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Preliminary Study on Potential Use of Rapid Prototyping For Designing Casting Mould

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Abstract: The rapid prototyping (RP) process is being used widely with great potential for rapid manufacturing of functional parts. Rapid Prototyping is being used since its origin by designers in different field as product design, automobile industry, medical applications, arts, and it has been proved that it is an essential tool in any design process. Rapid prototyping and process simulation techniques for rapid development of intricate castings, required for replacement purposes. Several widely-used rapid prototyping options are analysed for their impact on fabrication time, development cost, dimensional accuracy and surface quality of the part. Casting process simulation enables reducing the number of shop-floor trials to optimise the methoding and process parameters. It is superior to the traditional approach in terms of yielding more predictable and consistent results, but at present can be economically justified for only one-off intricate castings required in a short time.

INTRODUCTION

Prototypes are used to visualize those complex shapes not easily seen or understood on conventional drawings. It gives to the designer the possibility of verifying the shapes of the product, validate if it fits into the assembly or if it complies with the desired functions. It cuts down the required time to design a product. For this Rapid Prototyping (RP) has become one of the fastest growing new technologies. By means of this technology it is possible build prototypes and touches them in just a few hours, from a CAD file in which the geometry of the model is defined in 3D. This technology was covered an industrial applications to speed up the design and manufacturing process. The company was founded in 1986, and since then, a number of different RP techniques have become available. RP potentially offers great benefits in terms of time and cost reduction as well as improved quality of the final product when used during a product development process [6]. RP has also been referred to as solid free-form manufacturing; computer automated manufacturing, and layered manufacturing (LM). RP has obvious use as a vehicle for visualisation. In addition, RP models can be used for testing, such as when an airfoil shape is put into a wind tunnel. RP models can be used to create male models for tooling, such as silicone rubber moulds and investment casts. In some cases, the RP part can be the final part, but typically the RP material is not strong or accurate enough. When the RP material is suitable, highly convoluted shapes (including parts nested within parts) can be produced because of the nature of RP. Among these technologies are stereolithography (SLA), selective laser sintering (SLS), fused deposition modeling (FDM), laminated object manufacturing (LOM), inkjet-based systems and three dimensional printing (3DP). RP technologies can use wide range of materials (from paper, plastic to metal and nowadays biomaterials) which gives possibility for their application in different fields. RP (including Rapid Tooling) has primary been developed for manufacturing industry in order to speed up the development of new products. They have showed a great impact in this area (prototypes, concept models, form, fit, and function testing, tooling patterns, final products - direct parts). Preliminary research results show significant potential in application of RP technologies in many different fields including medicine.

BASIC PRINCIPLE OF RAPID PROTOTYPING PROCESSES

RP process belong to the generative (or additive) production processes unlike subtractive or forming processes such as lathing, milling, grinding or coining etc. in which form is shaped by material removal or plastic deformation. In all commercial RP processes, the part is fabricated by deposition of layers contoured in a (x-y) plane two dimensionally. The third dimension (z) results from single layers being stacked up on top of each other, but not as a continuous z-coordinate. Therefore, the prototypes are very exact on the x-y plane but have stair-stepping effect in z-direction. If model is deposited with very fine layers, i.e., smaller z-stepping, model looks like original. RP can be classified into two fundamental process steps namely generation of mathematical layer information and generation of physical layer model. Typical process chain of various RP systems is shown in figure 1.

