RAPID PROTOTYPING AND VACUUM CASTING IN PRODUCT DEVELOPMENT

E. Weiss, B. Waraczyński

Poznań University of Technology

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Abstract: *Integrated product and process development involve data integration and time shortening. It require to use innovative product development technologies to prove and verify the designs evens in the very early stage of the development. For this purpose we use among other things rapid prototyping and rapid tooling.*
In the paper will be present:
- the role and place of RP, RT and VC technologies in product development,
- short view on RP processes and their actual possibility,
- utilize the Vacuum Casting technology to increase the possibilities of the Rapid Prototyping methods range of apply,
- presentation of some practical use of the RP and VC processes by product development.

1. GENERAL INFORMATION

Rapid Prototyping techniques are very often used in early stages of product development. However they have more and more application in the last stages like: tests, examinations etc. Rapid Prototyping techniques offer used wide range of materials, from which it is possible to produce different models or prototypes. But it is dependent from used concrete RP technique. Beside variety of materials it is necessary to pay attention to characteristic features of each RP technique, because not in all applications these features are acceptable. More than once target material couldn't fulfill requirements for product in aspects of durability or accuracy. To solve this problem the number of techniques (Rapid Tooling), which gives possibilities to direct or indirect producing of tools for product manufacturing were worked out. Using of these techniques give us the chance to made models and prototypes or tools much faster and cheaper with reference to classical manufacturing techniques. More than once it has also influence on quality and reliability of product.

2. RAPID PROTOTYPING IN PRODUCT DEVELOPEMENT

Rapid Prototyping techniques gives unprecedented possibility for producing complicated shapes of different product models in very short time. Prototypes, made by RP techniques, can be used for example in areas: presentations for customers, analysis of structural correctness, estimation of design, testing, analysis of assembly and disassembly, etc. Researches of utilization parameters are also significant. Models produced with use of RP techniques are usually used for fast development processes not only in industry but also in architecture and medicine and culture. Product development steps in relation to various model definitions by use of RP techniques is presented at Fig.1.

Rapid Prototyping devices usually have small producing volume. To produce large prototypes the simplest and cheaper way is to divide large model into parts and produce each one separately. Next step after producing and post processing is to join all pieces by binding with glue together. Example parts produced with use of this processes are presented on Fig.2.

RP device (3DP) used by Poznan University of Technology in Rapid Prototyping Laboratory gives possibility for producing conceptual prototypes in general. Base function of this models is to represent outside shape of developed product and inside construction with keep every features and proportions of finished product. Prototypes like this are used in stage of product development for assessment applied solution. This gives possibilities better communication between designers and customers and decision-makers, before making decision about producing industrial prototypes which are connected with necessity of producing expensive and time-consuming tools. Through using prototypes it is possible to detect very early mistakes

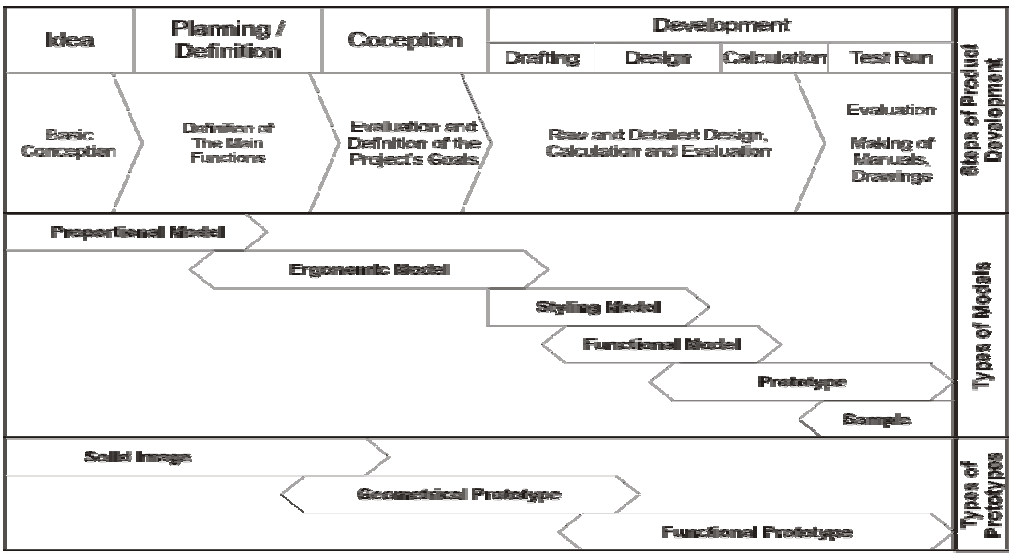

Fig.1. *Steps of product development in relation to various models definition [2].*

