A REVIEW ON OPTIMZATION OF FUSED DEPOSITION PROCESS PARAMETERS

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Abstract - Fused deposition modeling (FDM) is most popular additive manufacturing technologies and they are applicable in automobiles, air crafts and medical fields. The FDM process is initially used for rapid prototyping models after that additive manufacturing technology. Further developed into rapid prototype to rapid manufacturing as we can see the present production technology tires hard to meet customer needs like quality quantity and cost of products. Recently researchers explored various ways to improve the mechanical properties and part quality. This article aims to review the research done so far in determining and optimizing the process parameters.

***Key Words*:** Fused deposition modelling (FDM), Additive manufacturing, process parameters, rapid prototyping.

1.INTRODUCTION

Fused Deposition Modeling is the most widely used 3D printing process and material extrusion type additive manufacturing process. Stratasys founder S. Scott Crump first developed and patented this process in 1988. And when the patent expired in 2009, it paved the way for commercial FDM printers. In FDM 3D objects are created from thermoplastic materials and applied layer by layer onto the printer bed. This material is continuously melted and applied from an extrusion die. The material is in filament form and is fed to a moving heating nozzle. Over the past decade, AM has made great strides in the following areas: Customer-specific areas of production where this change is taking place It was at a major stage that allowed us to shift focus from traditional manufacturing methods. This form of AM is commonly referred to as Rapid Prototyping (RP). 3D printing that lets you build parts layer by layer Approach small volumes with smaller size and complexity Bespoke design. Notable Developments in Various AMs the process helps create a variety of mechanical parts without using traditional tools and dies. This additive is being improved almost every day. The manufacturing process helps us make our products better Strength, dimensional accuracy, surface roughness. at the same time Temporarily, various restrictions act as barriers to their rules Manufacture of fully functional mechanical parts. cause High raw material costs, long manufacturing lead times, etc. Due to the production of large quantities of components, its scope is restrained, Limit your application to small components. in the process new product design and manufacturing development, these phases It is called the critical area because decisions can be made in this phase. The impact on the final product is greater. The most important factor is Focus is on recycling, minimizing risk, sustainability, Manufacturability, materials, durability, assembly, cost, maintenance and other factors. The biggest challenge in AM technology is producing components with comparable sound quality. Simultaneously with requirements such as form, function and cost Time to secure AM system production capacity

2.LITERATURE REIVEW

R.Rezaie (2013): This paper investigates the issues and opportunities for the application of topology optimization methods for (AM). Converting topology optimization output files to usable AM input data for production of meso-scale structures for realizing intermediated density regions are investigated. This methodology is then implemented for the fused deposition modeling process (FDM). Based on the implemented tool a case study is redesigned, fabricated and evaluated.

Mohamed (2016): This study also aims to develop mathematical models in order to establish nonlinear relationship between process parameters and dimensional accuracy. The results show that I-optimality criterion is very promising technique in FDM process parameter optimization. Confirmation experiments show that the proposed method has great advantages in the aspect of both accuracy and efficiency compared with traditional methods proposed in previous studies.

Abeykoon (2020): This research is focused on studying the properties of 3D printed specimens (i.e., mechanical, thermal and morphological) with varying processing conditions such as infill pattern, infill density and infill speed, and also with different printing materials. A number of testing techniques such as tensile, bending, compression, differential scanning calorimetry (DSC), thermal gravimetric analysis (TGA), thermal imaging, and scanning electron microscopy (SEM) were used for performing a comprehensive analysis.

Vijay B (2015): This paper discusses optimization studies on process parameters for fused deposition modelling (FDM). Layer thickness, Orientation angle and fill angle are the process variables considered for optimization. Ultimate tensile strength, surface roughness, dimensional accuracy and manufacturing time were considered as response parameters. Experiments were designed using well known Taguchi's L_9 orthogonal array, Taguchi's S/N ratio was used to identify optimum parameter values.

