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MANUFACTURING OF THE ACTIVE MOLD ELEMENTS AND OPTIMISATION OF THE NECESSARY MATERIAL USED FOR VACUUM CASTING PROCESS

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Abstract: *This paper presents the result of a comparative study concerning manufacturing of molds active components, focusing on the fabrication of the silicone rubber molds regarding the vacuum casting of the resin parts. Using the Visual Basic it was realized a program which calculates using the dimensions of a master model the necessary material for obtaining the molds and the parts.*
Key words: *rapid tooling, vacuum casting, molds active elements, rapid prototyping.*

1. INTRODUCTION

1.1. Evaluation of Rapid Prototyping technologies

Nowadays the fast and cheap manufacture of a model or products represents a major goal for any technologist. The emergence in the early '90s and the development RP technologies had and it still has a major impact on reducing of manufacturing time and prototype cost in areas where these prototypes have applicability. These new technologies are the result of extensive research in various fields from mechanics to numerical controls, laser technology to 3D geometric modeling packages, computers to materials science as presented in [1].Rapid Manufacturing technique was originally used to create prototypes for testing, demonstration and evaluation, but it is currently used in the production of several finished parts and also in production of very small batches. Considering the large diversity of products due to technological developments and market demand, RP techniques are increasingly being recognized as a significant method having a major effect on reducing time to market, as well as on decreasing the costs of product development. Thus, RP techniques focus primarily on rapid product development in a manufacturing environment, but also covering applications within other areas such as medicine and construction. The use of layer manufacture approaches in tooling is well established for prototype tools, which take advantage of the low lead times available from layer manufacture systems to reduce product development times, but there have been fewer applications in the field of full production tooling. Nowadays, several methods to manufacture the active elements of molds are used in the practice, the main technological processes being: cutting conventional machining, machining on CNC machining centers, cold pressing, EDM, metal spraying and vacuum casting [2], [3], [4], [5], [6]. For each of these technologies (summarized in Table 1) have been remarked some of the advantages and disadvantages by a comparative study in terms of dimensional accuracy, surfaces, roughness, productivity and cost price. This analysis allows assessing the rapid manufacturing technology of flexible molds and the vacuum casting among the conventional technologies presented taking considering the aspect that this technology is recommended for non-metallic parts manufactured in small series in a short time and with lower manufacturing cost.

Classical manufacturing technologies of molds active elements (cutting processes, non-conventional processes and forming technologies)

will remain the basic technologies for manufacturing dies and molds used in large batches and mass fabrication. The traditional technological processes cannot be replaced by the unconventional techniques. These new Rapid Tooling (RT) technologies are a complement to conventional technologies, which remain the most used methods in machine building industry. However, these new technologies require theoretical study and especially experimental research, in order to optimize their manufacturing performance and to determine their application limits. A variety of approaches have been studied based on 3D printing [7], electron beam melting [8], injection molding [9], direct metal laser sintering [10], and indirect selective laser sintering (SLS) [11]. Previous work on the creation of injection mold tools using indirect SLS, identified accuracy and surface finish as significant issues to overcome [11], [3], [4].

Considering the variety of products and the customization of some of them (ranging from color to the shape and dimensions), the small fabrication batches are required, that means a larger number of tools and technological processes with different processing parameters will be used. But such tools are expensive and that`s why it is tried to find an easy way to accomplish such tools and to use new materials to reduce the cost price of the finished piece.

Table 1

Comparative study of molds active components manufacturing technologies

Comparison criteria / Technology	Dimensional accuracy[mm]	Roughness Ra [µm]	Batch size	Productivity	Execution time	Price
Cutting processes	0.05-0.1	super finishing: 0.01-0.02 finishing: 0.08 roughing: 6.3	Big	acceptable	weeks	high
Cold forming	0.05-0.1	1.6-3.2	Big	good	days/weeks	acceptable
CNC centers	0.01-0.05	0.8-1.6	Big	high	days/weeks	very high
EDM massive electrode	0.01	super finishing: 1.6-3.2 finishing: 0.4-0.8 roughing: 12.5-25	Big	acceptable	weeks	high
EDM wire	0.001	0.2-0.8	Big	good	days/weeks	high
Metal Spraying	According to master model	same with the master model quality	Medium	2-3 pieces/day	days	acceptable
Silicon rubber mold	According to master model	same with the master model quality	Small	2-3 pieces/day	hours	acceptable

As mentioned before vacuum casting in silicone rubber molds is a technology that meets these requirements.

