15th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2011, Prague, Czech Republic, 12-18 September 2011

# RESEARCH ON RAPID PROTOTYPING INFLUENCE IN MANUFACTURING TECHNOLOGY

**Ilmars Brensons**
**Riga Technical University, Mechanical Engineering Institute**
**Ezermalas 6k - 426, LV-1006, Riga**
**Latvia**

**Natalija Mozga**
**Riga Technical University, Mechanical Engineering Institute**
**Ezermalas 6k - 426, LV-1006, Riga**
**Latvia**

## ABSTRACT
*The article objective is to discuss the development of innovative product development to production phase, resulting in a functional prototype with a rapid prototyping method. The article analyzes the advantages of using rapid prototyping technologies for product development process. It compares various fast rapid prototyping systems that are being used, categorizing them by the type of raw material used. It consists of both the theoretical and experimental part. This article goes through a development of the product from idea to functional prototype, making 3D model, analysis of the components the model contains, prototyping, post-treatment.*
**Keywords:** rapid prototyping, modeling, product development, innovative

## 1. INTRODUCTION
The development of competitive new products is a prerequisite for many companies success. Product development does not necessarily mean discovering revolutionary new inventions, nor does it just involve re-vamping old solutions. A successful product often results from thinking along new lines, free from conventional approaches and traditional choices of materials and designs. Here the word product we will be using in the sense of a mechanical product. The full production of any product includes a wide range of activities. Kochan and Chua [2] describe the impact of RP technologies on the entire spectrum of product development and process realization. The activities required for full production in a conventional model compared to the RP model depending on the size of production can save on time and cost ranging from 50% up to 90%!
Today rapid prototyping has developed to a level where it takes place in wide range of applications for making models like:

- Concept models;
- Functional prototypes;
- End use parts;
- Manufacturing tools.

The product designers can increase part complexity with little significant effects on lead time and cost. More organic, sculptured shapes for functional or aesthetic reasons can be accommodated. There will also be fewer restrictions in the form of parts design without regard to draft angles, parting lines or other such restrictions. Parts which cannot easily be set up for machining, or have accurate, large thin walls, or do not use stock shapes to minimize machining and waste can now be designed. They can minimize material and optimize strength/weight ratios without regard to the cost of machining.

[2,9] While there are more than 20 producers or Rapid prototyping systems, the methods they use can be categorized in following categories: photo-curing, cutting and gluing/joining, melting and solidifying/fusing and joining/binding.

## 2. ADVANTAGES OF USING RAPID PROTOTYPING TECHNOLOGIES FOR PRODUCT DEVELOPMENT PROCESS

Along with the developing market grows the complexity of parts that are being developed and carried from idea to serial production. In all those cases important is the „Time to market" time. Regards this issue it is important to receive a necessary prototype of any complexity in a relatively short period of time. It is observed that over the last 25 years products that are realized to the market have increased in complexity in shape and form [1,2]. As an example you can compare the car body of today with that of the 1970's. On a relative complexity scale of 1 to 3 as seen in Figure 1, it is noted that from a base of 1 in 1970, this relative complexity index has increased to about 2 in 1980 and close to 3 in the 1990s. More interestingly and ironically, the relative project completion times have not been drastically increased. Initially, from a base of about 4 weeks' project completion time in 1970. it increased to 16 weeks in 1980. However, with the use of CAD/CAM and CNC technologies, project completion time reduces to 8 weeks. Eventually, Rapid Prototyping systems allowed the project manager to further cut the completion time to 3 weeks in 1995. [2]

