed [1] [2] [3] [4] [5] that enable comparison of the manufacturing costs and investments of the different production processes involved.

Recently, ceramic machinery manufacturers have developed technologies for forming ceramic products that allow manufacture of larger sizes than those that could be obtained previously by conventional uniaxial hydraulic presses. This new technology, a priori, offers greater versatility and productivity in large sizes.

3. OBJECTIVES

The aim of this paper was to compare the manufacturing costs and investments needed to produce large-size ceramic tiles (larger than 60 cm x 60 cm), using two different forming technologies:

- CONVENTIONAL: Pressing in hydraulic presses.
- LARGE SIZE: Pressing using forming technologies that enable production of large-size slabs

4. CASES ANALYSED AND FACILITIES DESIGN

In order to properly compare the manufacturing costs of the evaluated technologies, different production schemes are examined for the different forming technologies studied. The four cases analysed in this paper, referred to as processes 1 to 4, are shown in **figure 1**

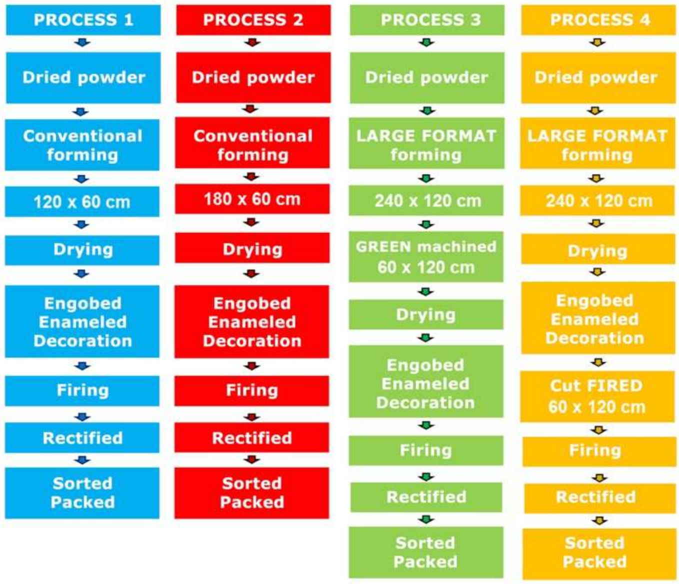

Figure 1. *Production Processes Analysed.*

Processes 1 and 2 use conventional hydraulic presses. In process 1, slabs of 60 cm x 120 cm are formed which, after drying, decorating, firing and rectifying, are classified and packaged for sale. Process 2 differs from process 1 only in terms of the size of the manufactured pieces (60 cm x 180 cm), which implies having to work with presses with a greater capacity.

Processes 3 and 4 use the new forming technologies, capable of producing large slabs. In process 3, slabs 120 cm x 240 cm in size are formed, which are cut in the unfired state, yielding 4 slabs of 60 cm x 120 cm which, after drying, decorating, firing and rectifying, are classified and packaged for sale. Process 4 differs from process 3 in that the 120 cm x 240 cm slabs are fired, without previous cutting, and they are then cut to 60 cm x 120 cm and rectified. Process 4 may be deemed to resemble a just-in-time process in which, instead of storing pieces of different sizes, large fired slabs are stored that can later be cut to the size needed by the company.

The characteristics of the products and the production data for the cases studied are shown in **figure 2**. As a common denominator, a work regime of 5 days/week in 3 shifts from Monday to Friday was assumed, equivalent to 6,000 h/year. As can be seen, the firing cycles differed, depending on the thickness and size produced in each process. Therefore, in order to equalise the annual production, the kilns were sized such that they produced about 7,200 m^2/day in all cases (about 1,800,000 m^2 per year). The kilns remained on stand-by at low temperature (about 700°C) during the weekend, this being taken into account in the calculation of kiln thermal consumption.

Regarding the characteristics of the tiles produced, a single porcelain stoneware tile composition was considered. This composition was used to manufacture floor tiles (12-mm thick) and wall tiles (6-mm thick), with a 50% production of each type of product. The calculation of glazing and decoration consumption took into account production of 70-30% gloss-matt for wall tile production and 10-90% for floor tile production. All the products put on sale were dry rectified and cut in the unfired or fired state, depending on the production process.

