



TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics

Vol. 56, Issue I, March, 2013

## SOME CONSIDERATIONS ABOUT COMPOSITE MOLDS MANUFACTURING

Adela HODOR, Petru BERCE, Paul BERE, Marian BORZAN

**Abstract:** *In the present paper we propose the study of a under development Rapid Tooling technology. We developed a study based on Glass Fiber Reinforced Composite mold of a mannequin head. The paper describes a brief explanation of reinforced composite molding process Rapid Tools. Thanks to intensive research and development in the areas of material, process, software, and equipment, applications to rapid tooling have been developed by directly or indirectly employing rapid prototyping processes in the tool, die and mold fabrication. Usually, through Rapid Tooling there can be obtained tools called "soft" – of modern conception – which resist only at small or middle production series. While these tools are made, the "hard" tools can also be finished – the classical ones – which already allow big series productions.*

**Key words:** *Rapid Tools, Rapid Prototyping, composite tooling, "lay up" process, glass fiber reinforced epoxy mold.*

### 1. INTRODUCTION

Rapid Prototyping (RP) can be defined as a group of techniques used to quickly fabricate a scale model of a part or assembly using three-dimensional computer aided design (CAD) data. What is commonly considered to be the first RP technique, Stereolithography, was developed by 3D Systems of Valencia, CA, USA. The company was founded in 1986, and since then, a number of 80 different RP techniques have become available [1].

The term *Rapid Tooling* (RT) is typically used to describe a process which either uses a Rapid Prototyping (RP) model as a pattern to create a mold quickly or uses the Rapid Prototyping process directly to fabricate a tool for a limited volume of prototypes [2].

### 2. MAIN FEATURE OF COMPOSITE MOLDING

RT is distinguished from conventional tooling in that [3]:

-Tooling time is much shorter than for a conventional tool. Typically, time to first

product is below one-fifth that of conventional tooling.

-Tooling cost is much less than for a conventional tool. Cost can be below five percent of conventional tooling cost.

-Tool life is considerably less than for a conventional tool.

-Tolerances are wider than for a conventional tool.

Composite tooling bridges the gap between silicone rubber soft molds and aluminum "soft tools". It has advantages in between the two RT methods:

- Composite tooling can use production materials (thermoset plastics).
- Less expensive than an aluminum tool. Lower lead time than aluminum tool.
- From one mold, 50-500 pieces can be produced.
- Part can be of moderate to high complexity.
- Mold Fabrication Time: 2-6 weeks.
- Production Rate: cycle time of 3 to 15 minutes.
- Accuracy: As good as the SLA pattern:  $\pm 0.127$  mm.

- Cost: \$2000 (about half that of an Al soft tool) for a consumer product part of 12.7x12.7x7.6 mm.
- Advantages increase with the complexity of the molded part.

Table 1

Longevity of the Glass Fiber Reinforced Mold.

Longevity of the Mold	
Thermoplastic Resin	Number of Shots
Investment Casting Wax	1000-10000
Polypropylene	400-4000
Polyethylene	400-4000
Polycarbonate	100-1100
PC/ABS Blends	100-1100
PBT	100-500
Nylon (filled with glass fiber)	300-3000
Nylon (virgin)	200-1200
ABS	300-3500
Acetal	300-3500

**3. REINFORCED COMPOSITE MOLDING PROCESS STEPS [4]**

A master male pattern is made. The master can be made from any material that can tolerate epoxy, such as foam or wood. See the figure below.



Fig. 1. The master part

An RTV mold is made of the master pattern and a urethane male pattern is made from the mold. The reason for this is that in the epoxy mold fabrication process, the male pattern is

typically destroyed. A parting line surface is added, as shown below.

Therefore, draft and small undercuts are not considerations. With a composite tool, the pattern must be drafted. Also, the manufacturability of a part design must be reviewed to ensure that an undercut or backdraft feature will not prevent part ejection.

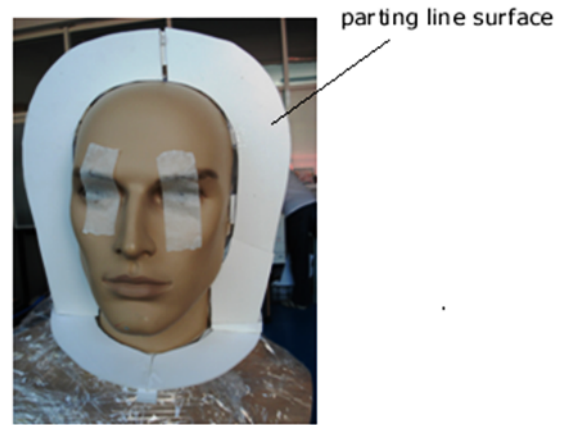


Fig. 2. The parting line surface

Epoxy and glass cloth are layered around the male pattern to form the mold and are cured successively in layers. The figure below shows the beginning of the "lay up" process for the top half of the mold.

