MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Kazakh National Research Technical University named after K.I.Satbayev

Institute of Architecture, construction and energetics named after T.K.Bassenov

Department "Construction and construction materials"

Orazbayeva Alisha Emil’evna

"Mini-factory for the production of facade cladding ceramic tiles with a capacity of 5 million m^2 per year in Akmola region"

EXPLANATORY NOTE

to the final thesis

Specialty 5B073000 – Production of building materials, products and structures

Almaty 2019

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ALLOWED TO PROTECT
Head of Department "Construction and construction materials "
______________ Kyzylbaev N.K.
"___" _________ 2019

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Completed by Orazbayeva A.E.

Review
Candidate of technical sciences
____
Orynbekov E.S.
"___" _________ 2019 y.

Scientific head
Candidate of technical sciences
____
Abdrakhmanova K.K.
"___" _________ 2019 y.

Almaty 2019

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APPROVED
Head of the department
"Construction and
construction materials"
_____________ Kyzylbaev N.K.
"___" __________ 2019 y.

THE TASK
to complete the final thesis

Teaching student *Orazbaeva Alisha Emil'evna*
Topic: *Mini-factory for the production of facade cladding ceramic tiles with a capacity of 5 million m^2 per year in Akmola region*
Approved *by order of the Rector of the University №___dated "__" _______2019 y.*
Deadline for completed work: *"___" __________ 2019 y.*
Baseline data to work: *Mini-factory for the production of facade cladding ceramic tiles with a capacity of 5 million m^2 per year in Akmola region*
The list of questions to be developed in the thesis project:
a) *technological part*
b) *heat engineering part*
c) *architectural and construction part*
d) *economic part*

The list of graphic material: general plan of the enterprise, plans and sections of the main production departments of the enterprise, the technological scheme of production, technological map of the product, technical and economic indicators of the plant
List of graphic material: ____ *slides of the work presentation are presented*
Recommended main literature:

1 Avgustinik A.I. Ceramika – M.: Promstroyizdat, 2002 – 592 p.
2 EN ISO 10545-1:2014 Specifies rules for batching, sampling, inspection, and acceptance/rejection of ceramic tiles
3 ST KazNRTU-09-2017 General requirements for the construction, presentation, design and content of textual and graphic material - Almaty, KazNTU

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Department "Construction and construction materials"

SCHEDULE
preparation of the graduation project

Name of sections, list of issues under development	Dates representations of the scientific head	Note
1 Technological part	March 4 - March 13	
2 Heat engineering part	March 13 - March 25	
3 Architectural and construction part	March 25 - April 3	
4 Economic part	April 3 - April 19	

Signatures
of the consultants and the normcontroller for the completed final thesis indicating the relevant sections of the project

Sections titles	**Consultants, full name (academic degree, rank)**	**Date signing**	**Signature**
Technological part	Abdrakhmanova K.K.		
Heat engineering part	Abdrakhmanova K.K.		
Architectural and construction part	Abdrakhmanova K.K.		
Economic part	Abdrakhmanova K.K.		
Normcontroller	Bek A.A.		

Scientific head _______________________________________ Abdrakhmanova K.K.

The task was accepted for execution by the student ____________Orazbayeva A.E.

Date "____" _______________ 2019 y.

CONTENT

АҢДАТПА

Дипломдық жобаның мақсаты Ақмола облысында қуаттылығы жылына 5 млн $м^2$ фасадты қаптама керамикалық тақтайшаларды шығаратын мини-зауытты жобалау.

Жобалау кезінде технологиялық және жылу техникалық есептер шешілді, бас жоспар бойынша сәулет-құрылыс жоспарлау шешімдері жүргізілді, негізгі және қосалқы нысандардың орналасуы жасалды, негізгі техника-экономикалық көрсеткіштері есептелді.

Дипломдық жоба 48 беттен тұрады, оның ішінде 19 кесте, 4 сурет, 4 формул, 2 қосымша, 20 сілтеме.

Түйінді сөздер: фасадты қаптама тақтайшалар, саз, өндіріс, мини-зауыт.

АННОТАЦИЯ

Целью данного дипломного проекта является проектирование мини-завод по производству фасадных облицовочных керамических плиток производительностью 5 млн. $м^2$ в Акмолинской области.

При проектировании выполнены технологический и теплотехнический расчеты, обоснованы архитектурно-планировочные решения по генеральному плану, произведена компоновка основных и вспомогательных объектов, рассчитаны основные технико-экономические показатели.

Дипломный проект изложен на 48 листах, включает 19 таблиц, 4 рисунков, 4 формул, 2 приложений, 20 литературных источников.

Ключевые слова: фасадные облицовочные плитки, глина, завод, производство, мини-завод.

ABSTRACT

The aim of this final thesis is the construction of a mini-factory for the production of facade cladding ceramic tiles with a capacity of 5 million m^2 per year in Akmola region.

When designing, technological and thermal engineering calculations were made, architectural planning decisions were justified according to the master plan, the layout of the main and auxiliary facilities was made, and the main technical and economic indicators were calculated.

The final thesis is presented on 48 pages, includes 19 tables, 4 figures, 4 formulas, 2 appendixes, 20 references.

Keywords: facade cladding tiles, clay, production, mini-factory.

INTRODUCTION

The building materials industry is a major component of the economy of any country. Being the main material base for construction, it significantly affects the growth rates in other sectors of the economy and the social condition of society as a whole. In Kazakhstan, it includes about 600 enterprises, while only 30 of them are large and 100 are medium-sized. An analysis of the consumption of building materials in Kazakhstan showed that 75% of them make up the cement industry (38%), ceramic (23%) and glass (14%) industry.

In the Republic of Kazakhstan, the production of ceramic building materials, and in particular facade ceramic tiles, has not been established due to the lack of research of mineral resources suitable for the production of this type of building material. The most developed industry facade ceramic tiles in Western Europe and Central Asia.

Facade tile has stable physical and chemical properties, the quality of raw materials and production processes is ensured from a batch-to-batch geometry of the panels. The weight of the terracotta panel is more than two times less than the weight of natural stone. Subject to compliance with the installation technology, the ventilated facade of facade tiles withstands difficult climatic conditions and is able to serve for many years. Ventilated facade tiles are safe and environmentally friendly, are non-flammable, therefore, tiles are well suited for the protection and decoration of buildings for any purpose, any number of floors. Facade tiles are resistant to temperature extremes, weathering, very easy to use.

The aim of the project is the construction of a new factory for the production of facade cladding tiles up to 5 million m^2 per year using modern equipment and production technologies. Meeting the needs of the construction market of Kazakhstan and the nearby CIS countries in facade tiles made from environmentally friendly local raw materials, as well as meeting the growing demand for ceramic products, improving the quality of products in the market of building materials. The project is of great relevance and fully satisfies the demand for a different type of facade ceramic tiles.

Justification of site selection for construction

The projected factory will be located in Akmola region, in the village of Tonkeris. Tonkeris is a village in Tselinograd district, located 42 kilometers from Nur-Sultan city and the village has a favorable location, is a transport, industrial center. The population of the city is about 1000 people.

The most important and positive factor in the design and construction of a factory in the village of Tonkeris is the presence of the Tonkeris clay deposit, located 3 km from the Tonkeris railway station. Local clay is suitable for the production of high-quality effective facing materials, and also has the necessary technological properties necessary to obtain ceramic tiles. The great advantage of building a factory in Tonkeris is also the presence of gas, which is the best, effective type of fuel for burning products.

1 Technological part

1.1 Factory mode

The calculation of the factory operation mode is the basis for calculating the process equipment, raw materials consumption and the composition of workers. Characterized by the mode of operation of the factory number of working days in the number of working days per year, the number of working gangs per day and the number of working hours per gang. The product of these three indicators is determined by the nominal annual fund of the operating time of the factory.

When assigning modes of operation, one should strive to avoid a three-gang organization of labor, only in the case when it is not required by technological standards.

Due to for this factory with continuously operating furnace equipment, the following mode of operation has been chosen:

- admission department - discontinuous week, 1 gang;
- preparatory and molding department - discontinuous week, in 2 gangs;
- roasting department - continuous week, in 3 gangs [1].

The nominal annual fund of working time of equipment on the limits is determined by the formula:

$$F_{eq} = N \cdot N_g \cdot t = 250 \cdot 1 \cdot 8 = 2000 \text{ days}$$

where N – the number of working days per year;

N_g – the number of gangs per day;

t – the duration of the work gang in hours.

The estimated time of operation of technological equipment in hours on a continuous and discontinuous week, on the basis of which the production capacity of the whole individual lines is calculated, is determined by the formula:

$$T_{est} = D \cdot H \cdot K_{eq} = 365 \cdot 8 \cdot 0{,}9 = 2628 \text{ days}$$

where D – the number of working days per year, h;

K_{eq} – average annual utilization rate of equipment (0,8-0,95);

H – the number of working hours per day.

Estimated working time of continuously operating equipment per year:

$$T_{eq} = F_{eq} \cdot K_{eq} = 2000 \cdot 0{,}9 = 1800 \text{ days}$$

For the systematic repair of equipment was selected the coefficient of technical use of equipment K_{eq} = 0,8-0,95.

The number of working days per year for discontinuously operating lines can be determined by the formula:

$$N_{wd} = 365 - (W+H) = 365 - (100+15) = 250 \text{ days}$$

where W – the number of days off at a five-day work week;
H – the number of holidays.
Adopted in the factory operation mode is reduced in table 1.