	PROCESS			
PRODUCT	1	2	3	4
Composition	Porcelain	Porcelain	Porcelain	Porcelain
Production (m^2/day)	7,200	7,200	7,200	7,200
Production (m^2/year)	1,800,00	1,800,000	1,800,000	1,800,000
Thickness (mm)	6 - 12	6 - 12	6 - 12	6 - 12
% Production	50 - 50	50 - 50	50 - 50	50 - 50
Gloss/Matt (%)	70/30 –	70/30 – 10/90	70/30 – 10/90	70/30 – 10/90
Size formed (cm)	60 x 120	60 x 120	60 x 120	60 x 120
Rectified/Cut	YES/NO	YES/NO	YES/YES	YES/YES
Type of Cutting	-	-	Unfired	Fired
Size sold (cm)	60 x 120	60 x 180	60 x 120	60 x 120
Firing cycle (min)	52 - 62	52 - 72	52 - 62	55 - 90

Figure 2.*Characteristics of the Products and Production Data for the Cases Studied.*

The facilities required for each of the four processes are summed up in **figure 3**. In process 1, 6,500 t conventional presses were used, while presses with a higher pressing force (10,000 t) were needed for process 2; the large-size forming system was used for processes 3 and 4. The dryers were common to the four processes, a multi-deck horizontal dryer with a processing capacity of up to 8,000 m^2/day being used. The glazing, decoration and (dry) rectifying systems were also common to the four processes. The kilns used in processes 2 and 4 were longer in order to equalise production in all the processes since, due to the larger sizes of the products to be processed, longer firing cycles were required.

		PROCESS			
FACILITIES		**1**	**2**	**3**	**4**
FORMING		2 Presses 6500 Tm	3 Presses 10.000 Tm	Large-size technology	Large-size technology
DRYERS		1 Horizontal	1 Horizontal	1 Horizontal	1 Horizontal
DECORATION		2 INK JETS	2 INK JETS	2 INK JETS	2 INK JETS
KILN	Units	1	1	1	1
	Length (m)	147	177	147	197
	Width (m)	2.85	2.85	2.85	2.85
	m^2/day	7200	7200	7200	7200
RECTIFICATION	Type	Dry	Dry	Dry	Dry
	Motors per side	14	14	14	14

Figure 3. *Design of the Facilities for Each Studied Case.*

5. RESULTS

5.1. INVESTMENTS AND AMORTISATION

In order to calculate the investment to be made in each type of process, items such as civil construction work and installations for different supplies (electricity, gas, water, compressed air...) were taken into account. The different stages in the production process were also considered, such as spray-dried powder reception and the tile forming area, glazing and decoration area, box buffer and moving area, firing area, cutting and rectification area, packing and sorting area; and, finally, the laboratory and office areas.

5.1.1. CIVIL CONSTRUCTION WORK

Civil construction work expenses were considered common to all the analysed processes and amounted to €2,498,623. The items requiring the highest investments were the foundations, costing more than €700,000, and the metal structure, costing about €600,000.

5.1.2. INSTALLATIONS

Installations expenses were considered common to all the processes analysed and included the installation of water, electricity, compressed air, natural gas and generator set. The item with the highest investment cost was the electrical installation, which cost €250,000.

5.1.3. FORMING AREA

The forming area was divided into three sections: spray-dried powder reception, storage and movement to hoppers and pressing. The first two sections were common to all processes and the last section differed depending on the case at issue.

The investment cost for the spray-dried powder reception area was estimated at €148,176; the storage and handling area, which had 6 storage silos, required an investment of €192,640. Together, both areas required a total investment of €340,816.

For process 1, an investment of €5,567,856 was estimated for the pressing area, the highest cost being the dryer (common to the 4 processes) at €2,251,200 million. For this process, 3 double dies with an approximate cost of €60,000/unit were assumed. For process 2, an investment of €8,155,056 was estimated for the pressing area, the highest cost being the presses at €4,536,000, followed by the dryer. For this process, 3 double dies were required with an approximate cost of €80,000/unit. For processes 3 and 4, the investment was the same and amounted to €6,189,456, with the large-size forming facility being the item with the highest investment cost at €2,688,000. For these processes it was considered necessary to have 2 forming sections at an investment of €150,000. A summary is shown in **table 1** of the total investment for the spray-dried powder forming area.

