

DEVELOPMENT OF THE CERAMIC TILE AND TILE INDUSTRY IN THE REPUBLIC OF TURKEY

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SYNOPSIS

Having been settled in Anatolia for over 900 years, The Turks formed the Seljuk and Ottoman Empires before the modern day Republic of Turkey culminating in a rich cultural heritage. From the 11th to 17th centuries roof tiles, pottery, tiles and other forms of building and home materials had been used which were influenced by ancient Anatolian culture and Islamic art. We especially see that tile reached its most advanced level during 16th century. Following this climax, tile production declined as did Ottoman Empire and was replaced by European tile. Turkish tiles started to gain favor again after the foundation of the first state owned companies in 1945, followed by private companies in 1955. The private sector development started from a yearly capacity of around 20 million square meters today reaching nearly 200 million square meters and becoming a very strategic industry for Turkey. Thus, Turkey is the third largest tile producer in Europe and fifth largest in the world. Turkey now exports 30 % of its total production to nearly 80 countries around the world. EU countries consume nearly 50 % of its export capacity. Turkey also enjoys rich raw material supplies for its production. The tile production technology has also shown great improvement with single firing which allows going from forming to the packaged product in under 2 hours for a single tile. The technology used in the factories is state-of-the-art, producing high quality tiles preferred all around the world. Turkey is now in a unique position to take its competitive advantage in ceramic tile coverings into 21st century. This paper will try to analyze development of ceramic tile and tile industry in Turkey looking at many aspects of industry and market developments.

1. INTRODUCTION

Anatolia is the land which hosted numerous principalities and empires such as Hittites, Frigs, Lydians, Carians, Greeks, Romans, Seljuk Turks and Ottomans. Each civilization has found a place for itself on this land. Relics from these civilizations show us a rich tradition of ceramic art as part of their development. The accumulation of all these civilizations reached to its most advanced stage with tiles during the Seljuk Turks era. With the Ottomans, this art had arrived to another dimension in the richness of colours and shape. The Iznik tiles of this period represent centuries of cultural heritage and artistic treasures of Roman, Seljuk, and Ottoman Empires.

The contemporary Turkish Republic has combined this 4000-years-old traditional art with the new technology. The work, which started in 1950's, has reached to a global scale in the last 50 years with a capacity of nearly 200 million square meters. The tiles industry has achieved rankings of 3rd and 5th for Europe and world respectively confirming its importance in Turkish economy.

2. HISTORY

The earliest pottery found in Anatolia dates back more than 4000 years. The soil is blended with water, shaped and baked to produce jars, pots and pans, playing an important functional role in daily lives of people. The progress in ceramics also indicates the material and spiritual development of human civilization during this era. Following the advent of Turks into Anatolia in 11th century, ceramic tile production showed great improvement since it had become a new art form encouraged under Islamic cultural heritage. Tile and ceramic art in Anatolia showed very important developments through applications on significant architectural constructions during the Seljuk and Ottoman periods. These constructions grew rapidly in the 16th century during the reign of Ottoman sultan Süleyman the Magnificent including mosques, palaces and hostels located in important imperial cities such as Jerusalem, Baghdad, Damascus and capital city Istanbul. During this period the demand for tiles increased considerably forcing development of new production technique of under glazed tile. This technique was developed in Iznik that had become tile capital of Ottoman Empire where more than 300 tile shops were located in the second half of 16th century. The colours of Iznik tiles included white, blue, green, black, and purple. In 1555, red was introduced as a major innovation of its time. Floral designs and animal figures were the main design elements of this period resulting in an unbelievable richness and varying compositions. During the Ottoman era, the Iznik tiles and pottery were exported to other countries via the island of Rhodes, then under Turkish rule. The demand from Istanbul for the use of these tiles in major public buildings such as mosques and palaces had fallen during the period of decline of Ottoman Empire. Even during these decline years, the Yildiz Porcelain Works were established by the state in 1892 as the first step for the production of ceramic art and tiles. This was a turbulent period, which marked the fall of Ottoman Empire in the aftermath of World War I and the foundation of the modern Turkish Republic in 1923.

The Yildiz Porcelain Works were not able to satisfy the demand for tiles as the young republic in 1950's embarked upon a fast construction drive. The Bozoyuk Ceramic Factories were formed by the state in 1955 as the new venture in this area to help satisfy the potential demand and introduce new technologies to Turkey. In the meantime, Turkish entrepreneurs noticed this opportunity at an early stage. The Turkish Ceramic Tile Sector has started the first ceramic tile production in the current industrial sense through the

work of Mr.Dr.Ibrahim Bodur, founder and owner of Kale Seramik Group of Companies, in 1957 in Can,Turkey. Today through his vision the Turkish industry exports to more than 80 countries in five continents and has become a major force in the world tile industry.