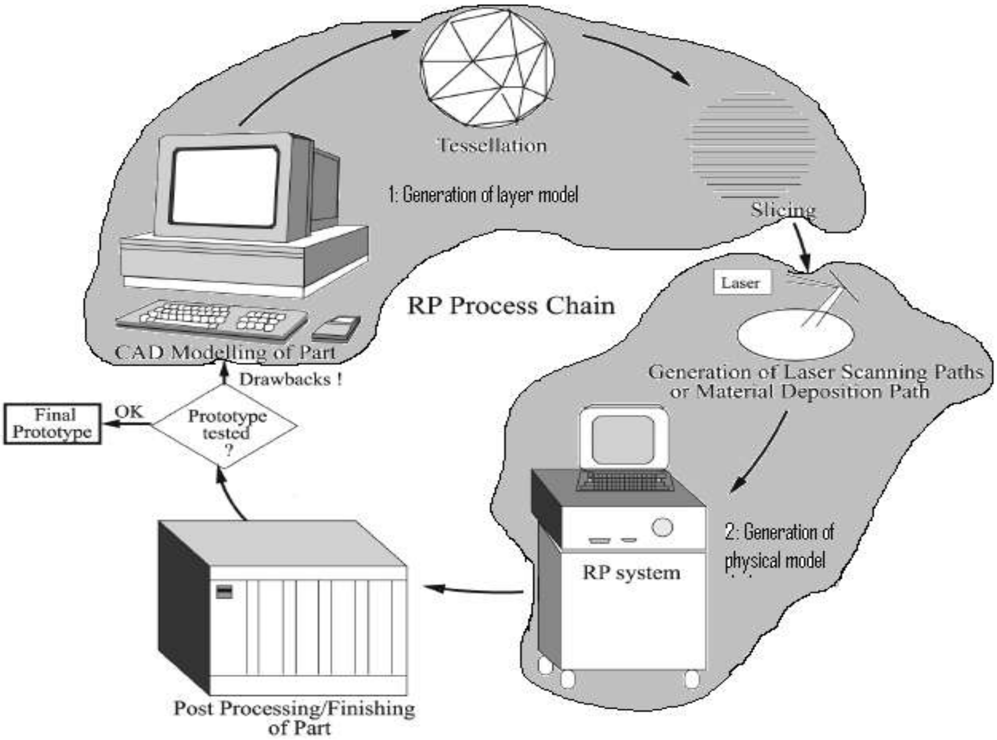

Figure 1: RP process chain showing fundamental process steps

It can be seen from figure 1 that process starts with 3D modeling of the product and then STL file is exported by tessellating the geometric 3D model. In tessellation various surfaces of a CAD model are piecewise approximated by a series of triangles (figure 2) and co-ordinate of vertices of triangles and their surface normals are listed. The number and size of triangles are decided by facet deviation or chordal error as shown in figure 2. These STL files are checked for defects like flip triangles, missing facets, overlapping facets, dangling edges or faces etc. and are repaired if found faulty. Defect free STL files are used as an input to various slicing softwares. At this stage choice of part deposition orientation is the most important factor as part building time, surface quality, amount of support structures, cost etc. are influenced. Once part deposition orientation is decided and slice thickness is selected, tessellated model is sliced and the generated data in standard data formats like SLC (stereolithography contour) or CLI (common layer interface) is stored. This information is used to move to step 2, i.e., generation of physical model. The software that operates RP systems generates laser-scanning paths (in processes like Stereolithography, Selective Laser Sintering etc.) or material deposition paths (in processes like Fused Deposition Modeling). This step is different for different processes and depends on the basic deposition principle used in RP machine. Information computed here is used to deposit the part layer-by-layer on RP system platform.

Literature Review

When an object is sliced, horizontal slice planes are intersected with the sides of the triangular facets at each particular slice height. Those collective intersecting points are then adjacently joined by straight lines to form contours at each height [1, 2, 12]. It is apparent that if there are more intersected triangles, there would be more points available, and thus, the contour would be more accurate. This process is repeated until contours are created for the entire object from top to bottom [12]. The slicing process will bring about a layering error [1] that would affect the surface finish of the prototype. The layering error increases with increased slice thickness [4]. Fadel and Kirschman [1] stated the possibility of over-tessellation with respect to slicing. This occurs when there are triangles present that are not intersected by slice planes and, hence, do not contribute to the slice contours or slices. Therefore, they are not necessary. Determining ways of eliminating such unwanted STL data would lead to the usage of less

Dheeraj Nimawat, Mahaveer Meghvanshi Vol. 2, Issue 2, Mar-Apr 2012, pp.215-219 IJERA[2] Works on the Rapid Prototyping Technology In Mechanical Scale Models he used different case study for his work. He conclude that The use of Rapid Prototyping technologies is essential in any design fields. Although it was conceived as an medical application, arts, architecture applications, the mechanical field can also take benefit from this technology. It gives the mechanical engineer, the possibility to visualize those complex shapes not easily seen or understood on connectional drawings, and touch them to verify the shape. It can be used to in early design stages to build a conceptual model or in later stages when details are needed. Complex shapes can be obtained using surface and solid modeling CAD software, and then build the physical model. In a few hours the model can be built easily, in a similar way as a 2D drawing is plotted. In a short time, rapid prototyping will become a technology that will be used routinely by many design engineers in conjunction with the traditional existing ways of creating scale models of mechanical parts.