2. RAPID TOOLING

Rapid Tooling (RT) is becoming the new standard in the industry. It is used for prototype tooling, bridge tooling and for low-volume production tooling. RT is distinguished from conventional tooling in that:

- 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;
- Tooling time is much shorter than for a conventional tool. Typically, time to first articles is below one-fifth that of conventional tooling [12].

3. SILICONE RUBBER FABRICATION

Vacuum casting is a modern technique that has proved its appropriateness and effectiveness in the development of new products, allowing to manufacture the parts in small batches and even in production of unique items at low prices and in a reduce time, being one of the most interesting and spectacular applications of the RP models. The silicone rubber mold is created from a master pattern typically an RP model. The pattern is used to create a silicone rubber mold. The silicone is poured around the pattern

to produce a core and cavity of a mold. The RP model is then removed, leaving a negative image into which resin is cast. These molds can produce up to 20 parts per mold and it can be made as family or multi-cavity molds. Based on the Visual Basic program (fig.2) using the dimensions of the master model it generates automatically the box so that the quantity of the silicone rubber used to be minimally [13]. Around the master model the box was fabricated considering 30 mm and the height of 80 mm towards the highest point of the part. This application also calculates the exact quantities of the resin (component A and component B) considering the mixing formula from the technical data. The cast materials integrated in Visual Basic program were: polyurethane resins SG95 and F19, epoxy resin Larit L285 and polyester resin ENYDYNE H68372TA.