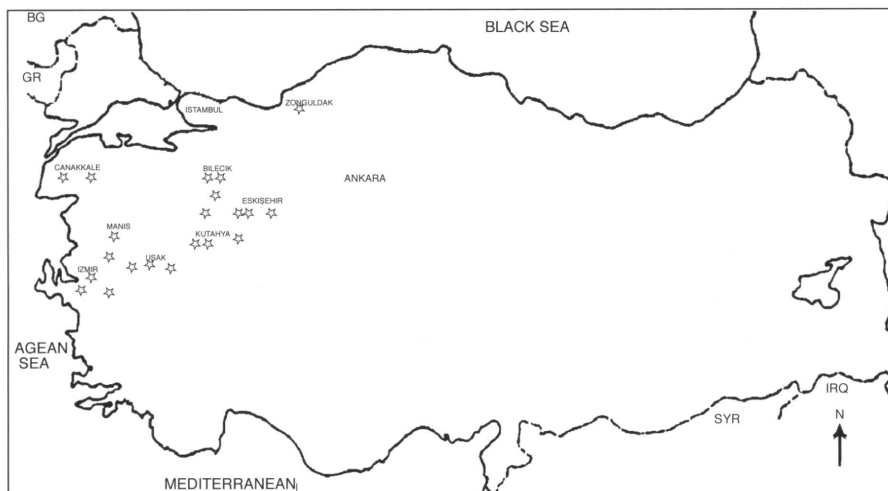
3. TURKISH CERAMIC TILE INDUSTRY

3.1.- CURRENT SITUATION

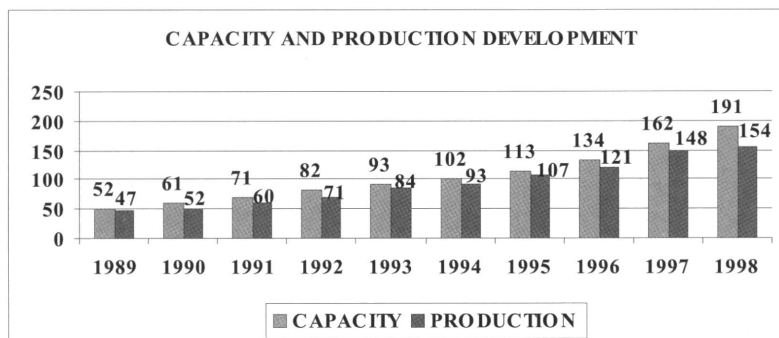
Turkish tile industry is in a growth phase affected by two key factors : 1. Relatively low per capita consumption rate of 1.7 square meters showing a growth potential in domestic market. 2. Per year growth rate of 8.5 % in global markets offering export opportunities. There are approximately 25 manufacturing companies with varied capability, of which 21 are listed below in the sector with a total capacity of nearly 200 million square meters. The factories are mainly located in the northwestern part of Turkey due to proximity to raw material sources and main ports and markets.

TILE MANUFACTURING COMPANIES	CAPACITY (000 m ² /year)	%
1. KALE GROUP CANAKKALE SERAMIK-KALEBODUR	50.000	26,0
2. TOPRAK	25.000	13,0
3. EGE	22.000	11,5
4. KUTAHYA	11.600	6,0
5. ECZACIBASI	12.000	6,3
6. SOGUT	9.000	4,8
7. HITIT	9.000	4,8
8. TAMSA	8.400	4,4
9. YURTBAY	7.300	3,9
10. TERMAL	6.000	3,1
11. SERAMIKSAN	5.500	2,8
12. ERCAN	5.000	2,6
13. EFES	4.000	2,1
14. YUKSEL	3.500	1,8
15. ANATOLIA	3.300	1,8
16. USAK	3.000	1,6
17. SERANIT	1.600	0,8
18. ALTIN CINI	1.500	0,7
19. PERA	1.500	0,7
20. GRANIST	1.500	0,7
21. BOZUYUK	1.200	0,6
TOTAL	191.900	100

**THE MAP SHOWS THE CONCENTRATION OF
MAIN MANUFACTURERS IN WEST OF TURKEY.**

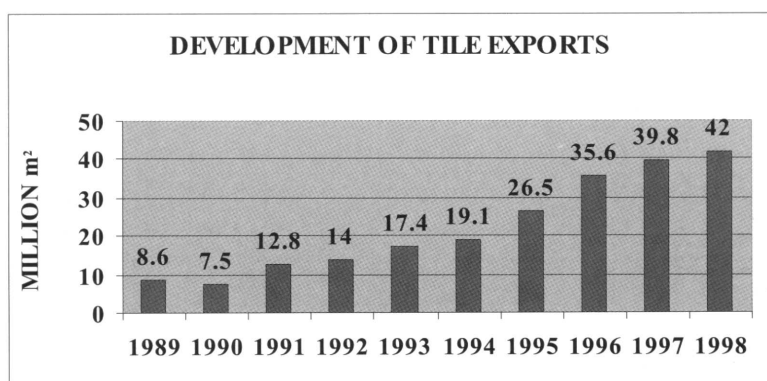


Turkish tile industry with its current manufacturing capacity has reached number 5 ranking in the world following China, Italy, Spain and Brazil. Turkey with its more than 110 million square meters consumption level ranks number 8 in the world.

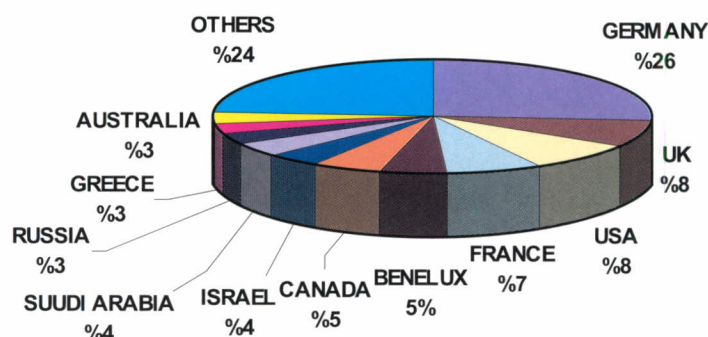


Turkish tile industry has been mainly influenced by the European design trends in the development of its models and follows the fashion trends diligently to keep up with the latest consumer demands. In addition, new merchandising and display techniques are encouraged by the producers to generate additional sales over other forms of coverings.

Turkish tile exports have increased more than twofold over a 5 year period ending in 1998.



