UNIVERSITY OF PITESTI
FACULTY OF MECHANICS AND TECHNOLOGY
SCIENTIFIC BULLETIN
AUTOMOTIVE series, year XV, no.19, vol. A

RAPID PROTOTYPING IN ITERATIVE DESIGN, USING CATIA V5 AND ZPRINTER 310 PLUS

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Abstract: *In this paper we present a method of rapid prototyping based on construction of the parts in CATIA V5 and building of the part whit a 3D printer (ZPrinter 310 Plus). The part build in CATIA is exported to the soft of the 3D printer in "stl" format. This soft permit: to analyze the part, to simulate the prototyping process and to optimize the prototyping process parameters.*
For this purpose we have analyzed a laboratory experiment make it at University of Pitești, in the Design Product Laboratory.
The rapid prototype machine "ZPrinter 310 Plus" is fast and versatile, allowing engineers and product designers to make their vision a reality in a fraction of the time and cost of other rapid prototype machines. These methods of rapid prototyping provide the ability to: identify problems early, communicate more effectively and perform iterative design.

Keywords: rapid prototyping, iterative design, ZPrinter

INTRODUCTION

Product design is a process dynamic and complex. It can be defined as the idea creation, concept development, prototyping, testing and manufacturing of an artifact. The designers conceptualize and evaluate ideas, making them tangible through products in a more systematic approach.

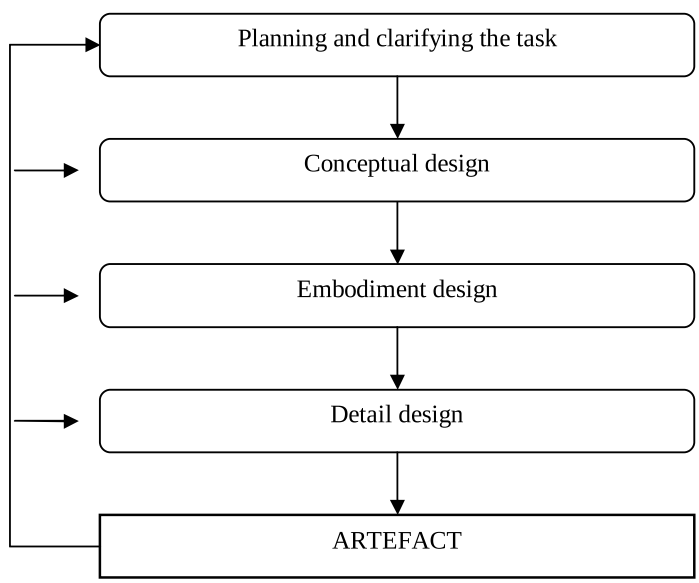

Fig. 1. Pahl and Beitz's model of design, [2].

It is almost impossible to have a once through execution of tasks in a design process. One or more repetition of the tasks is necessary to obtain the expected results.

THE ITERATIVE DESIGN

Pahl and Beitz, in their work [Pahl 1996] define iterations as a process by which a solution is approximated step by step.
Evaluation of a solution involves a comparison of concept variants or, in the case of a comparison with an imaginary ideal solution, a "rating" or degree of approximation to an ideal (Pahl & Beitz 1996).
Osborne [Osborne 1993] has observed that iteration is a significant component of the product development cycle time and represent about one third to two thirds of project effort.

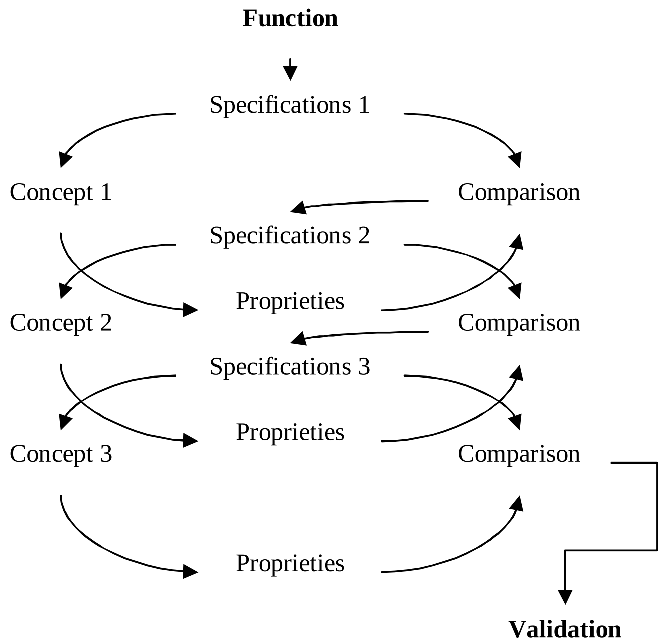

Fig. 2. Iterative design

Roozenburg and Eekels (1995) give some typical characteristics of design decisions:

- Various properties of alternatives versus the criteria of specification play a crucial role in the decision, and the expected properties are measured on different scales.
- Some criteria are quantitative, such as "cost" and "life in service", while some others are qualitative, such as "adjustable without tools".
- Not all criteria are equally important; for example, the decision-maker may consider "comfort" important and "adjustability" unimportant.
- A given alternative never has systematically better properties than the other alternatives, so there is no "dominant" solution.

