An Analysis of Digital Light Manufacturing Process

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***Abstract*: - The word of engineering design is under revolution at present designers and engineers are able to produced results within hours or days while this process used to take a period of week or month just a decade ago. Such advancement in field of Designing can be attributed to the technology known as 3D printing for Rapid prototyping. 3D printing is about to make a huge impact in our daily life after transforming the world of Designing completely. This work Lays emphasis on how Rapid prototyping is changing the word of manufacturing and tool designing and analysis is done on number of rapid prototyping techniques. Aim of the author is to point out the factors that have led to such revolutionary growth in the field of manufacturing and designing and also try to find out solution to some of the problems faced by the industry in the above given process. In 1981 a researcher with the name of Hideo Kodama of Nagoya Industrial Research Institute published research on photopolymers it was the first functional Rapid prototyping system build. In 1984, 3 years after him Charles Hull created history by inventing a completely new process of 3D prototyping known as a stereo lithography, this new technique for the very first time allowed designers to create 3D models directly from CAD inputs the first ever tangible 3D prototype was manufactured. The industry is going under Rapid development and research and there is a competition between different organizations to come up with new research on Rapid prototyping processes the material used for 3D painting. Manufacturing better 3D printers using the computer network and internet to take 3D prototyping on a global scale and allowing development 3D printing Laboratories which can be accessed by an inventor sitting on other hemisphere of the planet. Very soon Rapid prototyping process will overtake conventional manufacturing process.**

I. INTRODUCTION

Digital light manufacturing process is a new type of rapid prototyping Technology developed in recent years in this chapter we will do a complete analysis of the process as well as its effect on the results. This technique was first introduced by Envisiontec Limited a company based in Germany in the year 2002. This process is comparatively very new and has accuracy level equal to FDM and SLS process. This process builds one slide simultaneously rather than building at a single Line or point at a time. This process comes with great advantages like this process comes up with great advantages like very low initial investment cost, very low operating cost, and a very high build up Speed. These qualities of this process make the centre of attraction for small scale as well as large scale industries.

In this work an Emphasis was laid on research and development and result in Mechanical properties of parts fabricated using acrylate R5 Raisins. The aim is to try and establish the relationship between the desired output and the process parameter settings using Taguchi technique and statically tools. In this particular case the output we are expecting is better tensile strength, high build accuracy and surface hardness. Keeping in mind the above parameters and the information Rapid prototyping parts can be engineer to meet the above requirements. In this chapter we try to establish the relationship between various parameters and processes like build accuracy material property and surface finishing compare two different Rapid prototyping techniques and hence evaluate this new process.

II. RESEARCH METHOD

The aim is to see application of digital light manufacturing technology in designing of injection moulding tooling for plastic polymers. The different stages followed are

1. Use of Computer aided design to make a 3D model
2. Rapid prototyping for checking the path use of rapid prototyping for checking the part
3. Analysis of the injection mould.
4. Using DLM Machine to build the mould tool.
5. Injection moulding trial.

The first three stages given in the list what are undertaken by the design section and output was provided to carry out the further process.

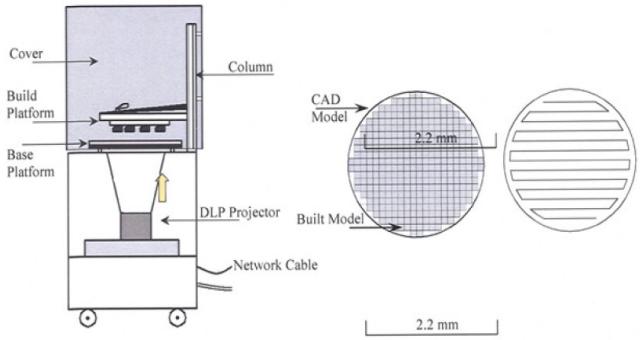
The experiment was conducted by arranging the group into pixel size in run in the increasing order of the pixels. The process was carried out again and again adjusting the pixel size as it takes about an hour to adjust the pixel size setting and recalibrate the machine for the results. While it takes only few seconds to recalibrate the other parameters. The hardness and different values were obtained. Accuracy values were measured in the range of 0.04 mm- 0.63 mm, which depends upon combination of parameter used. It is to be taken under consideration that these values are measured aviation from actual is specified value. The value from the experiment was normalized taking in consideration of lowest value in each class. The value for accuracy and build speed multiply suitable factor for representation purpose.

