

QUALITATIVE ANALYSIS OF CONSEQUENCES OF THE USE OF DIFFERENT METHODOLOGIES FOR SINGLE-FIRING PRODUCTION

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Abstract. *The present paper proposes a concept analysis of the cost and quality consequence, that different production methodologies generate over ceramic tiles obtained by the single-firing process. Remarkable differences are mostly observed, in the world market, between Italy and Brazil, in two basic phases of the process: the body preparation and the product storage before and after the firing phase. The single-firing process is analyzed, identifying the mentioned divergences; the world market situation supplies numerical data to evaluate and measure the effects of different technological preferences. As a result of the analysis, some strategical recommendations are extended, to improve quality and competitiveness throughout Brazilian industry.*

Keywords: *ceramic tiles, production, single-firing, ceramic market, production methodology.*

1. INTRODUCTION

The production methodologies of ceramic tiles, even if highly standardized into the biggest world producers, still differ in some process steps, generating relevant consequences in terms of product cost and quality. The leading producers in the world market are China, Italy, Spain and Brazil. Analyzing the production processes it's noticed a total similarity between Italy and Spain and substantial differences in Brazil. China, even if is the first world producer, it will not be considered for being a new market and for the lack of reliable data. The most important divergences are observed in these two process steps: raw material preparation and product firing.

The paper focuses the technologic, economic and market aspects. Verifying relevant differences in terms of the adopted technology, quality, product mixing, prices and managing strategies, the goal is to analyze the consequences over market and production.

Some recommendations will be underlined, to orient the strategic choice that is necessary to warrant the survival and the expansion of the Brazilian ceramic tile market.

The analysis is limited to ceramic tiles, obtained by "single-firing" production methodology, nowadays the most diffused one and representing 80% of the whole world production; is also limited to Italy and Brazil, 2nd and 4th world producers, in terms of capacity (Assopiastrelle, 2006).

2. THE PRODUCTION

In the "single-firing" process, the glaze application, when necessary, is made on the "green" base; the firing is single, to obtain contemporarily the base sintering and the glaze maturing (Venturi, 1986); it's realized in rapid rolls kilns.

This successful technology permits high economy, in terms of time, space, energy and labor, due to quick firing cycles, mechanical characteristics rise, easy glazing, large size production and the possibility to use extremely advanced automation.

The process starts with raw material receiving and stocking; goes on with the proportion of ingredient to formulate the product and the milling, that can be wet or dry, to reduce the dimension and homogenize the raw materials; the milling degree influences the dimensional stabilization, final product porosity, process economy and efficiency (Bordignon, 2004). The wet milling needs the previous solubilization of part of the clay feeded into the miller and the atomization (drying of wet milled body), obtained evaporating the water and generating spherical particles. The milled body is then stocked.

The successive phase is a security sieving of the body and the pressing, to compact and form the base. Pressing is also an important step; to obtain the maximum density of the "green" body in order to avoid defects along the firing, it's realized in high power hydraulic press (up to 7000 t) with specific pressure on the body from 20 up to 45 MPa.

The "green" product goes to the drying where the residual humidity (4-7%) is eliminated to warrant the dimensional stability and rising of the mechanical resistance necessary to face the serigraphic glazing stress.

The following step is the product decoration, for glazing. The final product determines the type and number of applications, from 4 up to 25 or more, depositing 300 g/m² up to 3 kg/m² of glaze.

The product goes to the firing phase, where all the reactions that determine the desired technical and esthetics characteristics are developed, by body sintering and glaze maturing. The firing cycles vary from 35 to 65 minutes and the upper temperatures from 1080 °C to 1240 °C.

The final step is the selection and packing. Selection is based on the automatic control of the dimensional parameters (caliber and flatness) and on the manual control of surface defects and glaze tonality; this step depends only on the operator's skills and the environment illumination conditions. Packing is widely automated.

Some *gres porcellanato* lines include a product finishing, with polishing and grinding, normally in a separated line. Figure 1 summarizes the production process.

