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# CREATION OF VACUUM-FORMING MATRICES FOR MAKING ART-DESIGN PRODUCTS FROM CONCRETE

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***Abstract:*** *The study examines the financial and technological possibilities of a start-up business company, which creates boutique concrete elements (in ancient styles such as Renaissance, Baroque, and Gothic) with an optimal budget for the activity. The main problem is the extremely high cost of the matrices, which until now have been made of silicone and polyester resin. The investment for each mold is substantial and this changes the price of the final product. The present study shows the application of a PVC blister packaging machine in producing decorative concrete elements, using the vacuum forming method. The technological time and the value of the matrix have been optimized several times, showing the methodology's effectiveness and the way of working.*

***Key words:*** *Vaccum-forming, Matrices, Art-design, Concrete, PVC Molds.*

## 1. INTRODUCTION

Even in ancient times, the most important and major buildings in every big city were built from much more durable and long-lasting materials than all the other ones. Cathedrals, temples, amphitheaters, basilicas, and many others can be shown as examples of buildings that have survived over the years. In addition to their sustainable structure, they are distinguished by lavish and rich decorations on the facades. Emphasis on the symmetry and correct geometry of the elements is noted. Uniform repetition of columns and pilasters, as well as proportionality of arches, domes, and niches. As a finishing touch, the presence of sculptures and figures depicting gods, historical figures, or scenes from mythology is often observed. We can find all these features in trends such as Renaissance, Baroque, Gothic, and others. [1-3]

Although passed away tens of centuries ago, these styles are still as popular today. Despite the progress in architecture, construction, and innovations in technology and materials, there is still a great demand for authentic decorative elements for the construction of modern buildings. Every day new apartment buildings, hotels, private homes, and parks appear all over Europe, the architecture of which resembles Ancient Greek or Ancient Roman architecture.

This report will examine a unit of activity of a company engaged in the design, manufacture, and installation of decorative elements of concrete that are applicable in interior and exterior environments with an Antique style. The products that are designed are for mass production or boutique single orders.

## 2. INFORMATION

### 2.1 Application field and problem description

The main problem for the functioning of the activity is not only the need to purchase special equipment but also the production of many expensive molds, through which the decorative elements are cast from concrete. When it comes to mass production, then using the traditional method of creating a mold of polyester resin and silicone is recommended. [4] The price is relatively high, but the mold can produce hundreds of casts with good impression quality. However, when we are talking about unique products that are made to an individual order or in a small edition (up to 100 pieces), then it is

unnecessary to create a mold for such a large number of uses. Unfortunately, none of the known methods provide a good enough solution to the problem, and the only option remains the use of a standard mold, which significantly increases the final price of the product. This factor is often the client's reason for order canceling or changing the main idea of the project.[3]

After a long study of various systems and technologies, there was an idea, which subsequently gave the desired result. Dozens of samples and tests were made on elements of different volumes and shapes, to reach optimal quality and minimum cost for making each mold.

## 3. USED METHODS AND STAGES OF RESEARCH

### 3.1 3D Modeling and used software

The experimental part begins as a result of an assignment for two types of round wall reliefs depicting a grape and a dove. Their purpose is purely decorative for the courtyard of a newly constructed Mediterranean-style building. (Fig. 7. and 8.)

The first step is to create a 3D model using a 3D modeling program. There are set the exact dimensions of the product and the depth of the imprint.

The software used for this purpose is "Aspire". It manipulates the edges polygons and vertices of the elements, but its most basic function is to generate G-code, which is then imported into other software, that are used to create a real object, from the 3D model. (Fig. 1.)

The other software, that were part of the process are "Mach 3", which controls a 3-axis CNC router, and "Cura"- the one that was used for 3D printing some of the elements.

### 3.2 Creating a real model

The next step is creating a real model of the three-dimensional detail. For this purpose, two methods can be used - one with material removal and the other with accumulation.

#### 3.2.1 Subtraction method

For the subtraction method, a three-axis CNC router (CNC mill) was used, in which the element is cut from a natural MDF board. (Fig. 2.) In this way, the model's base and the wreath of flowers serving as a frame were created. The imprint is clear and detailed enough. [5]

#### 3.2.2 Accumulation method

The second method is by accumulating material. A 3D printer working with standard PLA filaments was used there. Thanks to this technique, the most detailed elements were created, namely the grape and the dove. (Fig. 3.) Experiments with a CNC cutter show that their fine contours are hardly suitable for cutting from MDF board, as much of the depth of the impression is lost and the quality is not good. The CNC machine, that was used is professional, but the software had some issues, that may have been the real cause of the failed centerpieces experiment.

**Fig. 1.** 3D model of the elements.

**Fig. 2.** The frame, created by subtraction method.

**Fig. 3.** The centerpieces, created by accumulating material.

On the other hand, the method with material accumulation through a 3D printer is much more suitable, and the production time is optimized twice – from 30 minutes to 16 minutes (for the dove). The only drawback is the fine texture that the filament leaves is visible, but for products, with a size over 30cm, it is hardly noticeable. [6]

It should be noted here that in the existence of a ready model or sample of the desired item, the above steps are completely unnecessary.

## 4. MOLDING AND RESULTS

### 4.1 Molding

From here we move on to the actual process, and subject of this report, which is the preparation of a mold according to the given model, using a vacuum forming machine.

As mentioned at the beginning, what others do as a traditional matrix for such relief involves multiple steps and mostly laying different layers of certain materials. Such, for example, are chemical separators, polyester resin, polyurethane, and others, each of which is applied between 2 and 7-8 times. It takes time for each layer to dry before applying the next, and the fact that everything is done by hand adds to the build time. All these processes take place within a few days and are highly dependent on the temperature and humidity of the room. The finished mold is suitable for making hundreds of castings, but its price is high. In cases where the task is to make one or a few castings, according to an individual unique project, this method is very slow and unprofitable.

