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Process Parameters Optimization Of FDMProcess And Application Of Taguchi Approach And ANN – The Review

RajendraDarbar [1] Prof. D. M. Patel [1]Prof. Jaimin Patel [2]
Research scholar Associate professor Assistant professor
[1] U. V. Patel College Of Engineering, Ganpat University, Kherva, Mehsana
[2] K. J. Faculty Of Engineering And Technology, Mehsana

Abstract
Rapid prototyping (RP) refers to a class of technology that can automatically construct the physical models from computer aided design (CAD) data. Fused deposition modeling is one of the RP process that produced prototype from plastic material by lying track of semi molten plastic filament on to a platform in a layer wise manner from bottom to top. The quality of FDM made parts are highly depends upon various process parameters of FDM process.Hence optimization of FDM process parameters is necessary in order to improve the quality of parts. The purpose of this paper is to explore the reviews for various optimization methods used for process parameter optimization of FDM process and application of Taguchi approach and Artificial neural network (ANN).
Key words: Fused Deposition Modeling (FDM), Optimization, Taguchi approach and ANN

I. Introduction
Today there is a great competition in the manufacturing industries. So, it has become important for the new products to reach the market as early as competitor. Hence the focus of industries has shifted from traditional product development methodology to rapid prototyping in order to save both time and cost. The Fused deposition modeling is one of the RP technology by which physical objects are created directly from CAD model using layer by layer deposition of extrusion material. But, the quality of FDM produced part is highly depends upon various process parameters used in this process. So, it is necessary to optimize FDM parameters. Optimization of process parameters helps to finding out correct adjustment of parameters which improve the quality of the prototypes. The Taguchi method is most widely used for design of experiments because it can be provide simplification of experimental plans and reduced the number of experimental runs. The Artificial neural network is the powerful tool which may be used for prediction of experimental results.

II. Problem Formulation
The quality and cost of the product is most important things to satisfy the customer. But as discussed earlier the quality of FDM produced parts are highly depends upon various process parameters of the process. So, it is necessary to carried out the optimization of FDM parameters. It will improve the quality of functional parts. There are so many methods used for optimization, design of experiments and prediction purpose. Without brief review it is difficult to say which one is better. This paper helps to find out which method is better for its particular application and we will use best method to achieve our goal.

III. Process Parameter Optimization Of FDM Process
Es. Said et al. [1]have studied the effect of different layer orientation on mechanical properties of ABS rapid prototype solid model. The sample was fabricated by a Stratasys rapid prototyping machine in five different layer orientations. They conducted impact test on ABS prototype and found that o degree orientation where layer were deposited along the length of the sample displayed superior strength and impact resistance overall the other orientations. It is also observed that the anisotropic properties were probably causes by weak interlayer bonding and interlayer porosity.

B. H. Lee et al. [2] have perform the experiments for finding out the optimal process parameters of Fused deposition modeling rapid prototyping machine in order to achieve maximum flexibility of ABS prototype. Selected FDM parameters and their levels are shown table 1. They have used Taguchi method for design of experiments. They also employed signal-to-noise (S/N) ratio and analysis of variance (ANOVA) to investigate the process parameters in order to achieve the optimum elastic performance of ABS prototype. From the results it was found that FDM parameters layer thickness, raster angle and air gap significantly affect the elastic performance of the compliant ABS prototype.

Table 1 FDM parameters and their levels

Symbol	FDM parameter	Unit	Level 1	Level 2	Level 3
A	Air gap	mm	Solid fine	Sparse	Double wide
B	Raster angle	degree angle	0	45	60
C	Raster width	mm	0.305	0.655	0.980
D	Layer thickness	mm	0.178	0.254	0.305

A. K. Sood et al. [3] Have studied the effect of five important FDM machine process parameters such as layer thickness, part build orientation, raster angle, raster width and air gap on compressive strength of test specimens. They also develop the statistically validated predictive equation to find out optimal process parameters setting. The experiments were conducted using central composite design (CCD) method. Effect of various factors and their interactions are explained using response surface plot. They have found that fibre-fibre bond strength must be strong which can be achieving by controlling the distortions arising during part build stage.Optimization of process parameters gives the maximum compressive stress of 17.4751 MPaand the optimum value of layer thickness, orientation, raster angle, raster width and air gap as 0.254 mm, 0.036 degree, 59.44 degree, 0.422 mm and 0.00026 mm respectively.

