Product Design and Development using Polyjet Rapid Prototyping Technology

Mohd Javaid Lalit Kumar Vineet kumar Abid Haleem
Department of Mechanical Engineering, Jamia Millia Islamia New Delhi, INDIA
haleem.abid@gmail.com

Abstract
The Rapid prototyping process has proved to be a good approach since all requirements could be fulfilled. With the help of this technology design and size of product will be easily changed.Complicated small shape products are also manufactured easily. We integrate polyjet technology for product development which is used to become a game-changing innovation for designers, engineers and manufacturers. It improves customer satisfaction. 3D printing helps organizations get better products to market faster than ever before. It enables design teams to quickly produce a high-quality, realistic prototype with moving parts, at low cost when compared to other methods such as CNC machining or outsourcing .The modifications on the product are simple to execute. The Poly Jet technology for manufacture of prototype models is adequate with respect to shape as well as dimension requirements. The advantages are obvious particularly in case of exacting shapes which would be difficult to manufactured by conventional processes or the price would be too high and the time of manufacture too long. Taking into consideration the experience in rapid manufacture of prototype models, their applicability and the responses of users, In cases only a few products not exposed to high mechanical loadings are needed, the models made by Poly Jet process are undoubtedly a good solution.In this paper we also reviewed effect of process parameter on mechanical properties and takentime consideration.
Keywords: 3D Printing, Model Making, Additive manufacturing, Innovation, Polyjet Technology, Rapid Prototyping

1. INTRODUCTION

Prototyping or model making is one of the important steps to finalize a product design. It helps in conceptualization of a design. Rapid Prototyping (RP) by layer-by-layer material deposition, started during early 1980s with the enormous growth in Computer Aided Design and Manufacturing (CAD/CAM) technologies (Kumaravelan, 2014).

Rapid Prototyping is defined as a group oftechnologies used to quickly produce a scale model of acomponent or group of components using 3-dimensionalcomputer aided design (CAD) data. Due to the worldwidecompetition of the product the manufacturing industries hasgiven more important in the product development phase.

Therefore the RP and manufacturing techniques plays the vitalrole in a product development. It has been high prospective toreduce the cycle and cost of product development. It is animportant tool in digital manufacturing in rapid productdevelopment. There are a variety of methods that can be usedin RP to deposit the material for creating a proto modelthrough RP technique. The some of the important methods areused in industries for manufacturing the product model such as Stereolithography (SLA), Selective Layer Sintering (SLS), 3DPrinting (3DP), Fused Deposition Modelling (FDM).(Kumaravelan, 2014).

Rapid Prototyping can automatically construct physical models from computer-Aided Design (CAD) data or is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. The “three dimensional printers” allow designers to quickly create tangible prototypes of their designs rather than two dimensional pictures. Such models have numerous uses.Any changing is done in the design, shape and size of product (Mahindru& Priyanka Mahendru 2013).

2. 3D PRINTING AS A RAPID PROTOTYPING TOOL

3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. It is also known as rapid prototyping, is a mechanized method whereby 3D objects are quickly made on a reasonably sized machine connected to a computer containing blueprints for the object. The 3D printing concept of custom manufacturing is exciting to nearly everyone. This revolutionary method for creating 3D models with the use of inkjet technology saves time and cost by eliminating the need to design; print and glue together separate model parts. Now, we can create a complete model in a single process using 3D printing. The basic principles include materials cartridges, flexibility of output, and translation of code into a visible pattern. 3D Printers are machines that produce physical 3D models from digital data by printing layer by layer. It can make physical models of objects either designed with a CAD program or scanned with a 3D Scanner.Polyjet technology can be useful in following ways

- To increase effective communication
- To decrease development time
- To decrease costly mistakes
- To minimize sustaining engineering changes
- To extend product lifetime by adding necessary features and eliminating redundant features early in the design
- Reduced lead times and costs
- Improved quality of product
- Better visualization of the product
- Customization
- Complexity
- Tool less
- Sustainable/environmentally friendly

Some of the major disadvantages of poly jet technology is as follows:

- Size of the prototype is limited.
- Limited material properties
- Varying accuracy in x-y planes & z plane
- Surface finish
- Part accuracy:
- Staircase appearance for a sloping part surface due to layering
- Shrinkage and distortion of RP parts

In future we may use Rapid Prototyping for creating personalized and hard to replace objects such as heirlooms, sculptures, puzzles and other toys, jewelry, custom fitted eyewear, home decoration fix-it-parts, missing chess pieces.