and to make research, and this fact gives acceleration of development process and acceptation of new conception. Disadvantage of prototypes produced in 3DP technology is fact that they have low functionality – this result from low durability of used materials. Use of the models after 3DP technique is very significant extended by apply wide possibilities of Vacuum Casting of different resins and casting with lost-wax process

a) b)

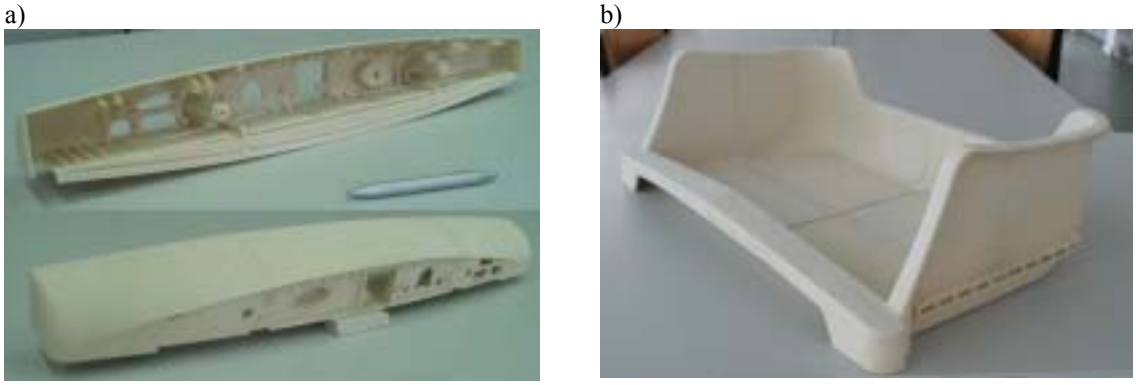

Fig. 2. *Models produced with use of 3DP technique (divided on small parts and glued together): a) front panel from fridge (width 600mm), b) drawer from freezer (width 480mm).*

3. VACUUM CASTING IN PRODUCT DEVELOPEMENT

Possibilities of use RP techniques could be significantly extended by taking advantages of devices for Vacuum Casting. It enable to produce models from different resins (with properties very similar to finished plastic or rubber products) and wax models for lost-wax casting process. VC System consist of: vacuum chamber and heat chambers. Vacuum chamber herself gives possibilities for producing silicon rubber moulds and resin free of air bubbles generated during mixing. Main use of vacuum chamber is casting of resins, waxes and other plastics in silicon moulds - prepared in the first step from the RP models. It is easy to reach wide range of resins, which gives possibilities to achieve variety properties of produced products. It is possible to produce objects which are similar in hardness and elasticity to rubber, and also to significantly harder and less elastic like ABS plastic. Additionally it is possible to produce dye models. It is possible also to produce wax models. In this case is necessary to install additional unit to melt wax through heating up to proper temperature. Next, wax models can be used in die casting process for producing ceramic moulds.

Vacuum chamber is equipped in driver which manage all processes: pumping out air from chamber, mixing resin components, and pouring ready resin to mould.

Characteristic technical data about our device for vacuum casting are:

- Working area which determine maximum dimensions of produced moulds 450 x 425 x 530 mm;
- Time for silicone rubber mould preparation: 12h;
- Time for single resin casting: 40-50min.

