



## **Technology for Production and Experimental Furnace for Hitting of Article "Yellow Bricks"**

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### **Abstract**

In the laboratory, prototypes of yellow pavements for street pavement have been prepared by creating and testing technology for their production from Bulgarian raw material based on sedimentary marble rocks. On the basis of the technological parameters a design assignment was prepared a thermal furnace for production of yellow paving stones was designed to cover experimental sections from the center of Sofia, aiming at continuous testing and proving in real conditions their tribological indicators.

**Keywords:** Mergel rocks, yellow pavers, “Clam” thermal furnaces.

### **1. Introduction**

Bulgaria has a variety of deposits of sedimentary rocks (marble rocks) suitable for the development of recipe compositions and technology for the production of yellow pavers. The elaborated prototype technology is based on the classical methods [1-3] used in the silicon industry, which enables the rapid organization of production with available standard equipment. The indicators of the finished samples are consistent with the requirements for this type of ceramic flooring and the existing standard [4]. Based on this experience and material from sedimentary rocks (marble), a production table for the petrochemical material was developed and tested in an experimental technological line and yellow pavers were produced, equivalent in color to the so-called yellow pavers, which were paved at the center of Sofia, but which excelled them in physic and mechanical, climatic and tribological indicators, introduced at the beginning of the last century. Works have been reported at international conferences and published in collections and journals [5-8]. The use of heat treatment is a widely used technological method for the synthesis of various phases characterized by a diverse structure [5-11]. For this reason, it is of interest to construct new furnaces, equipment and aggregates tailored to the specifics of the final products.

An experimental plot has been set up for the production of yellow paving stones based on sedimentary rocks in the Firm “Parent industry” of town Popovo.

What is missing for a small production of new products – the paving, not dependent on the natural raw material, is a furnace with a homogeneous temperature field and temperature programming for conducting high temperature liquid phase synthesis of a newly created original petrographic color material.

### **2. Aim**

The aim of the present work is the creation of a therm and technical facility with a homogeneous temperature field with the possibility of programming a temperature regime of firing with a performance of 20-24 pavements per day and the development of technology for production of artificially created compositions for yellow and other colored paving stones – white, green, brown and others.

The conditions for achieving the objective are to create a white base composition which, by modifying with various additives, achieves the listed colors and qualities of the paving material from natural raw materials.

### 3. Experimental technology

The elaborated prototype technology is based on a patent – protective base composition of washed kaolin, hydrated lime powder, magnesium oxide and colorants in a specified ratio. The mixture is homogenized in a mixture, plasticized with a humidity of 18-20%, left to stand for 2 days and pressed into paving molds. Sizes of the press for plastic pressing.

The resulting blanks are dried in a vacuum drier to 1-2 % residual moisture and processed according to the selected temperature regime for the respective composition and color.

The thermal treatment is carried out in a "Mida" furnace with a programmable process regulator for programmed process guidance.

- Heat rate: 1 – 2 to 3 – 4 °C / min;
- Temperatures, time and number of inhibitions according to the chosen composition and color;
- Maximum working temperature up to 1220 °C up to 5 hours depending on composition and color;
- The cooling rate is also 6 – 7 to 8 – 10 °C / min.

The new samples are also characterized by about 80 times lower surface porosity and 19 times lower water absorption compared to the original yellow pavers. The following characteristics of prototypes were found:

- compressive strength – 2900-3000 kg / cm<sup>2</sup>,
- wear resistance – 0.05 g / cm<sup>2</sup>,
- micro-hardness – 760-800 kg / mm<sup>2</sup>,
- thermal resistance of 30 °C (500 to 20 °C).

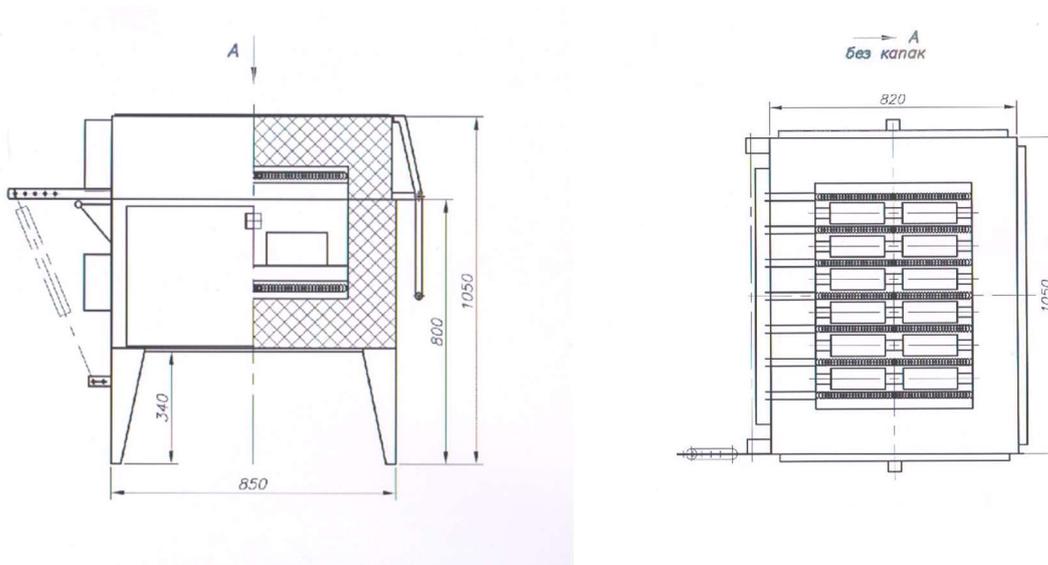


Fig. 1. Mounting drawing of a "Mida" furnace

#### 4. Construction characteristics of population furnace – type "Mida"

Technical specifications for a setting for the furnace design are the next parameters:

- Useful working area of the furnace 900 x 600 x 250 mm;
- Heaters – heater A1 2 x 7 pieces with common power 20 kW two-sided;
- Maximum firing temperature up to 1250°C;
- Programmer for execution of the temperature regime of synthesis;
- Hair homogeneity with 2 thermocouples with possibility to place two more pieces;
- Isolation of the working space – high temperature corundum wadding plates.