JaiminPatel et al. [4] they have investigate the effect of three important FDM parameters like layer thickness, orientation angle and raster width on tensile strength and flexural strength of FDM fabricate test specimens. They have selected three FDM parameters each of at three levels for study. Taguchi method was employed for design of experiments. Analysis of variance and signal to noise ratio were used to find out which parameter is significant over output response. After the experimental work and ANOVA analysis they have conclude that the layer thickness and orientation angle is highly significant to response characteristics whereas raster width have a little effect on it which is shown in Figure 1.

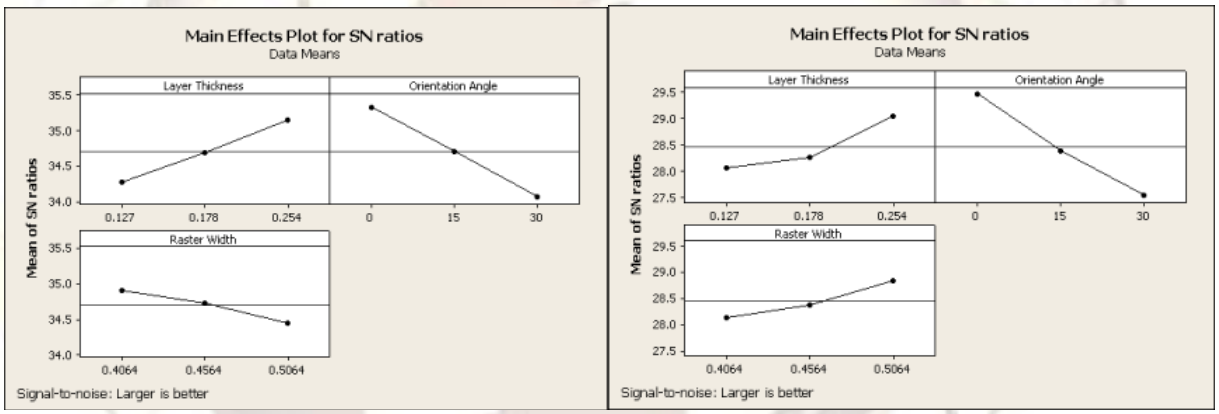

Figure 1 Effects of FDM parameters on Tensile and Flexural strength of test specimen

Anoop Kumar et al. [5] have studied the influence of important process parameter viz. layer thickness, part orientation, raster angle, and air gap and raster width along with their interaction on dimensional accuracy of fused deposition modeling (FDM) process ABS parts. They have observed that the shrinkage is dominant along with the length and width direction of built parts. But the positive deviation from the required value is observed in the thickness direction. Optimum parameter settings to minimize percentage change in length, width and thickness of standard test specimen have been found out using Taguchi's parameter design. They were used artificial neural network (ANN) for prediction purpose. Finally they conclude that for minimizing percentage change in length higher layer thickness (0.254 mm), 0orientation, maximum raster angle (60), medium raster width and 0.004 air gap will give desire results. On the other hand lower value of layer thickness (0.127mm), orientation (0), raster angle (0) and higher value of raster width and minimum value of air gap (0.004mm) will minimize percentage change in thickness of test specimen. They adopted grey Taguchi method to fabricate the part in such a manner that all the 3 dimensional shows minimum deviation from actual value. Finally maximization of grey relational grade shows that layer thickness of 0.178 mm, part orientation of 0 degree, raster angle of 0 degree, road width of 0.4564 mm and air gap of 0.008 mm will produced overall improvement in part dimensions.

Application of Taguchi Approach

Leladhar et al. [6]They have done experimental investigation to conduct research of WAJM machining parameters impact on MRR and

surface roughness of work piece of AL 7075. Taguchi method was applied to find optimum process parameters for abrasive water jet machining (WAJM). The approach was based on Taguchi's method, analysis of variance and signals to noise ratio to optimize the WAJM process parameters for effective machining and to predict the optimal choice for each WAJM parameters such as traverse speed, abrasive flow rate, standoff distance and abrasive grit size. After the experimental work they have conclude that traverse speed and abrasive grit size is most significant factor on MRR and surface roughness respectively.