3. BRIEF LITERATURE REVIEW

Ben Utela, Duane Storti, Rhonda Anderson & Mark Ganter (2008) presented the steps involved in process development for new material system in 3 DP which makes the material flexibility in 3DP. The numbers of steps involved are: (1) formulation of a powder, (2) selection of a binding method, (3) formulation of the liquid binder and testing its suitability for printing and interaction with the powder, (4) specification of printing process parameters, and (5) specification of post-processing procedures. The authors also provides different literature available to support each step and following these steps almost every material that can be converted into powder form can be used for 3 DP easily.

Rahmati Sadegh, ShiraziFarid&BaghayeriHesam (2009**)** redesign the 3DP machine, using piezoelectric demand-mode technology head in order to improve accuracy, surface finishing and color quality of constructed models. The layers created with aforesaid system were between 25 to 150 µm (steps of 25 µm). The advantages and disadvantages of piezoelectric and thermal heads were investigated. Based on the results, parameters such as accuracy, life time and diversity of materials, and piezoelectric heads were recognized as the most adapted to rapid prototyping applications. Based on the new design, piezoelectric demand-mode technology was employed to jet the binder from nozzles. Moreover, the capability of layer dispending mechanism is improved by up to 3 times (minimum layer thickness is 25 µm), and the surface finishing of fabricated models is also improved.

S. Kumar, J.-P. Kruth(2010) The use of rapid prototyping (RP) technology for rapid tooling and rapid manufacturing has given rise to the development of application-oriented composites. Thus furnishes succinct notes of the composites formed using main rapid prototyping processes such as Selective Laser Sintering/Melting, Laser Engineered Net Shaping, Laminated Object Manufacturing, Stereolithography, Fused Deposition Modeling, Three Dimensional Printing and Ultrasonic Consolidation

DheerajN ,MMahaveer(2012) Discuss in his paper that the use of Rapid prototyping technology (RP) into mechanical engineering. In the development of a new product it is invariably necessary to produce a single prototype of a designed product or system before the allocation of large amount of money to new production facilities or assembly lines.

Ren C. Luo, JyhHwaTzou& Yi Cheng Chang (2000)present software and hardware technologies to build a LCD panel display based Rapid Prototyping system. Software design for the system includes slicing algorithm, LCD photo mask display process, user interface and motion control program. Hardware configuration of the architecture includes LCD photo mask, optical system, z-axis elevator, resin supply system and PC based control system.

Junfeng Mei, Michael R. Lovell, & Marlin H. Mickle (2005) presented two different formulations of particle-free conductive solutions that are low in cost, easy to deposit, and possess good electrical properties. A novel aqueous solution consisting of silver nitrate and additives is initially described. This solution demonstrates excellent adherence to glass and polymers and has an electrical resistivity only 2.9 times that of bulk silver after curing. A metallo-organic decomposition (MOD) ink is subsequently introduced. This ink produces a close-packed silver crystal microstructure after low-temperature thermolysis and subsequent high-temperature annealing. The electrical conductance of the final consolidated trace produced with the MOD ink is very close to bulk silver. In addition, the traces produced with the MOD material exhibit excellent wear and fracture resistance.

When utilized in a specialized continuous inkjet (CIJ) printing technology system, both the inks were determined to be compatible with CIJ printing technology and capable of being printed in three dimensions with conductive traces in three dimensions. Such a characteristic has a broad range of application in the electronics industry in several areas including the printing of radio frequency identification tags (RFID) on products and the elimination of printed circuit boards by printing traces directly on the product such as a case or interior surfaces to connect electronic components.