The iteration in the design process has the differents sources: specification changes, task interdependence and the design errors.

- Specification changes

In this case, design objectives and requirements are unstable or new requirements are added. It is particularly the case of tasks using preliminary information supplied by non-finished upstream tasks.

- Task interdependence

It is the case of mutually dependent tasks for which several iterations are necessary to reach an acceptable solution. For this case, the total time of the design process depends on the initial scheduling of the tasks.

- Design errors

Design errors and mistakes that could have a negative impact on the design process. Generally, failures in achieving design tasks are due to human errors, calculation errors, decoding and encoding errors [Busby 2001], [Cook 2002] and [McMahon 1997].

THE ROLE OF THE PROTOTYPE IN DESIGN

The prototypes are used to represent, to test, and to correct the design concepts. Their purpose is to test certain aspects or characteristics of a desired system without incurring the cost or time. Prototypes include just enough functionality, data, and presentation features to build mutual understanding between designers and users and to test key elements of the design. They are not developed into a final product, but inform its later development through iterative testing, discussion, and evaluation.
Prototypes can range from sketches to partial systems, depending on the complexity of the design to be tested.

THE RAPID PROTOTYPING

Rapid Prototyping 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.
The prototyping soft takes virtual designs from computer aided design, transforms them into thin horizontal cross-sections and then creates each cross-section in physical space, one after the next until the model is finished.
The Zprinter machine reads the data from a CAD drawing and lays down successive layers of liquid and powder and in this way builds up the model from a series of cross sections. These layers, which correspond to the virtual cross section from the CAD model, are joined together to create the final shape.

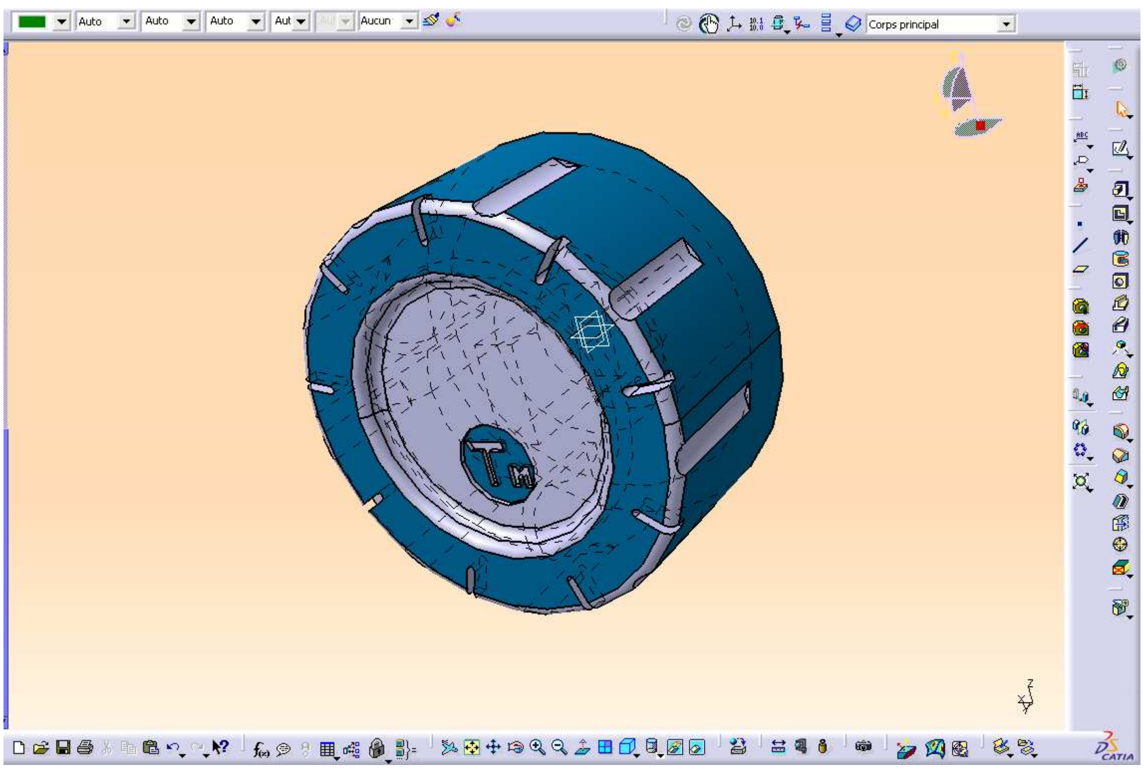

Fig. 3. The 3D part in Catia V5

The standard data interface between CAD software and the machines is the STL file format. An STL file approximates the shape of a part or assembly using triangular facets. Smaller facets produce a higher quality surface.

