DESIGN AND ANALYSIS OF EXTRUDER HEAD OF FUSED DEPOSITION MODELING

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ABSTRACT - In this study, Additive manufacturing (AM) technologies enables the manufacturing of parts or products directly from 3D CAD models. The earliest 3D printing manufacturing equipment was developed by Hideo Kodama of the Nagoya Municipal Industrial Research Institute, when he invented two additive methods for fabricating 3D models. In distinction to the traditional methods of manufacturing where in the raw material is fabricated to the final product based on subtractive principles, these Additive manufacturing processes are based on additive principle for the part manufacturing. Different Additive manufacturing processes use different methodologies of adding up the material to form the final product. Advantages like manufacturing complex geometries, zero tooling along with no human intervention, manufacturing in single set-up etc., are few of them. Additive manufacturing (AM) was developed initially as a technique for rapid prototyping, to visualize, test and authenticate a design, before end-user production of the design. In recent years, Additive Manufacturing (AM) technique Fused Deposition modeling (FDM), has developed to become a rapid manufacturing technique because of the ability to produce complex parts layer-by-layer in lesser production cycle time than as compared to conventional machining processes. During the last decade, Additive manufacturing has attracted huge attention in various industries ranging from manufacturing, medical, automotive concept development etc., in developing products to meet the expectations of both the designers as well as manufacturers. Fused deposition modeling (FDM) is one among those most popular Additive manufacturing technologies where in the filaments are added one beside other forming a layer, and then layer upon layer to build the final product. Besides the simplicity of operation like ability to fabricate parts with locally controlled properties with varied materials, fused deposition modeling has resulted in manufacturing parts not only for prototyping but also functional parts.

Keywords-AM,FDM,3D Printing

I INTRODUCTION

Fused deposition modeling (FDM) is a process for developing rapid prototype (RP) objects by depositing fused layers of material according to numerically defined cross sectionalgeometry. The quality of fused deposition modeling produced parts is significantly affected by various parameters used in the process. The object to be built is modeled using a Computer-Aided Design (CAD) software package. Solid modelers, such as Pro/ENGINEER, tend to represent 3-D objects more accurately than wire-frame modelers such as AutoCAD, and will therefore yield better results. The various CAD packages use a number of different algorithms to represent solid objects.To establish consistency, the STL (stereo-lithography), the first RP technique) format has been adopted as the standard of the rapid prototyping industry.A structure support base is positioned on an elevator structure and immersed in a tank of liquid photosensitive monomer, with only a thin liquid film above it. A UV laser locally cross-links the monomer on the thin liquid film above the structure support base.Additive manufacturing method where the cross section of the detail is cut into a thin material which is then successively glued to the previous layer and cut to shape with a knife or laser cutter. Objects printed with this technique may be additionally modified by machining or drilling after printing.

In particular, a number of attempts have been made to determine the optimum fused deposition modeling parameters associated with the best surface finish, dimensional accuracy, and tensile strength. The surface finish is a greater handicap than strength for Rapid Prototyping parts, because the functionality of the part can be affected severely by a poor surface. Part orientation and raster angle are important process parameters that affect mechanical properties. Very few attempts have been made to determine the effect of part deposition orientation on mechanical properties together with production cost. However, more importantly, part orientation and production costs are closely related issues. By selecting an optimal part orientation in a fused deposition modeling process, it is possible to shorten the production time and reduce material consumption. Manufacturing of different components simultaneously and sequentially, especially for low volume production, is possible. Most machines should be designed in such a way that they have inherent trade-offs among part size, accuracy, strength, surface smoothness and speed. In the current research work testing of the parts that can be printed using different input parameters then reading the output parameters followed by testing of the printed partsis done.

III. DESCRIPTION OF THE PROPOSED WORK

A. RESPONSE SURFACE METHODOLOGY

Response surface methodology is very useful and modern technique for the prediction and optimization of machining performances. In the present study, the strength of PLA material part made by fused deposition modeling machine has been predicted and also process parameters have been optimized by Response surface methodology. In this chapter, overview of Response surface methodology has been discussed. Response surface methodology (RSM) is a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes. The most extensive applications of Response surface methodology are in the particular situations where several input variable potentially influence some performance measure or quality characteristic of the process. This performance measure or quality characteristic is called the response. The input variables are sometimes called independent variables. The field of response surface methodology consists of the experimental strategy for exploring the space of the process or

independent variables, Empirical statistical modeling to develop an approximated relationship between the yield and the process variables. Also, with the help of response surface methodology, optimization can be done for finding the values of the process variables that produce desirable values of the response.