M. Oudjene, L. Penazzi, J.-L. Batoz(2007) Discuss rapid prototyping, sheet metal stamping tools can be made by an assemblage of steel sheets or layers and joined by several techniques (such as screws, bolts, brazing, adhesive).

T.T. Le et al. (2012)presents the hardened properties of a high-performance fiber-reinforced fine-aggregate concrete to build layer-by-layer structural components in a printing process (extruded through a 9 mm diameter nozzle).The effects of the layering process on density, compressive strength, flexural strength, tensile bond strength and drying shrinkage were presented together with the implication for mix proportions. A well printed concrete had a density of 2350 kg/m3, compressive strength of 75–102 MPa, flexural strength of6–17 MPa depending on testing direction, and tensile bond strength between layers2.3-0.7 MPa. The well printed concrete had significantly fewer voids greater than 0.2 mm diameter (1.0%) when compared with the mold-cast control (3.8%), whilst samples of poorly printed material had more voids (4.8%) mainly formed in the interstices between filaments. The additive extrusion process was also shown to retain the intrinsic high performance of the material. However further research is required to assess the structural behavior under simulated service conditions as well as to establish their durability, particularly in relation to any adverse effects of the layering process.

C. Cajal, J. Santolaria, J. Velazquez, S. Aguado&J. Albajez (2013) proposed volumetric error compensation technique (software volumetric compensation.) based on pattern artifacts. This technique was applied to an Objet 350V 3D printer. The pattern artifact is a very successful method to materialize points in space. The point density was much higher than the use of spheres & the amount of material required in manufacturing was also smaller. It is very easy to implement this volumetric correction on other machines. . In fact, this method can apply to any rapid prototyping technology since it has been shown that while the sources of error are of systematic nature their combined action can be compensated. It is just necessary to properly develop the kinematic model and obtain sufficient points density within the working volume.

The method consists of materializing points with a high density within the volume, and then measure them with a CMM (coordinate measuring machine, Zeiss PMC MMC 850 with VAST XT scanning head was used). These measurements are used to determine the 18 error functions, as in Zhang, Veale, Charlton, Borchardt and Hocken (1985) obtained through the polynomials coefficients. Each error was expressed by its 3 coefficients & these coefficients of the polynomials are determined to approximate the errors. After manufacturing various pieces of test patterns, the results achieved are close to 80% reduction in mean error points.

Brent Stephens, Parham Azimi, Zeineb El Orch& Tiffanie Ramos (2013) works on measurements of size-resolved and total ultrafine particle (UFP) concentrations resulting from the operation of two types of commercially available desktop 3D printers inside a commercial office space. They estimate size-resolved (11.5 nm116 nm) and total UFP (<100 nm) emission rates and compare them to emission rates from other desktop devices and indoor activities known to emit fine and ultrafine particles. Estimates of emission rates of total UFPs were large, ranging from $2.0*10^{10}$ per min for a 3D printer utilizing a polylactic acid (PLA) feedstock to $1.9*10^{11}$ per min for the same type of 3D printer utilizing a higher temperature acrylonitrile butadiene styrene (ABS) thermoplastic feedstock.

These results suggest that more controlled experiments should be conducted to more fundamentally evaluate particle emissions from a wider arrange of desktop 3D printers. Because most of these devices are currently sold as standalone devices without any exhaust ventilation or filtration accessories, results herein suggest caution should be used when operating in inadequately ventilated or unfiltered indoor environments.

W N Prakash, V. G. Sridhar(2014) Present Rapid Prototyping that in any manufacturing process, design is the first step where most of the important decisions are made which affects the final cost of the product. Research have used Design for manufacturing and assembly (DFMA) to re-design a fluid flow control valve and optimized its design to ensure the reduced number of parts, safety, reliability, time to market and customer satisfaction. In this research work the main emphasis was given to the design stage of a product development to obtain an optimum design solution for an existing product, DFMA concepts were used to produce alternative design ideas and the rapid prototyping process was used to develop a prototype for testing and validation of these alternative designs. Optimum design, low cost and good quality with quick delivery was the outcome of this research work.

