Effect of Acetone Vapor on Tensile Strength of Fused Deposition Modeling Printed Part

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1. ABSTRACT – Additive Manufacturing (AM) has the benefit being capable to create very complex geometries, which could be impossible with traditional methods or fabricated at a high cost [1]. For material cost properties, the cost of 3D printing parts is mostly related to the size of the product. The research is used polymer-based material specifically acrylonitrile butadiene styrene (ABS). In this research, an acetone vapor post process will be employed to investigate the effect of tensile strength of the printed part after applying the vaporing process. Mechanical anisotropy behaviour of the specimen are investigated via tensile test. The results of the implementation of acetone vapor as post processing of FDM printed part are compared with the original printed part in term of their tensile strength.

1. INTRODUCTION

There are many post-processing [2] solutions can be applied for improving the mechanical properties of the printed part [3]. Therefore, it can be differentiate the mechanical properties [4] of the original part with the part that undergo post-processing process. The purposes of this research writing is to study the effect of acetone vapor on mechanical properties to be specific in term of tensile strength of fused deposition modeling (FDM) printed part.

2. METHODOLOGY

A) Specimens Preparation

In this research, two sample tensile specimens have been built for original and four different vaporing times using acrylonitrile butadiene styrene (ABS) material. ABS has high mechanical strength, is low cost and is convenient for fabrication and 3D printing. The substrates were built by adding ABS layers that were 0.20 mm thick. The specimens were fabricated using a UP Plus 2 3D Printer machine. The 3D specimens were modeled in Solidworks 2016. The outputs were exported as STL files that were imported by the FDM software. Thus, the process is proceed with printing of the specimens.

B) Tensile Test

Tensile strength test were conducted using Instron Universal Testing Machine equipped with a 50-kN load cell. Tensile strength tests were performed according to ASTM D638 (plastics: determination of tensile properties) with 5 mm/min crosshead speed. Figure 1 shows the shape and dimensions of the test specimens. The specimen was gripped with Wedge Action Grips. An extensometer was used to determine the elongation and tensile modulus of the part.

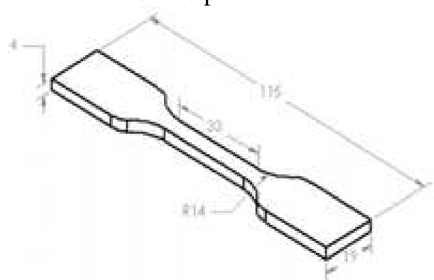

Figure 1 Test specimens, all dimensions are in mm: tensile test specimen

3. RESULTS AND DISCUSSION

Tensile test was conducted to measure the tensile strength of the specimens. Each specimen was gripped at both end before pulled until it breaks or meet the failure. The results showed the maximum load applied and ultimate tensile strength of the material for each specimen so that it can be compared. Figure 2 shows the graph of maximum load versus specimens. Based on the graph, the highest value for maximum load that to be compared with the original part was the specimen of sample 1 for 45 minutes vapored part with the value of 657.8956 N. Meanwhile, the lowest value for maximum load was the specimen of sample 2 for 30 minutes vapored part valued 579.2352 N. There were two samples for each part. Therefore, the mean or average of the value for those two samples were required for further analysis. The highest average value for maximum load was 45 minutes vapored part with the value of 650.3140 N. Specimen of 15 minutes vapored part was the second highest value of average maximum load with 626.0480 N and followed by specimen of 30 minutes vapored part that valued 609.9648 N.