Table 1 – Factory operation mode

Name of redistribution	Amount		Duration of		The annual operating time, hour
	days in year	gang in day	weeks	gang	
1. Reception of raw materials	250	1	5	8	2000
2. Raw material preparation	250	2	5	8	4000
3. Molding	250	2	5	8	4000
4. Drying	350	3	7	8	8400
5. Firing	350	3	7	8	8400
6.Finished products warehouse	350	2	7	8	5600

1.2 Product Range

Extrusion ceramic tiles – ceramic tiles, cut of a given length from a strip molded by an extruder from plastic mass. Facade tiles are designed for cladding facades of buildings as part of a ventilated facade system consisting of a suspended system, insulation and cladding panels. Facade tile is voluminous, hollow inside, easy, economical and easy to install. Its horizontal joints provide the best protection against precipitation. The patch has two mounting options: mounting on a vertical profile system using clamps and dovetail mounting. The tile has a fire safety class non-combustible [2].

Table 2 – The range of products

Name	View	Sizes, mm	Specific weight, kg/m^2
Facade tile FT2		300x600x18	32
Facade tile FT2 C1		300x600x18	32

Continuation of table 2

Name	View	Sizes, mm	Specific weight, kg/m^2
Facade tile FT2 C2		300x600x18	32
Facade tile FT2 C3		300x600x18	32
Facade tile FT2 C4		300x600x18	32

Table 3 – Technical specification of facade tiles

Characteristic	Specification	EN14411 Standard	Test Method
Dimensions/Surface quality			
Length	±1%	±2%	ISO10545-2
Width	±1%	±2%	
Thickness	±10%	±10%	
Physical properties			
Water absorption	3-7,5%	6-10%	ISO10545-3
Breaking strength	>2700 N	≥750 N	ISO10545-4
Modulus of rupture	>15 MPa	≥9 MPa	ISO10545-4
Abraision resistance	<460 mm^3	Max.1062 mm^3	ISO10545-6
Resistance to thermal shock	Fulfilled	Pass according to EN ISO 10545-1	ISO10545-9
Freeze-thaw resistance	Fulfilled	Pass according to EN ISO 10545-1	ISO10545-12
Moisture expansion	<0,02%	Declared value	ISO10545-10
Reaction to fire	Class A1	Class A1 or A1FL	
Chemical Properties			
Chemical Resistance			
Low Concentrations of Acids and Alkalis	ULA	Declared value	ISO10545-13

1.3 Characteristics of raw materials

The main raw material for the production of facade tiles is refractory clay. Refractory and refractory clays are characterized by a high content of alumina (20-42%), high cohesiveness and plasticity. They serve as raw materials for various ceramic industries, primarily for the production of sanitary faience, refractory and acid-resistant products. Refractory clays have a monomineral composition (kaolin or monothermite) and refractoriness not lower than 1580°C. Refractory clay is usually not sustained in mineral composition and has refractoriness from 1350 to 1580°C. There are no uniform requirements for the quality of refractory and refractory clays.

Tonkeris field located in the Akmola region, 45 km north-west of Astana, 3 km from the Tonkeris station.

The chemical composition of clays,%: SiO_2 - 50,42-72,35 (56,32); TiO_2 – 0,4-2,52 (0,89); Al_2O_3 – 16,95-34,27 (26,18); Fe_2O_3 – 0,24-14,61 (1,94); CaO – 0,1-0,81 (0,4);MgO – 0,1-1,19 (0,32); Na_2O – 0,1-0,3 (0,2); K_2O – 0,3-2,7 (1,48); SO_3 – 0,05-1,33 (0,11); impurities during calcination IDC - 4.39-10.75 (8.77).

Physical and mechanical properties of clay: bulk density - 1.9 g/cm^3; sintering temperature -1100-1150°C; fire resistance - 1690-1710°C.

The composition of kaolin-clay mica and kaolin-montmorillonite. Clay and dust fraction is 53-97,55% (average 82%). Inclusions are represented by quartz grains, earthy accumulations of iron hydroxides, pyrite grains, feldspar, hydromica scales. Plastic clay (plasticity number from 8 to 37, average 22), dispersed, semi-acid and basic. The content of clay chlorides is heterogeneous, prevailing with a content of 6 mg /EQ per 100 g of substance. By sintering also heterogeneous, depending on the content of alumina and potassium oxide. Clays are characterized by a high content of coarse-grained inclusions.

Laboratory and pilot tests, confirmed by the process of further production, established two ceramic groups: the first is highly plastic clays with a plasticity number of 20 and higher, the second is moderately and medium -plastic with a plasticity number of 19 and below. Clay is suitable for the production of facing facade, mosaic tiles and sanitary ware. Clay fusible. The sintering interval is 1100–1250°C. They are fire-resistant (1630–1710°C) by fire resistance. The clay reserves accounted for by the state balance as of 01/01/96 are in categories $A+B+C_1$ – 1954 thousand tons. The field is being developed. Since the beginning of mining, 184 thousand tons have been produced [3].

1.4 Calculation of the need for raw materials and semi-finished products

Mini-factory for the production of facade ceramic tiles with a capacity of 5 million m^2 per year in the Akmola region by plastic molding.

Initial data:

1) The composition of the mass,%: clay - 100;

2) Humidity of raw materials,%: W_o = 10;

Weighted average humidity of raw materials,%: W_{cf} = 10%;

3) Losses when piercing raw materials,%: = 8,77;

Weighted average loss during calcining raw materials,%: LDC = 8,77;

4) Technological parameters of production:

- molding moisture mixture - 18%;
- moisture after drying - 3%;

– the mass of ceramic tiles after firing is 5,76 kg or 0,00576 tons.

5) Defect and production losses:

– defect during firing - 2%;
– defect during drying - 3%;
– defect during dosing and transportation - 1%.

Factory capacity:

C_f = 5000000 · 5,76 = 28800000 kg = 28800 tons

For the comparability of articles of income and consumption of material balance, the yield of products and semi-finished products are calculated in tons per year [3]:

1. Tiles should come out of the kiln by the baked mass, taking into account the defect during firing:

$$Q_1 = C_f \cdot 100/(100 - K_1) = 28800 \cdot 100/(100-2) = 29388 \text{ t/year}$$

where C_f – factory capacity, t/year;

K_1 – defect during firing.

Defect during firing:

$$Q_1 - C_f = 29388 - 28800 = 588 \text{ t/year}$$

2. Tiles enter the kiln, taking into account losses when piercing through absolutely dry mass:

$$Q_2 = Q_1 \cdot 100/(100 - LDC) = 29388 \cdot 100/(100-8{,}77) = 32213 \text{ t/year}$$

where LDC – losses during calcining.

$$LDC = Q_2 - Q_1 = 32213 - 29388 = 2825 \text{ t/year}$$

3. It enters the tiles in the furnace according to the actual mass, taking into account the residual moisture:

$$Q_3 = Q_2 \cdot 100/(100 - W_0) = 32213 \cdot 100/(100-3) = 33209 \text{ t/year}$$

where W_0 – residual moisture of products.

Evaporation of moisture in the kilns:

$$Q_3 - Q_2 = 33209 - 32213 = 996 \text{ t/year}$$

4. Stones should come out of the dryer by the absolutely dry mass, taking into account the defect during drying:

$$Q_4 = Q_2 \cdot 100/100 - K_2 = 32213 \cdot 100/100\text{-}3 = 33209 \text{ t/year}$$

Defect during drying:

$$Q_4 - Q_2 = 33209\text{-}32213 = 996 \text{ t}$$

5. Stones should come out of the dryer according to the actual weight, taking into account the residual moisture:

$$Q_5 = Q_4 \cdot 100/100 – W_o = 33209 \cdot 100/100\text{-}3 = 34236 \text{ t/year}$$

6. Enters dryers according to the actual mass:

$$Q_6 = Q_4 \cdot 100/100 - W_{cf} = 33209 \cdot 100/100\text{-}18 = 40499 \text{ t/year}$$

Moisture evaporates in dryer:

$$Q_6 - Q_5 = 40499\text{-}34236 = 6263 \text{ t}$$

7. The need for process water for the preparation of the mixture:

$$Q_7 = Q_6 - (Q_4 \cdot 100/100 – W_{av}) = 40499 - (33209 \cdot 100/100\text{-}10) = 3600 \text{ t}$$

The need for process water, taking into account the 10% loss will be:

$$Q_7 = 3600+360 = 3960 \text{ t}$$

8. Required raw materials for the stable operation of the dispensers for absolutely dry mass, taking into account losses during transportation:

$$Q_8 = Q_4 \cdot 100/100 - K_3 = 33209 \cdot 100/100\text{-}1 = 33545 \text{ t/year}$$

Losses in transit:

$$Q_8 - Q_4 = 33545 - 33209 = 336 \text{ t}$$

9. Raw materials required by actual weight:

$$Q_y = Q_8 \cdot A_{clay}/100 - W_{clay} = 33545 \cdot 100/100\text{-}10 = 37272 \text{ t/year}$$

where A_{clay} – clay content.

Table 4 – Material balance of the technological line of the factory

Coming	Consumption
1. Enters the stock of raw materials: - clay 37272 t 2. Receives - process water 3960 t	1. Enters the finished product warehouse 28800 t 2. Irretrievable losses at: - calcining 2825 t - firing 588 t - drying 996 t - transport 336 t 3. Losses - process water 360 t 4. Moisture evaporates in: - dryers 6263 t - kilns 996 t
Total: 41232 t	Total: 41164 t

The balance discrepancy is 41232 - 41164 = 68 t/year, i.e. 0,16%. The allowable discrepancy is 0,5%.