B.M. Tymrak, M. Kreiger& J.M. Pearce (2014)quantifies the basic tensile strength and elastic modulus of printed components using open-source Rep Rap 3-D printers in realistic environmental conditions. The mechanical properties of ABS and PLA components made using various desktop open-source Rep Rap 3-D printers were characterized through standard tensile tests to determine tensile strength, strain at maximum strength and elastic modulus. The results show that the average tensile strength of Rep Rap printed parts is 28.5 MPa for ABS and 56.6 MPa for PLA with average elasticmodule of 1807 MPa for ABS and 3368 MPa for PLA. These results indicate that the 3-D printed components from Rep Raps are comparable in tensile strength and elastic modulus to the parts printed on commercial 3-D printing systems. While considerations must be made for the settings, tuning, and operation of each individual printer as well as the type, age, and quality of polymer filament used, functionally strong parts can be created with open-source3-D printers within the bounds of their mechanical properties.

5. SOME RECENT RESEARCH FINDINGS WITH 3D PRINTING

A brief of some recent findings in usage of 3D printing is provided below in tabular form.

S.No.	Authors Name	Title and Journal/Conference Name	Objective & Finding's
1	C.S. Lee, S.G Kim	Measurement of anisotropic compressive strength of rapid prototyping parts. Journals of materials processing technology 187-188(2007)637-630	• In this paper FDM, 3DP, NCDS used for preparing compression test specimen with different material and different process parameters w.r.t to machines. • For FDM ABS material and axial, transverse, raster angles were the parameter. • For 3DP ZP102 plaster powder material and parameter were axial, transverse and diagonal. • For NCDS acrylic hydroxyapatite composite material and Parameters were axial, transverse, • Result of test showed that specimen made by 3DP had low compressive strength compared to others. • FDM parts had high compressive strength. • Compressive strength showed that parts made by FDM, 3DP and NCDS had anisotropic characteristics.

2	Tomislavgaleta, PhD ME University in Osijek croatia	Effects of processing parameters on hardness of 3DP parts 11th international research/expert conference ,2007	• In this paper researcher found the effects of the layer thickness, building direction and post processing on the hardness of the three dimensional printed model.
			• Result showed that the variations of considered parameters do not had a significant influence on the hardness of the three dimensional printed model.
			• X-indicates the gantry direction of travel.
			• Y-axis indicates the binder cartridge direction of travel and finally Z axis indicates invert building piston direction ie layer direction.
			• Post processing parameter considered in this research were
			  • Green mod without post processing label z
			  • Heat treated green model T
			  • Infiltration with z board iecyanoakcrylate B
			  • Infiltration with wax (W)
			  • Heat treated and z bond infiltration BT , heat treated and wax infiltration VT , heat treated and wax followed by Z Bond infiltration MT.