In general, the relationship between the response y and independent variables ξ_1, ξ_2, ..., ξ_k is $Y = f(\xi_1, \xi_2, \ldots\ldots\ldots\xi_k) + \varepsilon$ ....(4.1) where ε includes effects such as measurement error on the response, background noise, the effect of other variables, and so on. Usually ε is treated as a statistical error, often assuming it to have a normal distribution with mean zero and variance σ^2. Then,

$E(y) = \eta = E[f(\xi_1, \xi_2, \ldots\ldots\ldots\xi_k)] + E(\varepsilon) = f(\xi_1, \xi_2, \ldots\ldots.\xi_k)$ ....(4.2) The variables ξ_1, ξ_2,...., ξ_k in equation are usually called the natural variables, because they are expressed in the natural units of measurement, such as degrees Celsius, pounds per square inched. In much Response surface methodology work, it is convenient to transform the natural variables to coded variables x_1, x_2, ... X_k, which are usually defined to be dimensionless with mean zero and the same standard deviation. In terms of the coded variables, the response function equation (4.2) can be written as $\eta = f(x_1, x_2 \ldots\ldots\ldots\ldots x_k)$ ....(4.3) because the form of the true response function is unknown, it should be approximated. In fact, successful use of Response surface methodology is critically dependent upon the experimenter's ability to develop a suitable approximation. Usually, a low-order polynomial in some relatively small region of the independent variable space is appropriate. In many cases, either a first-order or a second-order model is used. The first-order model is likely to be appropriate when the experimenter is interested in approximating the true response surface over a relatively small region of the independent variable space in a location where there is little curvature in response function. For the case of two independent variables, the first-order model in terms of the coded variables is given by, $\eta = \beta_0 + \beta_1 x_1 + \beta_2 x_2$ ..... (4.4) the form of the first-order model in equation (4.4) is sometimes called a main effects model, because it includes only the main effects of the two variables x_1 and x_2. If there is an interaction between these variables, it can be added to the model easily as expressed below: $\eta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2$ ....

(4.5) this is the first-order model with interaction. Adding the interaction term introduces curvature into the response function. Often the curvature in the true response surface is strong enough that the first-order model (even with the interaction term included) is inadequate. A second-order model will likely be required in these situations. For the case of two variables, the second-order model is: $\eta = \beta 0 + \beta 1 x_1 + \beta 2 x_2 + \beta 11 x_{21} + \beta 22 x_2 2 + \beta 12 x_1 x_2$…..……(4.6) this model would likely be useful as an approximation to the true response surface in a relatively small region. The second-order model is widely used in response surface methodology for several reasons: the second-order model is very flexible. It can take on a wide variety of functional forms, so it will often work well as an approximation to the true response surface. It is easy to estimate the parameters in the second-order model. The method of least Squares can be used for this purpose. There is considered to be practical experience indicating that second-order models work well in solving real response surface problems. In general, the first-order model is: $\eta = \beta 0 + \beta 1 x_1 + \beta 2 x_2 + \ldots\ldots\ldots + \beta k x_k$……(4.7) and the second-order model $\eta = \beta 0 + \ldots\ldots..$ (4.8) Finally, it should be noted that there is a close connection between RSM and linear regression analysis. For example, say, the following model is considered: $\eta = \beta 0 + \beta 1 x_1 + \beta 2 x_2 + \ldots\ldots\ldots + \beta k x_k + \varepsilon$ ……………..………………(4.9) the β's are a set of unknown parameters. To estimate the values of these parameters, the experimental data must be needed.

III CONCLUSION

Effect of four process parameters layer thickness, extrusion temperature, infill density and air gap are studied on three responses viz., tensile strength, flexural strength and impact strength of test specimen. Experiments were conducted using centre composite design (CCD). The main reason attributed for weak strength is the distortion within the layer or between the layers. To get the optimal level concept of simultaneous optimization of three responses desirability function is used for maximizing the all the responses and found out the optimal parameter setting.

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