Buraaq Alrawi (2017): The presented paper provides an experimental study to investigate the independent effect of each processing parameter on the mechanical properties and dimensional accuracy repeatability of FDM parts. A total of 18 test specimen samples were printed using varying processing parameters. In order to investigate the repeatability and resulted tolerances, the dimensions of these specimens were measured and compared with a 3D CAD model. The presented work utilizes a tensile test per ASTM D638 standards to obtain the mechanical properties of each fabricated sample.

Rao (2015): The NSTLBO algorithm proposed to solve the multi-objective optimization problems of the FDM process in this work is a posteriori version of the TLBO algorithm. The NSTLBO algorithm is incorporated with non-dominated sorting concept and crowding distance assignment mechanism to obtain a dense set of Pareto optimal solutions in a single simulation run. The results of the NSTLBO algorithm are compared with those obtained using non-dominated sorting genetic algorithm (NSGA-II) and the desirability function approach. The Pareto-optimal set of solutions for each problem is obtained and reported. These Pareto-optimal set of solutions will help the decision maker in volatile scenarios and are useful for the FDM process.

Villalpando (2014): From this paper, a model is developed that serves as a predictive tool to: (i) estimate the mechanical properties and (ii) calculate the build time and materials utilized based on various internal structural configurations for the component's application. A model that generates an optimal solution (minimum material, minimum build time, etc.) needs to be developed. Using the collected data as a foundation, an optimization model that considers the build time, material usage, surface finish, interior geometry, strength characteristics, and related parameters is presented and can be used to assist designers making informed decision with respect to strength, material usage and time, etc. is developed using the Genetic Algorithm approach.

D Addona (2021): This article focuses on the optimization of FDM process parameters using an approach based on Desirability Function.

Qattawi (2018): This review article results shows, that for generally better dimensional accuracy, a lower extrusion temperature, smaller layer thickness, lower infill percentage, and hexagonal infill pattern were required. In addition, current FDM fabrication process usually generates parts with larger dimensions as compared to the CAD model. On the other hand, to increase the strength of FDM parts, a higher extrusion temperature, an optimized layer thickness, a triangular infill pattern, and a higher infill percentage are required. Ductility can be improved by switching to rectilinear infill pattern and by increasing the layer thickness.

Saty Dev (2021): The aim of this study is an experimental investigation and optimization of FDM process variables using a hybrid statistical approach to attain desired flexural strength. The hybrid approach combines response surface methodology (RSM) and genetic algorithm (GA). The test samples are manufactured using FDM type 3D printer. The dimensions of samples considered according to American Society for Testing and Materials (ASTM) D790 standard. The acrylic butadiene styrene (ABS) of standard grade is considered as manufacturing material.

3.FUSED DEPOSITON MODELING:

In today's competitive environment, to meet customer-specific requirements Customer requirements and satisfying needs, it must Be an established condition of use for any AM process. There are several related methods, until 3D printing, Fused Deposition Modeling (FDM) is the most comprehensive Methodology used. The printers used are used with FDM technology Using a thermoplastic filament type, this filament is Heated until melting temperature is reached, then layer by layer Extrusion Brings 3D Manufacturing structure. FDM became commercially available Schematic diagram of the 1990s and principle The function of in et al. The FDM process described is shown in Figure 1. Uninterrupted Availability of Materials Given Used to print parts on top of each other. heating system Elements present in the condenser head are used to bring the filament into a semi-liquid phase extruded through a die Go to the print area to print the actual component. The most important task in this particular process is to fuse subsequent layers before solidification. Fusion can have a significant impact on other properties of the building part. The FDM process has many advantages and limitations. Process simplification costs are incurred and higher Print speed is considered to be the most informative fact on the other hand, complex process parameters that directly affect Component design is seen as a major limitation and there is not enough literature available to be comprehensive. Analysis of all parameters. Researchers are now working on it This main concern for getting optimized parameters A generalized process that can be addressed to meet customer-specific requirements The body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material.