3	R.Singh, M.Verma	Investigation for deducing wall thickness of aluminium shell casting using three dimensional printing Journal of AMME,vol-31,Issue-2,Dec-2008, 1-5	• In this paper Authors verified the feasibility study of decreasing the shell thickness in rapid shell casting based upon 'three dimensional printing technology". • In this study the result indicates that at 5mm shell thickness the hardness of the casting is improved by 3.79% and production cost and production time reduced up to 54.6 and 55.4% respectively in comparison to 12 mm recommended shell thickness. • This paper shows highest surface hardness of the shell at 5mm of wall thickness when wall thickness varies from 2 to 12 mm.
4	Dr. Troy ollision	Three dimensional printing build variables that impact cylindericity Journals of industrial technology, vol 26, 2010	• In this paper study showed the simultaneous comparison b/w diameter 1inch and 0.75 inch and their build orientation 0^0 ,45^0,90^0 and eleven print head life categories with regard to the cylindericity of build part. • The result showed that build orientation 0^0,45^0,90^0,rotation about the x axis will affect part cylindericity. In many cases a choice can be made as to which build orientation to use during the printing of 3dp core or mould if cylindricity is great importance then build orientation needs to be considered.
5	P.Vijay, P. Danaiah, K.V.D Rajesh	Critical parameters effecting the rapid prototyping surface finish Journal of Mechanical Engineering and Automation 2011 ,17-20	• This paper presents an experimental design technique for determining the optimal surface finish of a part built by varying build orientation, layer thickness and keeping other parameter constant using FDM • The design investigates the effect of these parameter on the surface finish. • Result in graph showed that layer thickness and roughness both increases with variation in build orientation from 20^0 to 45^0 and from 45^0 to 70^0 the graph showed that roughness decreased and layer thickness increased.
6	Jose M. Arenas	Multi criteria selection of structural adhesives to bond ABS parts obtained by rapid prototyping International journal of	• This paper analyze five different families of adhesives Cyanoacrylate, Polyurethane ,Epoxy, Acryic and silicone to select the structural adhesive for mechanical benefits and adaption to FDM by AHP Technique. • Three criteria considered in this paper 1. Technological criteria sub criteria (a). Joint strength (b). Adaption to

		Adhesion & Adhesives. 2012,67-74	substrate (c). Dispersion 2. Adjustment to FDM- a. Safety and health. b. runtime adhesive bonding c. preparation and bonding. 3. Economic – cost Final ranked in this analysis was Polyurethane, Acrylic SF, cyanoacrylate, epoxy and silicate, on the basis of above criteria and sub criteria.
7	N. Simunic, N. Mustapic	Ergonomic Design of handle using rapid prototyping technology. 5th international conference ergonomics 2013	• The feasibility study of this approach verified by authors through time estimation for prototyping process of ergonomic handle of wheel chair. • The handle was designed using a hand grip impression in the clay model. • In second step after acquiring a hand grip impression model was digitized with steinbechler comet 5 3D scanners. • CAD model of the ergonomic handle was designed upon on the cross sections obtained from .stl scanner file. • The prototype for assessment was built on the Z corp 3D printer. • Final Result showed total time Clay model acquiring time- 45 min. Drying in the oven -15 min Digitizing with 3D scanner -30 min. Post processing time - 30 min. CAD modelling - 10 hrs. 3D printing ----------2hrs 24 min. Drying 45 min. Additional processing (dipping) 1 hr. Total time 15hr 45 min.
8	Tomislav, Galeta,Iveca	Influence of processing factors on the tensile strength of 3D printed models. MTAEC9,47(6),781(2013)	• Three factor layer thickness (0.1mm and .0875mm), building orientation (x ,y) and infiltrate type (wax ,epoxy, cyanoacrylate) taken by author for analysis. • The result of analysis shows that sample infiltrated with epoxy resin obtained in comparison with the other infiltrate types. • 2YE and 2XE showed highest strength where X and Y w.r.to orientation, E w.r.to Epoxy resin, 2 for second level. • The additional increase in strength can be obtained by selecting two processing factors.
9	M.N. Islam	An Investigation of dimensional accuracy of parts produced by three dimensional printing. WCE 2013,VOL-1,London, UK	• Authors examined variation in linear dimension and variation in hole diameter and their effects on the dimensional accuracy of a typical component for End milling , WEDM ,3D printing. • The calculated value showed that in terms of linear dimensional accuracy 3D printed performed poorly compared to the CNC End milling process, however the precision level of 3D printing was similar to WEDM.
10	M. Rima sauskas ,G.Balevicius	The influence of water absorption of photo polymers used in poyjet process. 18th international conference Mechanica - 2013	• This paper deals with the change of material properties under various conditions of parts which was manufactured from photopolymers using poly jet RP. • Investigation conditions were 1. Absorption of fluid under normal condition (27^{0}C distilled water for 24 hrs). 2. Immersion in dyes in order to investigate the depth and mechanics of absorption of the parts. 3. Immersion under high pressure 8 bar and tep. 50^{0}C • Investigation result showed that highest absorption percentage was achieved at surface area 29% greater than volume. • Dye absorption depth was found up to 1mm in to part and that absorption did not occurs on horizontal layers. • Under high pressure 8 bar and temp at 50^0 C it was found that this condition did not have any influence on absorption.
11	A.Cerardi , M.Caneri	Mechanical characterizatio of polyamide cellula structures fabricated usin selective laser sinterin technologies , 2013	• In this paper authors investigated the influence of porosity rate on mechanical properties using Finite element analysis. • Results showed inverse proportionality between material strength properties and porosity rate and stiffness of sample depends on structure topology.
12	Ahmed Hussen, Liang Hao	Advanced lattice suppo structures for metal additiv manufacturing, Journal o materials processin technology,3013,pp1019-1026	• Metal additive manufacturing (MAM) of complex parts requires the use of sacrificial support structure to hold part during the process. • The design and selection of support structure influenced the manufacturability of complex metal parts, material and energy utilization, manufacturing time and cost. • Experiments were conducted in direct metal laser sintering machine using titanium alloy Ti6Al4Vpowder. • Experimental results revealed that the type of structure, volume fraction and cell size are the main influencing the manufacturability.
13	A.K. Dubey,M.Y. Ansari	An Analysis of Surfac Roughness improvement o 3D Printed Material IJSRD,VOL-2,2014	• In this paper Author analyzed effect of powder size on surface roughness. • The result of this investigation showed that surface roughness increases with increase in powder size for a given set of parameter. • In this paper powder size varied from 19 micron to 21 micron and respective surface roughness 13130 nm to 11314 nm.
14	M.Sugavanes warn, G. ArumaikKumar	Modelling for randoml oriented multilateral additiv manufacturing componen and its fabrication ,2014	• In this paper a novel methodology is introduced for the fabrication of randomly oriented multi material ROMM using poly jet 3D Printing machine. • The distribution of plastic reinforcement in matrix elastomeric as modelled using computer aided design software. • CATIA VB SCRIPT has been used for ROMM CAD modelling. • Stress-Strain behaviour of poly jet 3DP Component with pure elastomeric and with randomly oriented plastic reinforced elastomeric is carried out in UTM. • It has been found that ROMM with plastic reinforcement provides significantly improved stiffness compared to pure elastomeric component.