Ahmed M. Romouzy-Ali, Siamak Noroozi, Philip Sewell, and Tania Humphries-Smith International Journal of Innovation, Management and Technology, Vol. 3, No. 4, August 2012 [3] works on the Adopting Rapid Prototyping Technology within Small and Medium-Sized Enterprises: The Differences between Reality and Expectation, he use different model and he give the difference between them he used cnc machine model, rp models CAD models. His discussion help to characterise a leading approach for new opportunities for the RP technology within SMEs. Undoubtedly raising awareness of the importance of human development is a key issue towards an effective decision making about the adoption of RP technology. Moreover there is a need for finding new financial resources alternatives through for example TT or KTP within an SME perspective. Ultimately the reality is not very far from expectation.

D. K. Pal1, B. Ravi2, L. S. Bhargava1 and U. Chandrasekhar3 Mechanical Engineering Department, Indian Institute of Technology, Powai, Mumbai, December 2004.[4]In this context, They work on integrated approach involving reverse engineering, rapid prototyping, process simulation and metal casting to achieve speed and economy in developing such parts. This approach has been successfully demonstrated by taking up an industrial case study of an impeller casting. They consider various RP techniques & accordingly give relation between different parameters like Accuracy, Layer thickness, Cost & time relation, Surface finish .This impeller casting is made on different types of RP techniques and their result according to accuracy & layer thickness is been shown by table as follows

	RP Machine	**System manufacturer**	**Material**	**Accuracy XY-plane (mm)**	**Accuracy Z-plane (mm)**	**Layer Thickness (mm)**
FDM1	FDM Titan	Stratasys	Polycarbonate	0.15	0.13	0.25
FDM2	FDM 250		ABS(P400)	0.15	0.13	0.25
FDM3	FDM 250		ABS (P400)	0.15	0.13	0.25
SLA1	SLA 5000	3D Systems	SLA5530 epoxy rein	0.1	0.10	0.10
SLA2	SLA 250		SLA5530 epoxy resin	0.1	0.10	0.10
SLAQ1	SLA 5000		SLA5530 epoxy resin	0.1	0.10	0.10
TJP1	Thermojet		TJ88 wax	0.1	0.10	0.10
LOM1	LOM-2030H	Helisys Technologies	Paper (LPH series)	0.25	0.30	0.20

They gives the relation between cost & time comparison according to different methods used

	Machine cost ($1000)	Machine rate ($/hr)*	Time taken (hr)	Material rate ($/kg)	Part weight (kg)	Total cost ($)
FDM1	100	12.56	7	330	0.19	**150.62**
FDM2	55	6.90	16	300	0.09	**137.40**
FDM3	55	6.90	8	300	0.09	**82.20**
SLA1	400	50.23	2.5	250	0.21	**178.08**
SLA2	200	25.11	4	250	0.21	**152.94**
SLAQ1	400	50.23	2.5	250	0.05	**138.08**
TJP1	60	7.53	6	225	0.16	**81.18**
LOM1	120	15.07	6	20	0.17	**93.82**
Conventional wooden pattern						**200.00**
Conventional metal pattern						**450.00**

