Developed an Algorithm for Dimensional Accuracy in Fused Deposition Modelling Process: A Novel Approach

Achyut Trivedi[1], Shakti Bhatt[2]

[1]*Assistant Professor, Mechanical Department, Marwadi Education Foundation Group of Institute- Rajkot, Gujarat, India*
[2]*ME-CAD/CAM (Pursuing), Mechanical Department, Marwadi Education Foundation Group of Institute- Rajkot, Gujarat, India*

***Abstract*_ Additive Manufacturing attends widely impact on Engineering Side. As in Additive manufacturing the element is made in layer wise manner. So it's reduced the wastage and save the material (can consider as Environmental friendly process). Fused Deposition Modeling (FDM) is very useful and simple technique in Additive manufacturing. Only problem with FDM is there dimensionally accuracy and surface finish, so to overcome this problem a novel approach has been proposed by using an algorithm in this Research work. Also Conclude by using that algorithm better surface finish may achieve. By using Multi-disciplinary concept is this main aim of this Research work.**

Keywords—Additive Manufacturing, FDM

I. INTRODUCTION

Additive Manufacturing is a layer by layer process for making prototype as well as nowadays it is also used for making fully densed parts. As in additive manufacturing the part is made by using layer by layer manner unlikely in conventional the part is made by doing machining or by removing material. Due to elegance in building structure, in layer by layer manner, additive manufacturing has pulled the all eyes towards them and shine like a revolutionary Industrial manufacturing process. As consumer are the driver of the such kind of market, as in early stages some industries making an creative and three dimensional printers for thermoplastic materials, by introducing approach of "DO-IT-YOURSELF" plastic three dimensional modeling became an good approach for consumers[1]. Sine industries also[2] take a benefit of customer design approach, as they provide online modeling tool and customized them. As the customer can be modeler and industries will build part in a customized manner. From the industrial prospect, additive manufacturing have significant impact on traditional approach for production of models. Multinationals interested for commercializing of metal based manufacturing technique for the purpose if re-manufacturing process. Apart of them still this process is in Developing phase. Surface finishing and dimensional accuracy are two major constraint. This paper stated in following sections: 1.Fused Deposition modelling, 2.Litrature Review, 3.Methodology, 4.CVLT Algorithm, 5.conclusion

II. FUSED DEPOSITION MODELLING

Fused deposition Modelling is a solid base additive manufacturing technique, as in additive manufacturing the component is made in layer by layer process. As shown in Figure1 the schematic diagram of Fused deposition modelling process. Also in Figure 2 the clear view is shown for the deposition of layer from the nozzle. In FDM process the input material is wire form and that wire passes through the nozzle. In high temperature nozzle the wire will Melt and the extrusion process will takes place. According to the Computer

Controlled process, the path of the wire diagram will follow. (programming path) Generally FDM is very popular for it's simplicity in Additive Manufacturing process. Thermoplastic are the mainly used material is FDM process. In that ABS is mainly used.