1.5 Production technology

1.5.1 Justification of the choice of method of production

In the project I will use the scheme for the production of products by the plastic method, since the clay used is rather high humidity, medium plastic. When processing clay in its raw form, the scheme for preparing raw materials is somewhat simpler and more economical, since less processing equipment is needed, therefore, less energy consumption. All equipment is more reliable and easy to maintain. The firing temperature of products is approximately 50°C lower than that of semi-dry pressing, which also makes it possible to reduce the energy consumption for firing and to some extent compensates for the high costs of drying [4].

In connection with the above, I chose the technology for the production of facade tiles by plastic molding method.

1.5.2 Description of the technological scheme of production

Lump clay at the beginning of the process is fed to the clay ripper IAPD - I35. Dosing of clay components and their uniform supply for subsequent processing is carried out by a box feeder SMK-214, in them there is not only dosing, but also partial loosening of raw materials. After dosing of raw materials, it enters the stone separator rollers SM-1198A for coarse grinding, in which the grinding and removal of solid inclusions from the mass occurs. Then the clay already without stony inclusions is fed into the rollers for further fine grinding SM-1096. Clay is dosed using disc dispensers. Pre-dosed clay gets into twin-shaft mixer SMK-126. In two cylinders, the mass is mixed by two rotating shafts, equipped with paddles. The mixer housing is slotted type humidification system that promotes uniform wetting mass. Further, a homogeneous mass is sent to the molding [4].

Plastic molding of tiles is carried out through vacuum extruders. A vacuum extruder TL-CXJ-450EII is selected in my project.

Table 5 – The main technical parameters of a two-stage vacuum extruder type TL-CXJ-FII56-45

Dimensions LxWxH (mm)	5465x2765x2315
Production capacity (tons / hour) adjustable by frequency converter	6-90
Vacuum degree (MPa)	≤0,095
Nominal diameter of the screw (mm)	560/450
Pressing pressure (MPa)	3,5
Motor power (mixing /extruding) (kW)	37/(75-110)
Weight (kg)	17000

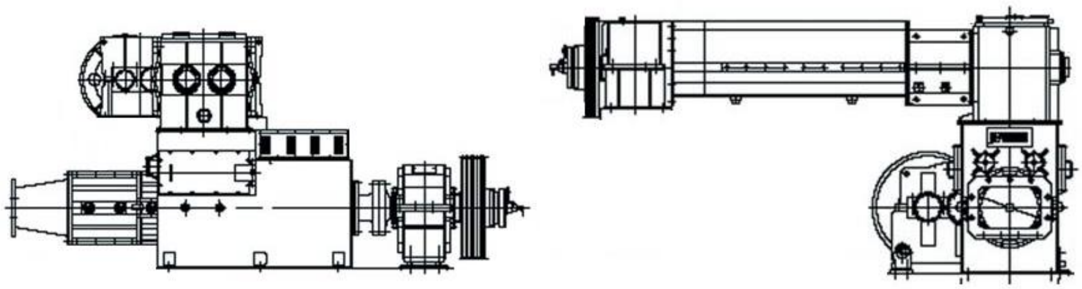

Figure 1 – Vacuum extruder type TL-CXJ-FII56-45

After the vacuum extruder, the tiles are dried in a five-channel roller dryer EM5, where the products are dried from 18% humidity to 3%. After drying, the tiles are fired in a two-channel roller kiln of the company's most environmentally friendly on the SACMI model furnace FBN325 (Figure 2).

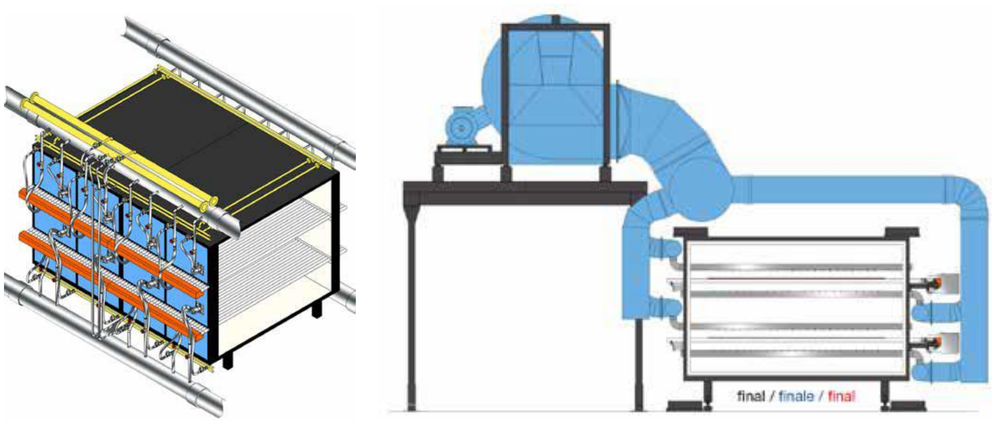

Figure 2 – Roller kiln FBN325

To accelerate the cooling of the tiles to a temperature below 40°C, blower devices are installed at the end of the furnace on a 4,5 m long section. Completing the process of manufacturing ceramic tiles sorting and packaging of finished products. Sorting and packaging installation sorted tiles by the length of the face, the thickness and curvature of the surface. Packed tiles in cardboard boxes with a covering last shrink plastic wrap.

Technological scheme of production of facade cladding tiles by plastic molding (extrusion)

Clay
↓
clay ripper
↓
box feeder
↓
stone separator
↓
fine grinder
↓
water → two-shaft mixer
↓
vacuum extruder
↓
machine cutter
↓
roller dryer
↓
roller kiln
↓
quality control
↓
sorting and packaging
↓
warehouse of finished products

1.6 Calculation of the capacity of the technological line of the factory

1.6.1 Selection and calculation of the main technological equipment

In this section, only the technological calculation of the main equipment is given, i.e., the productivity of the machines and the number needed to carry out the process for each conversion is determined [5].

For stable production, the performance of the feeding units must be 10–15% higher than the productivity of the equipment they serve. The general formula for calculating the process equipment is:

$$N_m = Q_{h.r.}/(Q_{h.m.} \cdot K_m) \quad (1)$$

where N_m – the number of machines to be installed;

$Q_{h.r.}$ – hourly productivity of this redistribution, t;

$Q_{h.m.}$ – hourly productivity of the machine of the selected size, t;

K_m – regulatory equipment utilization rate in time (0,8–0,9).

To calculate the equipment, it is necessary to know the costs of raw materials, so we will summarize the costs in table 6.

Table 6 – Calculation of consumption of raw materials

Name	Clay, t (m^3)			Output, t (m^2)		
	year	day	hour	year	day	hour
Facade cladding ceramic tiles	37272 (19617)	149 (78,5)	18,6 (9,81)	28800 (5 million)	82,3 (14285)	10,3 (1786)

1.Clay ripper

$$N_m = 18{,}6/\ (20x0{,}9) = 1$$

Accepted clay ripper IAPD - I35 in the amount of 1 pieces.

2. Box feeder

$$N_m = 18{,}6/\ (20x0{,}9) = 1$$

Accepted box feeder SMK-214 in the amount of 1 pieces.

3. Stone separator

$$N_m = 18{,}6/\ (25x0{,}9) = 0{,}83$$

Accepted stone separator SM-1198A in the amount of 1 pieces.

4. Fine grinder

$$N_m = 18{,}6/\ (45x0{,}9) = 0{,}46$$

Accepted fine grinder SM-1096 in the amount of 1 pieces.

5. Two Shaft Mixer

$$N_m = 20{,}3/\ (64x0{,}9) = 0{,}35$$

Accepted two shaft mixer SMK-126 in an amount of 1 pieces.
6. Vacuum extruder

$$N_m = 20,3/\ (20x0,9) = 1,12$$

Accepted vacuum extruder TL-CXJ-450EII in an amount of 2 pieces.
7. Automatic cutter

$$N_m = 1786/\ (1320x0,9) = 1,5$$

Accepted automatic cutters TL-QDJ-WSTB-ZD in the amount of 2 pieces.

Table 7 – Statement of equipment

Name of equipment	Capacity of equipment t/h	Required capacity t/h	Applied number of equipment	Power kW/h	Overall dimensions, mm
1. Clay ripper IAPD-I35	20	18,6	1	7,5	4810x1060x1500
2. Box feeder SMK-214	20	18,6	1	4	6600x2770x1650
3. Stone separator SM-1198A	25	18,6	1	43	3185x2805x1325
4. Fine grinder SM-1096	45	18,6	1	52	3800x3230x1220
5. Two-shaft mixer SMK-126	63	18,6	1	37	5970x1700x1650
6. Vacuum extruder TL-CXJ-FII56-45	20	20,3	2	75	5465x2765x2315
7. Automatic cutter TL-QDJ-WSTB-ZD	1320	1786	2	37	3160x1450x1280

Calculation of tunnel dryers
1. Annual capacity of kiln:

$$Q_y = Q_f \cdot 1,05 = 5000000 \cdot 1,05 = 5250000 \text{ pcs}$$

where Q_f – annual production capacity of the factory, pcs.
1,05 – coefficient taking into account the quantitative losses during drying and firing.
2. Single channel capacity:

$$Q_{ch} = 6 \cdot 133 = 798 \text{ pcs}$$

3. Annual capacity of one channel

$$Q_{y.ch} = Q_{ch} \cdot 0{,}9 \cdot 0{,}9/T_{dr} = 798 \cdot 350 \cdot 24 \cdot 0{,}9 \cdot 0{,}9/5 = 1085918 \text{ pcs}$$

where 0,9 – coefficient taking into account the use of thermal units;

0,9 – coefficient taking into account losses during drying and roasting;

T_{dr} – drying period of tiles, h.