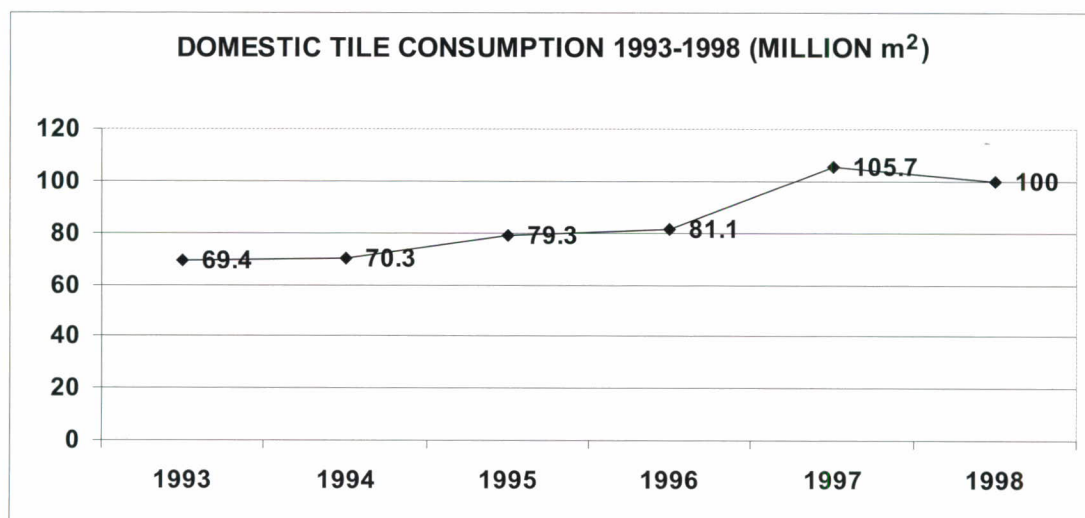
TURKEY'S EXPORT COUNTRY MIX, % 1998



When we look at distribution of Turkish tile exports among the markets, we see that the biggest share belongs to EU countries headed by Germany. USA is another key market where Turkish exports increased by 57 % in quantity in 98 over 97.

We have very limited level of imports in tiles which is no more than 2 % of total domestic consumption. Imported tiles are sourced mainly from Italy and Spain for up-segment products.

Domestic consumption of tiles have increased on average 13 % Per year between 87 - 97 period for a total market size of nearly 110 million square meters. However, we see that the growth rate has averaged 14 % in the first 5 years of this period and 8.5 % in the second 5 years of this period.



We also see that domestic consumption were 5 % less in 98 than 97 due to recession in the economy affecting construction industry negatively. The same trend continued in 99 due to global economic crisis in the first half of the year followed by the Marmara earthquake hitting Turkey's main economic belt.

The following tables show the trend in size increase for both wall and floor tiles in Turkey.

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3.2.- ENERGY USAGE

Energy is one of the main cost elements in the production of tiles with a range of 25 - 35 % among Turkish tile producers. By comparison, this figure is 15 % for Italian producers.

DIRECT COST ELEMENTS OF TILE MANUFACTURING

IN PERCENT FOR 1998	TURKEY (%)	ITALY (%)
Raw Materials	34	36,3
Labor	16	36,0
Energy	30	15,2
Production Materials	10	7,5
Packaging	10	5,5
TOTAL COST	100	100

As one can see from the above table, energy cost is a very critical component for tile industry in order to maintain a competitive position. In addition, European producers have reduced their unit energy requirements by 40 % over 80 - 95 period as well as their CO₂ emissions.

The best fuel for tile production is natural gas. However, many of Turkish manufacturers are using LPG since Turkey's natural gas pipelines do not cover all of the areas in which factories are located. It has been calculated that LPG is 35 % more expensive than natural gas on 1 kcal basis. The total effect of this difference in final cost can be as high as 10 to 15 %.

CONSUMPTION OF ENERGY IN 1998

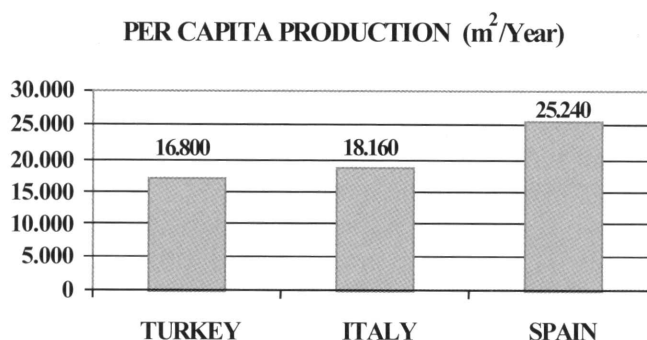
	ELECTRICITY Kwh/m ²	NATURAL GAS M ³ / m ²	LPG Kg / m ²
Minimum	2.5	2.1	1.6
Maximum	5.2	4.0	2.2
Average	3.5	2.4	2.0

We also see from the above table that there is a wide range of difference among the companies in the level of energy usage depending on the plant age and type of technology used.

3.3.- EMPLOYMENT

The tile industry employs nearly 10.000 people in Turkey. The level of employment is on the decline as the technology in use has been increased. The industry average on a

yearly per person production is around 17.000 square meters on a yearly basis. This level is considerably lower than Spain and Italy with respective figures of 25.000 and 18.000 square meters.



Source : Turkish Tile Manufacture's Association

We also need to take into account that Turkish plants have larger scales than Italian and Spanish plants hence requiring a more productive output on employment than these countries. However, considerably lower employment costs encourage Turkish manufacturers to use more labour without affecting competitive cost position in a negative way.

3.4.- RAW MATERIALS

Ceramic raw materials industry has developed quite considerably in quality and quantity in parallel to the developments of Turkish ceramic industry in recent years. Adequate quality and reserves of main raw material deposits of ceramic clays are present in Turkey. However, there is a need to import certain characteristic clays from the Ukraine and other sources.

Raw Material	Produced& Consumed in Turkey	Produced in Turkey & Exported	Imported	Description
Clay	1.700.000	100.000	50.000	Imported from Ukraine as crude, from other countries as processed
Kaolin	700.000	150.000	60.000	Processed
Albite – Na Feldspar	600.000	1.400.000	-	
Orthoclase- K-Feldspar	120.000	-	20.000	Imported from India & Egypt
Silica Sand	100.000	-	-	
Dolomite	40.000	100.000	-	
Calcite	80.000	100.000	-	
Quartz	80.000	40.000	-	
Mill Lining Stones & Flint Pebbles	30.000	10.000	2.000	Flint Pebbles Imported from France & Belgium
Others	50.000	-	15.000	Imported Talc, Zircon, etc.
Total	3.500.000	1.900.000	147.000	

PRODUCTION, MARKETING & CONSUMPTION OF CERAMIC RAW MATERIALS IN TURKEY



THE ABOVE MAP SHOWS THE MAIN SOURCES OF RAW MATERIALS ARE CONCENTRATED IN WEST OF TURKEY

Total production of raw materials are around 5 - 6 million tons of 2 million are exported. The biggest exported material is sodium feldspars from Milas region.