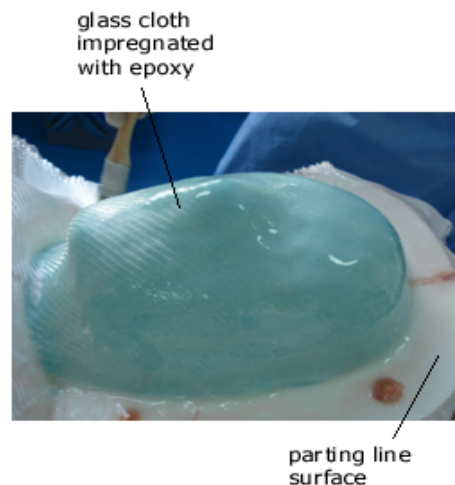


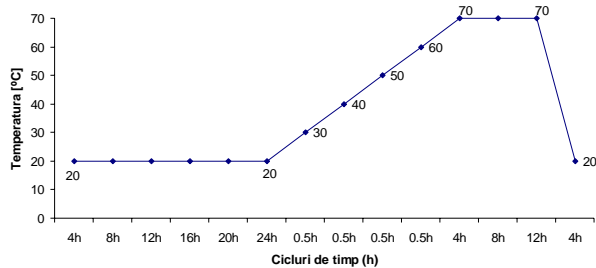
Fig. 3. Apply epoxy and glass

While in the vast majority of case polyurethane resins are recommended for mock-ups and prototypes, epoxy resins are essentially used in high-performance composite environments.

Properties of epoxy such as compression strength and hardness vary considerably from

product to product. Choosing the proper epoxy for a particular design is based on experience and manufacturers recommendations. The most important consideration is the intended production material.

Curing of the mold epoxy can take from 0.5 to 40 hours. Aging the mold at room temperature increases the longevity of the mold. For a complete polymerization, the obtained mold is heat treated after baking. Figure 4 shows the polymerization cyclogram, its time depending on oven temperature. (Figure 5)



**Fig. 4.** Polymerization process time-oven temperature cyclogram



**Fig. 5.** The timer oven's interior

The following figure shows the completed lay-up assembly for the top half of the mold.

With the completion of the polymerization the laminated composite can be removed from the support plate.

To structurally strengthen the mold and for fixturing, the epoxy lay up can be potted in a block of epoxy. This operation must be

performed with caution, applying pressure from the edges inward to prevent damage to the laminate and the support board.



**Fig. 6.** The glass fiber reinforced epoxy mold

After construction of the glass fiber reinforced epoxy mold, steel inserts can be added for complex slides and coring and machining of the epoxy may need to be undertaken for example, in areas where ejectors or gates could not be molded in.

#### 4. CONCLUSION

The use of rapid tooling can cut prototype tooling costs down by 75% and lead time by about half. Right now there are about 45 different rapid tooling techniques that can produce parts ranging in sizes from very small and complex to large and simple.

One of the problems with the manufacture of all reinforced composite mold is the shrinkage during curing. Normally it is about 7-8% shrinkage in volume, resulting in a linear shrinkage of approximately 2%. These values refer to pure polyester, but when adding reinforcement material, the shrinkage percent is lower because part of the total contraction is taken by the reinforce material, and this material is resistant to contraction. Polyester laminated with a high fiberglass reinforcement of 30% is theoretically a contraction in volume of approximately 4%, which is 1.8% linear shrinkage

## 5. REFERENCES

- [1] Wohlers T.T., Prototyping and Manufacturing by Additive Fabrication, *Composites Technology*, 2008.
- [2] Andrew T. Haglin, *Development of an expert system as applied to rapid tooling techniques for injection molding*, theses, 2005
- [3] <http://www.efunda.com>
- [4] Hodor, A., *Studii și cercetări privind realizarea de matrite flexibile pentru serii mici și mijlocii de fabricație*, theses, 2012.

### CÂTEVA CONSIDERAȚII PRIVIND FABRICAREA MATRITELOR DIN MATERIALE COMPOZITE

În lucrarea de față ne propunem studiul unei tehnologii Rapid Tooling aflata in curs de dezvoltare. Am dezvoltat un studiu bazat pe realizarea unei matrite din material compozit ranforsat cu fibra de sticla pentru un cap de manechin. Lucrarea cuprinde o scurtă explicație a tehnologiei de fabricare rapida a matritelor compozite. Datorită cercetării și dezvoltării intensive în domeniile materialelor, tehnologiilor de fabricare, software-ul și a echipamente, aplicațiile tehnologiilor RT au fost dezvoltate direct sau indirect, utilizand procesele RP, în scule, stante și matrite pentru fabricatie. De obicei, prin intermediul tehnologiilor Rapid Tooling se pot obține scule/matrite numite "soft" - de concepție modernă, care rezistă-numai la producția de serie mică sau mijlocie. În același timp se pot realiza și scule/matrite "hard" - cele clasice - care permit fabricarea pieselor de serii mari.

**Adela HODOR**, PhD. Student, Technical University of Cluj-Napoca, Manufacturing Engineering Department, [hodor\\_adela@yahoo.com](mailto:hodor_adela@yahoo.com), Bd. Muncii, no.103-105, Cluj-Napoca

**Petru BERCE**, Univ. Professor, dr. eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, [Petru.Berce@tcm.utcluj.ro](mailto:Petru.Berce@tcm.utcluj.ro), Bd. Muncii, no.103-105, Cluj-Napoca

**Paul BERE**, Dr. Eng, Technical University of Cluj-Napoca, Manufacturing Engineering Department, [bere\\_paul@yahoo.com](mailto:bere_paul@yahoo.com), Bd. Muncii, no.103-105, Cluj-Napoca, Tel.: +40-264-401729

**Marian BORZAN**, Univ. Professor, dr. eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, [Marian.Borzan@tcm.utcluj.ro](mailto:Marian.Borzan@tcm.utcluj.ro), Bd. Muncii, no.103-105, Cluj-Napoca