4. Number of drying channels:

$$N_{ch} = Q_y/Q_{y.ch} = 5250000/1085918 = 4{,}83 \text{ pcs}$$

where Q_y – the annual number of tiles to be dried, pcs.

We accept the construction of a five-channel roller dryer EM5 [6].

Calculation slit roller furnace

The project adopted the roller kiln FBN325 with a capacity of 5000000 m^2 per year with the following characteristics:

- oven length – 120000 mm
- furnace channel width – 3010 mm
- height to the arch of the furnace – 760mm;
- time of firing – 29 hours;
- annual productivity – 5000000 m^2
- the number of rollers with a diameter of 60mm – 4000 pcs
- size of tile for furnace calculation:
  a) length - 600mm
  b) width - 300mm
- one-time capacity of the furnace - 20000 pcs

Calculate the number of furnaces:

$$N = \frac{Q}{T} \cdot K_{f.p.} \cdot K_{u.k.} = \frac{20000}{29} \cdot 24 \cdot 350 \cdot 0{,}94 \cdot 0{,}96 = 5227670\, pcs/year$$

where Q – one-time capacity of the furnace - 45000 pieces;

T - firing time, hour;

$K_{f.p.}$ – coefficient of output of finished products – 0,94;

$K_{u.k.}$ – coefficient of using kiln – 0,96.

Adopted 1 kiln FBN325 (SACMI) [6].

For a given annual performance of the furnace P_y, the estimated hourly productivity P_h is determined by the formula:

$$P_h = \frac{P_y}{24 \cdot D \cdot K_{w.t}} = \frac{5227670}{24 \cdot 350 \cdot 0{,}96} = 649\, pcs/hour$$

where D – the number of working days per year (350);

$K_{w.t}$ – coefficient of working time (0,96).

1.7 Control of technological process and quality of finished products

The properties of raw materials and the quality of the finished products of the designed enterprise must comply with the requirements of [7].

To ensure the quality of products, it is necessary to exercise control at all stages of production: input control of raw materials, current operational control and control over the quality of the finished product. It is necessary to provide data on the functions of the factory laboratory, technical control department. On oversight results summarized in appendix A.

Delivered products must meet the highest environmental requirements and international standards ISO 9001-2000.

2 Heat engineering part

A crevice roller kiln for fronting ceramic tiles is the most common kiln. This project provides for a stove with a length of 120 m, a channel width of 3 m, a height of 0,76 m to the arch of the furnace.

A two-channel roller kiln consists of a body made in the form of a tunnel, a roller passing through it, and heating and ventilation systems. The principle of operation of the roller kiln is similar to tunnel kilns. Gas is used as a fuel. Tiles that have arrived on the conveyor from one side of the tunnel move along it in the opposite direction, to the end of the tunnel, passing through the preheating, roasting and cooling zones. On the blower conveyor located outside the oven, the final cooling is carried out. A crevice roller furnace, in contrast to a tunnel kiln, which operates with pulsating movement of products, continuously moves the material, as the kiln is included in the total process flow [8].

2.1 Initial data for calculation

A roller kiln for firing ceramic tiles with size 300x600x18 mm capacity of 20000 pcs, continuous operation mode, three gangs;

The annual time fund is 8000 hours;

The residual moisture of the tile after drying is ω = 3%;

Defect during firing - 2%;

LDC – 8,77%;

Fuel - gas,

Firing temperature - 1100°C;

Firing duration – 29 hours;

Atmospheric air temperature - 20°C;

Coefficient of excess air δ = 1,15

Temperature dischargeable products - 50°C;

The temperature of the exhaust gases from the furnace - 300°C;

Air temperature for drying is 400°C;

Product weight - G_1 = 5,76 kg;

2.2 Calculation of the duration of firing tiles

1) Calculations when heated to 100°C.

Determined the amount of evaporated moisture by the formula:

$$G_m = G_1 \cdot \omega = 5,76 \cdot 0,03 = 0,1728 \text{ kg}$$

The active surface of heat exchange and evaporation of a single tile is determined:

$$F = 2·b·s+2·l·s+b·l = 2·0,3·0,018+2·0,6·0,018+0,3·0,6 = 0,2124\ m^2$$

The amount of moisture per 1 m^2 of the active surface is determined by the formula:

$$G_F = G_m / F = 0,1728 / 0,2124 = 0,81\ kg/m^2$$

When removing moisture of about 0,04 kg/m^2h from the active surface *F*, the time required for heating to 100°C is determined by the formula:

$$\tau = G_F/0,4 = 0,81/0,4 = 2\ h$$

2) Calculations for the heating period from 100 to 800°C.

Is determined by the permissible rate of temperature rise by the formula:

$$\vartheta_{add} = \frac{\Delta t_{add} \cdot a}{(100 \cdot s)^2} = \frac{8,5 \cdot 40}{(100 \cdot 0,018)^2} = \frac{340}{3,24} = 104,9\ °C/h$$

where Δt_{add} – the maximum allowable temperature difference in the body of the product when it is heated or cooled, taken equal to 8,5°C;

a – coefficient of thermal diffusivity of the material, equal to 40 m^2/h;

S – thickness of tile, 0,018 m.

The heating time is determined in the range from 100 to 800°C according to the formula:

$$\tau_2 = \frac{t_2 - t_1}{\vartheta_{add}} = \frac{800 - 100}{104,9} = 6,7\ h$$

where t_1 and t_2 – the temperature at the beginning and end of the interval.

3) Calculations for the heating period from 800 to 1100°C.

Taking this period Δt_{add} = 2,5°C is determined by the allowable speed of ascent temperature by formula:

$$\vartheta_{add} = \frac{\Delta t_{add} \cdot a}{(100 \cdot s)^2} = \frac{2,5 \cdot 40}{(100 \cdot 0,018)^2} = \frac{100}{3,24} = 30,7\ °C/h$$

Is determined by the time heating the product by the formula:

$$\tau_3 = \frac{t_3 - t_2}{\vartheta_{add}} = \frac{1100 - 800}{30,7} = 9,77\ h$$

4) Is determined by the time of exposure of the product at the final temperature by the formula:

$$\tau_{exp} = 1100 \cdot s^2 = 1100 \cdot 0{,}018^2 = 0{,}36\ h$$

5) The permissible cooling rate of the product in the temperature range from 1100 to 500°C is determined by the formula with a value of Δt_{add} = 5,5°C:

$$\vartheta_{add} = \frac{\Delta t_{add} \cdot a}{(100 \cdot s)^2} = \frac{5{,}5 \cdot 40}{(100 \cdot 0{,}018)^2} = \frac{220}{3{,}24} = 67{,}9\ ℃/h$$

Determined in cooling time by the formula:

$$\tau_4 = \frac{t_4 - t_3}{\vartheta_{add}} = \frac{1100 - 500}{67{,}9} = 8{,}8\ h$$

6) The permissible cooling rate is determined by the formula in the temperature range from 500 to 300°C at Δt_{add}= 12,5°C:

$$\vartheta_{add} = \frac{\Delta t_{add} \cdot a}{(100 \cdot s)^2} = \frac{12{,}5 \cdot 40}{(100 \cdot 0{,}018)^2} = \frac{500}{3{,}24} = 154{,}3\ ℃/h$$

Determined in cooling time by the formula:

$$\tau_5 = \frac{t_5 - t_4}{\vartheta_{add}} = \frac{500 - 300}{154{,}3} = 1{,}3\ h$$

7) The total duration of firing products in the furnace is equal to the total time of heating, holding and cooling is determined by the formula:

$$\tau_{all} = (\tau_1 + \tau_2 + \tau_3) + \tau_{exp} + (\tau_4 + \tau_5) \tag{2}$$

$$\tau_{all} = 2 + 6{,}7 + 9{,}77 + 0{,}36 + 8{,}8 + 1{,}3 = 28{,}93\ \mathrm{h}$$

Thus, according to the optimal firing mode, calculated on the basis of the allowable temperature difference in the body of the product during its heating and cooling, the total firing time is 29 hours.

Based on the results of the calculations, a temperature schedule is plotted for a roller kiln is shown in the figure 3.