The so - called Anatolian structure of Turkey belongs to the Alpine orogenic belt, located between the Eurasian and African continents. Older rock series are found in western part of Turkey forming the source of many ceramic raw materials. In general, the geology of Turkey is quite complex. Recent seismic activity indicates the tectonic position of Turkey.

Mining is conducted only during the dry spring and summer seasons due to climatic conditions. In general, open pits are operated with open air stockpiling of raw materials. Mining and fiscal laws favour a mining system based on subcontractors which is in recent years slowly being replaced by a new approach of companies forming their independent mining firms to gain access to raw material export markets.

Ceramic clay deposits are located in the Kilyos, Sile and Beykoz regions of Istanbul and the Söğüt and Can areas. Qualities include low to high alumina clays with low to intermediate iron contents and reasonable plasticity which are overlayed by lignite.

The kaolin deposits are irregularly shaped and qualities vary due to the changing intensity of in-situ kaolinization. Kaolin content is in the range of 40..80%. Iron content is generally low. The crude rock is hard, and mining requires blasting. The material has low plasticity and mainly used in the production of wall and floor tiles.

CHARACTERISTICS OF VARIOUS CERAMIC RAW MATERIALS AVAILABLE IN WESTERN TURKEY															
Raw material	Area	Code	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	LoI	Shrinkage	Fring	Temp.	Moisture
			(mass - %)									(%)	Colour	(°C)	(%)
Kaolin	Duvertepe	111	72,0	0,3	19,1	0,4			0,2	0,1	7,5	1,1	Cream	1170	8
Pegmatite	Canakkale	103	71,0	0,2	16,9	1,1			3,0	5,4					5
Halloysite	Canakkale	151	38,5		37,4	0,5							White		20
Albite	Milas	633	68,5	<0,2	20,8	<0,1			9,5	0,2	0,1		Cream	1170	5
Clay	Kilyos	213	56,0	0,4	28,0	1,8			0,2	1,0	10,5	7,0	Cream	1080	15..20
Clay	Sile	220	62,9	0,7	24,0	2,7			0,5	1,9	5,7	2,2	Cream	1100	15..20
Quartzite	Canakkale	731	98,5										White		
Wollastonite	Canakkale	915	45,0		3,5		42,0				2,3				
Dolamite	Canakkale	903					24,5	20,3			44,7		White		
Sand	Sile	502	89,4		6,6	0,3									3
Marble	Canakkale	401		<0,1			55,8				42,6				
Orthoclase			66	0,1	19,0	0,15			4	9			White	1100	

Considerable development has taken place in the sodium feldspar(albite) sector in the last decade. Production and exports have grown rapidly over the last 10 years. Flotation plants are being formed for glaze production.

These raw materials are treated and being readied for the production of tiles in the plants according to plants' type of technology. The raw materials are first chosen based on the quality cost ratio and then evaluated for their physical and chemical properties and finally admitted to the plant for production process. The most modern method in the application of raw materials are the use of continuous production system whereby the raw materials are first treated for impurities then blended and sent to body production directly.

4. PRODUCTION AND QUALITY MANAGEMENT

In Turkey, there are 21 medium and large scale companies producing tiles. The factories are new and equipped with the latest technology. When compared with the other leading manufacturing countries, the Turkish factories are equipped with more modern technology due to the recent investment programs undertaken. Also, when compared with the other leading producing countries, the average production capacity Per firm is higher, which is around 7.5 million square meters.

4.1.- PRODUCTION PROCESS

Tile manufacturing process starts by preparation of raw materials and glaze production. Glaze production includes materials such as frits, clay, kaolen, zircon and dyes. All the materials necessary for the glaze production go through a test to approve their characteristics. This test is done at the Product Control Laboratory. The approved materials are then demetallized. This material is then placed at special containers for use. The most important attribute of glaze is its ability to fit to the biscuit in order to prevent possible cracks and other problems on the surface of the finished tile. This can be achieved through keeping the expansion the coefficient of glaze lower than that of the biscuit hence creating a more tolerable environment for the biscuit in case of water absorption, excessive heat, and stresses. The laboratory checks this factor by testing the expansion rate, thermal schocks and runs inventory age tests.

In parallel to glaze preparation, the body for tile production is also an essential part of the manufacturing process. All of the materials destined for the body preparation are tested for their physical and chemical properties. These materials need to have an appropriate particle size for their performance. The set target is that only 2 - 5 % of particles should be more than 63 microns. In addition to particle size, the variability of particle sizes is critical. The particles should not be homogenous in order not to cause air pockets in the body. Otherwise, bonding in the body will not be up to the expected standards. The material made up of these particles is then sent to mills for crushing bearing the following properties : 1. Physical properties of material 2. Water content 3. Deflocculant content 4. Existence of certain ions. The identification of level of deflocculant is done through measuring viscosity. Sodium silicate or sodium phosphate could be used as a deflocculant to give the body the right amount of viscosity. In conclusion, body production is done in 3 steps : 1. Clay preparation 2. Ball mills 3. Spray Dryers. Spray dryers dry the wet body with 35 % water content to 5 - 7 % water content. At this stage, the body takes on granule form and is ready for feeding into high pressure presses.

4.1.1.- Forming

The granulated body with a 5-7 % water content is formed by high pressure hydraulic presses exerting 250 - 350 kg/cm² (25 - 35 N/mm²) force on the material. The formed tiles come out from the presses in different sizes. These sizes can range from 10 * 10 cm. to 60*120 cm. The formed tiles go through the dryers to lower their humidity under 0.5 % and are ready for glaze application.