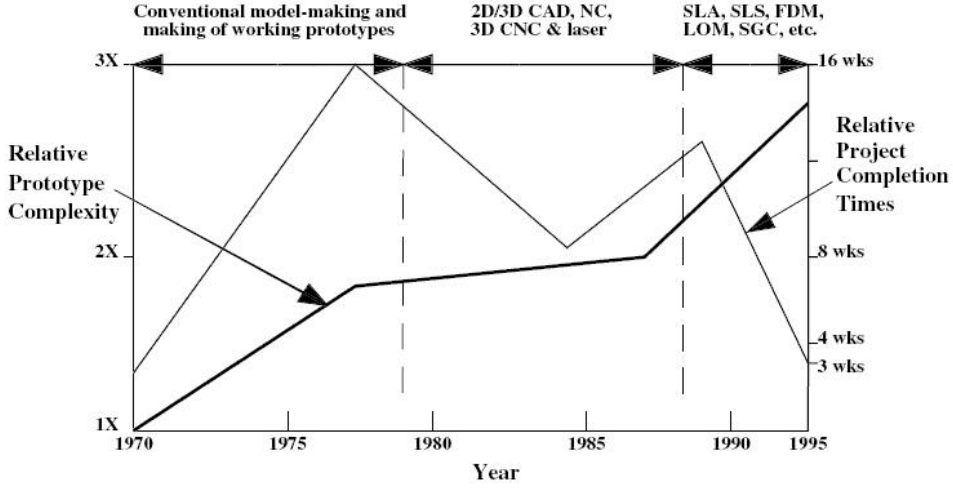


*Figure 1. Project time and product complexity in 25 years time frame.*

In process of making a single prototype or more complex it is important to know which method to use. Various systems can offer various tolerances and technical characteristics. Comparative table between main three methods (categorized by raw material they use to produce prototype) you can see in Table 1.

*Table 1. Comparative table of prototyping systems.*

| No. | Method | Min. Tolerances, mm | Advantages | Drawbacks |
|---|---|---|---|---|
| 1. | Liquid based | 0.24-0.07 | Large dimensions, Wide range of materials | Needs support material. Needs afterthreatment. |
| 2. | Solid based | 0.35-0.12 | Functional prototypes. Different materials | Limited accuracy. Slow process. |
| 3. | Powder based | 0.24-0.07 | No need for support material. | Needs afterthreatment. |

## 3. DEVELOPMENT OF THE PRODUCT FROM IDEA TO FUNCTIONAL PROTOTYPE

The quality of a final product that is being brought to market significantly depends on all early stages Where the product is being designed and tested. In this work the practical part was conducted as a task of getting an idea to an actual working prototype.
The work basically was divided in three parts as:

- 3D modeling;
- Prototyping;
- Assembly;

Prototyping in most cases will not be a 100% copy of desired product that is being developed therefore it is important to evaluate the product and the characteristics that needs to be tested before mass production. Firstly the whole part was divided in components for single part evaluation. As two main categories that were applied to part evaluation was: functional prototype or design prototype. [3,4,5] For each of this category afterwards different method of making a prototype was applied to get a desired effect in performance. As main evaluation criteria for choosing the method of prototyping was taken technical characteristics of each different method available. [6,7,9] Note that this rule applies to parts that are either long or inefficiently to make with conventional making methods as milling, turning, etc.

## 4. CONCLUSION

Process of product design is described including the benefits that novel technology as Rapid prototyping offers. Pruduct prototype making complexitty and lead times over the last years is analysed. Various systems with different methods are categorised and analysed. A new approach to product evaluation for better production of prototypes is offered. The new approach includes more accurate product evaluation by characteristics that needs to be tested leading to right method of making prototype.

## 5. REFERENCES

[1] Ulrich K.T., Eppinger S. D.: Product Design and Development, McGrawHill, Singapore, 2008.,
[2] Chua C. K., Leong K. F., Lim C.S.: Rapid Prototyping *Second edition*, World Scientific Publishing Co. Pte. Ltd., Singapore, 2003.,
[3] Mognol P., Rivette M., Jegou L., Lespier T.: A first approach to choose between HSM, EDM and DMLS processes in hybrid rapid tooling, Rapid Prototyping Journal. – 2007.,
[4] Smock D.: Make your own shoes, Design News. – 2009.,
[5] Kelvin Donaldson: Making the model project, Z Corp newsletter, 2007.,
[6] George Casaday, Cynthia Rainis: Models, Prototypes, and Evaluations for HCI Design International conference on Computer-Human Interaction CHI'95, Denver, Colorado, USA, 1995.,
[7] Jakobsen K., Andreasen M.: The Product Development Process, European Aluminium Association EAA, Norway, 1994.,
[8] Crow K.: Characterizing and improving the product development process, DRM Associates, USA, 2001.,
[9] Boehm T., Carnasciali M.I., Douglas M.E., Fernández M.G., Williams C.: Rapid prototyping industry analysis, George W. Woodruff School of Mechanical Engineering, Atlanta, Georgia, USA, 2004.