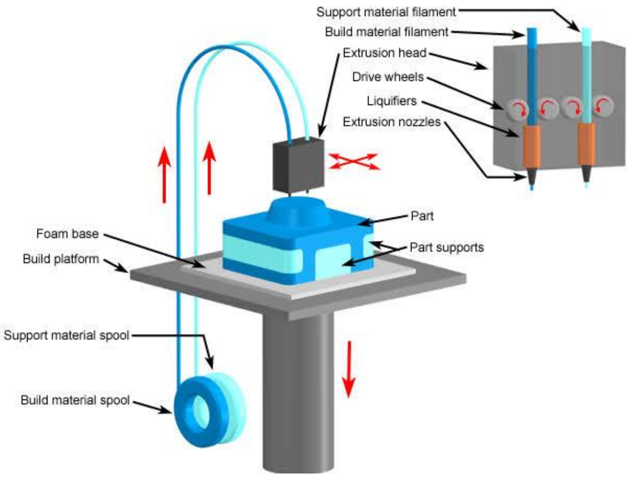

Fig 1 fused deposition modeling

4.FDM PROCESS PARAMETERS

FDM Process Parameters Several parameters have a significant impact on component properties and production efficiency. some most Critical factors are layer thickness, screen angle, build direction, fill density, print speed, fill pattern, extrusion temperature, screen width, die diameter, contour width, contour air gap, contour number, air gap.

4.1 Build orientation

Describes the path where a particular component is located Adjust on construction platform about 3 main axes: X, Y, Z each machine tool. Fenn et al. His print Two test patterns belonging to the PA12 filament category Using his FDM printer in different directions and its. definite direction of pressure Additionally demonstrated the effect that building orientation has Compression and Mechanical Properties of ABS (Acrylonitrile Butadiene Styrene) part made in FDM and they understood this the ultimate compressive strength shows a downward curve when Building pattern orientation changed The temperature maintained inside the heated nozzle of the FDM before the material is extruded is called the extrusion temperature. Affects the viscosity of the material used for printing

This affects part properties. The optimum temperature must be maintained as the filament material may become more or less fluid. This can degrade the components.

be forged. kings. shows that the residual stresses produced when the material is extruded from the die cool it from its initial temperature (associated with the glass transition) to the temperature of the chamber. This occurs as a result of variations in deposition rate. This internal stress can lead to strain between and within layers, and even failure of the manufactured parts. From 00 to 900 Tensile strength showed the same tendency as architecture Alignment varies from 00 to 900. Up to 60% reduction found in tensile strength values.

4.2 Layer Height

It is called the amount of material deposited along Vertical axis of FDM machine in one pass. height of the amount of material applied is always smaller than the nozzle diameter of extruder. This parameter is completely on the tip of the extruder diameter. Elena et al. shown in their experimental studies. Its layer height plays an inevitable role in bending and bending Impact properties of manufactured components. To get better flexural properties they suggested a minimum layer thickness. Increasing layer thickness showed better impact properties. In addition, Barrios et al. Considering this layer height as one, we developed an orthogonal experimental design to determine satisfactory values for various printing parameters Reduction Factors of Slip Angle and Surface Roughness FDM print components and their graphic representations A factor that is considered along with layer height.

4.3 Raster Angle

The raster angle affects the forming accuracy and the mechanical performance of the printed sample. Generally, the raster angle can be selected from **0° to 90°**. Thus, four levels of raster angle were selected: 0°, 15°, 30° and 45°. 2.4. Preparation of Samples the PLA samples were fabricated by an Ein Start-S 3D printer.

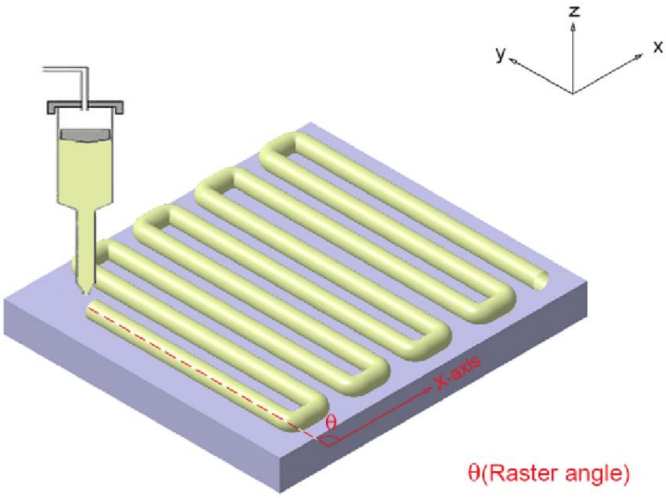

Fig 2. Diagrammatic representation of the layer height employed by Barrios et al

4.4 Printing speed

A good print speed for 3D printing ranges from **40mm/s to 100mm/s**, with 60 mm/s being the recommended. The best printing speed for quality tends to be in the lower ranges, but at the cost of time. You can test print speed by printing a speed tower to see the effect of different speeds on quality.