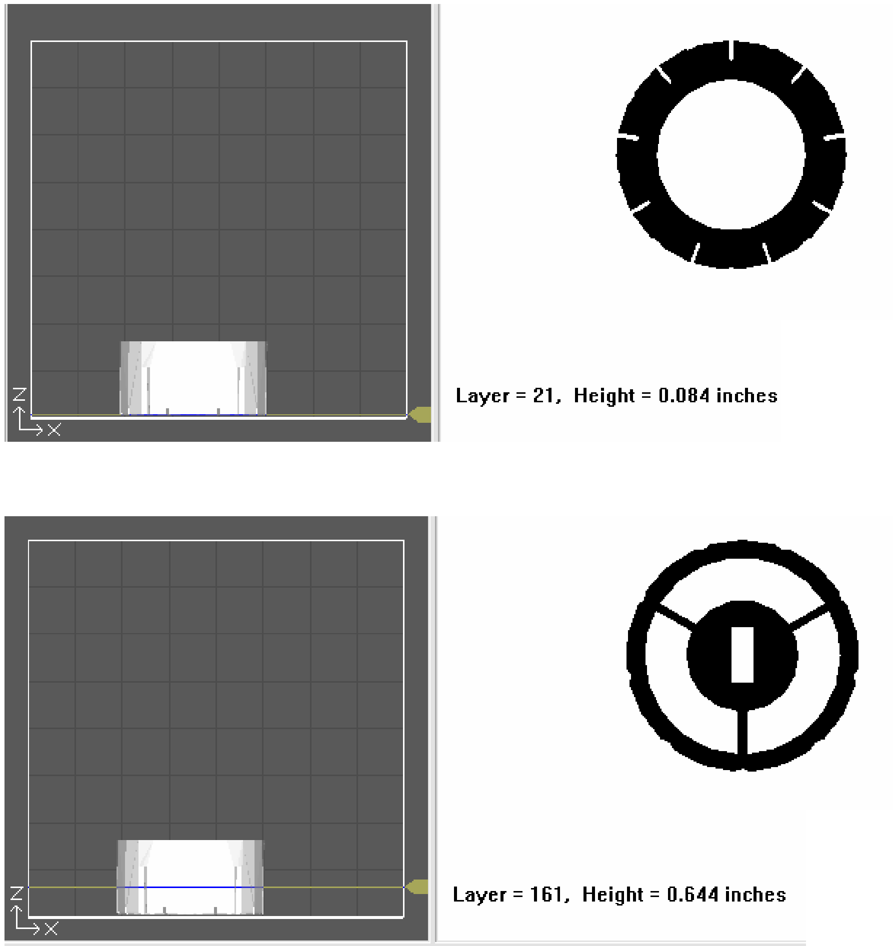

Fig. 4. Example of cross sections on the virtual model

To make the part presented in figure 3, we have used a composite powder (ZP131) and an epoxy binder.

The soft used by Zprinter has the possibility to simulate the printing process, step by step, and to make an estimation of binder usage, number of layers necessary to make the prototype, of total time etc, very efficiently for the designer in the process of decision making.