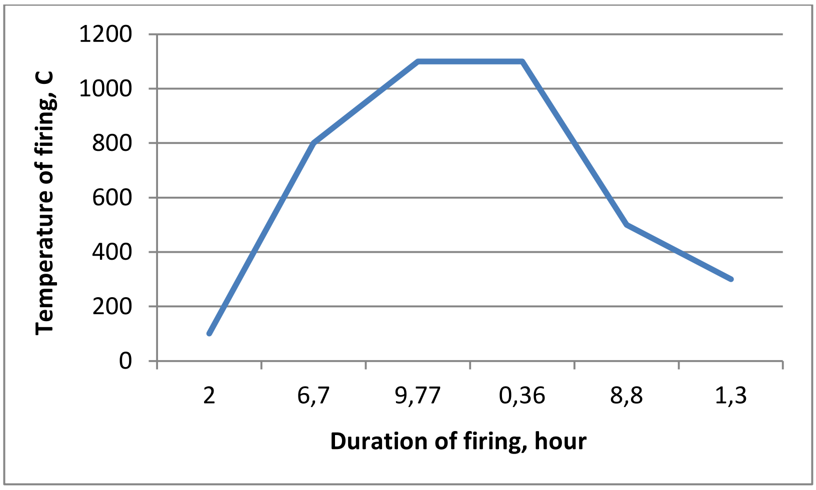

Figure 3 – Line chart of temperature mode of firing tiles in a roller kiln

2.3 Calculation of fuel consumption for technological needs

Roller dryer. For the calculations of the roller dryer, we take the coolant flow rate equal to P_t= 38 m^3/h.

1) The hourly coolant flow rate for 5 channels of the dryer is determined:

$$P_{c.h} = 38x5 = 190 \text{ m}^3\text{/hour}$$

2) The daily coolant flow rate is determined:

$$P_{c.d} = 190x24 = 4560 \text{ m}^3\text{/day}$$

3) The annual coolant flow is determined:

$$P_{c.y} = 4560x350 = 1596x10^3 \text{ m}^3\text{/year}$$

Roller kiln. When operating the furnace on gas, the standard gas consumption per 1000 pcs tiles is 576 m^3/thousand pcs.

1) The annual gas consumption is determined:

$$P_{g.y} = (5000000x576)/1000 = 2880000 \text{ m}^3\text{/year}$$

2) The daily gas consumption is determined:

$$P_{g.d} = (2880000/350) = 8228{,}5 \text{ m}^3\text{/day}$$

3) The hourly gas consumption is determined:

$$P_{g.h} = (8228{,}5/24) = 343 \text{ m}^3\text{/hour}$$

The results of the calculation are summarized in table 8.

Table 8 – Consumption of reference fuel for technological needs (for drying and firing products) factory

Name of equipment	Conditional fuel consumption, m^3		
	hour	day	year
Roller dryer	190	4560	$1596x10^3$
Roller kiln	343	8228,5	$2880x10^3$

2.4 Calculation of heat consumption for non-production needs

The costs of non-production needs include the cost of heat for heating, ventilation and hot water at the factory.

1) Determine the maximum hourly heat consumption for heating and ventilation of a building using the formula:

$$Q_m = [a \cdot q_0 (t_{in} - t^0_{out}) + q_{in} (t_{in} - t^{in}_{out})] \cdot V \qquad (3)$$

$$Q_m = [0,95 \cdot 0,36 \cdot (23-(-25))+0,1 \cdot (23-(-10))] \cdot 34214,4 =$$
$$= [0,342 \cdot 48+3,3] \cdot 32659,2 = 643909 \text{ kJ/h}$$

where a – coefficient taking into account the change in the specific thermal characteristics depending on climatic conditions, assumed to be 0,95 for the conditions of the Akmola region;

q_0 – the thermal characteristic of the building for heating, equal to 0,36;

t_{in} – the calculated temperature inside the building, equal to (23^0C);

t^0_{out} – the calculated outdoor temperature for heating design, equal to (minus 25);

q_{in} – thermal characteristics of the building for ventilation, equal to 0,1;

t^{in}_{out} – the calculated outdoor temperature for the design of ventilation, equal to (minus 10);

V – the volume of the building, equal to (132·24·10,8) = 34214,4 m^3.

2) The duration of the heating season is determined (October 4 - April 15):

$$T = 6 \cdot 30 \cdot 24 = 4320 \text{ h}$$

3) Determine the heat consumption for heating and ventilation of the building during the heating season by the formula:

$$Q_h = Q_m \cdot T = 643909 \cdot 4320 = 2782 \cdot 10^6 \text{ kJ/season}$$

4) The projected factory receives heat in the form of steam from the city's CHP. Based on this, the hourly consumption of steam for heating and ventilation is determined:

$$P_{hh} = \frac{Q_m}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{643909}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 323{,}25\ kg/h$$

where Q_m – maximum hourly heat consumption;

i_n – the vapor enthalpy entering the heater, equal to 2574;

i_k – the enthalpy of condensate, equal to 20;

η – the coefficient of efficiency equal to 0,8.

5) Determine the steam consumption for the entire heating season:

$$P_{hs} = \frac{Q_c}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{2782000000}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 1396586\ kg/season$$

6) Determined by the heat consumption for hot water supply of all workers and employees of the factory, working in 3 gangs per day:

$$Q_{hw} = K \cdot m \cdot n \cdot c \cdot (t_h - t_c) \tag{4}$$

$$Q_{hw} = 0{,}75 \cdot 45 \cdot 44 \cdot 1 \cdot (65 - 10) = 81675\ kJ/day$$

where K – coefficient that takes into account the number of people using a shower at the same time, is assumed to be 0,75;

m – the rate of hot water consumption per person, taken to be 40-50 kg according to sanitary standards;

n – the number of people working at the factory during the day in all gangs, assumed to be 44;

c – the heat capacity of water;

t_h – hot water temperature equal to 65^0C;

t_c – the average temperature of cold water, equal to 10^0C.

7) Is determined by the daily steam consumption for hot water by the formula:

$$P_{hwd} = \frac{Q_{hw}}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{81675}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 40{,}32\ kg/day$$

8) The annual steam consumption for hot water is determined in the form of:

$$P_{hwy} = 40{,}32 \cdot 350 = 14112\ \text{kg/year}$$

The results of the performed calculation are summarized in table 9.

Table 9 – Heat and steam consumption for heating, ventilation and hot water supply of an industrial building

The duration of the heating season, an hour	Heat consumption for heating and ventilation		Steam consumption for heating and ventilation		Daily heat consumption for hot water	Steam consumption for hot water	
	hour, kJ/h	season, kJ/season	hour, kg/h	season kg/season		day kg/day	year kg/year
4320	643909	$2782 \cdot 10^6$	323,25	1396586	81675	40,32	14112

3 Architectural and construction part

The factory for the production of facade cladding tiles is designed as an independent enterprise with all auxiliary facilities. The relief of the industrial site is relatively flat with a slight bias from the pre-factory zone, which provides normal conditions for the removal of rainwater runoff. When placing the factory, the wind rose is taken into account, taking into account the prevailing direction.

In this thesis project, a factory for the production of facade cladding tiles will be built in the village of Tonkeris in the Akmola region. On the basis of the data [9], we calculate and build the wind rose of the months of July and January.

Table 10 – Repeatability wind direction

Direction of the wind	N	NE	E	SE	S	SW	W	NW	calm
January	2	9	7	13	29	29	9	2	7
July	15	19	12	9	9	9	15	12	7
Year	7	12	10	12	18	20	15	6	6

Table 11 – Wind direction speed

Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	year
3,7	3,9	3,7	3,7	3,5	3,1	2,8	2,8	3,1	3,5	3,7	3,8	3,4

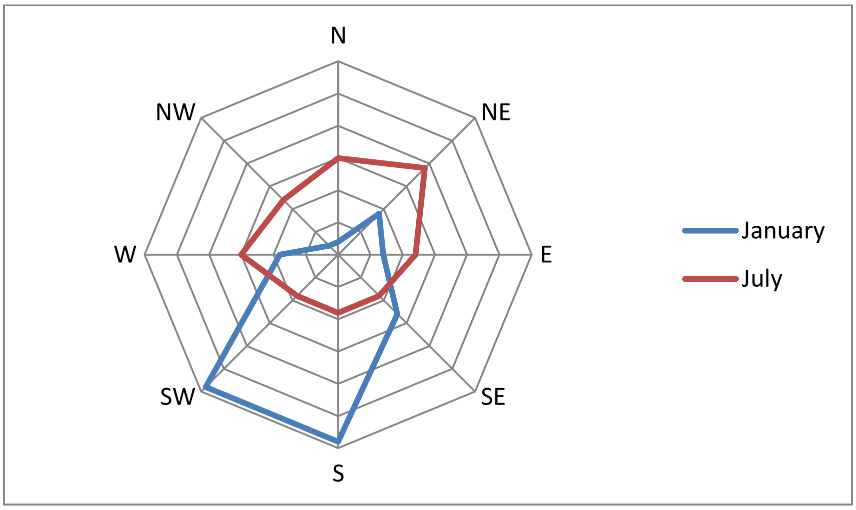

Figure 4 – Wind rose

3.1 Planning decisions of the master plan

Planning decisions are made in accordance with the wind rose. The site for the construction of the factory was assumed to be conditionally flat and with normal hydrogeological conditions.

According to sanitary standards, this company belongs to the 3rd class. The sanitary protection zone corresponding to this class is equal to 100 m.

At the factory there are: production building, a warehouse of raw materials, warehouse of material, warehouse of finished materials, administrative building, laboratory, parking for 20 cars.

The administrative building is located on the windward side. The transition from the administrative complex to the industrial building is carried out on the elevated gallery. The site in front of the administrative building is paved with paving slabs.

The clay storage tank is adopted outside the production building with dimensions of 26x18x6 m.

Transport communications are carried out on the roads provided for by the factory and adjoining the existing roads of the settlement. The width of the road is assumed to be 6 m, the roads in the factory are looped. For entry into the territory taken two entries.

