CAD AND RAPID PROTOTYPING AS AN ALTERNATIVE OF CONVENTIONAL DESIGN STUDIO

Amarendra Kumar Das

ABSTRACT

With the rapid advances in Computer Aided Design and Computer Aided Manufacturing, the traditional role of design studio is changing. The current market demand for increasing number of product versions and models, smaller batch runs, and shorter concept-to-market lead time has stimulated the research work on computer-aided industrial design (CAID) and other relevant technologies for product design in the last few decades. CAD although helps in easy visualization but being a two dimensional virtual model in a computer monitor is devoid of tactile sense and form and size. Thus in spite of advances in CAD/CAID, physical model making remains an important and integral part of Industrial Design profession. This resulted in newer technology like Rapid Prototyping to fulfill the demands of this profession with an effort to replace traditional model making processes. This paper analyzes the trend and possibilities of these new technologies performing the existing role of a traditional design studio used for model making and prototyping in addition to the various advantages provided by these technologies.

The paper concludes that the role of a design studio has changed from making of physical models in the traditional way to that of a computer aided design studio cum rapid prototyping and tooling center with all possible simulation and virtual reality gadgets.

Keywords: CAD, CAID, Virtual Prototyping, Rapid Prototyping and Tooling

1 INTRODUCTION

Design studio as understood by industrial designer is a place where design concept are presented through visual medium normally rendering followed by mock up models in variety of materials. These model making is the most important aspect carried out in a traditional design studio. Models can be mock up models for studying form, fit and function or any one of these. A variety of facilities are incorporated in a design studio of a design school. When these design schools are within technological institute as in the case of Industrial Design Center in Indian Institute of Technology Bombay or Department of Design in Indian Institute of Technology Guwahati, there is always a conflict for calling design studio as a studio from the view point of engineering faculty. This conflict in definition arising out of the concept of machinery/equipments placed in a design studio. For them it is nothing but a workshop. This conflict is resolved through the definition that a design studio is a facility where creative activity is carried out in expressing a design concept rather than carrying out a repetitive task again and again as in a workshop. Thus there is a metal studio, wood studio, ceramic studio, plastic studio,

craft studio etc. to make mock up models in respective materials or even working prototypes for form, fit and function study.

2 EMERGING TREND IN PRODUCT DESIGN

The current market demand for increasing number of product versions and models, smaller batch runs, and shorter concept-to-market lead time has put tremendous pressure on the industrial designers in recent years to deliver more number of products with even higher numbers of variations accompanied by pressing need for reducing product development lead times. Management tools like Concurrent engineering is the buzz word in this hectic activity. The two major bottlenecks in traditional product design and development process as practiced and taught to the budding industrial designer today hinder in achieving the above requirements. The first one is getting the design right and the second one is the cost and lead-time associated with generating the physical prototype from a given computer model of a part. In most product development cycles the design is frozen only after incorporating feedback based on the physical prototype thereby coupling the two problems.

2.1 CAID and Virtual Prototyping

The first bottleneck is due to the sequential nature of the design tasks and the lack of automation in transition between tasks in product development. This has resulted in the concept of virtual prototyping or digital prototyping. With the rapid advances in Computer Aided Design and Computer Aided Manufacturing, stimulated the research work on computer-aided industrial design (CAID) and other relevant technologies for product design in the last few decades. The basic objective is to use software tools to design both the part and the means to realize the part. By enabling CAID systems to support downstream life-cycle concerns during the design stage, it is possible to perform the design-analyze-evaluate-modify iterations integral to product design process in the computer using digital prototype to realize the final design in a timely and cost effective manner.

The virtual (or digital) prototype offers much greater flexibility in terms of the ability to vary design parameters and the environment in which the part will function. CAD although helps in visualization easily but being a two dimensional virtual model in a computer monitor is devoid of tactile sense and form and size. Thus in spite of advances in CAD/CAID, physical model making remains an important and integral part of Industrial Design profession. Similarly a physical prototype, becomes essential for communicating the design to tooling designers- to begin for manufacturing and design jigs and fixtures for the manufacture and assembly of the product, purchase- to initiate vendor development, marketing and other decision makers in the organization. This is because the representation of design thus far in the cycle – either a computer model or engineering drawings/blue prints is incomprehensible to a large number of the people involved in product development tasks.

2.2 CAID and Rapid Prototyping

The second bottleneck of the cost and lead-time associated with generating the physical prototype from a given computer model of a part can not be optimally solved using traditional design studios. This resulted in newer technology like Rapid Prototyping to fulfill the demands of this profession with an effort to replace traditional model making processes. Rapid Prototyping processes can be used to eliminate the second bottleneck

of obtaining the physical prototype using the data generated from CAID for the computer model of the part.