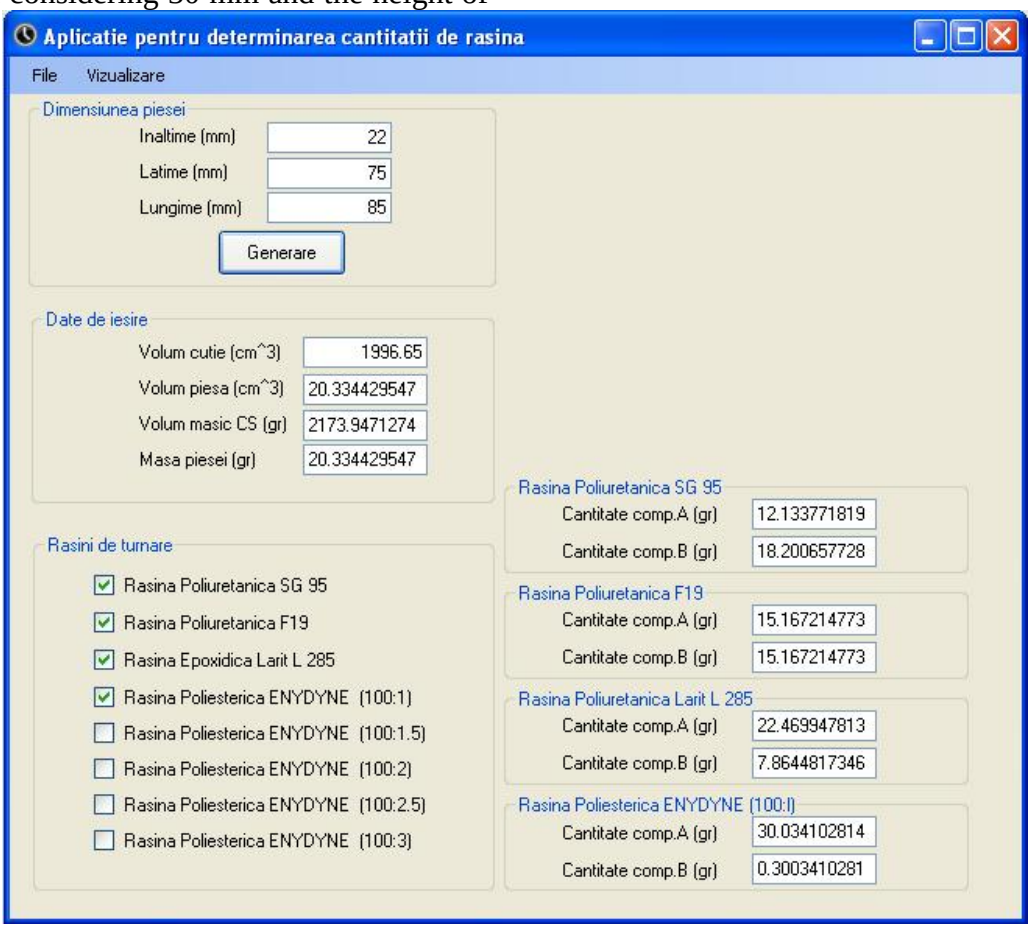

Fig.2. The interface of the Visual Basic application

A part of Visual Basic application you can see it:

```
        Part.editrebuild()
        massprop = Part.getmassproperties()
        vp = massprop(3) * 10 ^ 6
        mp = massprop(5) * 10 ^ 3
        Part.Save()
        swapp.CloseDoc("piesa.SLDPRT")
        vc = (lu * 100 + 6) * (la * 100 + 6) * (i * 100 + 8)
…….....
CheckBox4.CheckedChanged
        If CheckBox4.Checked = False Then
            GroupBox6.Visible = False
        Else
            GroupBox6.Visible = True
        End If
    End Sub
    Private Sub CheckBox3_CheckedChanged(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles CheckBox3.CheckedChanged
        TextBox14.Text = (mp + 10) / 101 * 100
        TextBox15.Text = (mp + 10) / 101 * 1
```

GroupBox7.Text = "Rasina Poliesterica ENYDYNE (100:l)

4. CONCLUSION

The unconventional technologies active manufacturing elements of the molds are a supplement of the classic technologies. Vacuum casting can be used for either fit and function testing, marketing and sales aids for new products or as a low volume production alternative. The silicone has sufficient flexibility that undercuts can be released by flexing the tool, although deep draws may require additional tooling splits.

5. REFERENCES

[1] Yan Y., Li S., Zhang R., Lin F., Wu R., Lu Q., Xiong Z., Wang X., *Rapid Prototyping and Manufacturing Technology: Principle, Representative Techniques, Applications and Development Trends*. Tsinghua Science and Technology, ISSN 1007-0214 01/38, 2009.

[2] Akula, S., Karunakaran, K.P., *Hybrid adaptive layer manufacturing: An intelligent art of direct metal rapid tooling process*. Robotics and Comp.Integrated Manufacturing, 22, pp. 113-123, 2006.

[3] Ilyas I., Taylor C., Dalgarno T., Gosden J., *Design and manufacture of injection mould tool inserts produced using indirect SLS and machining processes*, Rapid Prototyping Journal, 16**,** 6, pp. 429-440, 2010.

[4] Ilyas I.P., *Production of plastic injection molding tools using selective laser sintering and high speed machining*. PhD thesis, University of Leeds, Leeds, 2008.

[5] Song Y., Yan Y., Zhang R., Xu D., Wang F., *Manufacture of the die of an automobile deck part based on rapid prototyping and rapid tooling technology*. Journal of Materials Processing Technology, 120, pp. 237-242, 2002.

[6] Yang Y., Hannula S.P., *Development of precision spray forming for rapid tooling*. Materials Science and Engineering. 47**,** 7, pp. 63-68, 2008.

[7] Xu R.X. and Sachs E., *Rapid thermal cycling with low thermal inertia tools*. Polymer Engineering and Science, 49, 2, pp. 305-316, 2009.

[8] Rannar L.E., Glad A. and Gustafson, C.G., *Efficient cooling with tool inserts manufactured by electron beam melting.* Rapid Prototyping Journal, 13, 3, pp. 128-135, 2007.

[9] Dawson A.J., Coates P.D., Collis R., Owen L., Owen D., Rajamani H.S., *Injection molding process assessment by energy monitoring,* Plastics, Rubber and Composites, 33, pp. 19-25, 2004.

[10] Nagahanumaiah S., Subburaj K. and Ravi B., *Computer aided rapid tooling process selection and manufacturability evaluation for injection mold development,* Computers in Industry, 59, 2-3, pp. 262-276, 2008.

[11] Dalgarno K.W., Stewart T.D., *Manufacture of production injection mould tooling incorporating conformal cooling channels via indirect selective laser sintering,* Proceedings of Institution of Mechanical Engineers, 21**,** pp. 1323-1332, 2001.

[12] www.efunda.com

[13] Radu S.A. *Cercetari teoretice si experimentale privind turnarea sub vid a pieselor complexe nemetalice* Teza de doctorat, Universitatea Tehnica din |Cluj-Napoca, 2011

Fabricarea elementelor active ale matritelor si optimizarea necesarului de material folosit in procesul de turnare sub vid

Rezumat: In acest articol s-a realizat un studiu bibliografic comparativ, in legatura cu realizarea elementelor active ale matritelor, urmarind apoi in detaliu realizarea matritelor pentru piese fabricate in serii mici. In acest fel s-a prezentat succinct tehnologia de realizare a matritelor din cauciuc siliconic si s-a realizat un program in Visual Basic cu ajutorul caruia, pe baza dimensiunilor modelului master s-a calculat in mod automat cantitatea de cauciuc siliconic necesar dar si cantitatea de rasina necesara.

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