6. RESEARCH GAP

The major research gap ia evident from the literature can be summarised through following points

- Surface roughness and accuracy of infiltrated parts.
- Varying the viscosity of infiltrated material and other working condition like pressure and temperature.
- Effect of powder grain size on mechanical properties and surface quality.
- Effect of temperature and concentration etc on volumetric shrinkage.
- Effect of sanding process on surface quality and microstructure and hardness.
- Process in terms of Environmental friendliness analysis.
- Productivity and energy consumption rate analysis.
- Effects of porosity level on mechanical properties like tensile strength and stiffness.
- Recent research focuses on correlation between strength parameters and relative parts analysis.

7. PRODUCT DEVELOPMENT USING RAPID PROTOTYPING SYSTEM

3D printing was awarded on April 20, 1993; It is a process of making a three-dimensional solid object of virtually any shape from a digital model. Changing in design also done easily

PolyJet 3D printing is similar to inkjet document printing. But instead of jetting drops of ink onto paper, PolyJet 3D printers jet layers of liquid photopolymer onto a build tray and cure them with UV light. The layers build up one at a time to create a 3D model or prototype. Fully cured models can be handled and used immediately, without additional post-curing. Along with the selected model materials, the 3D printer also jets a gel-like support material specially designed to uphold overhangs and complicated geometries. It is easily removed by hand and with water.