4.5 Infill density

Fill density refers to the amount of material printed on each component. Infill density directly governs the properties of printed components. Lower densities have a greater impact on mechanical properties, while higher density components have better properties It has better mechanical properties than the former, but takes longer to prepare the component

4.6 Extrusion temperature

The temperature maintained inside the heated nozzle of the FDM before the material is extruded is called the extrusion temperature. Affects the viscosity of the material used for printing This affects part properties. The optimum temperature must be maintained as the filament material may become more or less fluid. This can degrade the components.be forged. kings. shows that the residual stresses produced when the material is extruded from the die cool it from its initial temperature (associated with the glass transition) to the temperature of the chamber. This occurs as a result of variations in deposition rate. This internal stress can lead to strain between and within layers, and even failure of the manufactured parts.

4.6 Nozzle diameter

The nozzle diameter greatly affects the road width. This is because the nozzle diameter directly affects the screen angle plot reported by Wu et al. In his experimental work on his 3D printing of components using polyetheretherketone.

Pressure drops across the condenser. Turner et al. It has been shown experimentally that her L/D ratio (length and diameter) of the nozzle also contributes to pressure drop variation. It can be seen that the pressure drops increases when the value of D is smaller than the diameter. Selecting the optimum nozzle diameter is critical to maintaining a good and even flow of extruded material. It has also been observed that the nozzle diameter has a significant effect on the extrusion time, which should be investigated in detail.

Consider all the factors that affect your particular process and optimize the nozzle diameter value. Larger nozzle diameter takes longer, smaller nozzle diameter takes longer Push out. It was also found that the nozzle diameter greatly affects the geometric error.

5.SURFACE ROUGHNESS AND DIMENSIONAL ACCURACY

Surface roughness and geometrical accuracy must be given much more attention if an FDM component is to be used as a readily accessible functional component. component parts produced by FDM to have good surface roughness and geometrical precision, there should be very little to no post-processing. Considering the current research findings, the critical variables that are important in assessing geometric accuracy and surface roughness layer thickness. Lower layer thickness allows us to create items with better geometrical and surface finish. From the preceding research, it can be inferred that, in addition to layer thickness and number, printing speed and lower extrusion temperature also contribute to increased surface roughness and geometric correctness.

The orientation of the build is a factor that affects geometric precision. Building in a z-direction aids in increasing dimensional accuracy. And as well According to research, the Surface roughness is diminished by negative air gap.

6.CONCLUSION

This review research provided a deeper understanding of the 4 ffect of the FDM process settings and the associated compone nts qualities.

These factors are important because they affect the printed par t quality and FDM process effectiveness.
After reviewing the effects of various processing parameters, i t is clear that layer height or thickness is regarded as a crucial element in defining the component quality.

However, there is a great opportunity for conducting research activities in these parameters as the current investigat ions are primarily carried out for the standard values of layer h eight, raster orientation, and nozzle diameter which may not h old well for in the era of customization. It is also observed that the orientation of the raster plays a dominant part in determini ng the mechanical features of polymer components.

There are still a lot of unexplored elements that need to be inv estigated since they may have a significant impact on the prod uct quality and process efficiency, despite the fact that researc hers are heavily focused on the important parameters and th eir optimization.

However, current investigations are mainly on the default values of layer height, grid orientation and nozzle diameter, so there is great opportunity for research activities on these parameters. It has also been observed that grid orientation plays a dominant role in determining the mechanical properties of polymer components. While researchers focus on critical parameters and their optimization, there are still many unexplored factors that need to be studied as they can have a significant impact on product quality and process efficiency.

7.METHODS FOLLOWE

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