For landscaping the site of the enterprise, local species of trees and shrubs were applied, taking into account their sanitary protective and decorative properties. The main elements of landscaping sites are lawns. The territory of the enterprise is fenced with reinforced concrete fence.

Engineering support of the factory (water supply and sewerage, electricity, heat) is provided by connecting to the existing networks of the village.

The removal of surface water has been resolved by imparting, to the planned sections and highways, slopes that ensure the flow of water according to the overall situational relief.

The geological structure of the soil for construction is favorable.

Sanitary area corresponds to 100 meters.

To create optimal working and rest conditions for workers during the lunch break, landscaping is provided at the site.

Consumer services for workers are provided for in the designed residential building [10].

3.2 Volumetric-planning and design solutions

Volumetric - planning and design solutions of buildings are made taking into account the maximum use of standard prefabricated reinforced concrete structures of factory production.

When considering the space-planning decisions, the average capacity of the factory and the need for compact production were taken into account. The production building is a 2 span building with a total length of 132 meters. The width of the industrial building has two spans: 12m and 12m.

The height of the building to the bottom of the supporting structures is 10,8m. The total construction volume is 34214,4 m^3.

Columns - prefabricated reinforced concrete foundations type glass. The building is blocked by reinforced concrete trusses, the slab is ribbed, and the roof is rolled. The first and last columns of each row are bound to a transverse axis of 500 mm. The pitch of the columns of the half-timbered frame is 6 m and has zero reference to the transverse axis.

The gate is taken in size 3,6x4,8m, the lighting is carried out at the expense of strip window openings of size 5x1,8m.

The cross section of the lower part of the columns is 500x600mm for a span of L = 12m. Columns are made of concrete grade 300 and reinforced with frames. The half-timbered columns have a cross-section of 400x400 mm and are made of grade 200 concrete.

Farms are made with a prestressing of the lower belt, the grade of concrete is 500. Wall expanded clay panels 6x1,8 m with a density of 1100 kg/m^3.

Administrative building

The building is a one-story building conditionally adopted in terms of 12x24m with a height of 6,6m. The walls are made of facing bricks (wall thickness 2,5 bricks). Foundations - monolithic, concrete. The roof is carried out on metal structures. As the roofing material used metal.

Finished products warehouse

For the storage of ceramic tiles is a concreted area serviced by an autoloader. At 1 m^2 warehouse 330 pieces of tiles are laid when laying them in 2 tiers.

Accepted area with dimensions: wide – 18 m; length – 18 m.

Material warehouse

It is designed in the form of a separate building and a shed. The detached warehouse has a ramp for easy handling and loading operations. The dimensions of a separate warehouse were taken as follows: width - 12 m; length - 24 m.

Special events

In accordance with the norms of construction design, the following general construction measures are provided:

– along the perimeter of all buildings, asphalt setting is carried out with a width of 1 m.
– fire prevention measures are provided, which consist in arranging evacuation exits, passages of appropriate width, and access roads to all buildings.
– in order to improve lighting and working conditions, it is envisaged to color the interior of the production premises, taking into account the physiological effects on the human body [10].

3.3 Calculation and selection of warehouses and auxiliary facilities

Calculation of clay storage

Take an indoor clay storage area with a shelf life of raw materials 30 days as part of the production building.

The volume of clay storage is calculated by the expression:

$$V = P_{day} \cdot t = 78{,}5 \cdot 30 = 2355\ m^3$$

where P_{day} – the daily need for raw materials, m^3;

t – the duration of storage, days.

A stack 15 m wide and 6 m high in a building with a span of 18 m was adopted. Then the length of the stack will be:

$$L = V/S = 2355/90 = 26\ m$$

where S – the sectional area of the stack, m^2.

Accepted area with dimensions: wide – 18 m, length – 26 m and high – 6 m.

Calculation of the warehouse of finished products

The finished goods warehouse for storing ceramic wall materials is a concrete pad served by a gantry crane.

330 pcs per 1 m^2 of the warehouse area, when laying in 2 tiers. The warehouse area is determined from the expression:

$$A = \frac{Q_{day} \cdot T_{st}}{Q_n} = \frac{14284 \cdot 7}{330} = 324\ m^2$$

where Q_{day} – the number of products arriving per day, pieces;

T_{st} – the duration of storage, days;

Q_n – the normative volume of products per 1 m^2 of area, pieces.

Other auxiliary objects

Other auxiliary objects selected for placement on the general plan without calculation include:

- administrative and household building - the project adopted the AHB of 24x12 m in two levels;
- warehouse of materials - indoor 12x24 m.

3.4 Calculation of the depth of the foundation

We calculate the normative indicator of the depth of soil freezing by the formula:

$$D_{fn} = d_0 \cdot \sqrt{M_t} = 0{,}23 \cdot \sqrt{15{,}1 + 14{,}8 + 7{,}7 + 5{,}5 + 12{,}1} = 1{,}71\ m$$

where d_0 – coefficient, the value of which differs for different types of soil (loamy soil - 0,23)

$\sqrt{M_t}$ – the square root of all sub-zero monthly temperatures in the region for one calendar year.

Table 12 – Average monthly and annual air temperatures

Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
-15,1	-14,8	-7,7	5,4	13,8	19,3	20,7	18,3	12,4	4,1	-5,5	-12,1	3,2

The calculated depth of soil freezing, on the basis of which the depth of foundation shall be determined, is calculated by the formula:

$$D_f = K_h \cdot D_{fn} = 0{,}5 \cdot 1{,}71 = 1{,}197\ m$$

where K_h – coefficient of thermal expansion (K_h = 0,5)

According to [9], the depth of soil freezing in the city of Nur-Sultan and surrounding areas is 1,83 m. Thus, the calculated depth of soil freezing turned out to be less than the standard, the depth of the foundation will be 2,1 m.

4 Economic part

Construction of a factory for the production of facade cladding tiles with a capacity of 5 million m^2 in year.

Project start: January 2020

Starting date of production: January 2022

Planning period: 7 years; 2020 – 2027 inclusive.

Discount rate: 10%.

4.1 Calculation of investment costs

Investment costs include the following cost items (table 13). The structure of capital investments summarized in appendix B.

Table 13 – The composition of investment costs

Expenditures	Amount, mln.tenge	Justification
Purchase and installation of equipment	2478,835	Price list of the manufacturer
Construction of buildings and structures	625,879	Estimated construction cost calculation
Total:	3104,7	

4.2 Calculation of production costs

Table 14 – Structure of production costs

The name of indicators	Per unit of production, tenge	Total, thousand tenge
Volume of production, thousand m^2		5000
Cost price		
Raw materials	44,5	40019
Water for technological purposes	0,13	119,552
Fuel for technological purposes	601	540900
Electricity for technological purposes	12,49	11241,8
Salary costs	70,8	63720
Payroll accruals	7,08	6372
Depreciation deductions	292,81	263530
Maintenance and repair	29,3	26353
Advertising expenses	0,247	222,4
Property tax	2,448	2203,35
Total cost	1060,8	954720
VAT, 12%	127,3	114566,4
Total	1188,1	1069286,4

Determination of enterprise profits from the sale of annual production.

Table 15 – Calculation of income derived from the sale of tiles

The name of indicators	Units	Amount
Facade cladding tiles	thousand m^2	5000
Price including VAT	tenge/m^2	2400
Total revenue	thousand tenge	2160000
Including VAT	thousand tenge	259200

Table 16 – Calculation of net profit

Indicators	Amount
Proceeds (gross income) from sales of products excluding VAT, mln. tenge	1900,8
Production costs, mln. tenge	954,7
Balance profit, mln. tenge	946,1
Profit tax * 20% to budget	189,22
Net profit	756,88
Depreciation charges, mln. tenge	263,53
Net profit + income from operations (depreciation), mln. tenge	1020,41

The payback period of the enterprise since its launch for the production of tiles is determined as follows:

Table 17 – Calculation of payback

The cost of creating the enterprise, mln.tenge	Net profit + income from operations, mln.tenge	The recoupment of the enterprise since its launch for the production of facade tiles, years
3104,7	1020,41	3

Given that the preparatory period for the establishment of the enterprise takes 1 years (development of design and estimate documentation, construction and installation work, manufacturing and supply of equipment, creation of the necessary infrastructure, organizational measures, etc.), the estimated payback period of the enterprise will be:

$$PP = 3 + 1 = 4 \text{ years}$$

4.3 Calculation of technical and economic indicators of the project

Calculation of profitability threshold (break-even point)

The break-even point is the volume of production at which revenue from product sales is equal to all the costs of producing these products.

To calculate the indicators characterizing the break-even of a project, it is necessary to classify all costs into fixed and variable [12].

Table 18 – Calculation of the threshold of profitability (break-even point)

The name of indicators	Per unit of production, tenge	Total, thousand tenge
Volume of production, thousand m^2		5000
Proceeds from sales without VAT	2400	1900800
Variable costs:		
Raw materials	44,5	40019
Water for technological purposes	0,13	119,552
Fuel for technological purposes	601	540900
Electricity for technological purposes	12,49	11241,8
Salary costs	70,8	63720
Payroll accruals	7,08	6372
Total variable costs:	736	662372,4
Fixed costs:		
Salary AMS	27,3	24600
Payroll accruals	2,73	2460
Depreciation deductions	292,81	263530
Maintenance and repair	29,3	26353
Advertising expenses	0,247	222,4
Total fixed costs:	352,387	317165,4
Total cost	1088,387	979537,8
VAT, 12%	130,6	117544,54
Total	1219	1097082,34
Break-even point, thousand m^2	1795	

The following technical and economic indicators are calculated.