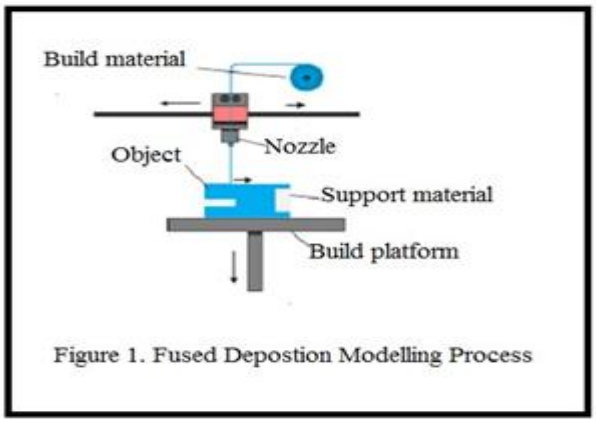

Figure 1. Fused Depostion Modelling Process

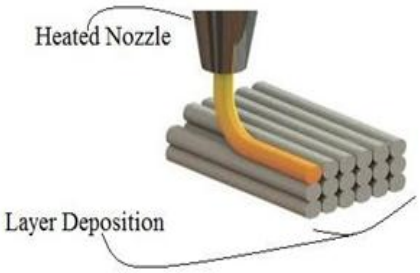

Figure 2. Layer depostion in FDM

 ISBN: 978-93-5288-448-3

III. LITERATURE REVIEW

B.V.Reddy et.al.[3] Performed 3 level Box-behnken experimental design for 3 process variable like nozzle temp.,chamber temp.,& road gap on interroad & inter layer bond strength in addition to bond strenght & surface roughness. P.J.Nuhez et.al.[4] used dimension elite 3D printer with ABS plus P430 thermoplastic,study analyzed dimensional precision,flatness error & surface texture obtaion with this material in order to establish quality range for professional 3D printing. Vijay B. Nidagundi et.al.[5] used Taguchis L9 orthogonal array using ANOVA to optimize process parameter like layer thickness, part orientation angle,fill angle & gives values & effect on UTS,surface roughness,dimensional accuracy and manufacuturing time. Tobias Lieneke et.al.[6] Investigate regarding dimensional accuracies were performed within project dimensional tolerances for additive manu.(DT-AM).A new method was developed that can be used systematically analyzed geometrical accuracies.finally derived tolerance value were compared to values reached by conventional manufacturing Techniques. Chil-chyuan kuo et.al.[7] developed acetone vapor polishing system for precision surface polishing of ABS parts fabricate by FDM.The surface roughness measure after and before polishing treatment using optical microscopy. C.A.Griffiths et.al.[8] shown an approaches to analyse the effect of machine build parameters on final properties of build part as well as on the effect of efficiency factors such as material usage & build time.build parameters are orientation, infill %,no. of shell(boarder printed for each layer),layer height(thickness) & output para. are 1.efficiency- build time,energy consumption, part weight,scrap weight&2. performance- tensile strength,young's modulus.used PLA filament of 1.75 mm diameter of material. Caterina Casavola et.al.[9] used classical laminate theory(CLT) to describe mech.behaviour of FDM printed part. Values of elastic modulus in longi.& transverse direction to fibre,shear modulus& poission's ratio experimentally determined. Finally comparision between CLT and experimental result. conduct on ABS and PLA has been carried out on symmetric and balanced speciman. in short orthotropic mech.properties fo FDM part by CLT. Yu-an Jin Hui Li Yong He Jian-zhong Fu[10] carried out quantitative analysis of surface profile in FDM.A new approach to characterize surface profile of FDM.Mathematical models for both top surface & side surface are developed.critical parameters are categorized into pre process parameter like layer thickness, stratification angle and fabrication parameter like ration between flowrate and feedrate to investigate their impact on surface profile. and then optimize the process parameter to enhance the surface quality.therefore much more desirable surface achieved in FDM after investigating surface profile. Vishal Francis et.al.[11] carried out experimental investigation on FDM of polymer-layered silicate nanocomposite.used OMMT(Cloisite 30B) material.The melt intercalation process used for developing nanocomposite.to investigate the interfacial interaction between nano clay &polymer,SEM(scanning electron microscopy) images were taken.DSC(differential scanning calorimetry) & TGA analysis carried out to examine thermal behaviour.3 different proportion of master batch were taken the find and compare the vales of tensile and yield strength,elongation at break, modulus & in part fabrication-effect on compressive strength, hardness, porosity and neck size. Nevin hill et.al.[12] proposed that orientation plays a major role in failure mechanism for FD polycarbonate parts.tensile speciman in horizontal orientation alone is considered in study & speciman varied from 0-90' in intervals of 15'.vertical and horizontal orientation are not considered in study. Sarat Singamneti et.al.[13] studied the mesostructure of curved layer deposition for thin shell like parts. The study reveals that the masostructure of FDM build parts plays a significant role in load bearing capacity. Sood et.al.[14] studied the compressive strength of FDM built ABS parts by considering parameters like layer thickness, part build orientation, raster angle, raster width,air gap. however author built the speciman only in horizontal orientation by varying the raster angle w.r.t. base of build table. Ahn et.al.[15] rep5rted the anisotropic strength of FDM parts depends on parameters like raster orientation, raster width,air gap,build temp.The research was carried out in varying the raster fill pattern of specimen in horizontal orientation but not considering other orientation.