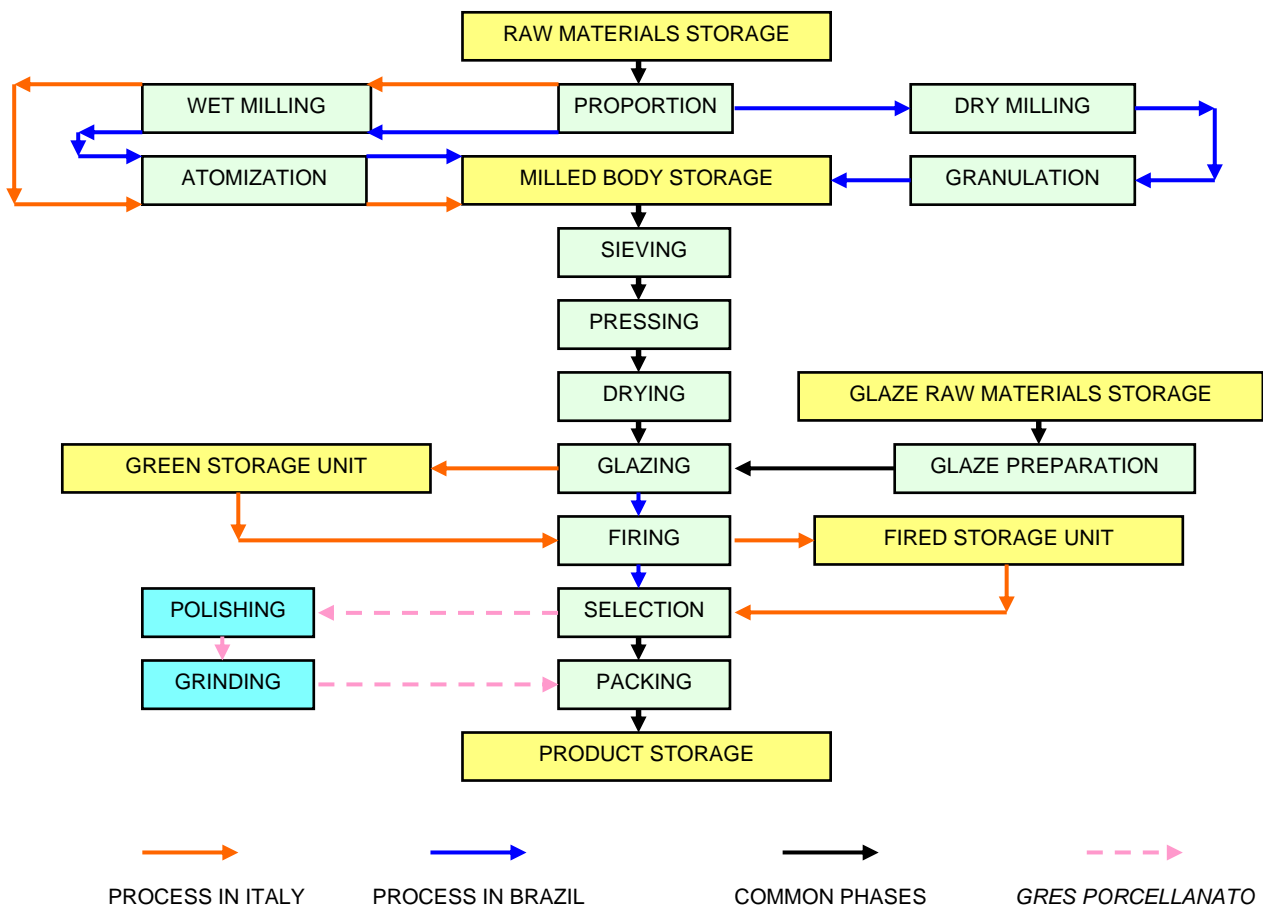


Figure 1. Single-firing production process (adapted from Bordignon, 2004).

In Italy, the extreme competition forced the producers to the generalized adoption of wet milled body and storage units before and after the firing. Sophisticated electronic applications allowed the complete process automation and product moving, using laser driven vehicles (LGV) for moving and storage of the “green” and fired products. The use of green storage unit allows, along the day (two shifts), to accumulate product enough to feed the kiln along the night period (third shift) and the weekend, when all the other equipments are inactive. In the same inactivity periods, at the kiln exit, the fired storage unit accumulates product to be processed, by the selection and packing phases, along the normal work time.

In Brazil it's more widely diffused the dry milled body and the national producers do not use storage units on the firing kiln.

The consequences of these technical choices are relevant.

The wet milled body presents technical characteristics that are strongly superior than those of a dry milled one. Tests made by the *Centro Ceramico di Bologna* (Nassetti, Palmonari, 1997) accurately compared wet milled and dry milled bodies, with the same composition, for red base single-firing tiles, observing that the granulated bodies (dry process) perform less firing retraction, more water absorption and less mechanical resistance.

Araújo, Romachelli and Martins (2001) underline that the wet milled bodies tend to supply best quality constancy.

Quality and constancy of the selection process are strongly increased if not operated along the night period.

The Brazilian ceramic tile producers can be divided into two groups, depending on the manufacturing process: the wet milled and the dry milled one. Only 42,4% of the Brazilian ceramic industries produce with atomized body (Anfacer, 2004), concentrated in the traditional Criciúma cluster, in Santa Catarina. Most of the dry milled body producers are located in the recent Santa Gertrudes cluster, in São Paulo. In term of competitive strategies, the Criciúma producers adopted a differentiation concept, looking for quality and selected market niche. In Santa Gertrudes the production is low price oriented (Nogueira, Gomes and Torkomian, 2001).