The profitability of production assets R_{PA} is determined by the following formula:

$$R_{PA} = (GP/FA_{av}+C_n)\cdot 100\% = (946,1/(3104,7+95,47))\cdot 100\% = 29,6\%$$

where R_{PA} – the profitability of production assets, %;

GP – gross profit, mln.tenge;

FA_{av} – the average for the period the value of fixed assets, mln.tenge;

C_n – normalized working capital (accepted in the amount of 10% of GP), mln.tenge.

The cost of basic production assets is determined by the exception of the total capital investments, the cost of preparing the construction site, improvement of the enterprise's territory, temporary dismantled buildings and structures, the maintenance of the directorate of the enterprise being built, the training of operational personnel, design and survey works.

Return on assets R_A is determined by the following formula:

$$R_A = (NP/A_{av})\cdot 100\% = (756,88/979,5)\cdot 100\% = 77,3\%$$

where R_A – the return on assets, %;

NP – net profit, mln.tenge;

A_{av} – the average value of assets, mln.tenge.

The profitability of the sold products R_S is determined by the following formula:

$$R_S = (NP/C)\cdot 100\% = (756,88/954,7)\cdot 100\% = 79,3\%$$

where R_S – the profitability of sales,%;

NP – net profit, mln.tenge;

C – cost of sold goods, mln.tenge.

The main technical and economic indicators in table 19.

Table 19 – Technical and economic indicators of the factory

Indicators	Unit	Value
Annual output		
a) in kind	m^2	5000000
b) in terms of value	million tenge	1900,8
The total cost of all marketable products	million tenge	954,7
Including 1 m^2	tenge	1060,8
Annual profit	million tenge	756,88
Production assets	million tenge	3104,7
Including basic production assets	million tenge	2767,5
Normalized working capital (10%)	million tenge	95,47
Profitability:		
a) production assets	%	29,6
b) sold products	%	79,3
Production costs for 1 tenge of commercial products	unit	0,5
Payroll number of people employed	person	44
Including workers		32
Annual output per worker		
a) in monetary terms	thousand tenge	43200
b) in kind	thousand m^2	20,455
Total estimated cost	million tenge	3105
Specific investment	tenge / m^2	3450
Project payback period	years	4
The amount of borrowed funds	million tenge	2639,1

Technical and economic indicators obtained for a factory with a capacity of 5 million m^2 facade facing ceramic tiles per year are generally favorable and the factory can be recommended for construction.

CONCLUSION

In this final thesis was developed the mini-factory for the production of facade cladding ceramic tiles with a capacity of 5 million m^2 per year in Akmola region.

Based on a comparison of existing production methods, as well as on the basis of the physical properties of refractory clay, the method of plastic molding (extrusion method) was adopted for the manufacture of facade facing ceramic tiles. Also was calculated material balance. The technological calculation was performed, on the basis of which the main equipment of the factory was selected. The calculation of auxiliary facilities of the factory was carried out, the size of the clay storage and warehouse of the finished products was determined.

The placement and layout of the equipment has been made, a plan has been developed for the production building of the factory, its cuts. The production building with dimensions in terms of 24x132 m, height from the floor to the bottom of bearing structures is 10,8 m. A master plan of the factory has been developed taking into account the wind rose and the conditions for its efficient operation. The territory of the factory is 1,7 hectares.

A production plan of the enterprise was drawn up, including basic information about the products manufactured and requirements of standards for them, information about raw materials, technological parameters of production, quality control of the technological process and finished products, and measures to ensure safety and environmental friendliness of production. A master plan for the factory was developed, including a production building and additional buildings. Thermal calculations were made. The duration of roasting raw in the furnace was 29 hours.

The main technical and economic indicators of the factory’s production activity were determined. The amount of investment total was 3104,7 million tenge, of which the cost of the equipment – 2478,8 million tenge, for construction – 625,9 million tenge. The payback period of the factory is 4 years. The cost price and selling price for 1 m^2 of production is 2400 tenge, which is significantly lower than the cost in the construction market and this ensures timely sale of products.

The projected factory with a capacity of 5 million m^2 of facade cladding tiles per year has positive technical and economic indicators, and therefore quite competitive products will be produced, which will ensure its successful sale, as well as payback on the construction of the factory.

LIST OF ABBREVIATIONS

CIS – Commonwealth of Independent States
IDC – impurities during calcination
LDC – losses during calcining
ISO – International Organization for Standardization
AHB – administrative and household building
VAT – value-added tax
AMS – administrative and management staff
TEI – technical and economic indicators

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Appendix A

Table A.1 – Control of the technological process and the quality of the finished product

Material or operation	Controlled parameter	Period of control	Place of selection/ of control	Control method and error	Performers
Clay	1. Presence of foreign inclusions	1 time per gang	Career	Visually	QC technologist
	2. Humidity not more than 21%	Once a day	Box feeder	Weight, up to 0,2%	Laboratory
	3. Plasticity	Not standardized	Career	According to GOST 21216-2014; ± 0,1%	Laboratory
	4. Chemical composition,%: SiO_2, Al_2O_3, Fe_2O_3,CaO, MgO, Na_2O, K_2O, SO_3, IDC.	Controlled when raw materials change	Clay warehouse	GOST 3226-2001	Outside organization
	5.Specific effective activity of natural radionuclides up to 370 Bq/kg	When changing raw materials (at least 1 time per month)	Clay warehouse	GOST 30108-2000	Laboratory
Mixing	1. The composition of the mixture,%: clay - 100,	1 time per gang	Stockpile	Weight, up to 0,2%	QC technologist
	2. Primary treatment. The gap between the rollers: on the projections - 4 mm; at the troughs - 10 mm	Once a day	Stone Roll Mills	Probe angle 90, accuracy class 2	QC technologist
	3.Mixing steam humidification and the clearance between the blade tip and the wall troughs 3 mm, the angle of the blades 15-17	1 time per gang	Clay mixer	Probe angle 90, accuracy class 2	QC technologist
	4. Humidity, 16-21%	1 time per gang	Stockpile	Weight, up to 0,2%	Laboratory
	5. The gap between the rolls - 4 mm	Once a day	Fine grinder	Probe Set	Laboratory
	6. Mixing and steam humidification the gap between the end of the blade and the wall of the trough is not more than 3 mm	Once a day	Mixer	Probe Set	QC technologist

Continuation of Appendix A

Continuation of table A.1

Material or operation	Controlled parameter	Period of control	Place of selection/ of control	Control method and error	Performers
Molding	1. Molding timber. Gap between the cylinder and blades of 3 mm	Once a week	Press	Probe Set	QC technologist
	2. Depth of vacuuming, 3,5 kPa	1 time per gang	In the vacuum chamber	Vacuum meter VTI GOST 2405-2008	QC technologist
	3. The size of the outlet of the mouthpiece	Once a day	Press	Metal ruler	QC technologist
	4. The temperature of the tile, 30-35°C	2 times per gang	When leaving the press	Thermometer technical. Immersion of the thermometer in the center of the timber	Laboratory
	5. Humidity of a bar, 16-21%	1 time per gang	When leaving the press	Weight, up to 0.2%	Laboratory
	6. Cutting Cutting wire thickness 0.8-1 mm	Once a day	Cutting semiautomatic	Shatngenzirkul	QC technologist
	7. Raw. Measurement for sizing and oblique	2-3 times per gang	After cutting: 300±1x600±1,5x18±1	Metal ruler, triangle 90, accuracy class 2	QC technologist
Drying	Dried raw	Once a day	After drying, humidity 3%	Weight, up to 0,2%	Laboratory
Firing	1. Maximum temperature	Every gang	Tunnel kiln, 1100°C	Thermo couple THA	OTC, burner
	2. Firing mode. According to the temperature curve	Every gang	By zones of the tunnel furnace	Thermo couple THA	OTC, burner

Continuation of Appendix A

Continuation of table A.1

Material or operation	Controlled parameter	Period of control	Place of selection/ of control	Control method and error	Performers
Finished tile	1. Appearance and size	Once a day	Exhibition area	In accordance with EN ISO 10545-2	QC technologist
	2. Water absorption 3-7,5%	1 time per month	Exhibition area	In accordance with EN ISO 10545-3	Laboratory
	3. Strength	1 time per month	Exhibition area	In accordance with EN ISO 10545-4	Laboratory, quality department
	4. Resistance to deep abrasion	1 time per month	Exhibition area	In accordance with EN ISO 10545-6	Laboratory
	5. Frost resistance	1 time per quarter	Exhibition area	In accordance with EN ISO 10545-12	Laboratory, quality department

Appendix B

The structure of capital investments includes: the cost of construction of buildings and structures (industrial buildings, administrative and residential buildings, the length of the projected engineering communications), including the development of design and engineering works, the cost of equipment, including the cost of equipment installation and others.

The estimated cost of construction is determined by the object estimate, compiled on the basis of enlarged estimated standards in the prices of 2019.