An orthogonal array was selected to conduct the experiment and testing was done on the parts for properties of strength hardness and accuracy, the parameter was selected and the best value of these responses were recorded. In the experiment it was seen that exposure time had an effect on hardness and strength but after a value of 10,000 ms touch the peak value and there were no changes further. While working on strength

and hardness building in X direction was producing the best results while in the case of accuracy Z direction was most accurate. With increasing thickness of the lower layers strength hardness and accuracy also improved, the test was conducted for all the parameter the conclusion is set value of one can be appreciated without sacrificing any other.

The building process

This technique utilizes the technology call the digital light processing. A high power resize light projector is used, projector polymerises a photosensitive raisin by individual layers the system develops a Mask in discreet voxels which approximately equal to the boundaries of the layer.



DLM Setup

Important process parameter and settings

Based on previous test experiment and observations it is seen that some parameters have more effects on accuracy, strength, hardness then others. It is important that we predefined the parameters in the experiment and prevent unnecessary expenditure and also save time hence below we have made a table of the parameters we have narrowed upon.

Machine settings for the process

Work Area – Minimum - 120mm x 96mm

Maximum - 190mm x 152mm

Orientation axis – X,Y, Z.

Details of process parameter and settings

Thickness of layer - This can be defined as the thickness of the build layer form during the process or the gap between Silicon base and the layer which solidified above. It is measured in microns and the range for this process is 30 Micron 100 microns. The DLP projector will convert resin between the caps into solid.

Velocity of peel off - The velocity with which the Build platform is peel off are separated from the platform below it. Layer after being cured by light is separated from Silicon platform the below. Peel off is performed by fixing the Silicon base plate in the front and then pulling a downward using a mechanism based on stepper motor.

Waiting time - waiting time can be divided into two main components which are

Waiting time after the Peel off.

Waiting time after levelling

Waiting time is fixed according to the individual requirement of the experiment as the user requires. Both the waiting Times are independent of each other in this experiment they are combined as one.

Exposure time - the time during which most of the curing process takes place is known as the exposure time i.e it is during this time that the resin in liquid form is exposed to the Mass player, hence the result is curing. Although some amount of curing take place after the building process is complete.

S.No	Chosen parameter	Standard unit used	Minimum	Maximum
1	Thickness of layer	Microns	30	100
2	Velocity of peel off	microns per second	1000	3000
3	Time taken	Millisecond	0	2000
4	Exposure time	Millisecond	4000	15000

Work Area - the work area can be defined as the total area in which the process takes place a small work area requires the light to be focus in concentrated manner as compared to large work area. It is the result of fixed size pixels in the projector, to change the effective size falling on the resin can be achieved by moving the lens in upward and downward direction. A higher pixel size points towards a larger work area. There are a number of work area settings available in the machine some of them are indicated in the table given below.

Dimension of the work area available in mm square
120.00 x 96.00
128.00 x 102.40
140.80 x 112.64
153.60 x 122.88
160.00 x 128.00
166.40 x 133.12
179.20 x 143.36
185.60 x 148.48

Layout of the experiment

Orthogonal array was chosen for layouts of the experiment, the reason for choosing this array was that it can accommodate a number of factors. The first two columns have an inbuilt interaction, the interaction of three level columns is distributed uniformly to all other three level columns it becomes very easy for the investigation of benefits during the experiment.

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III. RESULT AND DISCUSSION

3.1 Accuracy testing

This project was carried with an objective to keep how correct the mould part can be formed with respect to the prototype and after the formation it was seen that mould can be easily fit and easily remove without use of any excessive force at healthy accuracy of the final mould part was 97.8% and the remaining error of 2.2 % can be due to the designing stage and also to the sector that mould after cooling will Twinkle Little that from its original size due to the changes in the mechanical property of the substance. It can be seen that accuracy of mould tends to change with change in injection pressure and temperature, the permission in making the mould can only be maintained if the temperature of the molten polymer is kept precisely 200 to 220 degree Celsius. Any temperature above 220 degree Celsius will lead to fracture and tearing.

3.2 Surface finish testing

It is one of the most important properties of any material if the manufacturing word the perception of product and Company depends heavily upon the quality of surface finish provided by them. A very good surface finishing in the product results into customer satisfaction and making the product more attractive.

Define good surface finish a parameter known as Ra is used it is internationally recognized. It can be defined as automatically mean of variance of roughness profile from the mean line.

No of Specimen	Ra value Average (5 readings)
1	1.22μm
2	1.08μm
3	1.09μm
4	1.96μm
5	0.98μm
Average Ra value =	1.266μm

Conclusions of rapid tooling Investigation

After the manufacturing of injection moulding tooling using the direct light machining Rapid prototyping Technique the following conclusion was reached.