From the technological point of view, the dry milling followed by powder regranulation, can be used for tile production, especially with double-firing process, when the body composition is rich in clay and the raw materials

present similar morphological characteristics; on the other hand, it's difficult to produce porous single-firing tiles (*monoporosa*) by using this process (Sacmi, 2003).

It's the case of the Santa Gertrudes cluster, where very uniform clay is widely available, but it's used to produce low density materials (*monoporosa*).

The regional cluster of Santa Gertrudes has grown quickly since the 90's, making use of some competitive advantages of the dry process, as the more economic process (30% lower than the wet process) and less initial investment, single raw material almost ready to use, restricted mix of products, proximity to the biggest consumer market.

To enter the international market, the Brazilian product had to be seriously changed; the biggest alteration was to obtain the standard ISO 13006.

The protectionist policies of the 80's and the cost of labor, cheaper than in Europe, limited the automation expansion, so that very few producer used intermediate storage along the production line and no one adopted the automatic storage system before and after the firing phase (see Fig. 1), universally used in high production plants in Europe. This situation also generated high inercy among the national producers, with lower quality, obsolete technology and lack of export commercial structures, comparing to the European standard.

Some general information about the production characteristics are shown in Tab. 1.

Table 1. Information about ceramic tile producers in Italy and Brazil (Assopiastrelle, 2006; Anfacer, 2006)

PARAMETER		ITALY	BRAZIL
Enterprises	#	228	94
	production units	317	117
	Employees	29.817	25.486
	Cluster	1 (Sassuolo)	2 (SP – SC)
Investment for technological and product innovation	Value miUS\$	290,0	- ⁽¹⁾
	% of invoicing	4,5%	- ⁽¹⁾
Specific productivity	mi US\$ / employees	0,217 ⁽²⁾	0,06 ⁽²⁾
	m ² / employees	19.760 ⁽²⁾	22.202 ⁽²⁾
Average price	US\$ / m ²	11,0	2,72 ⁽²⁾

(1) Investments restricted to installation of new production lines.

About the energetic consumption, Italy reached very high efficiency levels, investing in thermal insulation, heat recuperation and co-generation; today the co-generation is present in more than 35% of the plants and the specific thermal energy consumption lowered to 2,5 Nm³ of natural gas for m² of the tile produced. Historical data indicate that in the last 20 years the production doubled, while the thermal consumption kept constant. In Brazil co-generation still hasn't entered in the process and the specific consumption is evaluated at 3,5 Nm³/m² for the most modern plants and near 5 Nm³GN / m² for the double-firing.

With respect to the environmental aspects, Brazil up to now has not faced seriously the problem and does not have limits for emissions, inspection and development guide-lines.

3. THE MARKET

To have a clear market's image it's possible to limit the analysis in two informations: production and export, strictly related to consumption. Up to date data are listed in Tab. 2.

Table 2. Comparison of production and sales data (Assopiastrelle, 2006; Anfacer, 2006)

PARAMETER		(2004)	ITALY	BRAZIL
Total production	[Mm ²]		589,20	566,00
	world %		9,00%	8,60%
Total sales	[Mm ²]		601	574
	bi US\$ ⁽¹⁾		6,48	1,56 ⁽²⁾
National sales	[Mm ²]		188,50	448,00
	% on total production		30%	78%
	bi US\$ ⁽¹⁾		1,82 ⁽²⁾	1,16 ⁽²⁾
Export	[Mm ²]		412,50	125,80
	% on total production		70%	22%
	bi US\$ ⁽¹⁾		4,66 ⁽²⁾	0,34
Average price	US\$ / m ²		11,0	2,72 ⁽²⁾

(1): Euro value, converted by average change tax of june, 2004. (Ministério da Fazenda, 2006).

(2): data extimed by the author, in lack of official data.

The main destination of Italian export is Europe; Italy is the world leader in technology and design and appears in a privileged position, to be difficult for the competitors to substitute its products. Italian production shows the best commercial performance, even being the most expensive of the global market, probably due to the high credibility of the *made in Italy*; this brand is, probably, the best competitive strength, over the good quality of competitors' products.

The Brazilian export privileges the west hemisphere, mainly the USA and does not shows significant strength and leverage points, only exporting common quality products. Part of this depreciation is due to the lack of alliance and organization of the business field. Most of export is due to buyers looking just for the low price, creating a very volatile market.

A business field development policy with producer alliance is strictly necessary, generating new marketing strategies, reducing the export of the USA and Argentina's markets diversifying countries and clients' segmentation (Oliveira, 2002).