<table>
<tr><th>PROCESS</th><th>INVESTMENT (€)</th></tr>
<tr><td>1</td><td>5,567,856</td></tr>
<tr><td>2</td><td>8,155,056</td></tr>
<tr><td>3</td><td rowspan="3">6,189,456</td></tr>
<tr><td></td></tr>
<tr><td>4</td></tr>
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***Table 1**. Investment in the Forming Area According to the Process*

5.1.4. GLAZING AND DECORATION AREA

The investments to be made in the glazing and decoration area were common to all processes and amounted to €1,288,714, the most important outlay being that corresponding to the decoration machines for digital ink printing, which cost approximately €500,000 per unit.

5.1.5. BUFFER AREA, BOX MOVING AND LOADING/UNLOADING MACHINES

The buffer area for boxes, moving and loading and unloading machines would be the same for the four processes and would require an investment of €1,201,128. It should be noted that the most expensive item in this investment would be transport by self-guided vehicles at €360,000, followed by storage boxes at €203,940.

5.1.6. FIRING AREA

The kilns chosen for all processes had the same width of 2.85 metres, with different lengths. A price of €8,500/m kiln was considered. The following table shows the investment to be made for the firing area in each process.

PROCESS	Kiln length (m)	Investment (€)
1	147	**1,249,500**
2	177	**1,499,400**
3	147	**1,249,500**
4	197	**1,677,900**

Table 2. *Investments in the Firing Area.*

5.1.7. CUTTING AND RECTIFICATION AREA

Processes 1 and 2 would not have a cutting area since the material was pressed to sale size and rectified. In process 3, cutting would in the unfired state and the cost of the cutting equipment was already included in the cost of the forming area. For process 4, the fired piece would be cut; the cost of the cutting equipment for the fired pieces would have an insignificant impact on the investment and was not considered. As for rectification, an investment was considered, common to the four processes, amounting to €460,000, of which €100,000 would go to the dust extraction system and soundproofing.

5.1.8. SORTING, PACKAGING AND PALLETING AREA

The facilities in the sorting, packaging and palleting area would also be treated as common to the four processes and would amount to an investment of €599,150.

5.1.9. LABORATORY, OFFICES AND COMPANY VEHICLES

The investments required to have a laboratory with basic equipment, office furniture and vehicles were also taken into account. This investment would be €150,565.

5.1.10. SUMMARY OF INVESTMENTS AND AMORTISATION COSTS PER PROCESS

A summary of the investment according to the area considered as it relates to the total investment is shown in **table 3**. It also shows the annual amortisation cost that would be incurred in each process if an amortisation time of 20 years for the civil construction work and installations and 5 years for the remaining items were considered.

	1	2	3	4
Construction	2,498,623	2,498,623	2,498,623	2,498,623
Installations	485,500	485,500	485,500	485,500
Presses	5,567,856	8,155,056	6,189,456	6,189,456
Glazing	1,288,714	1,288,714	1,288,714	1,288,714
Boxes / Moving	1,201,188	1,201,188	1,207,188	1,201,188
Kiln	1,249,500	1,499,400	1,249,500	1,677,900
Sorting / Packaging	599,150	599,150	599,150	599,150
Laboratories / Office	99,656	99,656	99,656	99,656
Company Vehicles	51,000	51,000	51,000	51,000
Cutting and Rectification	460,000	460,000	460,000	460,000
TOTAL INVESTMENT	**13,501,187**	**16,338,287**	**14,128,787**	**14,551,187**
Amortisation (€/year)	2,252,619	2,820,039	2,378,139	2,462,619

Table 3. *Summary of Investments and Amortisation Costs per Process.*

5.2. MANUFACTURING COSTS

As has been done for the calculation of the investment, the manufacturing costs are broken down below.

5.2.1. ELECTRICITY COSTS

The data set out in the Energy Saving Guide for the Ceramic Tile Sector were used to calculate electricity consumption [6]. The guide was drawn up based on a multitude of power consumption measurements taken in all the process and ancillary stages in different ceramic sector companies, providing as end result an average consumption per square metre in the different sections. Data supplied by SYSTEM and SACMI on power consumption in the forming stage with large-size technologies were also used.