Table B.1 – Calculation of the cost of the main construction objects (in prices of 2019)

Name	Unit	Amount	Cost of units, tenge	Total estimated cost, thousand tenge
1. Industrial building	m^2	3168	55684	168387,525
Total:				168387,525

Table B.2 – Calculation of the cost of construction of a building and auxiliary facilities

Name	Unit	Amount	Cost per unit, tenge	Total estimated cost, thousand tenge
1. Administrative building	m^2	288	60254	17253,152
2. Finished products warehouse	m^2	324	21227	49034,37
3. Material warehouse	m^2	288	20084	5784,192
4. Clay storage	m^2	468	18000	8424
5. Hydraulic fracturing	m^2	20	30000	600
6. Parking	m^2	415	13750	7287,5
Total object estimate				88383,214

Table B.3 – Local estimate for construction and installation work on energy facilities (in prices of 2019)

Name of works	Unit	Amount	Cost, thousand tenge	
			unit	full
1. Transformer substation	kw	64	20	1260
2. Low voltage cable networks	m	180	1,62	291
3. Telephone, radio	m	160	2,11	337
Total:				1888
4. Overhead	%	12		226
Total				2114

Continuation of Appendix B

Table B.4 – Calculation of the cost of equipment

Name of equipment, brand	Unit	Amount	Price per unit, thousand tenge	Amount, thousand tenge
1. Clay ripper IAPD - I35	Pcs	1	3000	3000
2. Box feeder SMK-214	Pcs	1	1500	1500
3. Stone separator SM-1198A	Pcs	1	2300	2300
4. Fine grinder SM-1096	Pcs	1	1250	1250
5. Bunker	Pcs	8	160	1280
6. Plate feeder	Pcs	1	1145	1145
7. Two-shaft mixer SMK-126	Pcs	1	5250	5250
8. Vacuum extruder TL-CXJ-FII56-45	Pcs	2	92625	185250
9. Automatic cutter TL-QDJ-WSTB-ZD	Pcs	2	22706,9	45413,8
10. Vacuum pump group type TL-ZKB	Pcs	2	3325	6650
11. Five-channel roller dryer EM5	Pcs	1	760000	760000
12. Two-channel roller kiln FBN325	Pcs	1	1140000	1140000
13. Forklift TALID	Pcs	1	2470	2470
Total:				2155508,8
14. The cost of installation and lining equipment	%	15		323326,32
Total cost of equipment and installation				2478835,12

Table B.5 – Local estimates for transport management and communications

Name of works	Units	Amount	Cost, thousand tenge	
			for 1 m^2	Full
1. Road	m^2	500	5,98	2990
2. Overhead	%	12		358,8
Total				3348,8

Table B.6 – Local estimate of the cost of external networks and the construction of water supply, sewerage, heat supply and gas supply

Name of works	Unit	Amount	Cost, thousand tenge	
			for 1 m	full
1. Water pipes	m	180	9,717	1749
2. Heat pipe	m	180	26,02	4683
3. Sewage	m	180	6,468	1164
Total:				7596
4. Overhead	%	12		911
Total				8507

Continuation of Appendix B

Table B.7 – Estimated construction cost calculation factory (Compiled in prices in 2019).

Name of chapters, objects, works and costs	Estimated cost, thousand tenge.			Total, thousand tenge
	CAW	equipment	other expenses	
2	3	4	5	6
Chapter 1. Territory preparation	3084			3084
Chapter 2. The main construction objects	168387,525	2478835,12		2647222,645
Chapter 3. Auxiliary objects	88383,214			88383,214
Total chapter 2-3	259854,739	2478835,12		2738689,859
Chapter 4. Energy facilities	2114			2114
Chapter 5. Transport and communication facilities	3348,8			3348,8
External engineering networks	8507			8507
Chapter 7. Improvement and landscaping	4445			4445
Total for chapters 1-7	278269,539	2478835,12		2757104,659
Chapter 8. Temporary buildings and structures, 2.7%	7513,277			7513,277
Total for chapters 1-8	285782,816	2478835,12		2764617,936
Chapter 9. Additional costs				
Winter rise, 1%	2857,82816			2857,82816
One-time reward for longevity 1%			2857,828	2857,82816
To pay for additional holidays 0.4%			1428,914	1428,914
Total chapter 9	2857,82816		4286,7421	7144,57032
Total chapters 1-9	288640,6442	2478835,12	4286,7421	2771762,506
Ch. 10. The content of the directorate of the enterprise under construction, 0,49%			21,005	21,005
Ch. 11. Training of operational personnel. 0,4%			17,147	17,147
Ch. 12. Design and exploration work, designer supervision, 4.1%			175,756	175,756
Total for chapters 1-12	288640,6442	2478835,12	4500,6501	2771976,414
Total estimated calculation:				
At current prices in 2019	288640,6442	2478835,12	4500,6501	2771976,414
Taxes, fees, obligatory payments (2%)			90,013	90,013
Estimated cost at current price level			4590,663	2772066,427
VAT (12%)			332647,97	332647,97
Construction cost	288640,6442	2478835,12	337238,63	3104714,397

Continuation of Appendix B

Production capacity of the factory is 5 million m^2 of tiles per year. Production costs include costs directly related to the production of bricks.

Table B.8 – Requirement for materials

Types and names of raw materials	Annual demand, tons	Density, t/m^3	Annual requirement, m^3	Unit price, tenge/m^3	Cost thousand, tenge
1. Clay	37272	1,9	19617	2000	39234
2. Auxiliary materials			2%		785
Total					40019

Table B.9 – The need for fuel, electricity, water

Types and names of raw materials	Units	Annual consumption	Unit price, tenge	Sum of expenses, thousand tenge
1. Gas	m^3	$10818{\cdot}10^3$	50	540900
2. Water	m^3	3960	30,19	119,552
3. Electricity	kWh	647567,5	17,36	11241,8
Total				552261,3

Depreciation of fixed assets

Taking into account the purpose and characteristics of buildings and structures, as well as the sectoral affiliation of the equipment used, the following weighted average values of depreciation deduction standards for the full restoration of the enterprise as a whole are taken:

– for buildings and structures – 2,5%
– on equipment with installation – 10%

Table B.10 – Amortization charges

Titles	Initial book value, mln. tenge	Depreciation rate (%)	Depreciation, million tenge
Buildings and facilities	625,879	2,5%	15,65
Equipment	2478,835	10,0%	247,88
Total	3104,7		263,53

Salary Costs

Plant performance refers to the enterprises of average power. In this regard, the staff number is adopted with the maximum possible combination of professions.

In total, the plant employs 44 people, 12 of them are administrative staff, factory staff includes 32 workers.

Administrative and management personnel, supply and sales department, planning and finance department, accounting, preparatory department, logistics and sales department, technical control department, factory laboratory, production personnel are provided for.

Continuation of Appendix B

Table B.11 – Monthly and annual payroll

Name of divisions and professions	Number of employees, people			Total people	Salary, tenge	Salary costs, thousand tenge
	1 cm	2 cm	3 cm			
1. Director	1			1	500000	500
2. Director of operations	1			1	200000	200
3. Mechanical engineer	1			1	150000	150
4. Energy engineer	1			1	150000	150
5. Technologist	1			1	180000	180
6. Secretary	1			1	100000	100
7. Cleaning lady	1			1	80000	80
8. Engineer economist	1			1	120000	120
9. Chief accountant	1			1	160000	160
10. Accountant	1			1	110000	110
11. Head of supply and sales	1			1	150000	150
12. Head of human resources	1			1	150000	150
13. Foreman	1			1	120000	120
14. Feeder on duty	1	1	1	3	100000	300
15. Preparatory department operator	1			1	100000	100
16. Extruder operator	1	1		2	100000	200
17. Machine operator	1	1		2	100000	200
18. Dryer	1	1	1	3	100000	300
19. Burner	1	1	1	3	100000	300
20. Rejection worker	1	1	1	3	100000	300
21. Forklift driver	1	1		2	100000	200
22. Heat engineer	1	1		2	100000	200
23. Electrician on duty	1	1		2	100000	200
24. Mechanic on duty	1	1		2	100000	200
25. Technological equipment locksmith	1	1		2	100000	200
26. Plumber	1	1		2	100000	200
27. Laboratory assistant	2			2	120000	240
Total	16	13	4	44		5310
Total for year						63720

Loan calculation

For implementation of the investment project is supposed to use borrowed funds. But at the same time, according to the legislation of the Republic of Kazakhstan, 15% of the total amount of the investment should be financed with own funds.

The total investment costs for the creation of the enterprise amount to 3104,7 million tenge. At the same time, own funds amount to 465,6 million tenge.

Loan rate – 11% per year in tenge. Accrual and payment of interest annually. To simplify the calculations, interest is paid in the current year for the current period.

Continuation of Appendix B

The scheme of issuing the principal amount of the debt - from 2020 to 2026 inclusive, taking into account the available funds in the orders.

The planned date of receipt of the loan is quarter 2020, the interest accrual for 2020 is appropriate. It takes place from the first quarter. All interest on the loan is included in the cost of production.

Table B.12 – Capital investment for the project, million tenge

Item of expenditure	Total for the period	Planning period						
		2020	2021	2022	2023	2024	2025	2026
Design and survey work	0,176	0,176						
Construction work	293,06	146,53	146,53					
Equipment and transport	2478,8	1239,4	1239,4					
Total without VAT	2772,1	1386,05	1386,05					
VAT, 12%	332,65	166,325	166,325					
Total with VAT	3104,07	1502,07	1602					
Depreciation	255,228			51	51	51	51	51
The residual value of fixed assets at the beginning of the period		1386	3054,5	3003,5	2952,5	2901,5	2850,5	2799,5

The depreciation rate per year – 5%.