4.1.2.- Glazing line application

The dried tiles receive engobe and glaze application. In the mean time, by using different types of decoration techniques the decorative elements are applied on to the tiles. There are two techniques for this operation namely cylindrical printing and screen printing. Following the decoration application, tiles either go into inventory for future firing or in the case of continuous lines, first dry in the dryers and then go to firing.

4.1.3.- Firing

There are basically two types of firing for wall tiles ; single and double firing. For wall tiles, both types are used almost equally in Turkey. In the case of floor tiles single firing is now being used in majority of the cases.

4.1.3.1.- Double firing process

The definition of double firing is that first biscuit tile is fired at roller kilns which is called 1st firing and following glaze application 2nd firing takes place. For the 1st firing 1050 -1100 °C is required and for the 2nd firing 950 - 1000 °C is required.

4.1.3.2.- Single fire production process

The definition of single firing is that the body and glaze are fired simultaneously. The dried and pressed tiles arrive at the initial dryers before glazing takes place. After glazing the tiles arrive at the kilns which is fired at temperatures of 1130 — 1250 °C. These kilns are 75 - 100 meters long with a drying length of 10 - 20 meters. These kilns are double

deckers and two different types of production could take place depending on the needs. The following table lists time and heat values of kilns.

KILN FIRING TEMPERATURES AND PERIODS FOR SINGLE FIRING

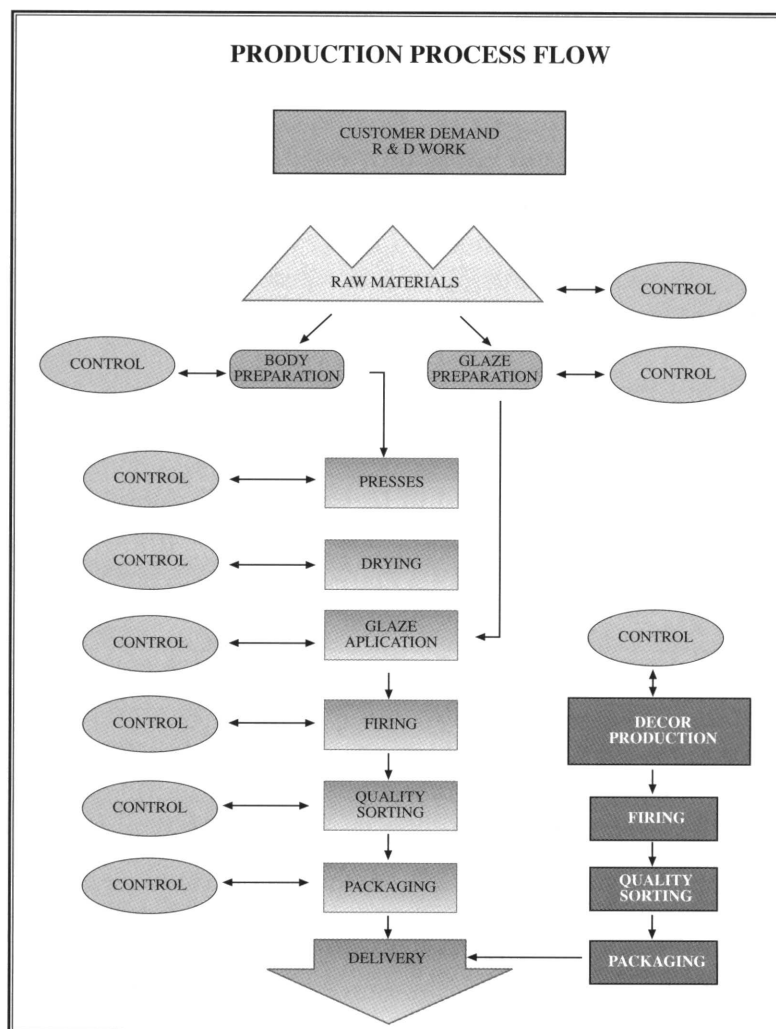
	<u>TEMPERATURE (°C)</u>	<u>FIRING PERIOD (MIN.)</u>
33X33 Floor Tile	1180-1220	50-60
20x25 Wall Tile	1125-1150	45-50

KILN FIRING TEMPERATURES AND PERIODS FOR DOUBLE FIRING

	<u>TEMPERATURE (°C)</u>	<u>FIRING PERIOD (MIN.)</u>
20 * 25 Wall Tile 1 st firing	1180-1220	50-60
2 nd firing	1125-1150	45-50

The glazed and fired tiles then cool down to be readied for quality classification and packaging.

The following chart summarizes the process flow.



4.1.4.- Quality classification and packaging

There are 3 classifications of produced tiles :1. 1st quality 2. 2nd quality 3. Reject. The employees specially trained in this area mark the tiles according to these categories. Rejects go through optic reader and then broken. The other two categories go through the packaging line and receive a barcode number. The boxed and palletized tiles are then shrink wrapped to wait for shipping. 2nd quality tiles are usually no more than 10 % of total production. These tiles are only sold on special demand and are not part of the active trade channels.

4.1.5.- Decorated tile production

Glazed tiles are fired again at 800 - 1040 °C following transfer of filmed image of the design onto the tile surface. These tiles are fired in continuous process kilns with progressive temperature increase up to 800 - 1040 °C and then cooled down gradually. 1st quality tiles are the only classification done in this category.

4.2 QUALITY CONTROL PROCESS

The following characteristics should be present in the tiles produced assured by the quality control process.

4.2.1.- Water Absorption

This is the factor determining absorption level of tiles since tiles by their nature products that absorb water regularly. Floor tiles are classified according to this factor with the hardest tile having a ratio of no more than 2 %. Wall tiles can have a water absorption range of 15 - 18 %.