This is the reason why, trials and experiments began, in the direction of creating much cheaper molds, in a shorter time, which would be sufficient to make a smaller run of castings.

For this purpose, was used a vacuum forming machine whose real purpose is to make "Blister" and "Skin" packages. (Fig. 4.) [7,11,12] The manufacturer is MaBak, and the type of the machine is “semi-automatic” Products made by this method can be found everywhere in commercial networks and the food industry, but after successful experiments, they can now safely be used in construction as well.


**Fig. 4.** Vacuum-formed packaging.

The process is extremely simple but very effective. [8,9,13] The finished element on which we want to make a mold is placed in the machine. Over it is loaded a sheet material, type "Thermoplast“, more specifically “Polystyrene”, which is characterized by high flexibility and plasticity when heated to a certain temperature, as well as rapid hardening upon sudden cooling. [10] The thickness of this sheet is 3 mm, and it is heated for 3 to 5 minutes, depending on the climatic conditions in the room. When the temperature is reached, and the sheet softens, the machine makes an automatic "hit". This is a slow movement of the frame, that supports the preheated thermoplastic against the mold surface until it touches the bottom of the chamber, accompanied by a vacuum pulling off the remaining air between the flexible sheet and the embossed element. (Fig. 5.). Every vacuum-forming machine has different functional parameters. The one, that is used can produce a mold with maximal dimensions of L=600 mm; W= 500 mm; H= 100 mm.

The forming and cooling of the already finished mold are no more than 30-40 seconds, thanks to a built-in fan.

### 4.2 Results

The whole process from starting the machine to taking out the mold ready for work is no more than 5-10 minutes (depending on the temperature in the room and the thickness of the sheet). On the other hand, the processing time required to make a traditional resin mold is 4-5

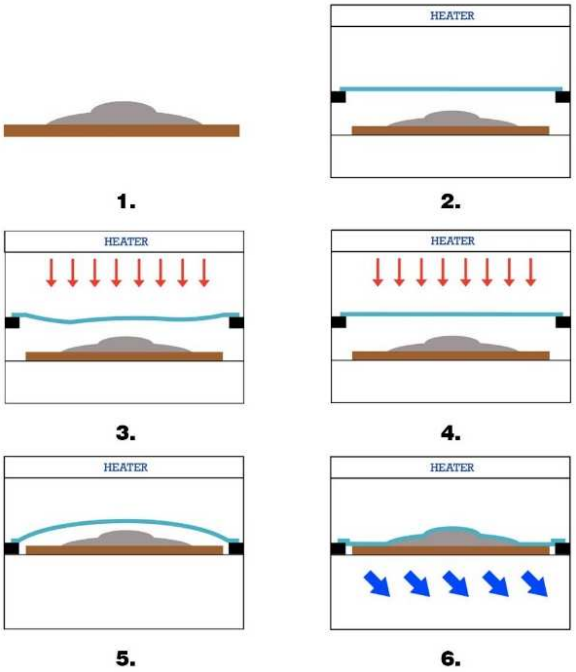


**Fig. 5.** The process of vacuum forming.

days to complete each drying cycle. In this case, we observe that with the vacuum forming method, the time is optimized about a thousand times, depending on the temperature of the room. The second factor that characterizes this method as extremely effective is the lower price of the raw material, which is ten times.

The finished matrix of figure 6 can be used immediately for its intended purpose since it represents a negative of the relief. Thus, when pouring with a mixture of polymer concrete, the finished dried product comes out identical to the model. The thin, smooth walls and flexibility of the thermoplastic material make this type of mold extremely easy to separate from the casting, which with other methods is sometimes a big problem due to the resulting adhesion of the concrete to the resin.

**Fig. 6.** Thermoplastic mold, ready for use.

## 5. CONCLUSION

In conclusion, it can be summarized that the technology presented above is extremely effective in cases where the mold will be used in a small run (about 100 castings, depending on the depth of the relief and the exploitation of the material). The main disadvantage of this method is the fragility of the molds, which, if not operated correctly and carefully, can be broken very easily. The molds themselves are extremely light and easy to separate from the concrete casting. The use of additional chemicals is kept to a minimum.

The result of the experiments is successful and the task is completed. Using this technology, 5 reliefs of each model were cast, intended as finishing decorative elements of a Mediterranean-style residential complex. (Fig. 7. and 8.).

**Fig. 7.** Casting of a grape relief, built in next to a pilaster in same the style

**Fig. 8.** Casting of a dove made out of concrete

## 6. ACKNOWLEDGMENT

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## CREAREA UNOR MATRIȚE PENTRU FORMAREA SUB VID ȘI DESTINATE REALIZĂRII PRODUSELOR ART-DESIGN DIN BETON

*Prin acest studiu, se analizează posibilitățile financiare și tehnologice de realizare a unei companii de tip start-up care să creeze elemente decorative din beton (în stiluri vechi, așa cum sunt cele renascentiste, baroce sau gotice), cu o optimizare a bugetului pentru o asemenea activitate. Principala problemă o constituie costul ridicat de obținere a matrițelor, care până acum au fost realizate din silicon și rășină de tip poliester. Investiția realizată în cazul fiecărei matrițe este substanțială, generând o creștere de preț a produsului finit. Prezentul studiu demonstrează posibilitatea utilizării unei mașini de ambalat cu folie din PVC pentru producerea elementelor decorative din beton, utilizând metoda de formare sub vid. Durata fabricării, precum și valoarea matriței, au fost optimizate în câteva etape, dovedind astfel eficiența metodei utilizate și modalitatea de implementare a acesteia.*

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