A STUDY OF AFFECT IN SLICES AND SUPPORT PARAMETERS ON DIMENSIONAL ACCURACY FOR FDM PROTOTYPE

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ABSTRACT

Rapid prototyping process enables creation of complex physical components in relatively shorter building time and wide materials utilization. Fused deposition modeling, often referred as FDM, is a type of rapid prototyping (RP) technology commonly used within engineering design and manufacturing environment. FDM works on an "additive" principle by laying down material in layers. 3D models are translated into .STL file to be used in FDM machine. The model is built up from layers as the plastic hardens immediately after extrusion from the nozzle. The data preparation process in the FDM machine prior to prototype building involves lot of parameters setting. The effect of these parameters on the product needs to be evaluated for obtaining product with optimum quality. This project study the effect of slice thickness and support parameters on the Water Soluble System, Fused Deposition Modeling (FDM) product quality in terms of dimensional accuracy produced during part building. The results obtained show that considered parameters influence the studied responses. The influences on the angular dimensional accuracies are higher as compare to the linear dimensions. Future work studies are being conducted to enhance the knowledge in understanding parameters setting that can be utilized to produce better quality product.

Keywords

Rapid prototyping ,Fused deposition modeling, slices, support, quality ,dimensional accuracy

1. INTRODUCTION

Dimensional accuracy is defined as the average absolute deviation between measured points from the actual part surface, and the associated nominal part surfaces as representing within the CAD model. Although the FDM prototypes are often used for visual assessment, the dimensional accuracies could directly affect its parts functionality when physical testing is the key objective.

Part build in FDM have restricted accuracy due to shape of the material used, the filament form. Typically, the filament used has a diameter of 1.27mm and this tends to set the limits on how accurately the part can be build. Shrinkage and distortion also affect the accuracy of the FDM process. As build material is extruded through heated head and cool rapidly after deposition, stresses invariably induced in the model. These shrinkage and distortion is unpredictable and normally compensated through adjustment of process parameters. Insight software has shrinkage factors for X and Y direction, thus evaluating the existing setting is also important.

2. A REVIEW ON DIMENSIONAL ACCURACY

The study on the parameters that effect on the dimensional accuracies was carried out by few researchers. They considers the slice thickness, temperatures, raster angle and etc. However the studies on the effect of support parameters on the dimensional accuracies were unfound.

The size of the nozzle tip is the significant factor that influenced the dimensional accuracy. However, the normal probability plot shows that there were no specific parameters seem to influence the accuracy of the dimensions (Nur Fazidah, 2001).

The position in the work envelope and the envelope temperature effects on FDM dimensional accuracies were also studied. The results show that the corner had lower deviation as compare to the part located in the centre of the envelope. This is due to higher radiant heat from the wall of the envelope as compare to the part in the middle (Pennington et al, 2005).

Ismir et al (2005) evaluated the geometrical dimensional accuracy of the FDM prototypes. His study showed raster angle with 45 degree setting will give good dimensional accuracy for solid part. In our project, the raster angle was set at 45 degree for the whole experiments.

Zieman et al showed that the most significant effect on dimensional accuracy was determined by the interior fill strategy. He concluded that there are other more significant factors might influence the accuracy of the part.

As studied by M. Mahesh et al (2004), the FDM machines are capable of producing certain geometries which less than 5% deviations. Some of the geometries with different dimensions are used in this experiment.

3. METHODOLOGY AND MEASURING EQUIPMENTS.

The full factorial method is used to determine the numbers of experiment need to be accomplished. The multiplications of the factors to be considered in the experiment give 18 numbers of experiments to be carried out. The parameters, levels and numbers of levels are as in the following table.

Table 1. Process variables and levels

Parameters	Level	Numbers of Level
Support Style	Sparse (default), Basic, Surround	3
Grow Support	Small (default), All and No	3
Slice Thickness	0.007 and 0.013 in	2

The Coordinate Measuring Machine (CMM), Mitutoyo Beyond Apex A504 was used to measure the dimensional accuracy of the specimen. The PH-9A probe is used with a stylus diameter of 2 mm. Geopack software was used to analyze the data collected from the CMM. Based on Azanizawi et al the measurement of the hole diameter was done using the profile projector. 15 features are measured under the experiments.

