



## Silicate Design of Hollow Ceramic Book to Illustrate Scientific and Secular Events

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### Abstract

The task development consists of conceptual and artistic object – hollow ceramic book model to illustrate scientific, social and educational events. Working process relate to contemporary silicate technology through colloid mullite-quartz slip casting system in plaster two parts mould. Chosen material is white high temperature ceramic mass with low shrinkage. The ceramic book sheets have encyclopaedic dimensions and the event illustrates on its top pages. Functional art object is decorated by the specific design occasion on the ready-made product. The silicate design takes finish type and can be take part of the architectural environment - interior and exterior.

**Keywords:** hollow ceramics, mullite-quartz ceramics, slip casting, oxides decoration

### 1. Introduction

Scientific and educational events are bonded with different artistic initiatives organizing in Bulgaria and abroad. The ceramic hollow book's event is on the 24<sup>th</sup> of May "Day of the holy brothers Cyril and Methodius, of the Bulgarian alphabet, education and culture and of Slavic literature", one of the brightness Bulgarian holidays. Every institution has operated in the science, education and culture field decorates a glorification place of the saint brothers. Consequently, Professor Ludmil Drenchev PhD, D.Sc., the director of IMSETHC-BAS assigns to Professor Lyuben Lakov, PhD, head of department "Technologies and equipment for non-metal materials" and its team to produce a ceramic hollow book. The silicate technology possibilities allow technical ceramic production with bigger dimensions with complex structure products. Due to specific proportions of the real encyclopedic book the chosen ceramic mass is copyright composition of mullite-quartz glass-ceramics [2].

### 2. Instrumental equipment

Design and construction are the first stages of any silicate moulding production, as well as in slip casting manufacturers. Project stage related to computer visualization of model with high firing ceramic mass shrinkage calculation. The design next few points are construction of a plaster model and mould for casting ceramic hollow book. Model and mould material is plaster of Paris (POP) – a gypsum modification of calcium sulfate hemihydrate,  $\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$  [3]. Dry matter - water mixing ratio is about 1,5 gr. plaster per 1 ml water. The modelling technique is a hand-made form by running profile template through the still liquid plaster. Thereby the model surface contour obtains (fig. 1). The cover and pages cutting process follows after the whole relief is form. The top part of the sheets has still smooth and the embossed lettering should be added. The inscription has represented an event date and quote from the "Cyril and Methodius" poem by Stoyan Mihaylovski, Bulgarian writer and social figure. The letterings are made from photopolymer silicone on 55 A by Shore durometer hardness. The silicone is fired

on infrared light for 4 min per 3 mm relief. For lettering preparations are use vector graphic editor and where after the finished file were sent to printing house of film exposure. Positive and negative sections are important stage of film creation. During the silicone firing process positives are seal while negatives remain unfired and can be remove. The used alphabet is Old Bulgarian font. Subsequently, the finished titles mount on the impregnate model (fig. 2). Casting of ceramic modelling equipment a two parts mould follows when the book body and the lettering are assembled. Book model position during the first part forming mould is on its front side. Distances of a 35 mm outline around the model where mount the formwork. The latter have similar book shape by the long side of the mould. Lightening the large casting form is necessary to improve subsequently ceramic moulding process. The model and mould turn around when the first part is ready (fig.3) and the second part is casting too (fig.4). Ready-made plaster mould is let dry at 40 – 50°C temperature about 24 - 48 hours and set to operation – slip casting moulding.



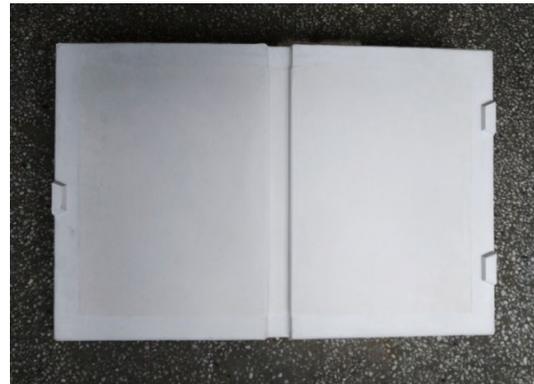
**Fig. 1. Plaster ( $\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$ ) running model and formed contour silhouette**