The furnace was created and tested for working capacity.

#### 5. Technical data regarding the temperature regulations

The temperature is controlled by a temperature controller "TC – 3L. The temperature increases linearly. The supply voltage is 220 V AC, -15% / + 10%. Supported types of thermocouples are: (nickel – chromium – nickel) or S (platinum – rhodium – platinum); non-volatile memory of all programs, points and parameters; number of programs up to 9; number of retention points in each program – 9; retention time: from 1 to 1000 minutes at resolution: 1 min; a rise time of 1 to 1000 minutes.

If the maximum allowed temperature is exceeded, the furnace switches off automatically. Operating ambient temperature range 0 to 55 °C. The furnace has three multifunction control buttons.



Fig. 2. Pictures of the manufactured and tested "Mida" furnace

#### Conclusion

1. Paving prototypes of a new, patent-patented base composition with modifiers and additives for colored paving stones including yellow without the use of sedimentary marble rocks have been prepared. Colorful pavers with stable colors are obtained.
2. Technological regimes for firing paving of different colors were created.
3. A high temperature furnace with a homogeneous temperature field and a programmable setting of the temperature regime was created, made and tested.

#### Acknowledgement

The authors express their gratitude to the Fund „Science Research” of the Ministry of Finance for Research project (Contract no № KII-06-OIIP03/4 of 14.12.2018), won in a competition for the financing of fundamental research in public Challenges – 2018.

## References

1. Hlavac J. The technology of glass and ceramics, Oxford, 1983.
2. Zhechkov G., L. Konstantinova et al., "A Reference on Building Ceramics", Sofia, Technika, 1986.
3. Gerasimov E., A. Gerasimov, A. Atanasov, V. Toshev, D. Petkov, D. Ivanov, L. Georgieva, L. Pavlova, H. Drenska, P. Vinarov, P. Petrov, S. Bachvarov, S. Panova, S. Bagarov, S. Serbezov, S. Stefanov, S. Dzhambazov, T. Stojkova, T. Datskova, H. Berlinov., "Technology of Ceramic Products and Materials", Edited by Prof. Bachvarov S. Saraswati press, Sofia, 2003.
4. Ceramic paving standard, BDS EN 1344: 2014, Ceramic paving, Requirements and test methods.
5. Encheva Sv., P. Petrov, D. Yanakieva, L. Lakov, K. Yankova, "Why are the yellow bricks yellow?" – In: Proc. National Conf. of Bulg.Geol.Soc. "GEOSCIENCES 2016", Sofia, BGS, pp. 25-26.
6. Lakov, L., N. Stoimenov, P. Tsonev, V. Vasilev, B. Jivov, Kr. Toncheva, "Physic and Chemical, Mechanical Properties and Tomographic Analysis of New" Yellow Pavements" of Petrographic Material, Collection of Papers, International Scientific Conference "Design and Construction of Buildings and Facilities ", DCB 2016 September 15-17, 2016, Bulgaria, pp. 115-120.
7. Lakov L., St. Encheva, P. Tsonev, V. Vasilev, B. Jivov, Kr. Toncheva, "Technology for Production, Chemical and Phase Composition of New" Yellow Paving "Based on Sedimentary Rocks", Collection of Reports, International Scientific Conference "Design and Construction of Buildings and Facilities", DCB 2016, 5-17 September 2016 Varna, Bulgaria, pp. 121-127.
8. Kandeва M., L. Lakov, P. Tsonev, V. Vasilev, Kr. Toncheva, "Tribological research of new Bulgarian" yellow pavers", HTCM Scientific Notifications, Days of Nondestructive Control 2016, issue. 1 (187), 2016, pp. 235-240.
9. Ilieva D., B. Jivov, D. Kovacheva, Ts. Tsacheva, Y. Dimitriev, G. Bogachev, Ch. Petkov, „FT-IR and Raman Spectra of Gd Phosphate Crystals and Glasses”, Journal of Non-Crystalline Solids, 293-295 (1), 2001, pp. 562-568.
10. Ilieva D., B. Jivov, G. Bogachev, Ch. Petkov, I. Penkov, Y. Dimitriev, „Infrared and Raman Spectra of Ga<sub>2</sub>O<sub>3</sub>-P<sub>2</sub>O<sub>5</sub> Glasses”, Journal of Non-Crystalline Solids, 283 (1-3), 2001, pp. 195-202.
11. Ivanova V. D., E. P. Kashchieva, B. T. Jivov, Y. B. Dimitriev, „Electron Microscopic Study of Lead-Borate Composites Containing PbMoO<sub>4</sub> Nanocrystals”, BAS, Nanoscience & Nanotechnology: Nanostructured Materials Application and Innovation Transfer, Eds E. Balabanova and I. Dragieva (Heron Press Science Series, Sofia, 2001), pp 30-32.