4. RESULT AND DISCUSSIONS

4.1 Linear Dimensional Accuracy

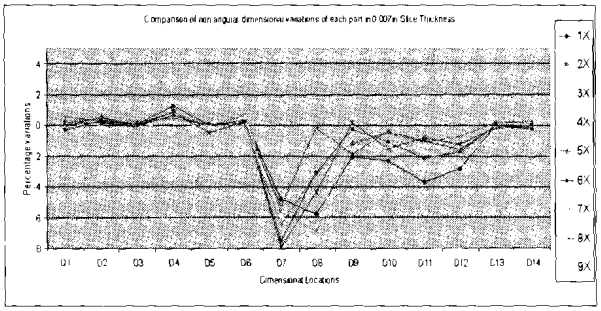

Figure 1. Dimensional Locations vs. % Variations in 0.007in Slice Thickness

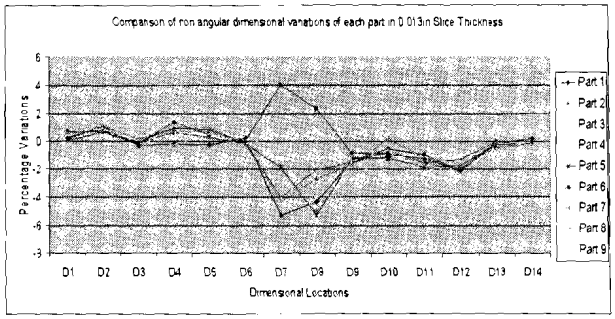

Figure 2. Dimensional Locations vs. % Variations in 0.013in Slice Thickness

The maximum linear dimensional variations obtained are less than 8%, while the average linear dimensional variations are small (< 3 %) except for D7 and D8. The graphs show that the dimension for those features varies and doesn't give good repeatability. The influence of considered parameters on the linear dimensional accuracy is considered insignificance as both of the graphs show similar pattern.

4.2 Angular Dimensional Accuracy

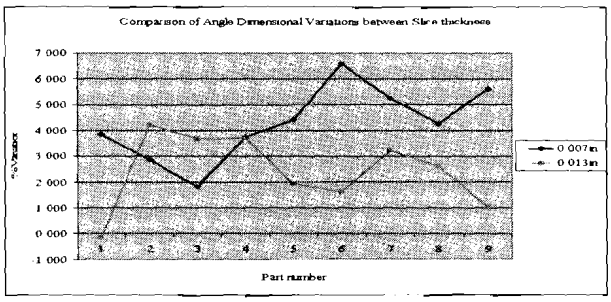

Figure 3. Part Number vs. % Variations for D15 comparing slice thickness

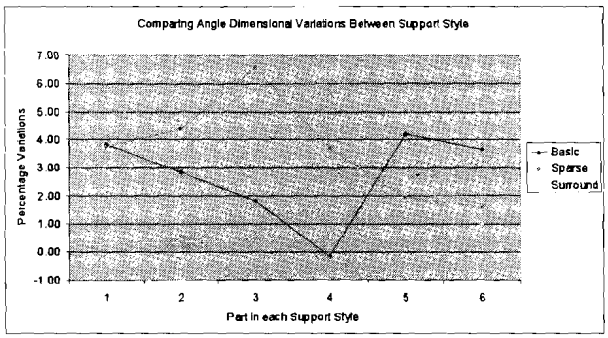

Figure 4. Part Number vs. % Variations for D15 comparing supports style

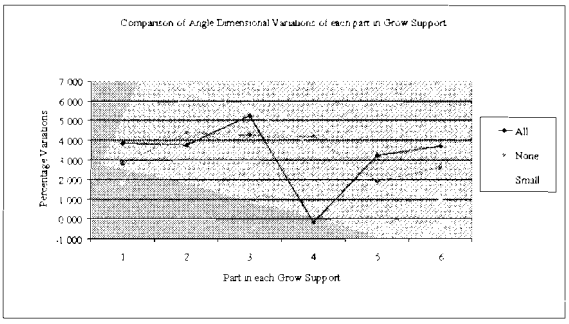

Figure 5. Part Number vs. % Variations for D15 comparing grow support

Figure 3, 4 and 5 shows percentage variations of angle dimension when comparing slice thickness, support style and grow support, respectively. For slice thickness, 0.007in give higher variations. The numbers of layer increase as the slice thickness decrease. Thus, the sum of variation in 0.007in is higher as compare to 0.013in. For support style, Sparse and Basic give more repetition of high and low value, respectively. Sparse structure has bigger air gap as compare to Surround and basic. Therefore, it is predicted that it will give lower dimensional accuracy. In the case of grow support, All and Small gives more repetition of high and low value of dimensional variations, respectively. We predict that None will give lower dimensional accuracy, however

5. CONCLUSION

In the analysis of the dimensional accuracy, all factors were not significant in influencing the linear dimensional accuracy, whereas, significance influence was observed on the angular dimensional accuracy. Results showed that a FDM had a good capability in producing parts which consist of hole, square based and inclined features. Linear dimensions could be created with minimum variation. Part consisted of hole, and square base can be built with less than 5% variations, however, for parts with inclination features, variations was not more than 10%. The results of this study agreed with other researchers which stated that the FDM machine was capable of producing part with circular holes and also square based with less than 5% dimensional variations (M. Mahesh et al , 2004). In most locations the dimensional variations was less than 0.127mm as dictated by Azanizawati. For angular dimension and inclined features, accuracy in Z direction could be influenced by stepping effect which leads to lower accuracy (higher variations).

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