**Fig. 2. Finished model with cutting pages and cover with mounted silicon lettering**



**Fig. 3. First part of plaster of Paris (POP) slip casting mould**

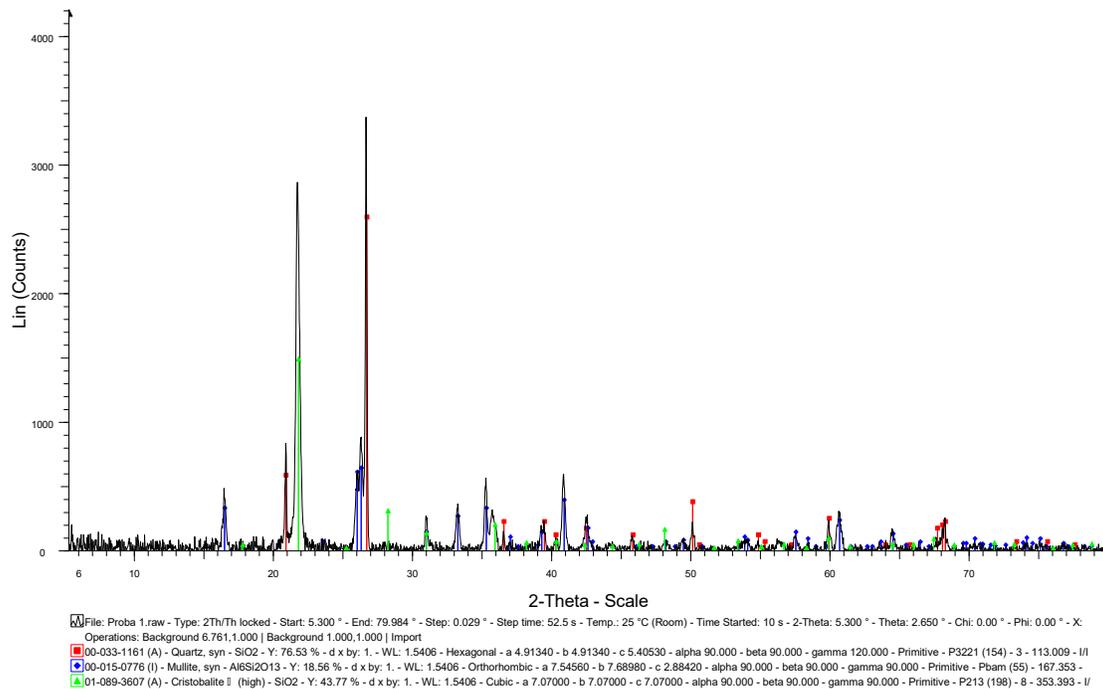


**Fig. 4. Second part of the mould**

### 3. Molding processes

Slip casting of water disperse colloidal system is the main molding process. Chosen silicate material for the task development is 7 Poise viscosity ceramic slip [1]. Mullite-quartz glass-ceramics is using composition for the ceramic book structure. Its phase analysis is represented

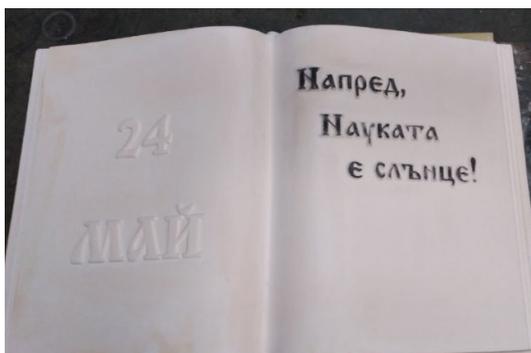
on fig. 5, where red line is Quartz ( $\text{SiO}_2 - 76.53\%$ ); blue graph – Mullite ( $\text{Al}_6\text{SiO}_2 - 18.56\%$ ); green – Cristobalite ( $\text{SiO}_2 - 43.77\%$ ).