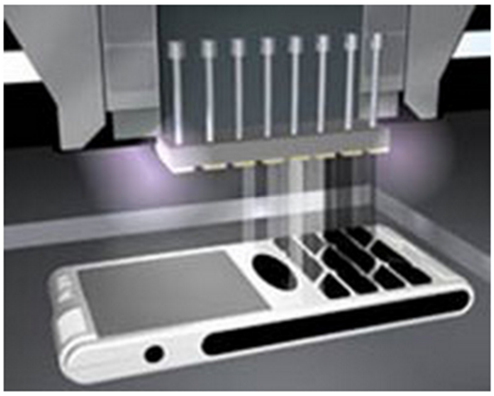

Fig 1:- Working of PolyJet 3D printing

3DP gives a unique opportunity to control the material composition of the product by jetting different materials from different nozzles as shown in Fig 1. These jetting materials can be used either in a molten form or in a slurry form. This can help manipulate various properties such as electrical conductivity, thermal conductivity, reflectivity, magnetic properties and hardness at various places of the product and make Functionally Graded Materials (FGM) or composites.

PolyJet 3D printing technology has many advantages for rapid prototyping, including superior quality and speed, high precision, and a very wide variety of materials. Based on PolyJet technology, Objet Connex 3D Printers from Stratasys are the only additive manufacturing systems that can combine different 3D printing materials within the same 3D printed model, in the same print job.

8. REASON TO INTEGRATE POLYJET TECHNOLOGY INTO PRODUCT DEVELOPMENT

It gives us better collaboration resulting in improved design and manufacturability. It has ability to quickly produce real working prototypes that teams can see and touch helps quickly bridge the gap between the virtual 3D CAD design and the final product. Design and manufacturing engineers can use these prototypes as a tool to better communicate how a design looks, feels and operates. This allows designers to better integrate their product designs. It improves customer satisfaction. 3D printing helps organizations get better products to market faster than ever before. It enables design teams to quickly produce a high-quality, realistic prototype with moving parts, at low cost when compared to other methods such as CNC machining or outsourcing. Ithas become a game-changing innovation for designers, engineers and manufacturers.Design is both an art and a science that starts with the imagination. 3D printing helps quickly transform something imagined into something that can be seen and touched. Prototypes are often used to help sell new concepts, so the more realistic the prototype is better.

9. SOME APPLICATIONSOF POLYJET TECHNOLOGY

- Medical and dental
- Aerospace
- Automotive
- Jewellery
- Art/design/sculpture
- Architecture
- Fashion
- Food
- Defence

Application of this technology is taking place in industry. However access of this machine is not very common and exploring new product designing will be a part of this technology.

Prototyping new products is the largest commercial application for 3D printing today, estimated to be 70 percent of the 3D printing market. Prototyping gives designers (and their customers) a way to touch and test products as concepts or functional objects early in the design cycle. This avoids expensive changes later in the process, saving significant time and money when bringing new products to market.

By rapidly printing prototypes, manufacturers can significantly shorten the development lifecycle. The technology is being applied to short production runs and does not require tooling, thus allowing flexibility, adaptability and speed to market. This is enabling countries with strong intellectual capital but high manufacturing costs to once again compete in manufacturing.

CONCLUSION

The Rapid prototyping process has proved to be a good approach since all requirements could be fulfilled. The number of products in question with rather complicated shape is small. We point out that only the product size influences the price of rapid manufacture of the prototype. Due to great number of requirements, the technology process has enabled us to establish adequacy of the housing by testing and to adapt it properly. As in case of rapid prototyping the data on the product shape have the form of a 3D printing, the modifications on the product are simple to execute.Taking into consideration the experience in rapid manufacture of prototype models, their applicability and the responses of users, we assume that the PolyJet technology for manufacture of prototype models is adequate with respect to shape as well as dimension requirements. The advantages are obvious particularly in case of exacting shapes which would be difficultly manufactured by conventional processes or the price would be too high and the time of manufacture too long. In cases only a few products not exposed to high mechanical loadings are needed, the models made by PolyJet process are undoubtedly a good solution

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