Rama rao et al. [7] they have studied the effect of various electro chemical machining parameters such as voltage, feed rate and electrolyte concentration on the material removal rate of the AL Sic material. The settings of process parameters were determine by using Taguchi's experimental design method. Orthogonal array of Taguchi, the signal to noise ratio, the analysis of variance and regression analysis are employed to find the optimal process parameter levels and to analyze the effect of these parameters on material removal rate values. Confirmation test with the optimal level of machining parameters was carried out in order to illustrate the effectiveness of the Taguchi optimization method. After the data analysis they have found that ANOVA and Taguchi's S/N ratio for data analysis drew similar conclusion. After the experimental work statistical result shows that the voltage, feed rate and electrolyte concentration affects the metal removal rate by 34.04 %, 58.09 % and 7.57 % in ECM respectively. At lastthe analysis of the confirmation experiment for metal removal rate has shown that Taguchi parameter design can successfully verify the optimum cutting parameters.

Srinivasathreya et al. [8]they have study to illustrate the procedure adopted in using Taguchi Method to a lathe facing operation. The orthogonal array, signal-to-noise ratio, and the analysis of variance are employed to study the performance characteristics on facing operation. In this analysis, three factors namely speed; feed and depth of cut were considered. Accordingly, a suitable orthogonal array was selected and experiments were conducted. After conducting the experiments the surface roughness was measured and Signal to Noise ratio was calculated.With the help of graphs, optimum parameter values were obtained and the confirmation experiments were carried out.These results were compared with the results of full factorial method. After the comparison they have conclude that the Taguchi's Method of parameter design can be performed with lesser number of experimentations as compared to that of full factorial analysis and yields similar results.It is found that the parameter design of the Taguchi method provides a simple, systematic, and efficient methodology for optimizing the process parameters.

Application OfArtificial Neural Network

Ramezan Ali et al. [9]They have conduct experimentsto optimize the surface roughness and material removal rate of electro discharge machining of Sic parameters simultaneously.Effects of three important input parameters of process viz., discharge current, pulse on time (Ton), pulse off time (Toff) on electric discharge machining of Sic are considered.Artificial neural network (ANN) with back propagation algorithm is used to model the process. A multi-objective optimization method, non-dominating sorting genetic algorithm-II is used to optimize the process.Experiments have been conducted over a wide range of considered input parameters for training and verification of the model.The MRR and surface roughness have been measured for each setting of pulse on time and pulse off time and current.ANN model has been trained within the experimental data which both are close to each other that demonstrate that the model is suitable for predicting the response parameters.

Mr.Ch.Madhu et al. [10]They have done experiments in order to find out effect of turning parameters on surface roughness of titanium work piece. Three important turning parameters such as cutting speed, feed rate and depth of cut are selected to study for this purpose. They have employed design of experiments in order to conduct the experiments. The model for the surface roughness, as a function of cutting parameters, is obtained using ANN in MATLAB7. After the experimental work comparison was carried out between experimental data and ANN value which was found similar. The results obtained conclude that ANN is reliable method and it can be readily applied to different metal cutting processes with greater confidence.

ShenChangyu et al. [11] they haveproposed a combining artificial neural network and genetic algorithm method to optimize injection molding process. The back propagation neural model was developed to build nonlinear relationship between process conditions and quality indexes of the injection molded parts. The genetic algorithm was used for process condition optimization. The combine ANN/GA method is used in the process optimization for industrial parts in order to improve the quality of volumetric shrinkage variation in the parts. After the results they have conclude that TheANNtechniquehasbeenshownasaneffectivemeth odtomodelthecomplexrelationshipbetweentheproces sconditionsandthequalityindexofinjectionmoldingpa rts.TheGAisespeciallyappropriatetoobtaintheglobal

optimizationsolutionofthecomplex nonlinearproblem.ThecombiningANN/GAmethodproposedgivessatisfactoryresultfortheoptimizationofthe injectionmoldingprocess.
Themodelingandoptimizationmethodsproposedshowthegreatpotentialincomplicatedindustrialapplications.

IV. Conclusion

From the above reviews conclusion can be drawn that the optimization of FDM parameters is necessary to achieve higher quality parts. Taguchi method is best approach for experimental design. Its tool such as orthogonal array, S/N ratio and ANOVA analysis is helpful to determine most significant factor which affect performance characteristics. We have also found that artificial neural network (ANN) is also versatile tool in order to predict the experimental results.

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