Italy is the second producer, after China, and world leader in terms of quality, price, service, innovation and export more than 70% of the production, that is concentrated in a single cluster, responsible for 80% of the total volume. The sector is characterized by a high investment rate, about 4,5% of the total invoicing, focused on production technology and finishing. This technology investment generates high innovation and modernization of the production park, looking for advanced and integrated automation, environmental protection, energy economy, labor condition improving. The finishing investment supports research about new materials and decoration methods, increasing esthetic and quality.

The production grows constantly and the invoicing increases more than linearly. All the producers have adopted the wet process.

Brazil is the fourth world producer; 78% of its production is consumed in the internal market, representing the second world consumer market. The Brazilian production is reaching the Italian one (just 6% lower), realized in almost half of installation and with less employees (85%), which suggest a larger scale economy. Actually, the production tipology is responsible for this difference. Italy produces 60% of *gres porcellanato*, which productivity is considerably lower than the traditional products one. On the other hand, the *gres* charges a higher added value. The Brazilian production of *gres porcellanato* is less than 3%. From this point of view, the Brazilian productivity is lower than the European's and comparable only due to its most recent installation.

The ceramic business field is characterized for low investment and obsolete industrial park, with limited automation.

Comparing the average price, it's observed a value of 2,72 US\$/m² for the Brazilian production, versus 11,00 US\$/m² of the Italian one.

4. THE COMPARISON

A deep comparison between the European and the Brazilian markets is extremely complex and has to be based on many historical, economical and social factors. The European producers, working in a very competitive market and facing growing costs, were obliged to continuously develop more sophisticated products, with high innovation content and added value, like the *gres porcellanato*, that nowadays represents over 65% of the products mix. In order to obtain maximum quality tiles but with controlled costs, the general option was to use the wet milled and atomized body, joined to adoption of extreme automation and development of new decorating processes and innovative raw materials.

In Brazil the single-firing process is also prevalent, but it's still possible to find some double-firing lines.

A short comment must be made about the double-firing process. In Italy it's still responsible for a moderate but significant volume, restricted to very expansive wall tiles, with sophisticated decoration; in Brazil this technology realizes a production of small format, conventional wall tiles, comparable with the Italian volume, but in obsolete plants that will be dead soon.

Comparing both realities from the technological point of view, Brazil shows an obsolete industrial park; investments stay in a very low level and limited to new plant; the capital cost limits new necessary investment to improve the energetic efficiency and the environmental control. New production units are installed without the care of a better automation, thermal efficiency and pollutant emissions.

The strong professional growth of the Italian producers has developed, over the last years, managing systems that evaluate the careful use of a high volume of data and reliable economic indexes. These informations, correctly shared, allow a pro-active participation of the sector association, Assopiastrelle, that executes and publishes studies, analysis, projections and determines guide-lines for the sector development, offering a very clear landscape about the world economy and consumers' tendency, suggesting new products, sales and market policies and environmental indications.

The national situation is totally different: the local associations are not able to actively participate in the enterprise life, because of the lack of a modern managing system; enterprises do not supply precious information to be analyzed and shared.

Synthesizing, the comparison between the ceramic sector in Italy and Brazil can be reduced into two aspects: the technological one, based on two salient differences, the use of wet or dry milled body and the automated storage unit on the kiln; the other aspect regards the management.

In both the reasons, the consequences on the finish product and the reflex in terms of price are unquestionable.

5. CONCLUSIONS

The Brazilian ceramic producers grew in a little competition situation and without the need of extreme development; the result is a high vulnerability, due to the obsolescence of production lines, managing and commercial structures.

It's easy to prove the immediate need, for the Brazilian ceramic sector, of developing strategic planning, in a medium and a long term, to carefully program the investment for new technologies, to renew the industrial park, to qualify the human resources (from the higher management down to operation level). It's also necessary to create real and conscient partnerships with Universities, sector associations, research poles, suppliers and professional distribution networks.

Other important aspect, that became necessary for Brazil reaching competitiveness, is to share and manage technical, economic and financial data, to generate analysis and comparison with other developed realities, optimizing the research and using existing experiences from other countries.

Brazil has much strength and a lot of opportunities, like the local availability of very high quality raw materials, low costs of labor and energy, easy access to technology, presence of excellent universities and research poles, to recuperate competitiveness and face the threats of the emerging competitors, like China, Mexico and Turkey.

Grahl (2004) reported about recent investments in the ceramic sector in the USA; the fact indicates that it's still possible to realize profitable activities, also in areas that are considered criticals, because of cost of labor, rigid laws and competition; it can be done using selected high quality raw material, advanced technologies and establishing strong partnerships with official and professional entities.

To confirm this tendency, Italian producers are recently moving production to foreign countries, the so called "internationalization of production", creating ceramic centers also in the USA (Assopiastrelle, 2006).

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