Fig. 3. *Vacuum chamber MCP 4/01 from HEK.*

As was mentioned, vacuum casting system contain also heat chambers. They are involved warming process of resins components or silicone rubber mould to proper temperatures. Through temperature control it is possible to have influence on speed of silicon rubber hardening and in case resins on properties of producing products.

a) b)

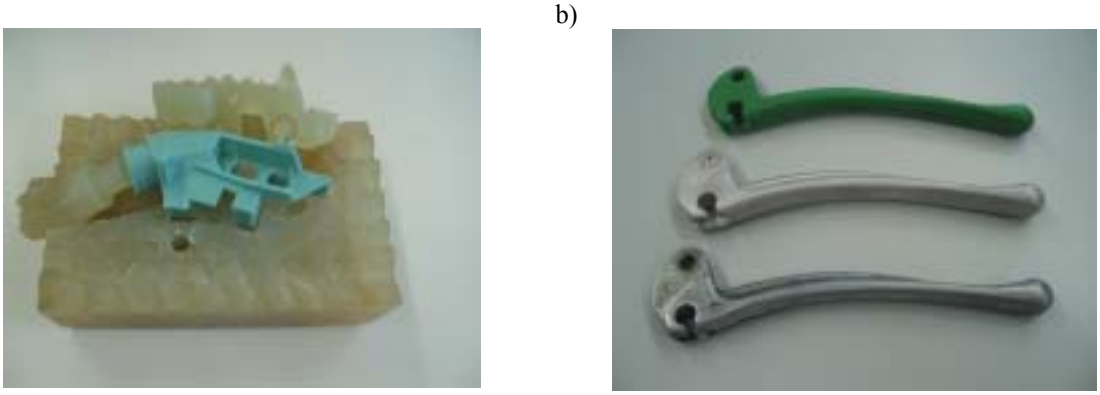

Fig. 4. *Prototypes produced with use Vacuum Casting technique: a) silicone mould with wax model; b) brake lever: from resin, from low melting alloy, original – aluminum.*

a) b)

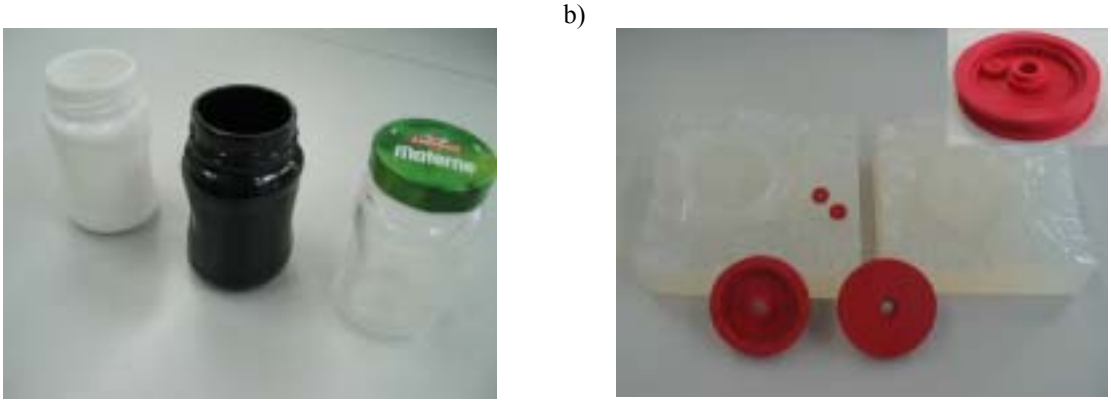

Fig. 5. *Prototypes produced with use Vacuum Casting technique: a) resin jar original - produced in 3DP technique (black) and resin prototypes casted in silicone mould; b) silicone mould and resin cogs (wheels).*

3. CONCLUSIONS

Rapid Prototyping technique play very important role in contemporary process of product development. It enable very effective use of Concurrent Engineering methods and cheep, fast, early and effective validation of the new product and production processes. Vacuum Casting technique significant extend possibilities of RP methods on preparing different tools (RT) and products (RM for unique and small batch production), using by product design and testing. Vacuum Casting technique isn't exactly Rapid Prototyping technique – we haven't possibility to produce physical models or prototype directly from 3D-CAD system. For Vacuum Casting is always necessary to have a master model. This model can be made in any technique: Rapid Prototyping, CNC Machining or manually.

Material used for master model preparing has no great importance – is only one condition: surface quality should be good. Rough surfaces of master model will produce rough surfaces on mould and it is inconvenient for VC processes.

4. REFERENCES

[1] Meyer R., *Euro-u Rapid 2005*, Fraunhofer Allianz Rapid Prototyping, Leipzig 2005.

[2] Gebhardt A., *Rapid Prototyping*, Hanser Publishers, Munich 2003.