For the calculation of electricity consumption in the cutting and rectification stages, the installed and absorbed power and the hours of use were used; this cost was common to the four processes and in process 4 an extra cost was added for power consumption on cutting the fired slabs. The electricity price was considered to be

€0.1717/kWh. The cost of electricity consumption in rectification was estimated at €143,359/year and cutting of the fired slab was estimated at €9,887/year with 6,000 hours of operation. An example of the calculation of the electricity cost for process 1 is shown in **table 4**. The same methodology was followed for the other processes. Overall, electricity costs were €628,310/year for process 1, €636.94/year for process 2, €573,782/year for process 3 and €583,458/year for process 4.

	Stage	kWh/m²	kWh/yr	€/yr
PROCESS	Pressing	0.350	648,593	76,339
	Drying	0.219	405,834	47,767
	Glazing	0.179	331,709	39,042
	Firing	0.365	677,131	79,698
	Cutting and Rectification	-	1,218,000	143,359
	Sorting	0.059	109,334	12,869
	Water treatment	0.041	75,978	8,943
ANCILLARY	Dust Extraction and Filters	0.282	522,580	61,508
	Lighting	0.128	237,200	27,918
	Compressed air generation	0.247	457,721	53,874
	Offices	0.060	111,187	13,087
OTHER (ancillary and/or process)		0.293	542,965	63,907
TOTAL			5,338,232	628,310

Table 4. *Electricity Costs for Process 1*

5.2.3. THERMAL ENERGY COSTS

As in the previous case, the Energy Saving Guide for the Ceramic Tile Sector was used for the calculation of thermal energy consumption [6]. The thermal energy price was considered to be €0.0270/kWh. Based on this guide, a consumption of 2,943 kWh/m^2 was estimated for drying 12-mm thick pieces and 1,472 kWh/m^2 for drying 6-mm thick pieces. Taking into account the estimated production, this resulted in a cost of €134,389/year for tile drying.

A kiln simulation program created by ITC was used to calculate kiln consumption, which estimates kiln consumption under different process conditions (slab thickness, cycle length, etc.) and under empty conditions at maintenance temperature during the weekends.

Total consumptions and costs for the drying and firing stages in each process are shown **table 5**.

PROCESS	kWh/year DRYING	kWh/year FIRING	kWh/year TOTALS	€/year
1	4,977,380	18,767,464	23,744,844	**641,111**
2	4,947,151	19,165,049	24,112,201	**651,029**
3	4,977,380	18,767,464	23,744,844	**641,111**
4	4,977,614	20,122,725	25,100,339	**677,709**

Table 5. *Summary of Thermal Consumption and Costs for each Process.*

5.2.3. LABOUR COSTS

All processes were assumed to require the same number of personnel (56 people). Of these 56 people, 15 people would work in management, offices and the laboratory and the rest would be section heads, operators, mechanics and cleaners. The working timetable involved either normal working hours or three shifts from Monday to Friday, depending on the job. In total, the labour costs were estimated at €1,451,520/year.

5.2.4. WATER CONSUMPTION COSTS

Water consumption was calculated based on studies by the ITC Area for the Environment and included landscaped areas, personnel, glaze preparation, cleaning and in-plant services. Water consumption was estimated at 16,500 m^3/ year with a cost of €5,819/year, which was common to all processes analysed.

5.2.5. COST OF SPRAY-DRIED POWDER

Since the production and type of product were approximately constant for all processes, the quantity of spray-dried powder consumed was very similar across every process, with slight differences depending on the loss produced by rectifying, which varied according to the size of the pieces. An annual consumption of spray-dried powder of approximately 43,000 tons was estimated, which at a price of €80/t resulted in a cost of €3,455,521/year.

5.2.6. FORMING SECTION TOOLS COST

For the calculation of the forming section tools cost, data supplied by two die makers and those supplied by SACMI and SYSTEM were used. It was taken into account that the dies used in processes 1 and 2 were double or mirror dies and that, therefore, the blade changeover would take place in both the upper and lower punches.

When calculating the cost of the tooling of the forming section by the conventional method, the useful life of the dies until their rectification, the duration of the punches until their repair, the useful life of the blades until replacement and the number of strokes/year were taken into account. For process 1 it was calculated that it was necessary to rectify the dies 6 times/year, carry out 12 punch repairs/year and change 12 blades. For process 2, since fewer strokes per year were needed for the same production, and as the pressed surface was greater, only 3 rectifications/year, 8 punch repairs/year and the replacement of 4 blades were considered necessary. These consumptions amounted to a cost of €72,000/year for process 1 and €60,000/year for process 2.