1. It can be used to perform injection moulding process for a polymer temperature of maximum 220 degree Celsius when the temperature exceeds the given limit wearing and tearing appears in the die.
2. The maximum pressure that can be retained is 80 MPa.
3. The product and the die show very impressive accuracy and good quality surface finish of the product.

It was found that DLM manufactured plastic parts are acceptable in the market but still need post processing earth surface finishing operations to increase the quality of the parts. Technique can be used to produce plastic parts however the technique is still not very good for production of parts with Complex geometry or delicate parts. It is most suitable for simple parts which do not require very high accuracy.

3.3 Discussion

The last two decades have been very important for Rapid prototyping Technology the industry has developed a very quickly there was a time When Rapid prototyping was seen as a laboratory experiment unable to manufacture usable components the accuracy as well as the reliability of the process was under doubt. Now it has emerged as a very important tool for organisations involved in product development and research especially for organisation with small capital. Using Rapid prototyping Technology evolution has been created in the market the companies evolved different methods of production and development of very complex objects in very less time which results into large reduction into lead time required for the project. it is also improve the functionality as well as quality. Development in this processes as highlighted by the work undertaken here and application of these techniques has created a great impact on product development process and also on the product itself.

Rapid prototyping comes with a unique ability to take input directly from Computer aided design and print in 3D this has allowed innovative and different product into the portfolio of the companies and customer satisfaction resulting in mass customisation. was the advent of rapid prototyping technique the manufacturing industry was of the view of Designing at once and using at multiple instances philosophy like " one design fits all" was basis for many manufacturing process the foundation of this very believe has been taken by the impact of rapid prototyping. In the modern world the industry has become more customers oriented then it was never before providing customer with power to choose add include personal customisation to product. This constant demand for customer input base market and manufacturing process and product development cannot be sustained using old development model the technique of rapid prototyping is answer for the customer demand. There is no surprise get the technology has seen wide reference in past two decades and also sees a promising future. Rapid prototyping industry has provided the manufacturer and designer ability that developed product which were considered non manufacturable due hurdles like processing required, material, Complex geometry. Presently Rapid prototyping Technology is being used in expensive products like in medical industry, but within few years the processes and material development will make it accessible to lower value products.

Out of all the powdered base process 3D printing stands out with the competitive Technology it has a clear advantage of build speed and no support requirements. it is very realistic and the product is coloured 3D printing this quality of the process makes it the best for representation 3D prototyping concept and product development.

We have focused on digital light manufacturing or DLM process which is a very new technique. We have conducted the experiment and seen how parameters interact with each other and their effect on result which leads to production of rapid manufactured parts. Optimisation of process parameters was done so that properties like surface finishing, accuracy in manufacturing, and strength of the part is increased. Application of digital light manufacturing process for tool design in polymer injection moulding process was also studied.

3.4 Conclusion

Investigation of Resin based Digital light manufacturing Process

The process of DLM is characterized and the optimisation of parameters strength of part, accuracy, hardness and surface finishing has been done with the help of experimental analysis.

An ANOVA test was done and the result obtained is as below

1. The property of hardness is affected mostly by layer thickness and the exposure time while it is least affected by waiting time and the velocity of peel off.
2. Strength of the material in digital light manufacturing process is affected more by the exposure time and waiting time why there is the minimum effect of feeling velocity and pixel size.
3. For high accuracy properties of layer thickness and orientation were most important factor where as they had a very negligible effect of pixel size and velocity of peel off.

The isotropic properties of the materials in the DLM process were established and it was found out that the best direction for party strength is in the Z-Y plane.

Finite element analysis techniques were applied and the result was that the final part as an increase the strength of 14%.

The process was developed for application in direct tooling and various parameters for polymer injection molding determined.

3.5 Further application

Number of topics has been investigated in this paper but at the same time there was certain new development in the field of rapid prototyping, this paper presents just few drops of the ocean of the world of rapid prototyping any other work very prominent in nature have came forward and demand for the studies in the field. The future scope includes

1- Developing form from DLM raisins using porous light structure which find their application in the field of medical.
2- A new test rig development call digital light manufacturing process which enables testing of material that are newly developed or under investigation.
3- Developing new materials for a structure of building of DLM process.
4- Analysis digital light manufacturing process in an analytical method which can lead the way to build performance and improve parameters like peeling layer after layer.

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