So far in most of Research the main aim is to increase the dimensional accuracy and improve surface roughness. Most of researchers have done work on either changing the material or they have optimized the process parameters. There are very little Research in way of making an proper methodology or an programmable tool they can work according to user requirement on finishing parameters. So in this work that Research gap have been adopted.

IV. METHODOLOGY

As from literature or previous Research work it had been conclude that for better surface finish some better methodology required. As From literature we can conclude that for better surface finish, Layer thickness became critical parameter. So in this work we had define an algorithm which generally this problem and by using this algorithm we can made an tool for future work. As layer thickness can be varying for top surface and side surface, so we can not use the same layer thickness for top and side surface for better surface finish[4]. This point might be not in touch with previous Researchers, so in this paper a novel approach is derived for the same.

V. CVLT ALGORITHM

Continuous Variable Layer Thickness(CVLT) is an systematic approach for getting better surface finish and surface quality. CVLT is mainly based on the way layer thickness varying for top surface and side surface. So in this algorithm it sensed the surface and according to that the layer thickness will varying. As shown in fig1. The flowchart of CVLT, the basic of that

 ISBN: 978-93-5288-448-3

algorithm is to identify the layer thickness for proper surface i.e. top surface or side surface.

As initial step is always to slicing the part file and defined the layer thickness for side surface and top surface. After that the tool with scan the full length of the object and according to that the object will divided in number of small element and also it will scan height of the object as well. For this work we have consider the object at zero degree orientation i.e. at horizontal position. So this is initial procedure that been done before initialize layer deposition process.

As shown in fig.1 after that the layer deposition process may begin. For that also the condition is used for the selection of proper layer thickness in the same. As initially the two layer thickness is defined as:

T1 = Layer thickness for top Surface

T2 = Layer thickness for side surface

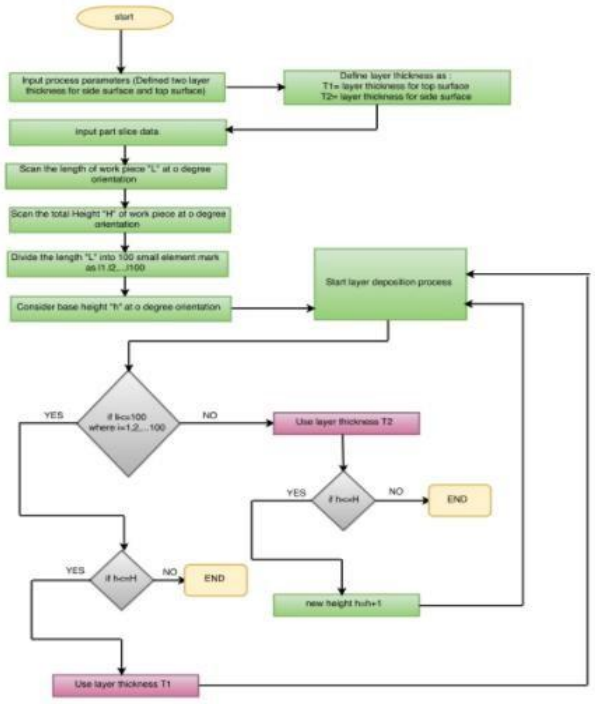

Fig.3 Flow chart of CVLT Algorithm

After that layer deposition process takes place. The condition is given that if the element is in arrange of top surface element, (it can be identified as top surface) and also that element having lower size than height H, so means it is top surface of the element and so that we have to use the T1 layer thickness. And after that again layer deposition process start. Another condition is shown in flow chart that if the above mentioned condition failed, so it means as the element or node is of side surface so the tool will change its layer thickness as T2. And as after that again layer deposition process takes place. So this process is repeated up to the total height of object H. as show in flow chart when the condition of In<H (n=1,2…) false the process will stop.