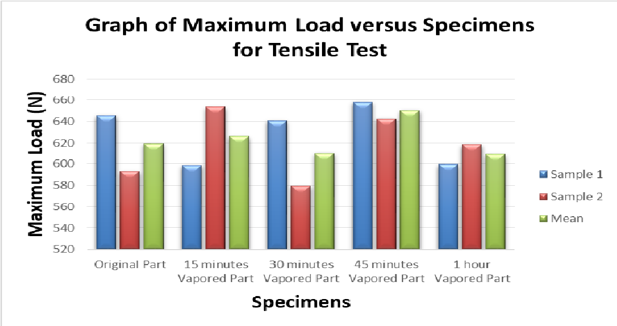

Figure 2 Graph of maximum load versus specimens for tensile test

The lowest was specimen of 1 hour vapored part with value of 608.8999N. All the specimens value were acceptable for further analysis as the increasing and decreasing percentage were below than 10 percent. Figure 3 below shows the value of tensile strength for each specimen. The highest tensile strength that to be compared with the original part was the specimen of sample 1 for 45 minutes vapored part at 27.412 MPa. Next, the specimen of sample 2 for 15 minutes vapored part gave the second highest value with 27.232 MPa and followed by sample 2 for 45 minutes vapored part with 26.772 MPa.

The fourth highest value of tensile strength was specimen of sample 1 for 30 minutes vapored part with 26.696 MPa and continued with specimen of sample 2 for 1 hour vapored part valued 25.594 MPa. Meanwhile, the specimen of sample 2 for 30 minutes vapored part gave the lowest tensile strength that valued 24.135 MPa followed by specimen of sample 1 for 1 hour vapored part as second lowest with the value of 24.883 MPa and sample 1 for 15 minutes vapored part valued 24.934 MPa as third lowest of tensile strength.

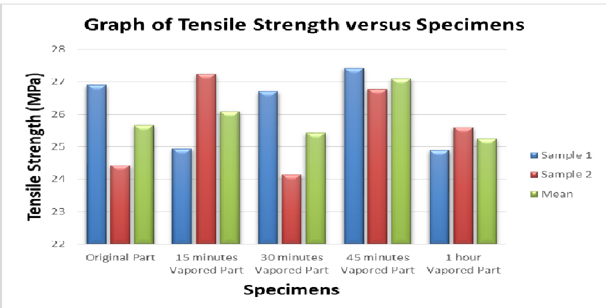

Figure 3 Graph of tensile strength versus specimens

Figure 4 shows the graph of average tensile strength versus type of part. As the test conducted for each type of part was performed with two samples, the average of the values were required for further analysis and to compare with the original part value. Based on the graph, the 45 minutes vapored part gave the highest value of tensile strength with the value of 27.092 MPa. Next, the 15 minutes vapored part gave the second highest tensile strength valued 26.083 MPa followed by 30 minutes vapored part with 25. 415 MPa. Meanwhile the 1 hour vapored part resulted as the lowest tensile strength with value of 25.238 MPa.

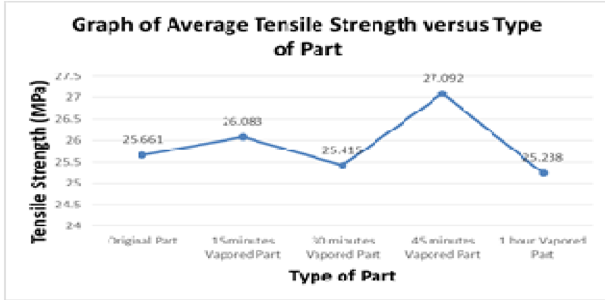

Figure 4 Graph of average tensile strength versus type of part

Therefore, based on the results, the original part gave the average tensile strength of 25.661 MPa. As compared with the original part, the 45 minutes vapored part gave the higher value with 27.092 MPa. Besides that, the value of 15 minutes vapored part also gave the higher value than the original part and as the second highest compared to 45 minutes vapored part with the value of 26.083 MPa. Thus, it shows that the implementation of acetone vapor with the duration of 45 minutes and 15 minutes had improve the tensile strength of the material.

4. CONCLUSION

As conclusion, after applying acetone vapor, it effected to the tensile strength of FDM printed part. As tensile strength studied, tensile strength had been improved by implementing the acetone vapor. The best duration of vaporing time is 45 minutes for tensile strength.

5. ACKNOWLEDGEMENT

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