3 COMPARISONS OF TRADITIONAL INDUSTRIAL DESIGN PROCESS INVOLVING DESIGN STUDIO VS CAID+RP

Comparison of the steps involved in design and design studio's contribution in model making in 'Traditional' Industrial Design methodology vs. CAID and RPT

Table 1. Comparison of Traditional ID process vs CAID+RP

	Traditional Industrial Design methodology	CAID +RP
1	Sketch- 2D	Solid modeling/Surface modeling- provides
2	Sketch model –3D	Development drawing -2D & 3D+
3	Development drawing -2D	
4	Rendering- 2D	Rendering- both 2D & 3D+
5	Appearance model- 3D#	
6	Appearance prototype- 3D#	Appearance, form, fit model- 3D*
7		Functional model=
	# involves design studio	+ involves CAD * involves Rapid Prototyping = possible with few RP machines in limited material

As seen above few additional facilities are provided by the latest technology such as:
Rendering: where as in the conventional practice, rendering and model making was separate activity may be carried out by designer and his associates or subordinates; in the new process of CAID and RPT, these can be integrated. If 3-D or solid modeling is done then the model can be rendered using the software itself and the same data base can be utilized for making models using CAM or RPT.
Detailed engineering drawing: In the traditional industrial design methodology, engineering drawing was a separate affair as well as detailing process. In the CAID process, these can be concurrent affair.
Many designers complain initially that the feeling of sketch and method of sketching using computer is different. With the advancement of technology, it is getting merged. Instead of using mouse (pointing device) one can use digitizers such as smart pen with tablet to draw and sketch almost traditionally and there is virtually no difference in the result obtained.
For Simulation of 3D activity like sculpture using hand, sensible technology has evolved to meet that gap between traditional and latest.
Virtual reality has given the opportunity to feel the scale unlike the small model simulated in a computer monitor.

4 ADVANTAGES OF CAID IN CONJUNCTION WITH RPT OVER CONVENTIONAL INDUSTRIAL DESIGN METHODOLOGY FOR PRODUCT DESIGN:

In case of traditional design studio set up, the following are the basic studios based on the main materials used and most of these can be supplemented simply by RPT set up as discussed below.

4.1 Wood studio- for wooden products including furniture design

In this area specially furniture design CAD in conjunction with CNC machines can complement rather than replace the wood studio. But where wood and wood substitutes are used for making mould etc. for vacuum forming etc, then based on volume and dimension, RPT can replace the activities of wood studio.

4.2 Metal studio

Based on the product designed and it's category, most of the product model and prototypes made in metal studio can also be made using RPT. Although there are a few RP machines available commercially that directly produces metal parts in bronze, brass and bell metal as well as aluminium mixed with polyamide powder, using plastic sacrificial patterns and Rapid Tooling a metal studio can be fully eliminated.

4.3 Plastic studio

Many of the RP technologies are based on plastics and polymers. Anything that is possible in plastic studio conventionally can be fully made using RP. Along with RP, RT can facilitate actual production level integration. Thus plastic studio can be fully replaced with CAD/RPT.

4.4 Sheet metal studio

Sheet metal studio-The only difficulty of replicating the product of sheet metal studio work with RPT is the present material used in RPT and the thinness of the sheet metal products. Thus it is still not feasible to replace sheet metal product prototyping with RPT. But with advancement of plastic technology itself, many of the previously sheet metal product or components are anyway being substituted by plastic products and components.

4.5 Ceramic studio

Almost all activities of a ceramic studio can be replaced with CAD/RPT. Since RP machine using ceramic powder itself is available commercially. Also mockup, models of products in ceramic can be successfully implemented using RPT. Thus implementation of CAD/RPT can replace conventional ceramic studio, except the cost of operating these machines are still much higher at present.

4.6 Crafts studio

There are variety of craft using different materials. Not all of these can be considered for CAD. But even though craft using wood, rattan, bamboo and variety of metals etc. that are based on 3D forms can be successfully implemented using CAID and RPT. Sculpture is one such area where CAID can greatly enhance productivity of a sculptor. Sensible technology provides for virtual sculpting using a computer with special input device. One can use plastic moulding clay or can directly work on the virtual clay and the item sculpted can be seen in the monitor. Thus as one moulds or sculptures on the

virtual clay, one sees the result i.e. the form of the object crated in the monitor. Every motion is recorded and can be edited. After practice one can do away with the plastic moulding clay. Here RPT can be an added advantage. Unlike actual clay where preparation of clay, drying etc. is required as well as once altered, it needs to be redone if what was altered was more preferable than the one done last. In case of sensible technology, one can save every alternatives separately and can compare, edit and manipulate form thus adding versatility. Here again, one need not wait for clay preparation as well as drying of the clay.