Based on the information supplied by SYSTEM and SACMI, it was estimated that the consumption of tools in the forming area for processes 3 and 4 would cost approximately €255,000/year on average for the two technologies at issue in the production considered.

5.2.7. CONSUMPTIONS AND COSTS OF THE GLAZING AND DECORATION RAW MATERIALS

For the calculation of glazing materials consumption, an amount of glaze of 0.30 kg/m^2 was considered for floor tile, for both glossy and matt material, and 0.60 kg/m^2 for wall tile, with losses of 3% in both cases. Regarding the engobe, an amount of 0.30 kg/m^2 was considered for both products and 0.05 kg/m^2 for rib engobe with losses of 3%. In the calculation of ink consumption for digital decoration, a necessary amount of 0.015 kg/m^2 and losses of 1% were considered for all cases. For the calculation of consumption of floor tile protection materials, an amount of 0.10 kg/m^2 was considered, both for the glossy and the matt material, with losses of 1%.

The consumptions were very similar for all the processes analysed and on average resulted in a cost of €2,055,030/year.

5.2.8. CONSUMPTIONS AND COSTS IN THE PACKAGING SECTION

In the packaging section, the number of boxes and pallets needed to package the annual production in each process were taken into account. Processes 1, 3 and 4 yielded the same results, since the final sales size was the same (60 cm x 120 cm), whereas the calculations differed for process 2 (60 cm x 180 cm). A consumption of 936,544 boxes and 34,687 pallets was calculated for processes 1, 3 and 4 at a cost of €450,582/year. A consumption of 1,243,888 boxes and 34,552 pallets was calculated for process 2 at a cost of €501,701/year.

5.2.9. WASTE TREATMENT COSTS

Waste treatment costs were considered common to all processes and included transport of the discarded raw material to the spray-drier, landfilling of the discarded fired material and cost of immobilising the residue from the kiln filter. The calculation was based on data obtained by the ITC Environment and Energy Area and a cost of €20,898/year was estimated.

5.2.10. MAINTENANCE COSTS OF THE FACILITIES

Maintenance costs were calculated as a variable percentage of the investment costs per area. The annual maintenance costs in the forming, glazing, sorting and packaging areas, laboratory, offices and vehicles were estimated at 5% of the investment. This was estimated at 8% for the firing area and at 20% for the rectification area. A maintenance cost was further estimated of €3,000/year for each digital printer and an annual renewal of the kiln rollers. The maintenance costs for process 1 would amount to €544,926/year; for process 2 they would amount to €697,607/year; for process 3 they would amount to €576,006/year; and for process 4 they would amount to €615,985/year.

5.2.11. COST OF CONSUMABLES IN CUTTING AND RECTIFICATION OPERATIONS

To calculate the cost of the consumables for cutting, the number of cutting discs necessary for the unfired slabs and the widias required for cutting the fired slabs, according to the linear metres to be cut, were taken into account.

To calculate the consumption of cutting discs for the unfired slabs in process 3, it was taken into account that each disc had a useful life of 30,000 linear metres and that two discs were used per cut to be made, amounting to a cost of €36,893/year.

For process 4, the consumables necessary for the firing operation were calculated. The calculation was made using both pre-cutting discs and marking widias. In the case of the widias, it was considered that 1.5 widias were used per day and cutting; in the case at issue, it would be necessary to perform 3 cuttings. For pre-cutting discs, a life of 9,000 linear metres per disc was considered, using 3 discs, one per cutting to be made. Both solutions resulted in very similar costs, as using the most economical widias meant it was necessary to use a greater number of them. On average, a cost of €11,700/year was estimated.

To calculate the cost of the consumables in the rectification operation, the number of grinding tools needed according to the annual linear metres to be rectified and the useful life of each type of grinding tool were taken into account. The data supplied by the grinding tool manufacturers indicated an average service life in linear metres depending on the type of tool: high cutting, medium cutting, pre-finishing or bevelling. For process 1, the cost of the grinding tools was estimated at €258,827/year, €233,599/year for process 2, €258,827/year for process 3 and €268,828/year for process 4.

A cost for losses in the rectification operation was also taken into account and was calculated bearing in mind that 1% of the production became losses on rectification.

In total, the annual cost of consumables needed to carry out the cutting and rectifying operations together with the cost of the operation losses amounted to €343,431/year for process 1, €357,224/year for process 2, €380,324/year for process 3 and €367,242/year for process 4.