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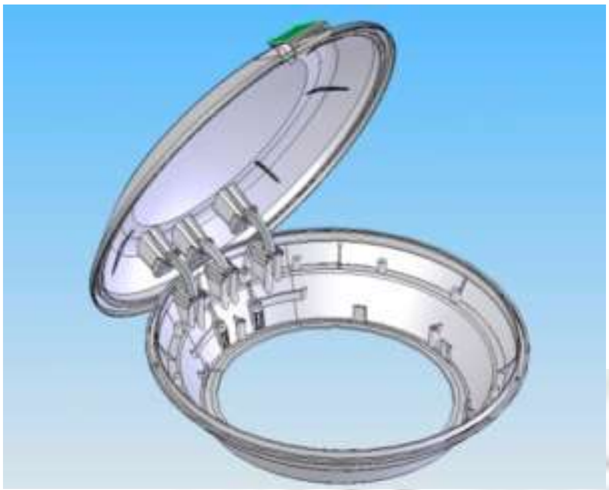
Integrating Rapid Prototyping into Product and Process Development Bahram Asiabanpour, Ingram School of Engineering Texas State University - San Marcos 601 University Dr. San Marcos, September 10, 2008[5] In his project an LOM machine was used to prototype a pattern to make a mold for the casting process. also an FDM machine was used to build the main body of the proposed design for the new luminaire fixture.




Zhi Yang Richard A. Wysk Sanjay Joshi Department of Industrial and Manufacturing Engineering, The Pennsylvania State University, University Park, PA 16802, Int. J. , Vol. x, No. x, xxxx [6]works on the Conventional Machining Methods for Rapid Prototyping and Direct Manufacturing, he give the idia overview of how conventional machining processes can be used for rapid prototyping and direct manufacturing processes. The methodologies of Computer Numerical Control machining for Rapid Prototyping (CNC-RP) and Wire Electronic Discharge Machining for Rapid Prototyping (WEDM-RP) are presented in this paper. A general discussion of selection criteria and cost comparisons among both current additive RP and conventional machining approaches to rapid manufacturing is also presented. He conclude that CNC-RP and WEDM-RP provide the possibility of using conventional processes, such as CNC milling and WEDM, as RM tools. One of the advantages for conventional subtractive process is their material processability. Additive processes have difficult in manufacturing full density part or parts with lattice structures. It will easier to subtract material from a block of material than to build lattice structures layer by layer. The better material processability also provides conventional subtractive processes better adaptability for new material. It is impossible to select one process as the single best solution for all RM applications. RM process selection can be based on the following criteria: geometric capability, accuracy, material flexibility, and manufacturing cost. The various RM processes vary dramatically in those criteria. Additive processes generally have good geometric capabilities, but are limited in material flexibility and accuracy. Conventional subtractive processes are capable of manufacturing variety of materials with good accuracy, but limited in geometric capabilities. Therefore, there is no unique answer for RM process selection.

Wanlong Wang, James G. Conley, Henry W. Stoll, and Rui Jiang Department of Mechanical Engineering Northwestern University Evanston, IL 60208-3111 [7]This paper reviews the general RP processes, discussed the tool path selection for sand casting, and investigates the decision factors and decision-making process for RP process selection. This investigation attempts to clarify the factors and their influences on the decision process so that a further optimal decision support system may be developed based upon this understanding. RP process selection for tool making, which involves the selection of a particular RP process and material, is a sub-decision that must be made as part of the tool path selection process. Choosing RP process involves two independent decision variables: RP process and material. Product requirements (time, cost and accuracy) generally determine which combination of RP process and material is best. If we view each of these decision variables as a dimension of the RP process selection process, we can envision a decision table for material to method of RP as shown in below Table

Table 1 Decision table for RP process selection

	SLA	LOM	SLS	FDM	SGC	3DP	SP
Polymer	X				X		
Paper		X					
Wax			X	X			X
ABS Plastics			X	X		X	
Metal Powder			X			X	
Ceramics		X	X			X	
Sand			X				
Composite		X					

CONCLUSION

As the rapid prototyping (RP) process is being used widely with great potential for rapid manufacturing of functional parts, because rapid prototyping are analysed for their impact on fabrication time, development cost, dimensional accuracy and surface quality of the part. Casting process simulation enables reducing the number of shop-floor trials to optimise the methoding and process parameters. Due to this reason RP becomes more popular than other manufacturing processes many researcher works on this RP to improve the strength & other parameters by doing different experimental set up with different models. but still lots of works to be done in future.

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