4.6.1 Sculpture

Similarly sculpture in metal (Bronze, brass, bell metal etc.) are made only once and it is quite time consuming and cumbersome, not to mention to make right first time without requiring further modifications and manipulations. Thus any modification and manipulation required needs more efforts and time. If done with CAD using Sensible technology can provide for all rectification, alteration and modification before final production. Also use of direct metal sintering RP machine it is not only possible to directly produce the sculpture from the CAD data but also removes the drudgery of traditional production process for this type of single object manufacture. Sensible technology can assist in filling the gap between traditional and latest process.

4.6.2 Jewelry design

Jewelry Design and personal embellishment design is another area, where RP is extensively used instead of traditional design studio.

5 ADDITIONAL BENEFITS OF CAID OVER CONVENTIONAL INDUSTRIAL DESIGN METHODOLOGY FOR PRODUCT DESIGN:

5.1 Data for analyzing physical properties

Major benefits of using CAD is that data being available in computer, these data is directly available for various analysis such as structural adequacy, strength etc. as well as for interface analysis also.

5.2 Simulation

Simulation of activities which are not possible unless full scale models/ mock up prototypes are available in traditional industrial design process can be easily carried out using computer data generated during CAD process.

5.3 Virtual reality

Virtual reality is another tool that enhances the simulation aspects of the CAD tools. Here natural working environment can be virtually built up to provide first hand experience to the user and can also provide true feed back.

6 DISADVANTAGES OF CAID AND RPT AS VIEWED BY USERS AT PRESENT

Designers and artists etc. who work with their own hands traditionally find it slightly artificial to work with many of the above technologies and feel that their creative abilities are not fully exploited when using these technologies. But for a fresh professional trained in these technologies feel that their potentials are enhanced and they became more productive. After all CAD is also nothing but a tool at the disposal of

a person. Time is the only factor that these technologies are adapted as an integral part of design process. The best example is Computer Aided Drafting vs manual drawing board drafting and present architectural design practice.
Another biggest argument against use of RPT for designing and prototyping compared to traditional processes in a design studio is that the types of machinery and equipments that are available in a design studio are either identical or similar to those exist in actual manufacturing set up. Thus what is possible in design studio will be also possible in a manufacturing set up.
The above arguments do not hold good, since present trend in manufacturing is based on principles concurrent engineering and different tools such as DFA and DFM etc. are widely used. These tools take care of all the above aspects in detail and CAD/CAM & RPT enhances these tools.

7 SUGGESTED CAID SET UP ALONG WITH RPT TO SUPPLEMENT TRADITIONAL DESIGN STUDIO:

Accepting the fact that traditional design studio can be supplemented with CAID & RPT a model is proposed as under consisting of computer hardware and softwar

Table 2. Suggested CAID and RPT setup in a design school

Sl. No.	Hardware	Software	Remark
1.	Personal computer with digitizers, smart pen Tablet etc	CAD software 2D and 3D design	For visualization
2.	Workstation including Reverse engineering equipments such as white light scanner, CMM etc	Special software for solid modeling and surface modeling, sensible technology etc.	For virtual prototyping, detailing, engineering drawing etc.
3.	Workstation	Simulation software	For generating feedback etc.
4.	Workstation with VR hardware	Virtual reality	User study, and feedback
5.	Server	Engineering analysis software, DFA and DFM software, plastic part design software etc.	For various engineering analysis for physical, structural adequacy, optimization etc.
6.	Rapid Prototyping Machines of different category with Server	Rapid Prototyping machine's software and operating system	For making RP models and prototypes
7.	Rapid Tooling equipments including vacuum casting	Based on the system to be procured	Short production run for low volume product or for market research to get feed back

All the above systems must be networked for ease of operation and efficiency. The various areas are segregated for accommodating specialists in their respective field

since an Industrial Designer himself may not be specialist in every area. Similarly instead of a single Rapid Prototyping machine different machines can be taken such as cheaper concept modeler for conceptualization and verifying form.

8 CONCLUSIONS CHANGING ROLE OF DESIGN STUDIO IN PRESENT CONTEXT

Thus the role of a design studio has changed from making of physical models in the traditional way to that of a computer aided design studio cum rapid prototyping center with all possible simulation and virtual reality gadgets.

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Contact information:
Amarendra Kumar Das, Assistant Professor
Department of Design
Indian Institute of Technology Guwahati
North Guwahati, Guwahati 781 039, Assam, India
Phone: +91 (0) 361 258 2454 (O)
+91 (0) 361 258 4454 (R)
+91 (0) 361 269 0951 (R)
Fax: +91 (0) 361 269 0762 (O)
Email: dasak@iitg.ernet.in
dasakdipon@yahoo.com