5.3. SUMMARY OF AMORTISATION AND MANUFACTURING COSTS ACCORDING TO THE PROCESSES CONSIDERED

The amortisation costs, manufacturing costs and totals for each process analysed are summarised in €/m^2 in **table 6**.

		1	2	3	4
	Production (m^2/year)	1,798,462	1,793,637	1,798,462	1,797,580
	Production (m^2/day)	7,194	7,175	7,194	7,190
AMORTISATION (€/m^2)	Construction	0.14	0.14	0.14	0.14
	Facilities	0.03	0.03	0.03	0.03
	Presses/Dryers	0.31	0.45	0.34	0.34
	Glazing	0.07	0.07	0.07	0.07
	Boxes/Moving	0.07	0.07	0.07	0.07
	Kiln	0.07	0.08	0.07	0.09
	Sorting/Packaging	0.03	0.03	0.03	0.03
	Laboratories/Office	0.01	0.01	0.01	0.01
	Company Vehicles	0.00	0.00	0.00	0.00
	Cutting and Rectification Area	0.03	0.03	0.03	0.03
	TOTAL (€/m^2)	**1.25**	**1.57**	**1.32**	**1.37**
MANUFACTURING COSTS (€/m^2)	Electricity	0.35	0.36	0.32	0.32
	Thermal Energy	0.36	0.36	0.36	0.38
	Labour	0.81	0.81	0.81	0.81
	Water Consumption	0.00	0.00	0.00	0.00
	Spray-dried Powder	1.92	1.91	1.92	1.92
	Pressing Tools	0.04	0.03	0.14	0.14
	Glazing Materials	1.14	1.14	1.14	1.14
	Boxes	0.19	0.22	0.19	0.19
	Pallets	0.06	0.06	0.06	0.06
	Waste Treatment	0.01	0.01	0.01	0.01
	Maintenance	0.30	0.39	0.32	0.34
	Cutting and Rectification Area	0.19	0.20	0.21	0.20
	TOTAL (€/m^2)	**5.38**	**5.50**	**5.49**	**5.53**
	Total Cost (€/m^2)	**6.63**	**7.07**	**6.81**	**6.90**

Table 6. *Summary of amortisation costs, manufacturing costs and total costs (€/m^2) according to the processes considered.*

6. CONCLUSIONS

- Of the processes analysed, the one that requires a greater financial investment is process 2 (€16,338,287), due to the need to use a greater number of hydraulic presses which were also more powerful. Process 1 requires the lowest capital investment (€13,501,187), 21% less than process 2.
- The investments needed to form the pieces using large-size technology (processes 3 and 4), are between 4% and 8% greater than if the pieces are made up to 60 cm x 120 cm by conventional pressing (process 1). The main differences are in the investment required in the forming/drying section and the need to use a longer kiln if large-size pieces are fired (process 4).
- Manufacturing costs are very similar for all processes, since many of the manufacturing stages, as well as the overall production of the plant, have been considered roughly the same for all processes. Process 1 has the lowest costs and process 4 has the highest costs, with a maximum difference of 3%.
- The process with the lowest total cost is process 1 (€6.63/m^2) and process 2 has the highest cost (€7.07/m^2), mainly due to the higher amortisation cost. The differences in the total manufacturing cost between the processes considered range from 7% (processes 1-2) to 2% (processes 1-3).
- In process 4, where just-in-time production could be used, the savings that would occur due to lower stock have not been taken into account; according to the literature consulted [7], these are estimated at €0.054/m^2 for an annual production of about 3,800,000 m^2. It may be noted that this process would also be favoured by other aspects that, due to their subjectivity and the difficulty in estimating them, have not been quantified here: lower prices of small production surpluses (peaks), improved customer service (due to being able to serve orders of different sizes more quickly), etc.
- Large-size technology yields a more versatile plant on being able to obtain multiple sizes from the same slab and to combine cutting of the unfired and the fired piece.

7. REFERENCES

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CAMBIAR EN LA FIGURA 1

Dried powder debería ser: Spray-dried powder

GREEN machined debería ser: UNFIRED cutting

Engobed debería ser: Engobing

Enameled debería ser: Glazing

Cut FIRED debería ser: FIRED cutting

Rectified debería ser: Rectification

Sorted debería ser: Sorting

Packed debería ser: Packaging