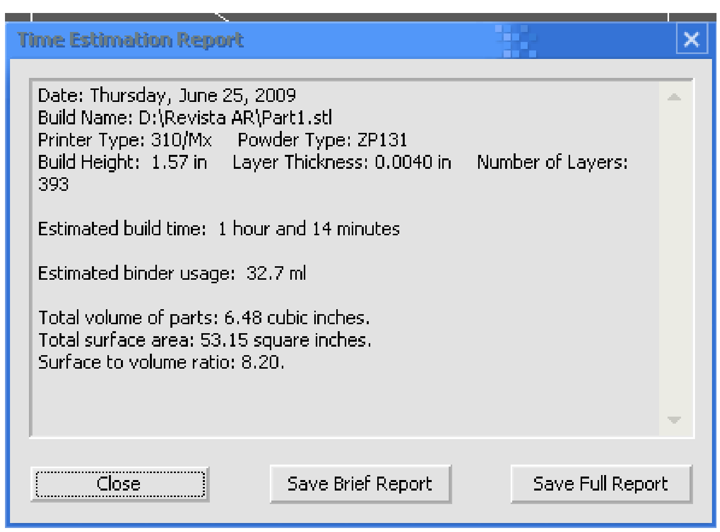

Fig. 5. Parameters estimation report

PROTOTYPE VS FINAL PART

The material of the final part is a polyamide. The properties of this material are different to the prototype material. We cannot make the mechanical or thermal tests, but we can make a series of other tests: geometrical tests, functional tests, technological tests, quality of surfaces etc.
We are analyzed a lot of function required by normal function of the part and the quality of surfaces, using the prototype.

FINDINGS

To achieve the Functional Analysis we have identified the environment of the product:

- The user;
- The mechanism;
- The board of vehicle

By the Functional Analysis, we are identified the functions (figure 6):

FP**-** (principal function) to allow the user to operate the mechanism;
FC1 – (constraint function) to adapt to user;
FC2 **-** (constraint function) to adapt to the shape and size of the mechanism;
FC3 **-** (constraint function) to adapt in the slot of the board.

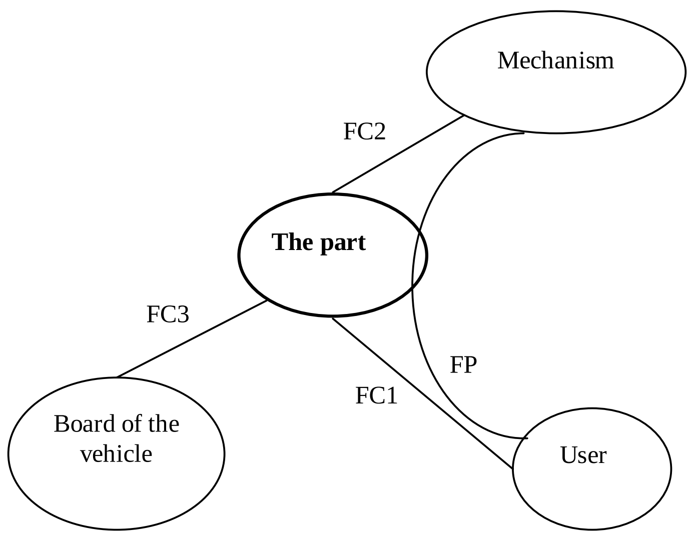

Fig. 6. Functional analysis

If the prototype will be used as a model for injection mold, dimensioning the prototype must take in consideration the contraction of the final part material, following its geometrical form and its dimensions.
The prototype was used to simulate the mechanism functions. Finally it validated successfully the set of functions to which the final part was designed to respond to.

The relations-ships between the prototype dimensions and those of the final part are being corrected by direct measurements of the prototype, compensating this way the theoretical model proposed during anterior phase.

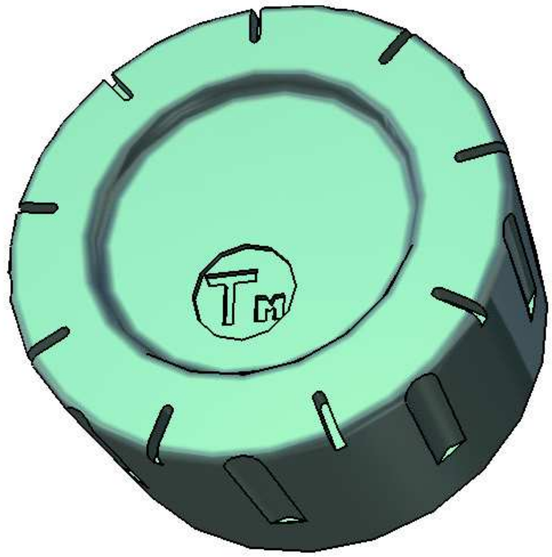

Fig. 7. The final part

CONCLUSIONS

The prototypes are an important role in the design process. It is used to aid the designers to view the "characteristics" of the product, to simulate the functions of the product or to construct the injection mold.

The advantage of rapid prototyping is the reduction of manufacturing times. The piece is more complex and the difference with a traditional production increases. In addition, rapid prototyping provides new opportunities for manufacturing.

The benefits to have and use a prototype are:

- detect design problems,
- testing alternatives
- validate the industrial feasibility,
- forms and optimize the cost of tooling,
- minimize the risk of modification,
- refine the operational characteristics,
- have a media object,
- carry out mechanical and thermal tests, etc..
- have a media object and avoid potential conflicts.

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