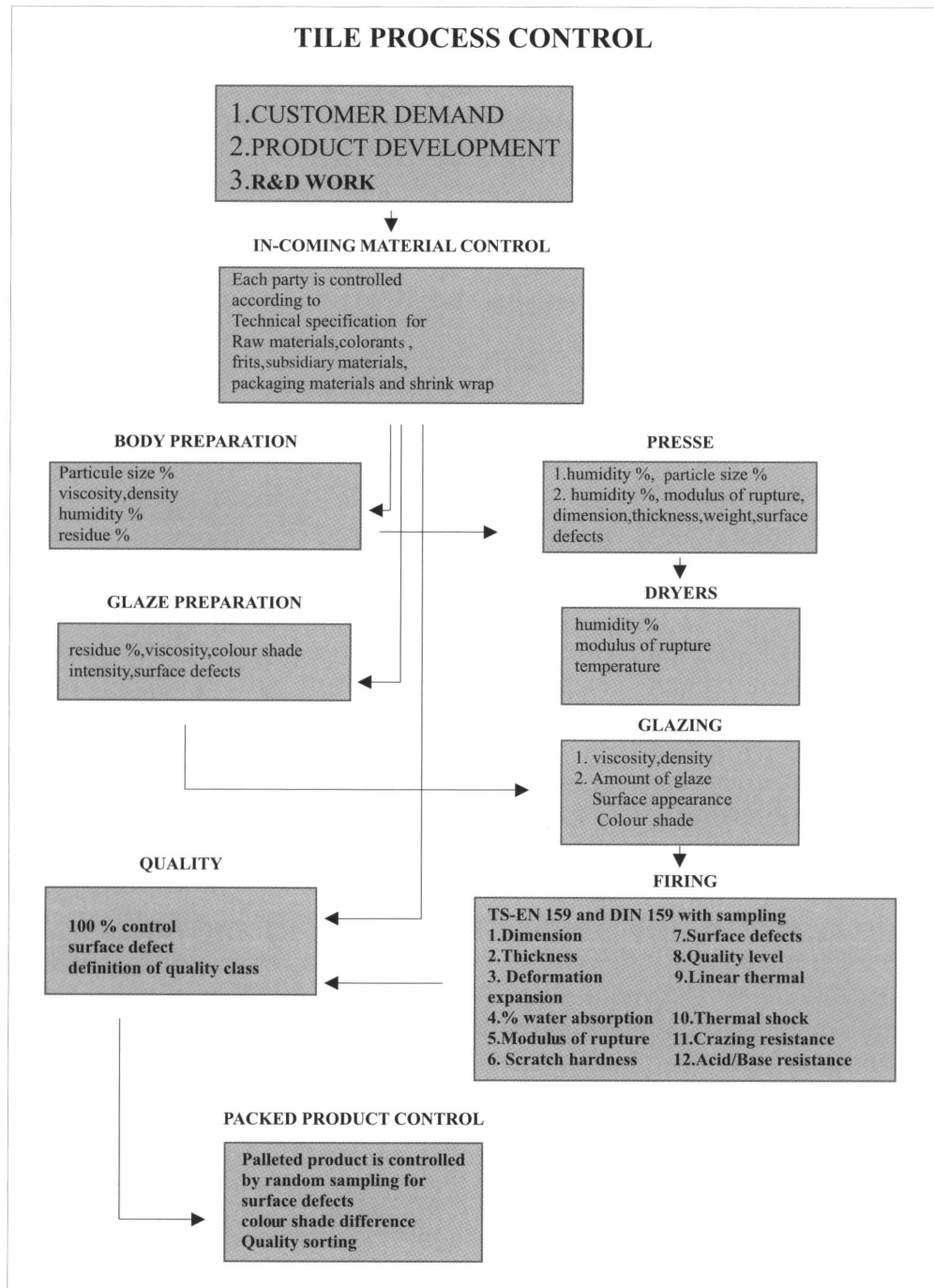
4.2.2.- Surface Quality and Sizes

Certain acceptable limits are defined for differences in size and surface conditions of tiles produced in the same batch. These limits are very narrow by definition, which makes detection by naked eye almost impossible.

4.2.3.- Physical and Mechanical Properties

4.2.3.1.- Rupture is the first factor we evaluate under this category. Rupture is measured as the tile's maximum resistance to a force applied at an increasing rate. General accepted value of this is minimum 150 kg/cm² for wall tiles and for floor tiles minimum at 230 kg/cm².

4.2.3.2.- Surface hardness is a mechanical property measured by Mohs method which ranks minerals found in nature by their hardness from diamond at the top to the talc at the bottom.



4.2.4.- Ability to withstand the Conditions of Heat and Humidity

4.2.4.1.- Linear Thermal Expansion defines changes in the size of tiles based on heat changes. In other words, materials expand with increases in heat and decrease with decreases in heat. We measure coefficient of linear thermal expansion in defining this property.

4.2.4.2.- Resistance to heat attack tested through Harcott method is done to see the fitness between glaze and body related to their linear thermal expansion coefficients. In other words, the tile should withstand changes in heat within a certain range. The standard for this range is 15 - 110 °C.

4.2.4.3.- Crack resistance is the ability of the tile to withstand very fast changes in heat. This is measured by autoclave test and accepted standard is that under a pressure of 4.5 atm., the tile needs to survive for 2.5 hours.

4.2.5.- Chemical Properties

This is defined as the tile's ability to resist the effects of chemicals on the surface of the tile. Certain tests are done against cleaning chemicals used at houses, hospitals and other places as well as stain removals and acids and bases. The standard here is to produce a tile that will resist everyday application of these chemicals.

4.2.6.- Quality assurance and control system

4.2.6.1.- Quality standards and documentation

Ceramic tile coverings are manufactured according to national TS-EN 87 and EN 87 European product standards in most of the companies in Turkey.

Water Absorption (E) : $E < \% 3$	Grup BI	TS EN 176
Water Absorption (E) : $\% 3 < E < \% 6$	Grup BIIa	TS EN 177
Water Absorption (E) : $\% 6 < E < \% 10$	Grup BIIb	TS EN 178
Water Absorption (E) : $E > \% 10$	Grup BIII	TS EN 159

Wall tiles are considered as high water content products with more than 10 %. Floor tiles should have much less water content for the desired outcome. All of our products are certified according to these standards and quality is closely monitored.