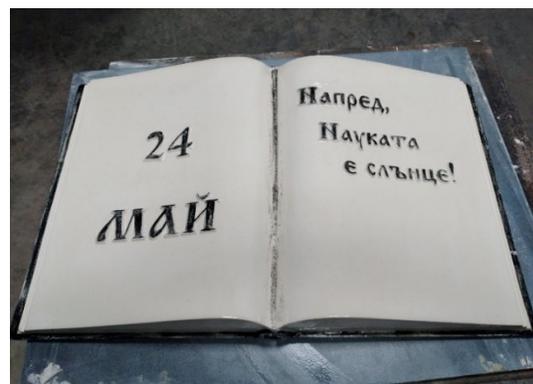
**Fig. 5. Phase analysis of high temperature mullite-quartz glass-ceramics**

Drying speeding and heating rate of technical ceramics fired up to 1250°C temperature is 1°C per 1 min, as well as cooling rate up to 50°C. High temperature soaking is about 2 hours. Biscuit shrinkage up to 1000°C is 2 %, while firing shrinkage at 1250°C is 4 %. Finished high temperature synthesized ceramic mass density is 2.6 gr per  $\text{cm}^3$ .

The possibilities of used ceramic material are applying to bigger and complex structure products, because of the high temperature ongoing processes. Quartz glass fireclay supplement contribute to low firing deformation, as well as the low coefficient of thermal expansion.



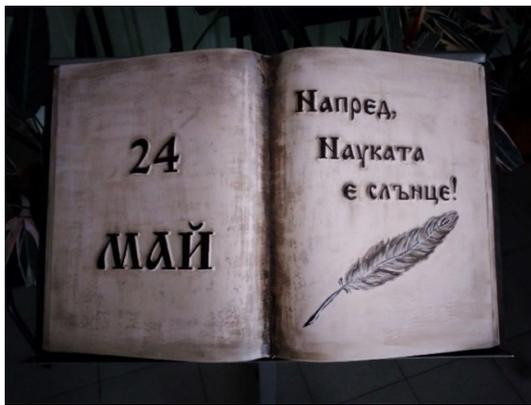
**Fig. 6. Under-glaze decoration with black ceramic pigment consist oxides of Mn, Co, Cr, ets.**



**Fig. 7. Under-glaze decoration and glazed high temperature firing ceramic book**

The complex hollow ceramic book structure is a result from the different casting thickness - in the hollow and at the edges of model. Drying process at 20-30°C for about 20 hours follows after the raw cast mould release. This helps the slowly and equally drying without deformation processes.

The cast product retouch is after the biscuit firing at 1000°C with temperature regime of 2 hours, as well as the hand-made decoration coloring (fig.6). Under-glaze decoration paints are Fe, Cr, Co, Mn high temperature oxides up to 1250°C. The glazed ceramic book (fig.7) can be over-glaze decorates with screen printed decals and liquid colloidal gold, platinum and third-time fired at 700 - 800°C [4]. Book model is decorated and once-fired at 1150°C (fig.8). Relatively lower temperature is sufficient of the ready-made book architectural position - interior exposure (fig.9).



**Fig. 8. Once-fired and decorated ceramic book model**



**Fig. 9. Architectural environment position – IMSETHC-BAS lobby exposure**

#### 4. Conclusion

Fireclay sanitary slip or semi-porcelain and low temperature mass with high fine fireclay fractions contain are the other possible molding materials. On the specific technology – high fired mullite-quartz glass-ceramic slip casting, a large range of decorating and operational possibilities can obtain. The development refers to different illustrate events and architectonic positions. Silicate compositions are great technical and artistic expression media. Ceramic materials are appropriate to complex surface products manufacture, to conceptual and functional objects situate in architectural environment - interior and exterior. Due of its high physical and mechanical properties silicates are suitable indoor and outdoor spaces, as well. Through the hollow ceramic book design for illustrating different initiatives emphasizes two main aspects:

- Production of complex silicate projects of fixed and random ceramic cast thickness through the contemporary technology processes and materials;
- Artistic and aesthetic aspects of the antique old book visualization through ceramic pigments decoration, appropriate to the illustrative event.

Technical and artistic 24th May ceramic book qualities increase through the silicate forming technique possibilities. High quality process of high temperature mullite-quartz ceramics allows to different visualizations and architectural exposition. Consequently, the ceramic book development confirms a rich experience of department №4 to IMSETHC-BAS to produce the modern silicate know-how – realization from the raw materials to the ready-made product.

### References

1. 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.
2. Technical Association of Refractories, Japan, 1980.
3. Бояджиев, Х. Технология на свързващите вещества. София, 2001.
4. Милдс, Мартин., Р. Лаушке. Фарфор, фаянс, майолика. Киев, 1975.