VI. CONCLUSION

In this Research work we had derived a new algorithm called "Continuous Variable Layer Thickness" in that the layer thickness of the deposited material is continuously varying according to the surface of the Component i.e. top surface or side surface. After defined that algorithm we can conclude that a novel approach may be lead to the new sight in Surface finish and surface quality or surface accuracy. Design a tool which work on that algorithm can be taken as future work.

REFERENCES

[1]. Anderson icemakers: the new industrial revolution, 1st ed.crown business; 2012
[2]. www.Staples.com,www.shapeways.com, www.sculpteo.com
[3]. B.V. Reddy, N.V. Reddy, A. Ghose, "Fused deposition modelling using direct extrusion", Virtual and Physical prototyping, Taylor & Francis Pub., 13 April 2007.
[4]. P.J. Nunez, A.Rivas, E. Garcia-Plaza, E. Beamud, A. Sanz-Lobera, "Dimensional and surface texture characterization in Fused Deposition Modelling (FDM) with ABS plus", MESIC 2015, Elsevier Pub., Procedia Engg. Vol. 132,2015, p.p. 856-863
[5]. Vijay B. Nidagundi, R.Keshavamurthy, C.P.S.Prakash, "Studies on Parametric Optimization for Fused Deposition Modelling Process", Elsevier Pub., Materials today: Proceeding vol.2, 2015 p.p. 1691-1699.
[6]. Tobias Lieneke, Vera Denzer, Guido A.O. Adam, Detmar Zimmer, "Dimensional tolerances for additive manufacturing: Experimental investigation for Fused Deposition Modelling", Elsevier Pub.,Procedia CIRP, vol.43, 2016, p.p. 286-291.
[7]. Chil-Chyuan Kuo, Rui- Cheng Mao, "Development of a precision surface polishing system for parts fabricated by fused deposition modeling", Taylor & francis Pub., Materials and manufacturing Processes, Sep. 2015.
[8]. C.A.Griffiths, J.Howarth, A.Rees,G. de-Almeida Rowbotham, "Effect of build parameters on processing efficiency and material performance in fused deposition modelling", Elsevier Pub., Procedia CIRP vol. 49, 2016, p.p. 28-32.
[9]. Caterina Casavola, Alberto Cazzato, Vincenzo Moramarco, Carmine Pappalettere, "Orthotropic mechanical properties of fused deposition modelling parts described by classical laminate theory", Elsevier Pub., Materials and design, vol. 2, 2016, p.p. 453-458.
[10]. Yu-an Jin Hui Li Yong He Jian-zhong Fu, "Quantitative analysis of surface profile in fused deposition modeling", Accepted Manuscript, Additive manufacturing, 2015.
[11]. Vishal Francis, Prashant K. Jain, "Experimental investigations on fused deposition modelling of polymer-layered silicate nanocomposite", Taylor & Francis Pub., Virtual and Physical Prototyping, Apr. 2016.
[12]. Nevin Hill, Mehrdad Haghi, "Deposition direction – dependent failure criteria for fused deposition modelling polycarbonate", Rapid prototyping journal 2014, 20(3), p.p. 221-227.
[13]. Sarat Singamneni, Asimava Roychoudhury, Olaf Diegel, Bin Huang, "Modeling and evaluation of curved layer fused deposition", Journal of material processing technology, 2012, 212, p.p. 27-35.
[14]. Sood, A.K., ohdar,R.K., Mahapatra, S.S., "Experimental investigation and empirical modeling of FDM process for compressive strength improvement", Journal of advanced research, 2012, 3, p.p. 81-90.
[15]. Ahn, S.H., Montero, M., Odell, D., Roundy, S., Wright, P.K., "Anisotropic material properties of Fused Deposition Modelling ABS", Rapid prototyping journal, 2002, 8(4), p.p. 248-257

 ISBN: 978-93-5288-448-3