4.2.6.2.- Product quality documentation

Turkish Standards Institute, SFV German Tile Installers Union, and ANSI American Standards Group have certified all of Kale tiles and monitor progress on a yearly basis. In addition, SVF group also certified unglazed clinker floor tile with DIN 18158. We are now trying to have this certification done by Turkish Standards Institute for all of our industry.

4.2.6.3.- Process quality documentation

Many manufacturers now carry ISO 9001 Quality Assurance System for their production process. This shows the Turkish manufacturers' desire to compete in the world tile markets with quality products and systems. I think it is very important to mark this fast development that occurred in a period of 5 years in parallel to the expansion of Turkish industry to the global markets. In addition, DQS, EQNet and CICS certification have also been received by some of the manufacturers during this period.

Please find below two tables summarizing standard values for wall, floor and clinker tile production.

REQUIREMENTS	TS EN 159 / EN 159 E ≥ 10%	TS EN 176 / EN 176 E < 3 % (Glazed & Unglazed)				DIN 18158 Clinker tile
Dimension and surface quality		Surface of the product (cm ²)				
Length & width		S ≤ 90	90 < S ≤ 190	190 < S ≤ 410	S > 410	
e The deviation in % of the average size for each tile from the work size (W)	L ≤ 12 cm ; ± 0,75 L > 12 cm ; ± 0,5 + 0,6 / - 0,3	± 1,2	± 1,0	± 0,75	± 0,6	± 1,5 max. ± 4 mm
f Tiles with spacer lugs	L ≤ 12 cm ; ± 0,5 L > 12 cm ; ± 0,3 ± 0,25	± 0,75	± 0,5	± 0,5	± 0,5	
Thickness	< 250 cm ² ± 0,5 mm > 250 to 500 cm ² ± 0,6 mm > 500 to 1000 cm ² ± 0,7 mm > 1000 cm ² ± 0,8 mm	± 10 %	± 10 %	± 5 %	± 5 %	± 10 % max. ± 2,5 mm
The deviation of the average thickness of each tile from the work size thickness						
Straightness of sides						
Max. Deviation in % related to the corresponding work size	± 0,3	± 0,75	± 0,5	± 0,5	± 0,5	± 0,5
Rectangularity						
Max. Deviation in % related to the corresponding work sizes	± 0,5	± 1,0	± 0,6	± 0,6	± 0,6	± 1,75
Tiles with spacer lugs	± 0,3					
Surface flatness : Max. deviation in %.						
a. Centre curvature	+ 0,5 / - 0,3 (+ 0,8 / - 0,1)	± 1,0	± 0,5	± 0,5	± 0,5	± 0,5
b. Edge curvature	+ 0,5 / - 0,3 (+ 0,8 / - 0,1)	± 1,0	± 0,5	± 0,5	± 0,5	± 0,5
c. Warpage, For tiles with spacer lugs are in mm (in brackets).	± 0,5 (S < 250 cm ² ; 0,5) (S ≥ 250 cm ² ; 0,75)	± 1,0	± 0,5	± 0,5	± 0,5	± 0,5
Surface quality	Min. 95 % of tiles shall be free from visible defects that would impair the appearance of the major areas of tiles	Min. 95 % of tiles shall be free from visible defects that would impair the appearance of a major areas of tiles				Colour shade difference is not to be considered as fault. On the proper surface no crack and rough spots are allowed.

REQUIREMENTS	TS EN 159 / EN 159 E ≥ 10%	TS EN 176 / EN 176 E < 3 % (Glazed & Unglazed)		DIN 18158 Clinker tile
Physical properties				
Water absorption (E) % by weight	Aver. ≥ 10. When exceeds 20 shall be indicated	Aver. ≤ 3 Individual max. 3.3		Aver. ≤ 3 Individual max. 4
Modulus of rupture in N / mm ²	Aver. 15 ≤ 7,5 mm thick. Aver. 12 > 7,5 mm thick.	Min. 27		Aver. min. 20 Individual min. 15
Scratch hardness (Mohs)	min. 3 (walls)	Glazed min. 5 Unglazed min. 6		-
Abrasion resistance				
a. Abrasion of unglazed tiles: removed vol. in mm ³	-	Min. 205 Class I to IV		Aver. max. 300 Individual max. 350
b. Abrasion of glazed tiles.				
Linear thermal expansion	max. 9 × 10 ⁻⁶ K ⁻¹	max. 9 × 10 ⁻⁶ K ⁻¹		max. 5-8 × 10 ⁻⁶ K ⁻¹
Thermal shock resistance	Required	required		required
Crazing resistance	Required	Required (glazed tiles)		-
Frost resistance	-	required		Required
Pressure resistance	-	-		Min 150 N/mm ²
Chemical properties				
Resistance to staining	min. Class 2	Min. Class 2 (for glazed tiles)		-
Resistance to household chemicals and swimming pool water cleansers	min. Class B	Glazed tiles Min. Class B Unglazed tiles Required		Required
Resistance to acids and alkalis (with the exception of hydrofluoric acid and its compounds)	Required if agreed	Glazed tiles Class AA – D Unglazed tiles Required		max. 4% material loss

5. TILE INSTALLATION

It is very important to state that tile installation is as important as the production of tiles since it is the opportunity to showcase tiles purchased by the end user. If the result is less than satisfactory, the end user will be dissatisfied and the manufacturing company will suffer from this. In order to prevent this from happening the tile manufacturers in Turkey are developing special training seminars that are conducted

free of charge. These courses are generally done at the plant locations supported by well-qualified staff. However, this process is yet to be certified by the Turkish Standards Institute which would have yielded a more structured approach to the process. Another area of concern here is the fact that it is very hard for the companies to follow development of course participants after graduation. In other words, a mechanism is lacking to track and control the installers throughout their careers. This is important in two senses :1. The fact that a particular installer could perform sub - standard jobs creating many unhappy customers. 2. There is a need to update the information base of installers in the face of constant developments of tiles such as porcelain tiles, which require even more effort to complete a quality job. Turkish Tile Manufacturer's Association is working on a system to standardise the installation methods to overcome the quality issues.

The objective of the current training system are twofold : 1. It should be protective of the surface covered. 2.It should be aesthetically right and its overall impact should be strong.

5.1.- TILE ADHESIVES

There are two ways to install tiles today, namely use of sand /cement mortars or adhesives. We prefer adhesives in installation of tiles for stronger and flexible bonding. There are wide variety of adhesives available in the marketplace for different functional benefits. Tile adhesives are coded by the Turkish Standards Institute for their quality and application properties. The following can be cited for the benefits of adhesives : 1. These products are environmentally safe and easy to use. 2. They do not expand in volume, crack over time and bond much stronger. 3. They are quickly applied saving considerable amount of time. A trained installer can cover 20 square meters of area in one day. 4. By using adhesives, there is no distance left between the tile and surface resulting in a uniform and strong installation. 5. By choosing the right type of adhesive thin cracks on the surface can also be covered due to the flexibility of this material.

5.2.- ADHESIVE APPLICATION AREAS

Tile adhesives can be classified by their types, production batch numbers, application areas, and characteristics, In addition, product application instructions, technical information and necessary warning statements are given with the product. One example of this can be followed from the example given below : KALEKIM Ceramic Adhesive System, Grey Color is the most used adhesive in Turkey. The product leaflet in the example states its characteristics, area of application, product instructions, technical information and special warning.

If we look at the above example, we see that this is a general use product with water absorption rate of around 3 % and can be used for inside and outside applications. It is in the form of grey thin granules that need to be mixed with water for installation. The prepared mix should be consumed in 3 hours and applied to the surface evenly up to 6 mm thickness. The temperature range for application is between 5 - 35 °C.

The key factor in this setting is to pick the right adhesive type according to the conditions of the installation work required for the best results.



According to the consumer research done for consumer dissatisfaction related to tile consumption, 0.8 % of the customers stated reasons related to the manufacturing company failures, 10 % of the customers reasons of wrong product selection, 20 % of the customers reasons related to problems caused by dealers and a whopping 60.2 % of the customers claimed installation failures. This research alone shows the importance of installation in creating happy customers which is one of the most critical factors in determining future success of our business.

6 . LEGAL FRAMEWORK OF CONSUMER PROTECTION IN TILE INDUSTRY

Following Turkey's customs union agreement with EC, there has been a new legislative movement to protect consumer interests. A new law in this regard had been accepted in 1995, which has brought new requirements for manufacturers in the area of consumer interests.

Most of the manufacturers offer a 1 year of guarantee on the tiles purchased locally and openly state conditions for exchange of products. Product and installation instructions are also supplied with the products sold.

7. ARCHITECTURAL APPLICATIONS

Ceramic tiles are finding increasingly more creative ways of being used in projects in Turkey. We see that application of porcelain ceramic slabs as big as 60 by 120 cm. is being used as facades of tall buildings. The tiles are also becoming popular for living rooms or patios of houses as new areas as well as keeping its more traditional areas such as bathrooms or kitchens.

I think there are several reasons for the increasing popularity of tiles in architectural applications : 1. Tiles are becoming more uniform in quality performing in areas that were before reserved for other types of covering materials such as carpet or wood. 2. With the development of new technologies, tile designs are more numerous than ever satisfying a greater taste palate. 3. New architectural trends with open areas and minimalist styles

are giving tiles a bigger role to play due to rich textures and flexible composition of sizes. 4. Tiles are very hygienic, appealing to the families with young kids. 5. Tiles easily blend with other covering materials offering functional solutions to tight architectural problems.

I think that it will be an ever greater challenge to satisfy the new needs and desires of today's architects but new developments on size, design and texture will certainly help in meeting this challenge.

8. CONCLUSION

Anatolia the cradle of civilization gave birth to ceramic art for more than 4000 years. The evolution from the development of pottery, roof tiles and jars to the Iznik tiles produced with underglaze technology carrying rich floral and animal figure designs in various hues including red to the modern Turkish republic, world's 16th biggest economy, has led to the creation of one of the biggest ceramic industries in the world. This cannot be considered as coincidence. This development is a synthesis of many factors working together towards one common goal ; to create a country that is well integrated to the world but also to present its rich cultural heritage to mankind through various ways. What better expression method can be found than the art of ceramics which reveals this heritage to the world. But we could not have stopped only there, developing artistic designs and forms. This would have allowed us only to achieve half of our goal, which is presenting our heritage to the world. We needed to achieve the integration to the world hence developing this vast industry based on tile production, that is number 5 producer and number 8 consumer in the world. However, it will be wrong to assume that Turkish tile industry will stop here. The integration with the world will continue as quality and design improvements continue as well as increasing proximity between East and West and cold and hot climates will produce even more desirable products. I believe there lies a long road ahead of us, one that will take us in this new millenium to the new frontiers of development in the areas such as developing new raw materials, creating new size, shape, texture and designs to satisfy varying demands, developing new technologies for ever cleaner process techniques, and achieving higher quality standards.

I believe that the tile industry has great potential for growth in the global markets. Tile is a unique product in that its from earth but yet to be discovered by millions of consumers around the world, it has hard physical properties but warms up a household with the right combination of tiles, it is universal but yet no two installations are alike given the ability of tile being tailored for individual tastes. I do not think there exists another product today that has these ironies inherent in it, which provide its biggest appeal over other type of products. Tile produced from the earth itself shows characteristics and textures similar to stones, rocks and marble all natural formations. With this unique characteristic tile can satisfy desires and aesthetic requirements of customers as good as natural products. Hence, tile use can stop irreversible decline happening to earth's crust as we use natural products excavated from the mines.

I believe the Turkish tile industry, based on all that is stated, will be developing fast well into this new millennium and world tile industry will be even more mutually interdependent to fill an increasing demand.

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